

Dewhurst 13-18H, Dewhurst 26-31 and Bibblewindi Multi-Lateral Pilots

Biodiversity Management Plan

Prepared for Santos NSW (Eastern) Pty Ltd

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	Clockwise from left: Calyptorhynchus lathami (Glossy Black Cockatoo) (ELA 2012), Felis catus
Cover photo	Feral cat (ELA 2014), Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest at
	Dewhurst 31 (ELA 2013).

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Abbreviations

Abbreviation	Description
AIS	Agricultural Impact Statement
ANOVA	Analysis of variance
ВМР	Biodiversity Management Plan
CAMBA	China Australia Migratory Bird Agreement
CSG	Coal seam gas
DoE	Commonwealth Department of the Environment
DP&E	NSW Department of Planning and Environment
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EP&A Act	NSW Environmental Planning and Assessment Act 1979
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999

Abbreviation	Description
FM Act	NSW Fisheries Management Act 1994
GDE	Groundwater dependent ecosystem
НВТ	Hollow bearing tree
JAMBA	Japan Australia Migratory Bird Agreement
LEP	Local Environment Plan
LGA	Local Government Area
MNES	Matters of National Environmental Significance
NW Act	NSW Noxious Weeds Act 1993
OEH	NSW Office of Environment and Heritage
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration Lease
PPE	Personal protective equipment
PPL	Petroleum Production Lease
ROKAMBA	Republic of Korea Australia Migratory Bird Agreement
Santos	Santos NSW (Eastern) Pty Ltd
SEPP	State Environmental Planning Policy
SSD	State Significant Development
SSI	State Significant Infrastructure
TEC	Threatened Ecological Community
TSC Act	NSW Threatened Species Conservation Act 1995

Executive summary

Eco Logical Australia (ELA) was engaged by Santos NSW (Eastern) Pty Ltd to prepare a Biodiversity Management Plan (BMP) to guide the management of biodiversity values associated with the proposed expansion of operations at Dewhurst 13-18H, Dewhurst 26-31 and Bibblewindi Multi-lateral Pilots. The purpose of this report is to identify the key biodiversity values, potential impacts and measures to mitigate and monitor these impacts. This report addresses the requirements for biodiversity monitoring given in the NSW Department of Planning and Environment (DP&E) Conditions of Consent for both the Dewhurst and Bibblewindi Expansions.

The BMP provides detail on specific biodiversity and habitat values of the study area (defined as a 20 metre buffer zone around all lease areas, access tracks and flowlines that are part of the proposed development), identifies the potential direct and indirect impacts of the proposed development, provides mitigation actions and includes a detailed monitoring plan to meet the DP&E requirements. The BMP is written to cover the lifespan of the pilot wells and includes management during pre-construction, construction, operation and rehabilitation.

The biodiversity and habitat values identified in the study area include one Endangered Ecological Community (EEC), three threatened plant species and 10 threatened fauna species. In addition, three high-priority Groundwater Dependent Ecosystems (GDEs) which could potentially be indirectly impacted by the proposed development occur in the wider study region. Vertebrate pests, weed incursions, and noise and dust increases are amongst the potential threats to the maintenance of biodiversity values in the study area.

Mitigation strategies for potential direct and indirect impacts on biodiversity values are described and include weed management, restriction of all activities to within the construction footprint, erosion control, minimisation of light spill and minimising loss of hollow bearing trees. Monitoring strategies that measure the effectiveness of these mitigation strategies are specified for representative taxa or guilds considered likely to be impacted by the development (e.g. microbats, woodland birds, native vegetation, Groundwater Dependant Ecosystems (GDEs) and vertebrate pests).

The monitoring program has been designed to test statistically for impacts of the proposed development on biodiversity and will allow evaluation of the success of mitigation measures. The twice-annual monitoring will provide a transparent and defensible platform on which to report. Reporting against the performance measures specified by the DP&E will be completed annually, and will detail whether indicative targets have been met. If targets are not achieved, further management actions may be triggered.

The BMP should be reviewed at the end of the proposed three year operational period for the pilots.

1 Introduction

Eco Logical Australia (ELA) was engaged by Santos NSW (Eastern) Pty Ltd (Santos) to prepare a Biodiversity Management Plan (BMP) to guide the management of biodiversity values associated with the Dewhurst 13-18H, Dewhurst 26-31 and Bibblewindi Multi-lateral Pilot Expansions. ELA has been involved in the development of the Narrabri Gas Project since 2010 and has completed a number of studies into the biodiversity values of the north-east Pilliga Forest, the biodiversity risks associated with coal seam gas (CSG) development, and success of rehabilitation activities to date.

This BMP has been prepared to meet the Department of Planning and Environment (DP&E) Conditions of Consent for both the Dewhurst and Bibblewindi Expansions. The requirements of the BMP are shown in **Table 1**, along with the section of the report that addresses each requirement.

Table 1: Requirements of BMP as specified in NSW Department of Planning and Environment conditions of consent

Require	ement of Biodiversity Monitoring Plan	Relevant report section	
a)	be prepared in consultation with the NSW Office of Environment and Heritage (OEH), and be approved by the Secretary prior to commencing construction of the development;	Consultation with OEH was undertaken during the preparation of this report.	
b)	describe the short, medium, and long term measures that would be implemented to minimise indirect impacts of the development;	Section 2.4.4	
c)	include a seasonally-based program to monitor and report on the effectiveness of these measures, and progress against the specified performance measures (see Table 2); and	Section 2.5	
d)	include details of who would be responsible for monitoring, reviewing, and implementing the plan.	Section 2.5	

The specified performance measures which must not be exceeded by the development are outlined in **Table 2.**

Table 2: Performance measures for biodiversity specified in conditions of consent

Biodiversity values	Performance Measure		
Groundwater Dependent Ecosystems	Negligible environmental consequences		
Threatened species, threatened populations, or endangered ecological communities	Minor environmental consequences		

The commencement of the monitoring program will be triggered by the start of the activity. This is defined as commencement of clearing at the Dewhurst well pads, and the commencement of drilling at the Bibblewindi well pads.

1.1 Project description

1.1.1 Dewhurst pilot expansion project description

The Dewhurst pilot expansion project (the activity) involves expansion of operations at the existing Dewhurst 13-18H Pilot and recently constructed 26-29 Pilot, including the construction of two new wells (Dewhurst 30-31) and operation of all wells for up to three years. The Dewhurst 13-18H Pilot is located on freehold land and Crown Land road reserve, approximately 25 kilometres south of Narrabri in northwestern NSW (**Figure 1**). The Dewhurst 26-31 Pilot is located in the Pilliga East State Forest, approximately 44 kilometres south of Narrabri (**Figure 1**).

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The activity includes drilling an additional two horizontal wells at each of the existing Dewhurst 16H, 17H and 18H pilot wells, installing surface and subsurface infrastructure (including a flare and water balance tank at Dewhurst 14), construction of a new gas and water gathering system to connect all wells within the Dewhurst 13-18H Pilot to the existing Dewhurst 14 well lease area, removal of the existing system, and operation of the whole pilot set for up to three years.

Dewhurst 26-29 is an existing four well pilot. The activity includes drilling two additional wells (Dewhurst 30 and 31), which will require the clearing of two lease areas of approximately one hectare each, clearing of two 10 metre wide service corridors between Beehive Road and the new lease areas and constructing access roads within each corridor. The activity also includes the installation of surface and subsurface infrastructure (including extension of the existing water and gas gathering system for Dewhurst 26-29 to Dewhurst 30 and 31 and construction of a flare at Dewhurst 28), and operating the six pilot well set for up to three years.

Also included in the activity is the management of the water and gas produced during operation and general maintenance activities, and the post-operation decommissioning and rehabilitation of pilot wells and ancillary infrastructure or suspension of wells for potential future use.

The construction footprint for Dewhurst 13-18H is 5.37 hectares; this includes the existing lease areas at Dewhurst 14, 16H, 17H and 18H and the proposed gathering system. Within this footprint, approximately 0.24 hectares of vegetation will be cleared. The construction footprint for Dewhurst 26-31 is 3.52 hectares including the lease area at Dewhurst 28 where a flare is to be constructed, the proposed lease areas at Dewhurst 30 and 31 and the proposed service corridor for Dewhurst 30 and 31. Within this construction footprint, approximately 2.2 hectares of vegetation will be cleared.

1.1.2 Bibblewindi pilot expansion project description

The Bibblewindi pilot expansion project (the activity) includes the construction and drilling of two additional pilot wells (Bibblewindi 31 and 32), installation of surface and subsurface infrastructure to connect the two wells to the existing Bibblewindi Multi-Lateral Pilot, and operation of the expanded Bibblewindi Multi-Lateral Pilot for up to three years.

The activity also includes management of the water and gas produced during operation, occasional maintenance, and the decommissioning of pilot wells and associated infrastructure and rehabilitation or suspension of well leases on completion of operations.

The Bibblewindi Multi-Lateral Pilot is located within Bibblewindi State Forest, approximately 40 kilometres south of Narrabri (**Figure 1**). It currently consists of 12 wells (Bibblewindi 12, 13, 14, 15, 16, 17, 18H, 19H, 21H, 27, 28H and 29). Each well is situated on a well lease area of approximately 0.8 hectares, which are connected via a series of access tracks branching off Little Tighes Road.

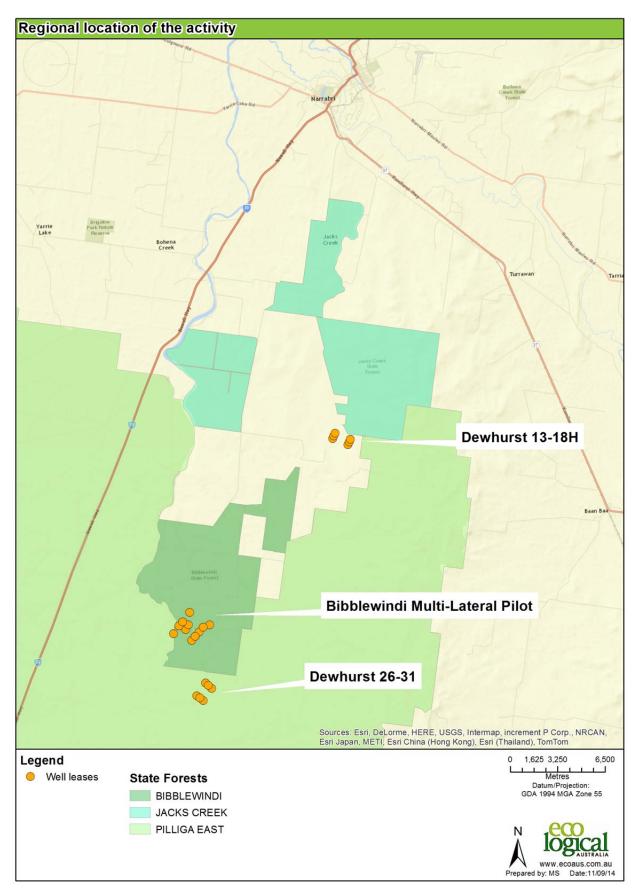


Figure 1: Regional location of well leases

The construction footprint for the proposed Bibblewindi 31 and 32 pilot wells is contained within the existing Bibblewindi 14 and Bibblewindi 19H well leases respectively, and construction access will be along existing access tracks. Therefore, no additional clearance of vegetation is required and no new disturbance will occur beyond the existing lease areas and access tracks.

1.2 Study area

During the ecological assessment process for the activity, surveys were conducted in the immediate vicinity of Dewhurst 13-18H, Dewhurst 30 and 31 and Bibblewindi 31-32.

However, this BMP considers the impacts to biodiversity resulting not only from the construction of these new developments but also the operation of all the wells in the pilots as specified in the project description in **Section 1.1.**

For the purposes of this document the following areas are therefore defined:

- 'study area' is the area surrounding the activities at Dewhurst 13-18H and 26-31 Pilots and the Bibblewindi Multi-lateral Pilot within which it is considered that indirect impacts to biodiversity will be contained. This area comprises a 20 metre buffer zone around all well lease areas and access tracks, and is the focus of this BMP.
- 'Study region' is defined as the area within Petroleum Exploration Lease (PEL) 238 which includes Petroleum Assessment Lease (PAL) 2 and Petroleum Production Lease (PPL) 3. This area is used to discuss the activity within the context of the broader north-east Pilliga Forest.
- 'Dewhurst study area' is the area surveyed during the ecological assessment process for the expansion of operations at Dewhurst 13-18H and 26-31. This includes the sites for the construction of the new Dewhurst 13 18H gathering system, the Dewhurst 30 and 31 wells and associated service corridors, and a 10 metre buffer around each.
- 'Bibblewindi study area' is the area surveyed during the ecological assessment process for the expansion of operations at the Bibblewindi Multi-lateral Pilot. This included the Bibblewindi 14 and 19H lease areas (the proposed locations of Bibblewindi 31 and 32), the access tracks to the lease areas, and a 20 metre buffer around each.
- 'subject site' refers to the area directly impacted by the activity (disturbance footprint for construction).

2 Biodiversity Management Plan

2.1 Legislative context

Various legislation, policies and guidelines apply to the assessment, planning and management of biodiversity values within the study area. These regulatory requirements were reviewed to determine their application to the activity. Summaries of statutory and policy requirements in relation to ecology are outlined below.

2.1.1 International agreements

Japan - Australia Migratory Bird Agreement (JAMBA) / China - Australia Migratory Bird Agreement (CAMBA) / Republic of Korea – Australia Migratory Bird Agreement (ROKAMBA)

The JAMBA, CAMBA and ROKAMBA list terrestrial, water and shorebird species which migrate between Australia and the respective countries. The majority of listed species are shorebirds.

These agreements require the parties to protect migratory birds by:

- Limiting the circumstances under which migratory birds are taken or traded
- Protecting and conserving important habitats
- Exchanging information
- Building cooperative relationships

The JAMBA also includes provisions for cooperation on the conservation of threatened birds (DoE 2014). Australian government and non-government representatives meet every two years with Japanese and Chinese counterparts to review progress in implementing the agreements and to explore new initiatives to conserve migratory birds (DoE 2014).

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; see **Section 2.1.2**) includes provisions for the protection and conservation of JAMBA, CAMBA and ROKAMBA listed species and their habitats, and gives effect to Australia's obligations under these agreements. Migratory species that were recorded or have the potential to be present or use the study area are included in **Table 4.**

2.1.2 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

The primary objective of the EPBC Act is to 'provide for the protection of the environment, especially those aspects of the environment that are Matters of National Environmental Significance (MNES).'

Environmental approvals under the EPBC Act are required for an 'action' that is likely to have a significant impact on MNES including:

- World Heritage Areas.
- National Heritage Places.
- Ramsar wetlands of international importance.
- Nationally listed threatened species and ecological communities.
- Listed migratory species.
- Commonwealth marine areas.
- Nuclear actions.
- Great Barrier Reef Marine Park.

 A water source, in relation to coal seam gas development and large coal mining development.

In addition, the EPBC Act confers jurisdiction over actions that have a significant impact on the environment:

- the actions affect, or are taken on, Commonwealth land
- are carried out by a Commonwealth agency (even if that significant impact is not on one of the nine matters of 'national environmental significance').

An 'action' is considered to include a project, development, undertaking, activity or series of activities.

MNES relevant to the study area are nationally listed threatened and migratory species and ecological communities. Ecological MNES that were recorded or have the potential to be present or use the study area are included in **Table 3** and **Table 4**.

Santos referred the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program (which includes the Dewhurst and Bibblewindi Pilot Expansions) to the Australian Government Department of the Environment (DoE) on 27 June 2013. A 'not controlled action if undertaken in a particular manner' decision was made on 1 October 2013 by the Minister for the Environment, meaning the program does not require Australian Government approval, provided it is undertaken in the particular manner set out in the decision notification.

2.1.3 New South Wales legislation

Environmental Planning and Assessment Act 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act) is the principal planning legislation for NSW. It provides a framework for land use control and assessment, determination and management of development.

The activities were designated State Significant Development (SSD) under Part 4.1 of the EP&A Act due to the proposed activities meeting the criteria listed in Schedule 1 of the State Environmental Planning Policy (State and Regional Development) (SRD SEPP) 2011.

Santos has prepared an Environmental Impact Statement (EIS) for both the Dewhurst and Bibblewindi Gas Exploration Pilot Expansions to address the Director-General's Requirements (DGRs) for the projects. The assessment of impacts to biodiversity values is contained within a technical appendix to both EIS documents (RPS 2013b; RPS 2013a).

This Biodiversity Management Plan has been prepared to meet the requirements given in the NSW Department of Planning and Environment (DP&E) Conditions of Consent for both the Dewhurst and Bibblewindi Expansions.

Threatened Species Conservation Act 1995

The *Threatened Species Conservation Act 1995* (TSC Act) aims to protect and encourage the recovery of threatened species, populations and communities listed under the Act. The TSC Act is integrated with the EP&A Act and requires consideration of whether SSD (Division 4.1 of Part 4 of the EP&A Act) or state significant infrastructure (SSI) (Part 5.1 of the EP&A Act) is likely to significantly affect threatened species, populations and ecological communities or their habitats.

Threatened species, populations and ecological communities that were recorded or have the potential to be present on or use the study area are included in **Table 3** and **Table 4**.

Fisheries Management Act 1994

The *Fisheries Management Act 1994* (FM Act) aims to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. The FM Act defines 'fish' as any marine, estuarine or freshwater fish or other aquatic animal at any stage of their life history, excluding whales, mammals, reptiles, birds, amphibians or other species specifically excluded.

No threatened fish species or endangered populations are known or expected to occur within the study area.

Noxious Weeds Act 1993

The *Noxious Weeds Act 1993* (NW Act) defines the roles of government, councils, private landholders and public authorities in the management of noxious weeds. The NW Act sets up categorisation and control actions for the various noxious weeds, according to their potential to cause harm to the local environment.

The objectives of the NW Act include:

- Identify noxious weeds in respect of which particular control measures need to be taken.
- Specify those control measures.
- Specify the duties of public and private landholders as to the control of those noxious weeds.
- Provide a framework for the State-wide control of those noxious weeds by the Minister and local control authorities.

Under the NW Act, noxious weeds have been identified for Local Government Areas (LGAs) and assigned Control Classes. Part 3 provides that occupiers of land (this includes owners of land) have responsibility for controlling noxious weeds on the land they occupy.

2.1.4 State Environmental Planning Policies (SEPPs)

State Environmental Planning Policy 44 (Koala Habitat)

State Environmental Planning Policy 44 (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline. As the activities are over 1 ha in size, and SEPP 44 applies to the Narrabri LGA in which the study area is located, an assessment under SEPP 44 was required as part of the Environmental Assessment process. As the Koala is also listed as a threatened species under the TSC Act and EPBC Act, impacts to Koalas and their habitat have also been assessed during the Environmental Assessment process.

2.1.5 Local Environment Plans (LEPs)

Narrabri Local Environment Plan 2012

The Narrabri Local Environment Plan 2012 (Narrabri LEP 2012) applies to Narrabri Shire Council LGA not including Boggabri and Narrabri municipal areas. The study area is wholly contained within the Narrabri LGA in the zones RU1 Primary Production and RU3 Forestry. One of the aims of the RU1 zone is to minimise the fragmentation and alienation of resource lands. Clause 3.3 of the LEP states that exempt or complying development must not be carried out on any environmentally sensitive area, which includes land identified in any environmental planning instrument as being of high biodiversity significance.

2.2 Habitat and biodiversity values of the BMP study area

Over 70 flora species and 110 fauna species were identified during field surveys in the Dewhurst 13 18H and Dewhurst 30-31 study area. Surveys in the Bibblewindi 31-32 study area recorded 25 flora species and nine fauna species (all avifauna). The low number of records at Bibblewindi is due to the existing lease areas and access tracks being largely clear of native vegetation aside from small patches of regeneration. A complete list of the flora and fauna species recorded for both study areas is provided in the EIS documents (RPS 2013b; RPS 2013a).

A number of introduced animal species have been recorded in the study area and adjacent habitat, namely *Vulpes vulpes* (European Red Fox), *Sus scrofa* (Pig), *Felis catus* (Cat), *Capra aegagrus hircus* (Goat), *Oryctolagus cuniculus* (European rabbit) and *Lepus europaeus* (Brown Hare).

Weed incidence is low across the study area. Weed species that have been recorded occasionally during surveys included *Anagallis arvensis* (Pimpernel), *Opuntia stricta* (Prickly Pear), *Hypochaeris radicata* (Catsear) and *Sonchus oleraceus* (Common Sow-thistle). Prickly Pear is a Class 4 noxious weed under the NW Act and a Weed of National Significance.

2.2.1 Vegetation communities

Vegetation types that have been mapped as occurring within the study area include:

- 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
- Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South-western Slopes Bioregion
- White Bloodwood Dirty Gum Rough Barked Apple heathy open woodland on deep sand in the Pilliga forests
- Red gum Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga -Goonoo sandstone forests, BBS Bioregion

Of these communities, *Fuzzy Box Woodland* is a listed Endangered Ecological Community (EEC) under the TSC Act. None of the other communities are commensurate with any Threatened Ecological Communities (TECs) listed under the TSC Act or EPBC Act.

The section of the study area surrounding Dewhurst 13-18H and Dewhurst 26-31 contains only *Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest.* The section of the study area surrounding the Bibblewindi Multi-lateral Pilot contains all four vegetation communities, but is dominated by *Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest.*

2.2.2 Fauna habitat

A range of fauna habitat features have been recorded during surveys throughout the Dewhurst 13-18H, Dewhurst 30-31 and Bibblewindi 31-32 study areas, and these indicative of habitat values of the broader study area. Vegetated areas of open forest provide important resources for arboreal mammals, microbats and owls, and winter-flowering eucalypts are utilised by migratory birds and arboreal mammals. Fallen timber is an important feature for reptiles, molluscs and birds, whilst leaf litter provides a foraging resource for birds and mammals.

Twenty five hollow-bearing trees were recorded within the Dewhurst 30 and 31 study area, with hollows ranging in size from 5 to 30 centimetres wide. It can be assumed this is indicative of the occurrence of hollow-bearing trees throughout the broader study area given the similarity in vegetation age, structure

and disturbance history. Hollow-bearing trees provide important habitat for a variety of fauna species including microbats, birds, and arboreal mammals.

2.2.3 Aquatic habitat

Several ephemeral creeks intersect the study area, including Mount Pleasant Creek, Cowallah Creek, and an unnamed tributary of Cowallah Creek at Bibblewindi Multi-lateral Pilot; Mount Pleasant Creek at Dewhurst 26-31; and an unnamed tributary of Jacks Creek at Dewhurst 13-18H. Under prolonged wet conditions, these creeks are likely to be characterised by shallow pools and runs, with poor instream diversity. They are considered to provide unlikely or minimal fish habitat (RPS 2013a), although may support some common fish species during migration and breeding. The ephemeral creeks potentially also provide breeding and foraging habitat for frogs and reptiles.

No aquatic vegetation has been identified during surveys in the study area.

2.2.4 Groundwater-dependent ecosystems

Groundwater dependent ecosystems (GDEs) may be defined as a community of plants, animals and other organisms which exist within a defined area with their species composition and natural ecological processes determined by groundwater (DLWC 2002; Commonwealth of Australia. 1996). Groundwater filters down through the earth's surface to the point where the layer of loose rock and earth becomes fully saturated with the top of the saturated zone known as the watertable (DLWC 2002). GDEs are located across a broad range of environments. (Eamus et al. 2006) have proposed three simple primary classes of GDEs:

- 1. **Aquifer and cave ecosystems:** These ecosystems are where stygofauna inhabit the groundwater resource. Examples include karstic, fractured rock and alluvial aquifers
- 2. All ecosystems dependent on the surface expression of water: This includes base-flow rivers and streams, wetlands, some floodplains and mound springs and estuarine seagrass beds
- 3. All ecosystems dependent on the subsurface presence of groundwater: These ecosystems typically access groundwater via the capillary fringe (non-saturated zone above the saturated zone of the water table) when roots penetrate this zone. This includes terrestrial ecosystems such as *Eucalyptus camaldulensis* (River Red Gum) forests on the Murray-Darling basin

Many native plant species utilise groundwater during their lifecycle including those plants utilising the groundwater resource at the surface (e.g. wetlands) and other plants where their roots penetrate into the watertable at some depth (DLWC 2002). GDEs can, therefore, include ecosystems with complete dependence on groundwater (i.e. stygofauna in aquifers) to those which may utilise groundwater on occasion, but are not necessarily dependant on the groundwater resource.

Within the study region, groundwater is generally close to the surface (<5 m) in the quaternary alluvium associated with the major creeks and floodplains (e.g. Bohena Creek, approximately 4 kilometres northwest of Bibblewindi Multi-lateral Pilot), while generally being much deeper in those areas characterised by Jurassic quartz sandstone (20–50 m) (SKM 2010). The majority of the vegetation within the study region on alluvial soils is likely to have a proportional association with groundwater. Vegetation along the major creeks and floodplains has the potential to be dependent on base-flow groundwater, whilst the vegetation on the alluvial plains is likely to utilise groundwater resources proportionally (depending on rainfall) whilst vegetation on Jurassic quartz sandstone is unlikely to be groundwater dependant.

There are minimal areas of permanent surface water within the study region over the course of a year; creeks within the study region were observed to flow for a period of days to weeks following significant

rainfall (depending on stream order) and then cease flowing. The few permanent areas of surface water include constructed dams and a number of relatively small groundwater-fed springs. There are three springs listed as high priority GDEs: Eather Spring, Hardy's Spring and Mayfield Spring, located approximately 10, 20 and 19 kilometres to the east of Dewhurst 13-18H, Dewhurst 26-31, and Bibblewindi Multi-lateral Pilots respectively. These springs are understood to comprise recharge rejection springs associated with the junction of the unconfined Pilliga Sandstone and the underlying Purlewaugh Formation. The Purlewaugh Formation acts as a barrier to further percolation of groundwater within the Pilliga Sandstone and thus groundwater discharges to surface at this interface. As the modelling of cumulative impacts has demonstrated that there is no impact to the Upper and Lower Namoi alluvium or the Pilliga Sandstone due to the operation of the pilots, there is also no expected impact to the GDEs.

The vegetation in the study area is considered a terrestrial ecosystem (Eamus et al. 2006) and has potential to be proportionally dependent on groundwater (Hatton & Evans 1998). This dependency would be stronger during periods of drought. In periods of rainfall, the vegetation in the study area would draw its water source from rainfall and subsequent soil moisture.

A water resources assessment has been prepared by CH2MHILL for the Energy NSW Coal Seam Gas Exploration and Appraisal Program (the Program) (CH2M Hill 2013). The assessment included the activity addressed in this report. A risk assessment was used to predict the significance of potential impacts to water resources which included identification of the following:

- The potential water resources which could be impacted by the activities, and the sensitivity of these water resources, were identified.
- The potential risks and significance of associated impacts to water resources were identified.
- Mitigation and monitoring measures to be applied were identified in order to reduce the risk of significant impacts occurring to water resources.

No significant impacts with very high or high likelihood of occurrence were identified.

2.3 Threatened species, populations and ecological communities

2.3.1 Threatened ecological communities

Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW South-western Slopes Bioregion, an EEC under the TSC Act, occurs within the study area in the area surrounding the Bibblewindi Multi-lateral Pilot.

2.3.2 Threatened flora

Three threatened flora species have been located during field surveys in the Dewhurst study area: *Tylophora linearis*, *Pterostylis cobarensis* (Greenhood Orchid) and *Polygala linariifolia* (Native Milkwort). In addition to these known species, two threatened species are considered to have the potential to occur in the study area under consideration in this report (**Table 3**).

Table 3: Threatened flora species known or predicted to occur within the study area.

Scientific name	Common name	TSC Act Status	EPBC Act Status	Likelihood of occurrence
Diuris tricolor	Painted Diuris	V	~	Potential

Scientific name	Common name	TSC Act Status	EPBC Act Status	Likelihood of occurrence
Monotaxis macrophylla	Large-leafed Monotaxis	E	~	Potential
Polygala linariifolia	Native Milkwort	E1	~	Known
Pterostylis cobarensis	Greenhood Orchid	V	V	Known
Tylophora linearis	-	V	E	Known

Note: TSC Act abbreviations -V = vulnerable, E = endangered, CE = critically endangered, $\sim = not listed$; EPBC Act abbreviations -V = vulnerable, E = endangered, M = migratory, Mar = marine, $\sim = not listed$.

2.3.3 Threatened fauna

Listed threatened or migratory fauna species predicted (potential or likely) or known from the study area are detailed in **Table 4.** Of these species, seven bird and three mammal species have been recorded during field surveys in the Dewhurst study area. A further 21 threatened or migratory birds and 11 mammals are predicted to occur in the study area. No threatened reptile, amphibian or invertebrate species have been recorded or are predicted to occur in the study area.

Table 4: Threatened and migratory fauna species known or predicted to occur within the study area

Scientific name	Common name	TSC Act Status	EPBC Act Status	Likelihood of occurrence				
Birds								
Anthochaera phrygia	Regent Honeyeater	CE	E, M	Potential				
Apus pacificus	Fork-tailed Swift	-	M, Mar	Likely				
Burhinus grallarius	Bush Stone-curlew	E	~	Potential				
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~	Known				
Chthonicola sagittata	Speckled Warbler	V	~	Known				
Circus assimilis	Spotted Harrier	V	~	Potential				
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	~	Likely				
Daphoenositta chrysoptera	Varied Sittella	V	~	Known				
Glossopsitta pusilla	Little Lorikeet	V	~	Likely				
Grantiella picta	Painted Honeyeater	V	~	Likely				

Scientific name	Common name	TSC Act Status	EPBC Act Status	Likelihood of occurrence	
Haliaeetus leucogaster	White-bellied Sea-Eagle	~	M, Mar	Known	
Hamirostra melanosternon	Black-breasted Buzzard	V	~	Potential	
Hieraaetus morphnoides	Little Eagle	V	~	Potential	
Hirundapus caudacutus	White-throated Needletail	-	M, Mar	Known	
Lathamus discolor	Swift Parrot	E	E, Mar	Potential	
Leipoa ocellata	Malleefowl	~	V	Potential	
Lophoictinia isura	Square-tailed Kite	V	~	Potential	
Melanodryas cucullata cucullata	Hooded Robin (south- eastern form)	V	~	Known	
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	٧	~	Likely	
Merops ornatus	Rainbow Bee-eater	~	M, Mar	Likely	
Neophema pulchella	Turquoise Parrot	V	~	Likely	
Ninox connivens	Barking Owl	V	~	Potential	
Pachycephala inornata	Gilbert's Whistler	V	~	Potential	
Petroica boodang	Scarlet Robin	V	~	Potential	
Polytelis swainsonii	Superb Parrot	V	V	Potential	
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~	Known	
Stagonopleura guttata	Diamond Firetail	V	~	Likely	
Tyto novaehollandiae	Masked Owl	V	~	Likely	
Mammals					
Aepyprymnus rufescens	Rufous Bettong	V	~	Potential	
Cercartetus nanus	Eastern Pygmy-possum	V	~	Potential	

Scientific name	Common name	TSC Act Status	EPBC Act Status	Likelihood of occurrence
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Potential
Chalinolobus picatus	Little Pied Bat	V	~	Known
Dasyurus maculatus	Spotted-tailed Quoll	V	E	Potential
Macropus dorsalis	Black-striped Wallaby	E	~	Likely
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	~	Known
Nyctophilus corbeni (syn. Nyctophilus timoriensis (South-eastern form))	South-eastern Long eared Bat / Corben's Long-eared Bat	V	V	Likely
Petaurus norfolcensis	Squirrel Glider	V	~	Potential
Phascolarctos cinereus	Koala	V	V	Potential
Pseudomys pilligaensis	Pilliga Mouse	V	V	Potential
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Potential
Saccolaimus flaviventris	Yellow-bellied Sheathtail- bat	V	~	Known
Vespadelus troughtoni	Eastern Cave Bat	V	~	Likely

Note: TSC Act abbreviations -V = vulnerable, E = endangered, CE = critically endangered, $\sim = not listed$; EPBC Act abbreviations -V = vulnerable, E = endangered, M = migratory, Mar = marine, $\sim = not listed$.

2.3.4 Threatened populations

No threatened populations listed under the TSC or EPBC Acts are known or predicted to occur in the study area.

2.3.5 Threatened aquatic species, populations and communities

No threatened fish species, endangered populations or endangered aquatic communities are known or expected to occur within the study area.

2.4 Actions to avoid and mitigate impacts

A number of impacts on vegetation communities and flora and fauna species present in the study area may result from the construction and operational phases of the proposed activities. Direct impacts include vegetation clearance, loss of flora habitat, and loss of fauna habitat. Potential indirect impacts include habitat fragmentation, sedimentation and erosion, contamination of soil or water through spills and leaks, introducing additional light, changing microclimates, increases in noise, traffic and dust, and encouraging weed invasion and feral animal predators.

2.4.1 Direct impacts

Approximately 2.44 hectares of *White Cypress Pine – Bulloak – ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion* will be cleared due to the proposed activities at Dewhurst. This includes 0.24 hectares at Dewhurst 13-18H and 2.2 hectares at Dewhurst 26-31. The activity at Bibblewindi has been designed to avoid any works being undertaken within the remnant vegetation, and no clearing is required.

The activity at Dewhurst will result in the removal of up to 2.44 hectares of potential foraging, breeding or roosting/sheltering habitat for fauna. In the Dewhurst study area, the location of hollow-bearing trees was mapped so as to minimise the number being cleared. At Bibblewindi, no hollow-bearing trees will require removal as part of the activity. No 'potential' koala habitat, as defined by SEPP 44, will be removed as part of the activity at either Bibblewindi or Dewhurst – nor does any occur within close proximity to the study area.

The activity at the Dewhurst subject site will require the clearing of individuals of several threatened flora species (*Tylophora linearis*, *Pterostylis cobarensis* and *Polygala linariifolia*), and will result in the removal of a very small proportion of potential habitat (2.44 hectares) for these species relative to available habitat across the Pilliga region. No clearing is required at the Bibblewindi subject site.

2.4.2 Indirect impacts

The potential for indirect impacts to flora and fauna as a result of the proposed activities is considered to be low given the existing environment and the minimal amount of vegetation clearance required. Due to the scale of the activity, it is predicted that the majority of potential indirect impacts would be contained within a 20 metre buffer around the lease areas and access tracks at both Dewhurst and Bibblewindi.

Habitat fragmentation may disrupt the dispersal of fauna and flora across the landscape, encourage the movement of feral animal predators and facilitate edge effects. Habitat fragmentation is considered to be minimal at the Dewhurst subject site due to the small extent of clearing as a proportion of available habitat and the use of existing tracks where possible; no patches of habitat would be isolated as a result of the activity. However, whilst the proposed activities do not provide new links for feral predator movement, the Dewhurst study area is already intersected by roads and is known to support range of feral animals. The Bibblewindi proposal will be carried out within a previously cleared area and will not involve any further clearing; therefore no fragmentation of the existing vegetation surrounding the subject site will occur.

The removal of vegetation, transport of soil and earthworks during the proposed activities would increase the risk of erosion, potentially leading to increased dust formation and increased sediment load entering aquatic systems. Further potential indirect impacts on aquatic habitats include contaminated runoff entering waterways or accidental leakage of produced water during operations.

The activities have the potential to impact on the vegetation structure and health in the study area. Vegetation on the edge of the subject sites will be subject to increased light, changes to microclimate, and increased dust. In addition, the activity has the potential to create favourable conditions for weed invasion within the study area, through soil disturbance and the increased movement of traffic. There is also the potential for the transport of *Phytophthora* into the study area through transport of contaminated soil or vegetative material via plant or machinery.

Short-term increases in noise, light and dust pollution as a result of the construction phase of the proposed activities have potential to temporarily disrupt foraging and roosting behaviour of some native fauna species within the study area and in adjacent habitat. At the Bibblewindi subject site, however,

the lack of intact overstorey vegetation is likely to lessen the potential impacts, as few fauna species sensitive to noise are likely to occur within the subject site or the surrounding study area. Impacts of ongoing noise during the operational phase of the proposed activities are considered to be contained within the 20 metre buffer zone.

The increased vehicle movements associated with the proposed activities have the potential to lead to fauna strike, resulting in injury or death.

2.4.3 Avoidance

The Dewhurst 30 and 31 lease areas and associated service corridors were sited so as to avoid key ecological values, including threatened ecological communities, hollow-bearing trees and riparian zones. The activity was designed to minimise additional vegetation clearance, by using existing access roads and utilising the Dewhurst 26-29 gas and water gathering system (with extensions to the Dewhurst 30 and 31 well subject sites).

At Dewhurst 13-18H, the proposed drilling and surface facility construction activities are located within existing lease areas. Re-entering of existing wells eliminates any additional surface impacts. The alignment of the proposed new gas and water gathering system at Dewhurst 13-18H was been designed to run adjacent to the existing access tracks to reduce the required footprint and minimise vegetation impacts during construction.

The activity at Bibblewindi is located within existing lease areas and access tracks which are cleared of vegetation as part of previously approved works. This avoids the need to disturb areas of higher ecological significance occurring within the surrounding Bibblewindi State Forest.

2.4.4 Mitigation measures

A range of short, medium and long-term mitigation measures will be implemented to minimise potential indirect impacts of the development. These are listed in **Table 5**, which also specifies the particular phase of the development during which the measures will apply (i.e. pre-construction, construction, operation, rehabilitation), and the personnel responsible for their implementation.

Table 5: Mitigation measures for indirect impacts of the activity

Mitigation measure	Timing	Responsibilities for implementation
Micro-siting of lease areas and service corridors locations will be undertaken at Dewhurst 30 and 31 during detailed design and pre-clearance survey stage to minimise impacts on the ecological communities and species.	Pre-construction	Site environmental manager Project ecologist
Clearing of hollow-bearing trees will be avoided where possible.	Construction	Site environmental manager Project ecologist
While clearing or disturbance to vegetation occurs, including removal of hollow-bearing trees, a fauna spotter/catcher will be onsite to supervise works.	Construction	Site environmental manager Fauna spotter/catcher
Fauna sensitive clearing procedures (developed by ELA and Santos) will be implemented, including vibrating the bucket on	Construction	Site environmental

Mitigation measure	Timing	Responsibilities for implementation
large trees (particularly hollow-bearing trees) prior to clearing, and dismantling large trees. Refer to Appendix A .		manager Construction personnel Fauna spotter/catcher
Hollow logs removed from the disturbance areas are to be relocated to habitats adjacent to the lease areas under supervision from the fauna/spotter catcher.	Construction	Site environmental manager Fauna spotter/catcher
The site boundary will be clearly demarcated and all contractors will be specifically advised of the designated work area.	Construction	Site environmental manager
 The following activities are not to occur outside of designated work areas to minimise impacts on native vegetation: Vehicle movements. Storage and mixing of materials. Vehicle parking. Machinery storage. Liquid disposal. Machinery repairs and/or refuelling. Construction within the Site office or shed. Combustion of any material. Stockpiling of soil, rubble or debris. Any filling or excavation including trenching, topsoil skimming and/or surface excavation 	Pre-construction, construction, operation, rehabilitation	All staff
All personnel should be informed of their responsibilities whilst working on site in relation to ecological values and undertake a site specific induction.	Construction, operation	Site environmental manager All staff
All vehicles/plant will travel only on existing roads and designated access tracks.	Pre-construction, construction, operation, rehabilitation	All staff
20 km/h speed limits will be implemented in the study area (i.e. lease areas and access tracks constructed for the activity) to reduce the potential of fauna strike and to reduce dust generation.	Construction	Site environmental manager All staff
Damping down of the soil within the roads and well sites should be undertaken to reduce the impacts of increased dust.	Construction	Site environmental manager
Appropriate measures will be employed to prevent surface damage to public roads (e.g. limiting dirt track access during wet weather and protecting bitumen surfaces where tracked	Construction, operation	Site environmental manager

Mitigation measure	Timing	Responsibilities for implementation
machinery is required to cross roads).		Construction personnel
The length of time trenches are left open will be minimised through appropriate planning.	Construction	Site environmental manager
Open trenches should be inspected twice daily by a suitably qualified fauna handler.	Construction	Fauna spotter/catcher
Only 'fauna friendly' exclusion fencing (without barbed wire) in accordance with Santos policies should be installed around well infrastructure.	Construction, operation	Site environmental manager
Light spill into adjoining areas will be minimised where possible by ensuring light sources are directed to work areas only. Light sources will be temporary and removed after the construction phase.	Construction	Site environmental manager
No domestic pets (including dogs or cats) will be allowed within the study area.	Pre-construction, construction, operation, rehabilitation	All staff
 Appropriate erosion and sediment control measures will be managed via the implementation of an erosion and sediment control plan in accordance with best management practices (such as the Best Practice Erosion and Sediment Control Guidelines (IECA 2008). This sediment and erosion control plan is outlined further in the EIS documents and, for Bibblewindi, the accompanying Agricultural Impact Statement (AIS) and includes the following measures: Excess topsoil and subsoil generated during site preparation activities will be stockpiled onsite and used as backfill following completion of drilling. Any excavated surface and subsurface soils will be stockpiled separately to avoid profile inversion. Any stockpiled subsoils should be covered to avoid compaction and water erosion. Stockpiles will be managed according to best management practices such as the measures outlined in <i>Managing Urban Stormwater: Soils and Construction</i> (Landcom 2004) ('the Blue Book'). Erosion and sediment controls will be implemented where necessary during construction activities, in accordance with best management practices (such as the Blue Book or IECA Guidelines). These controls will be maintained until disturbed areas of the site are stabilised. 	Pre-construction, construction, operation, rehabilitation	Site environmental manager Construction personnel

Mitigation measure	Timing	Responsibilities for implementation
Given the very high potential dispersibility of subsoils at the sites, any exposed subsoils should be protected either with vegetation (high ground cover), appropriate matting or preferred surface protection measures during both.		
All liquids (fuel, oil, cleaning agents, drilling liquids etc.) will be stored appropriately and disposed of at suitably licensed facilities.	Construction, operation	Site environmental manager All staff
Spill management procedures will be implemented as required. Rubbish will be collected and removed from the site.	Construction, operation	Site environmental manager All staff
Prior to earthworks, noxious weeds present onsite will be removed or treated with herbicide to help prevent or reduce their spread.	Pre-construction	Weed control contractors
 Weed management measures will be undertaken to prevent the spread of weeds both on and off site and will include: The establishment of wash down points for vehicles to prevent the transportation of seeds, soil and <i>Phytophthora</i>. Inspections of all equipment (machinery, tools, vehicles) brought on site to ensure that all equipment is free of materials where practicable (such as soils and seeds). Documentation and records that detail the use of wash down points and inspections. Measures to ensure that all weed growth is regularly and appropriately controlled in accordance with the NW Act. 	Pre-construction, construction, operation, rehabilitation	Site environmental manager Weed control contractors
If machinery is transported from an area of confirmed infection of <i>Phytophthora</i> to the Site, stringent wash down will be completed before leaving the area, removing all soil and vegetative material from cabins, trays, and under carriages.	Pre-construction	Construction personnel
Annual weed monitoring will occur throughout all phases of the activity. Additional regular (at least quarterly) weed inspections will be undertaken during the first 12 months after commencement of construction in the direct and indirect impact boundary. Weed removal will be carried out as necessary.	Pre-construction, construction, operation, rehabilitation	Site environmental manager Weed control contractors
Sites will be progressively rehabilitated as soon as practicable following best practice guidelines.	Rehabilitation	Site environmental manager Revegetation contractors
Construction personnel will be trained adequately in pest management and hygiene procedures.	Pre-construction	Site environmental manager Construction

Mitigation measure	Timing	Responsibilities for implementation
		personnel
In the event that the work area needs to extend outside the area investigated, further inspection will be undertaken by a qualified ecologist.	Pre-construction	Site environmental manager Project ecologist
Noise and dust indirect impacts will be assessed using data collected as part of the noise and dust monitoring for the project. This monitoring data is considered appropriate to inform dust and noise impacts during operation within the direct and indirect impact boundaries.	Operation	Site environmental manager Project ecologist

2.5 Ecological monitoring requirements

A list of taxa to be monitored has been derived from the list of known threatened species occurring in the study area that are likely to be affected by the above indirect impacts and represent a broad range of guilds. The following taxa or guilds have been selected to be monitored based on their conservation significance, ease of detection, likelihood of impact, or alternatively have been selected as they may benefit from disturbance and negatively affect species of conservation significance:

- microbats
- woodland birds
- native vegetation condition (including weeds)
- groundwater dependent ecosystems
- vertebrate pests.

The monitoring strategies for these taxa are outlined in **Table 6**. Monitoring will be set up to identify whether there are any adverse impacts from the proposed activities. Monitoring sites will therefore be located in control or reference areas as well as within the indirectly impacted area (the 20 metre buffer zone around all lease areas, flowlines and access tracks).

Sets of monitoring sites (i.e. impact and control) for each guild need to be located such that they are spatially independent from one another, in order to avoid interactions between the sites. On the other hand, locating the control sites too far from the impact sites increases the potential for confounding factors such as changes in soil gradients or topography to cause pre-existing differences in flora and fauna assemblages between the sites. A distance of 100 metres between the impact site and the control site was determined to address both of these factors.

To determine whether there are indeed impacts or otherwise, both the control and impact sites need to have replicated sampling locations to avoid confounding factors and spurious conclusions (Underwood 1997). This will be achieved by locating multiple monitoring sites at the proposed development areas (Dewhurst 13-18H, Dewhurst 26-31 and Bibblewindi Multi-lateral Pilots).

Sites should be appropriately stratified prior to being established. For example, for monitoring of native vegetation, sites will be stratified according to plant community types. Within each vegetation community, there will be an equal number of impact and control sites.

Sites will also be set up so that there is an equal number of sites per 'treatment' — that is, an equal number of sites inside the indirect disturbance zone (impact) and outside it (control). This will mean that data can be analysed using parametric analyses. These will include analysis of variance (ANOVA) to compare population size, activity levels, species richness, native vegetation cover, weed cover etc. between reference and impact sites for each taxon or guild. Multivariate analyses will be used to compare woodland bird species assemblages between impact and control sites.

Table 6: Species and taxa selected for monitoring, their potential impacts, details of monitoring plan and outcomes

Species / Taxa	Potential Impacts	Monitoring Details	Outcome	Action
Microbats	There are a range of microchiropteran bats (microbats) that may be affected by the development in the study area. Microbats include both threatened and non-threatened species. Microbats can be either cave / rock overhang dwellers or they may utilise tree hollows or decorticating bark. They will use a wide variety of habitats and often utilise riparian corridors for foraging. Microbats are a useful guild to monitor as they are likely to be affected by: Ioss of hollow-bearing trees changes to vegetation structure noise and light from operational and construction activities	 Monitoring sites will be established in the following areas: indirect impact areas (i.e. within the 20 m buffer zone surrounding well pads or tracks) reference (control sites) a further 100 m outside of the buffer zone Anabat detectors will be used to sample microbat activity levels and species richness. At each site, 1 Anabat will be set for 4 hours over 2 consecutive nights in a suitable flyway. A total of 8 monitoring sites will be established. This will include: 1 impact and 1 control sites at Dewhurst 13-18H 2 impact and 2 control sites at Dewhurst 26-31 2 impact and 2 control sites at Bibblewindi Multi-lateral Pilot Sites will be monitored once per year (spring). 	Estimate of changes in bat species richness and activity levels between reference and impact sites. Estimation of success of avoidance and mitigation measures.	Indicative target: no difference in activity and species richness between indirectly impacted areas and reference sites. Action: If significant differences are observed over 3 years of monitoring, this will trigger further study/consultation with regulators.
Woodland Birds	There are a range of woodland birds occurring in the study area. This includes several threatened species - Daphoenositta chrysoptera (Varied Sittella),	Monitoring sites will be established in the following areas: • indirect impact areas (i.e. within the 20 m buffer zone surrounding well pads or tracks)	Estimate of changes in bird population sizes, species richness and assemblages between reference and impact sites. Estimation of success of avoidance	Indicative target: no difference in species richness, abundance or activity between indirectly impacted areas and reference sites.

Species / Taxa	Potential Impacts	Monitoring Details	Outcome	Action
	Chthonicola sagittata (Speckled Warbler), Melanodryas cucullata (Hooded Robin) and Pomatostomus temporalis temporalis (Grey-crowned Babbler). Woodland birds are a useful guild to monitor for potential adverse impacts of the development as they are likely to be affected by:	reference (control sites) a further 100 m outside of the buffer zone Surveys will involve a 20 minute count of all species observed or heard within a fixed area, at both dawn and dusk over 2 days. If possible, the buffer zone site and the corresponding control site will be sampled concurrently by two observers.	and mitigation measures.	Action: If significant differences are observed over 3 years of monitoring, this will trigger further study/consultation with regulators.
	 changes in vegetation structure habitat fragmentation competition by abundant native bird species predation by cats and foxes invasion of weed species particularly exotic grasses noise from construction activities 	A total of 8 monitoring sites will be established. This will include: 1 impact and 1 control sites at Dewhurst 13-18H 2 impact and 2 control sites at Dewhurst 26-31 2 impact and 2 control sites at Bibblewindi Multi-lateral Pilot Sites will be monitored twice per year (autumn and spring).		
Native vegetation condition	There are four vegetation communities occurring in the study area: • Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the	Within each vegetation type within the study area, 50 x 20 m (0.1 ha) Biometric plots will be established within the indirectly affected areas (within the 20 m buffer zone). Control sites within the same vegetation types but 100 m further from the buffer	Estimate of changes in condition, species richness, cover and extent of native vegetation between reference and impact sites. Estimate of changes in invasive and noxious weed populations between reference and impact	Indicative target 1: vegetation in impact sites should remain above 95% native cover relative to the control sites. Weed cover maintained below 5%. No new weed species occur. Action: If there are expansions in

Species / Taxa	Potential Impacts	Monitoring Details	Outcome	Action
	Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion Fuzzy Box Woodland on alluvial brown loam soils mainly in the NSW Southwestern Slopes Bioregion White Bloodwood – Dirty Gum – Rough Barked Apple heathy open woodland on deep sand in the Pilliga forests Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, BBS Bioregion Vegetation structure and condition in the study area could	zone will also be established for comparison purposes. Monitoring sites will include: 1 impact site and 1 control site within Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest at Dewhurst 13-18H 2 impact site and 2 control site within Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest at Dewhurst 26-31 1 impact site and 1 control site within Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest at Bibblewindi Multilateral Pilot 1 impact site and 1 control site within each of other 3 communities occurring at Bibblewindi Multi-lateral Pilot: Fuzzy Box Woodland White Bloodwood – Dirty	sites. Estimation of success of avoidance and mitigation measures, particularly weed control, Phytophthora prevention measures and dust control.	areas affected by weeds in impact sites relative to control sites, this will suggest that mitigation measures are insufficient and that increased or improved control efforts are necessary. Indicative target 2: Exotic plant cover in control sites remains within 5% of current levels or reduced over 3 years of monitoring. Action: A >5% increase in exotic plant cover or number of species at the control sites may indicate that the indirect effects of the development are not contained within the 20m buffer zone, and that mitigation efforts may need to be extended to encompass a broader area.
	 increased light changes to microclimate increased dust weed invasion transport of <i>Phytophthora</i> 	Gum – Rough Barked Apple heathy open woodland Red gum - Rough-barked Apple +/- tea tree sandy creek woodland Both impact and control sites will be positioned in areas supporting known threatened flora where possible to		Indicative target 3: No decline in native vegetation condition class at impact sites relative to control sites; no decline in vegetation condition class at control sites over time Action: If vegetation condition

Species / Taxa	Potential Impacts	Monitoring Details	Outcome	Action
		ensure known threatened flora proximal to the impact site are monitored. Vegetation monitoring will focus on recording changes in vegetation condition over time, rather than collecting full floristic (cover abundance) data. The structure and Biometric condition class of the vegetation will to be recorded. Indicators of reproduction will be noted, including presence of flowers, fruits or buds. Presence and type of exotic species will be noted during the floristic surveys. Where invasive or noxious weeds are noted, a cover estimate will be recorded and the population locations marked		class declines, this may indicate that mitigation measures such as dust control or <i>Phytophthora</i> prevention are insufficient and should trigger further study/consultation with regulators.
Groundwater dependent ecosystems (GDEs)	Within the broader study region, there are three high priority GDEs which should be monitored for potential impacts of the proposed activities: • Eather Spring	using GPS. Sites will be monitored once per year (spring). 1 monitoring site will be established at each of the 3 springs. These sites need to be established and the initial sampling conducted before the commencement of the proposed development activities, so as to detect	Estimate of changes in condition, species richness, cover and extent of native vegetation of GDEs over time. Indication of potential indirect	Indicative target 1: native vegetation cover, extent and species richness remains above 95% relative to the baseline conditions. Action: If native vegetation cover
	Hardy's SpringMayfield Spring	any potential impacts that occur as a result. Surveys at the GDE plots will record	impacts of development on GDEs.	or species richness falls below 95% relative to the baseline conditions, this may indicate indirect impacts o

Species / Taxa	Potential Impacts	Monitoring Details	Outcome	Action
	These springs are located approximately 10, 20, and 19 km east of the Dewhurst 13-18H, Dewhurst 26-31, and Bibblewindi Multi-lateral Pilots, respectively. These GDEs could potentially be impacted by the proposed development through: • Declines in groundwater levels or changes in flux within aquifer system • Contamination of aquifers by drilling fluids • Contamination through spills of oil, fuel or chemicals	cover abundance of all aboveground vascular flora, vegetation structure and Biometric condition class. Indicators of reproduction will be noted, including presence of flowers, fruits or buds. Following the initial pre-disturbance sampling, sites will be monitored once per year (spring).		the development and should trigger further study/consultation with regulators. Indicative target 2: No decline in vegetation condition class relative to baseline conditions Action: If vegetation condition class declines relative to the baseline conditions, this may indicate indirect impacts of the development and should trigger further study/consultation with regulators.
Vertebrate pests	Previous surveys have detected a number of vertebrate pest species that are likely to impact threatened species either directly (predation) or indirectly (resource competition). Vertebrate pests recorded in the study area include: • Vulpes vulpes (European Red Fox) • Felis catus (Cat) • Sus scrofa (Pig) • Capra aegagrus hircus	Monitoring sites will be established in the following areas: • indirect impact areas (i.e. within the 20 m buffer zone surrounding well pads or tracks) • reference (control sites) a further 100 m outside of the buffer zone Remote cameras will be utilised to gain an estimation of pest populations. At each site, 1 remote cameras will be set for a minimum of 4 consecutive nights. Cameras will be located in high fauna utilisation areas.	Estimate of changes in population size and activity levels for feral animal species between reference and impact sites.	Indicative target 1: no difference in vertebrate pest population size or activity between sites within the buffer zone and control sites. Action: If population size or activity of vertebrate pests is increasing at sites within the buffer zone relative to the control sites, then vertebrate pest control should be implemented. Indicative target 2: Vertebrate

Species / Taxa	Potential Impacts	Monitoring Details	Outcome	Action
	 (Goat) Oryctolagus cuniculus (European rabbit) Lepus europaeus (Brown Hare). Vertebrate pest populations have the potential to increase as a result of the activity through: Habitat fragmentation and creation of additional edges and cleared areas Changes in vegetation structure 	Any indicators of feral animal presence on the sites including scats, tracks and digging will be noted. A total of 8 monitoring sites will be established. This will include: 1 impact and 1 control sites at Dewhurst 13-18H 2 impact and 2 control sites at Dewhurst 26-31 2 impact and 2 control sites at Bibblewindi Multi-lateral Pilot Sites will be monitored twice per year (autumn and spring).		pest populations or activity in control sites remain at or below current levels over 3 years of monitoring. Action: An increase in vertebrate pests over time at the control sites may indicate that the indirect effects of the development are not contained within the 20m buffer zone, and that mitigation efforts may need to be extended to encompass a larger area.

2.6 Monitoring and reporting responsibilities

Monitoring will be carried out twice a year (autumn and spring), initially for three years as this is the proposed time period over which the pilot wells will operate. The exception is the GDE monitoring sites, for which establishment and initial monitoring must be conducted prior to any disturbance occurring so as to give an indication of baseline conditions.

Monitoring results will be collated into an annual report, which will include a summary of the monitoring data collected during the past year, analysis of the results from the impact sites against those from the control sites, as well as analysis comparing the monitoring results between years.

This will allow evaluation of effectiveness of the mitigation measures that have been put into place to minimise impacts on biodiversity, in terms of progress against the performance measures specified in **Table 2.** Also included in the reporting will be any recommendations for action resulting from failure to achieve any of the indicative targets.

A review of the BMP will be undertaken at the end of the three year operational period for the pilots. Implementation of the recommendations resulting from the BMP will be the responsibility of Santos.

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Appendix A 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. Pre-clearing surveys by appropriately trained ecologists have been undertaken for all clearing work, marking all hollow-bearing trees (HBTs) or other significant fauna habitat features (nests, hollow bearing logs and stags) with yellow and black striped flagging tape 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 HBTs
- 4. Remove HBTs

Step 1: Planning

- 1. All appropriate licences with respect to working with native fauna are to be obtained prior to any clearing.
 - a. Ecologists working with fauna require a current scientific licence issued by the NSW Office of Environment and Heritage and ethics approval issued by the Animal Welfare Unit of the NSW Department of Primary Industries.
 - b. Project Approval is required.
- The nearest veterinary clinic should be notified of the clearing works prior to clearing commencing and their phone number on hand if any fauna are injured or distressed.
 - a. Veterinary clinic:
 - a. Practice: Western Namoi Veterinary Clinic
 - b. Principal Vet: Dr Michael Reed
 - c. Contact: 02 6792 2577
 - d. Address: 24 Francis Street. Narrabri.
 - a. WIRES: 13 000 WIRES or 13 000 94737
 - b. WIRES (central northern branch): 1300 131 554
- Discuss clearing procedure, equipment / machinery required, schedule. All staff
 and contractors involved in the clearing will undertake the ecological induction
 prior to commencing work.

Step 2: Slash shrub and ground layer

Clearing of shrub and groundcover vegetation around the HBTs can commence once habitat features have been surveyed and marked to encourage dispersal of fauna from the active features. It should be undertaken at least the day prior to any hollow-bearing tree felling.

Step 3: Tap HBTs

- HBTs are to be agitated (nudged by heavy machinery or with 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 4: Removing HBTs

- 1. A suitably qualified fauna ecologist 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 has signalled that it is safe to do so.
- 3. The "slow drop" technique is to be attempted when removing all HBT's. This technique aims to lower HBTs 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 bull dozer 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. JHA's and stepback are to be completed when completing felling activities.
- 4. Once on the ground, any hollows are to be inspected for resident fauna (fibre optic camera technology is useful for deeper and angled hollows). If any 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 for overnight on the ground giving any fauna trapped in the trees an opportunity to escape. Any hollows with fauna left inside should be rechecked 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.
- Some of the HBTs or other significant fauna habitat features should be relocated to adjoining vegetation or moved into areas of rehabilitation where feasible.
- 7. Note that if fauna are observed to be in the tree that cannot self-relocate (e.g. chics that haven't yet fledged) it may be necessary to contact an appropriately trained ecologist and/or wildlife carer to be present to encourage the removal and provide care for the animal/s. While translocation of fauna is not ideal, the DECCW Guidelines for Fauna Translocation are to be followed in these circumstances.

8. If Pilliga Mouse (*Pseudomys pilligaensis*), Koala (*Phascolarctos cinereus*) or Regent Honeyeater (*Anthochaera phrygia*) are observed in or in the proximity of the disturbance footprint, work must cease immediately. The breeding status of the individuals will be assessed by a suitably qualified ecologist before confirming the recommencement of work.

Communication

Positive communication between the ecologist 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 will outline the clearing procedure to be followed. This will include outlining the following communication points during the clearing process:
 - a. Confirm location ecologist should stand to observe felling (100 m if mulcher drum is operational, 10 m if mulcher drum is not operational).
 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).
 - b. 'Go ahead' to nudge the tree.
 - c. 'Go ahead' to start felling tree.
 - d. 'Go ahead' for ecologist to inspect hollows in felled tree (once felling has been completed and machinery has been switched off).
 - e. Stop clearing due to fauna observed or alternatively move to a next operational area.

Lessons learnt

Previous 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 and allowing heavy machinery to access the site can increase the potential risk to fauna.
- Not allowing adequate time for felled HBTs to remain undisturbed can lead to increased risk to fauna.

PRICKLY PEAR REMOVAL PROCEDURE

The following Prickly Pear removal procedure was developed to minimise risk to personnel conducting the weed removal, and to mitigate the risk of spreading the weed. The procedure was designed to be adaptive depending on site-specific conditions that arise during weeding. The clearing procedure comprises three steps:

- 1. Planning and personal protective equipment (PPE)
- 2. Prickly Pear removal
- 3. Collect and dispose of bags

Step 1: Planning and PPE

- 1. All personnel are to have the appropriate PPE for conducting the weed removal (i.e. minimum of long sleeved shirts and long pants in a heavyweight cotton, leather gloves, leather steel cap lace-up boots, sunglasses/safety glasses)
- The team leader is to have checked the necessary equipment is available for each team member, and is in proper working order prior to commencing weeding.
- The team will discuss the weed clearing procedure, equipment/machinery required, schedule. All staff and contractors involved in the clearing will review and sign the ELA SWMS, and will participate in a toolbox talk prior to commencing work.

Step 2: Prickly Pear removal

Carefully segment the above-ground foliage, taking care to minimise unnecessary fragmentation of the plant, and place the pieces in a hessian bag. Then dig up the base of the Prickly Pear to remove the root system and any other pieces of the plant from the soil. Also place these pieces in a hessian bag. When each hessian bag is full, tie it off and leave at the pre-agreed location for collection and disposal.

Step 3: Collect and dispose of the bags

The bags of Prickly Pear must be collected and disposed of at a refuse, recycling and waste processing facility.









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