Review of Environmental Factors

Dewhurst 22-25 Pilot Wells – PEL 238, Gunnedah Basin, NSW

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Executive summary

Overview

Santos NSW (Eastern) Pty Ltd (a wholly owned subsidiary of Santos Limited) (Santos), as a coal seam gas (CSG) operator on behalf of the titleholders of Petroleum Exploration Licence 238 (PEL 238), proposes to drill four petroleum exploration pilot wells, known as Dewhurst 22, Dewhurst 23, Dewhurst 24 and Dewhurst 25 (Dewhurst 22 to 25), and carry out ancillary activities within the Pilliga East State Forest along Monument Road, approximately 30 kilometres south of Narrabri, NSW (the proposed activity). The purpose of the proposed activity is to investigate the potential coal seam gas (CSG) resource of the Gunnedah Basin within Petroleum Exploration Licence number 238 (PEL 238).

RPS Australia East Pty Ltd (RPS) has prepared this Review of Environmental Factors (REF) as an assessment of the potential environmental impacts of the proposed activity. The REF addresses the requirements of section 111 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), clause 228 of the *Environmental Planning and Assessment Regulation 2000*, and the *ESG2: Environmental Impact Assessment Guidelines* (DTIRIS 2012a) (ESG2 Guidelines).

The proposed activity will require a water access licence (WAL) under the *Water Management Act 2000* (WMA) (see section 5.2.8 of this REF). As regards to that WAL, the Minister administering the WMA (Water Minister) is a 'determining authority' within the meaning of section 110 of the E&PA Act. Therefore, duties under Part 5 of the EP&A Act would ordinarily attach to the Water Minister's grant of the WAL. However, section 110E(c) of the EP&A Act provides an exemption. The effect of that section is that sections 111 and 112 of the EP&A Act will not apply in relation to the proposed activity once it has been approved by the Resources Minister in reliance on this REF. Accordingly, if and when the proposed activity has been approved by the Resources Minister in reliance on this REF, sections 111 and 112 of the EP&A Act will not apply in relation to the issue of a WAL for the proposed activity by the Water Minister.

Proposed activity scope

The scope of the proposed activity includes:

Site Establishment

- constructing four access tracks from Monument Road to lease areas (including one creek crossing)
- establishing four lease areas up to approximately one hectare in size each
- installing surface infrastructure on the existing Dewhurst 6 lease (previously approved 3 April 2009) and Dewhurst 22-25 lease areas, including separators, metering skids, power generation equipment, telemetry units, motor control centres and drivers
- constructing a gas gathering system parallel to the access tracks (inclusive of Dewhurst 6), Monument Road and Yellow Springs Trail to a flare at Dewhurst 22
- constructing a water gathering system parallel to the gas gathering system with associated piping and pumps at Dewhurst 22. The gathering system extends from the riser located at the edge of the pilot well lease area to the balance tank located at Dewhurst 22.

Drilling

- drilling two vertical wells (Dewhurst 22 and 24) to a depth of up to approximately 1005 metres
- drilling a tri-stacked horizontal well (Dewhurst 23) to intercept Dewhurst 22
- drilling a single horizontal well (Dewhurst 25) to intercept Dewhurst 24

Operation

- operating the Dewhurst 22-25 pilot well set (including Dewhurst 6) for the life of PEL 238 or until critical reservoir data is collected
- partial rehabilitation of Dewhurst 6, 23, 24 and 25 to well head and essential infrastructure
- installing a flare, water balance tank (approximate capacity 40 cubic metres) and pumps at the Dewhurst 22 lease area
- continued monitoring of pilot wells and gathering system
- maintenance and workover activities.

Construction of the proposed activity is scheduled to commence in the third quarter of 2013 and will take approximately three months for site preparation, drilling and completion. The proposed activity will operate for the life of PEL 238 (current licence is to 2 Feb 2016). These activities may occur up to 24 hours per day, seven days per week.

Justification

The proposed activity is necessary for the ongoing exploration and evaluation of the hydrocarbon potential in PEL 238 and will underpin future CSG production in the region. Development of the gas industry will bring capital investment and economic benefits to the region. It will also help to secure supply for domestic gas and alleviate the state's reliance on imported gas. The proposed activity will be consistent with ecologically sustainable development principles and is therefore justified.

Potential environmental impacts

The majority of potential environmental impacts of the proposed activity will occur during site establishment, drilling and completion activities. During this phase of work, land will be cleared, noise and dust generated and potential for spills is greatest. During operation, partial rehabilitation of Dewhurst 23, 24 and 25 will occur with water and gas collected from these wells transferred to Dewhurst 22 where excess gas will be flared and water will be stored in a balance tank. Abstracted water will be treated at an appropriate facility.

Land to be cleared within the Pilliga East State Forest includes narrow leaved ironbark woodland and riparian woodland. This habitat provides foraging, breeding, roosting and sheltering resources that is currently utilised by a range of faunal groups. This will result in the displacement of native fauna across the affected area. Displaced fauna will need to relocate into adjacent habitats, which will place short-term pressure on the available resources within these habitats.

Removal of riparian vegetation may result in disruption to the behaviour of the Pilliga Mouse, a vulnerable species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). However, as the proportion of habitat to be cleared only represents approximately 0.22 per cent of available habitat within the immediate 522 hectare area, and all heath vegetation is to be retained, it is considered that the impact will be relatively minor. The proposed activity is being referred to the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) for determination as to whether clearing of Pilliga Mouse habitat is a controlled action under the EPBC Act.

The ecological assessment concluded that there is not likely to be a significant effect on threatened species, populations, or their habitats arising from the proposed activity.

Groundwater modelling was undertaken to determine the impact of water abstraction. This concluded that there will be negligible impact to the upper aquifers, groundwater dependent ecosystems and registered bore users. A water licence will be required as the proposed activity will result in aquifer interference.

The noise assessment concluded that no sensitive receivers will be affected.

On balance, the proposed activity will have negligible to low adverse impacts on the environment and the community. These impacts will be temporary and of a small scale and can be mitigated through the measures identified in this REF.

Environmental impacts with reference to the ESG2 guidelines are summarised below.

Category	Element	Potential impacts	Potential impact category (with mitigation measures)
Physical and chemical impacts	Soil quality and land stability	▪ disturbance of up to approximately 6.29 ha of land ▪ soil erosion and loss of topsoil or spoil ▪ land contamination in event of a leak or spill	Negligible to low adverse
	Surface water	▪ sedimentation of surface waters due to increased erosion ▪ contamination of surface waters in event of a leak or spill	Negligible to low adverse
	Groundwater	▪ groundwater contamination due to mixing of aquifers, loss of drilling mud into the formation or inappropriate management of spills ▪ water abstracted for first 3 years, up to a total of approximately 288 ML, then at a rate of approximately 96 ML/yr for the remaining life of the PEL ▪ negligible change in flux or drawdown in the upper layers, no impact to registered bore users or groundwater dependant ecosystems	Negligible to low adverse
	Flooding	▪ site not in flood prone land ▪ pollution/contamination of surface waters in event of flooding and inundation of the site	Negligible
	Coastal process and costal hazards	▪ proposed activity not near a coastline	N/A
	Hazardous substance and chemical use	▪ land, water or air pollution, or fire, from improper use of hazardous substances or chemicals	Negligible to low adverse
	Gaseous, liquid and solid waste and emissions	▪ management of saline groundwater produced during operation of the pilot wells ▪ generation and disposal of various wastes ▪ contamination of groundwater, soils or surface water from illegal dumping or leaching of waste ▪ litter due to lack of suitable waste containment odours from improper storage or treatment of putrescible waste ▪ generation of greenhouse gas emissions	low adverse
	Dust, noise, odours, vibration and radiation	▪ generation of dust and other particulates ▪ generation of noise, particularly during drilling activities which may occur up to 24 hours per day	Negligible to low adverse

Category	Element	Potential impacts	Potential impact category (with mitigation measures)
Biological		▪ removal of up to approximately 5.99 ha of vegetation, 4.96 ha narrow-leaved ironbark woodland and 1.02 ha riparian woodland ▪ temporary disruption to breeding cycle, roosting, sheltering and foraging behaviour of fauna species ▪ minor impacts on Pilliga mouse	Low to medium adverse
Community	Infrastructure and services	▪ pressure on temporary accommodation in Narrabri area ▪ minimal generation of traffic on Monument Road and Yellow Springs Trail. ▪ temporary reduced amenity for neighbours from noise, dust and visual impacts ▪ introduction of hazard (construction activities, gathering system and flare) with potential safety implications	Negligible
	Economic issues	▪ economic benefits to Narrabri and surrounding region ▪ ongoing use of upgraded access track to benefit of Forestry NSW	Positive
Natural resources		▪ impact to Pilliga East State Forest ▪ no impact to agricultural land ▪ use of minor quantities of natural resources including fill material and fuels	Negligible
Aboriginal cultural heritage		▪ disturbance of unknown Aboriginal objects	Negligible
European cultural heritage impacts		▪ disturbance of unknown European heritage items	Negligible

Conclusion

The proposed activity is temporary and minor in scale. The site of the proposed activity has been selected to avoid significant environmental and heritage constraints, and reduce impacts to the surrounding community. The potential impacts of the proposed activity have been assessed and can be managed through the identified mitigation measures. On balance, the proposed activity will have a negligible to low adverse impact on the environment and the community.

The proposed activity is not likely to significantly affect the environment or any threatened species, populations or ecological communities, their habitats or critical habitat. Habitat for the Pilliga Mouse (listed as vulnerable under the EPBC Act) will be removed however this represents around 0.22 per cent of habitat available in the area and impacts are expected to be minor. The proposed activity does not require the preparation of an EIS.

The proposed activity will be referred to SEWPaC. The referral is under preparation.

1.0 Introduction

1.1 Background

Santos NSW (Eastern) Pty Ltd (a wholly owned subsidiary of Santos Limited) (Santos) as the CSG operator on behalf of the titleholders of Petroleum Exploration Licence 238 (PEL 238), proposes to drill four petroleum exploration pilot wells, known as Dewhurst 22, Dewhurst 23, Dewhurst 24 and Dewhurst 25 (Dewhurst 22 to 25), and carry out ancillary activities within the Pilliga East State Forest along Monument Road, to the south of Narrabri, NSW (the proposed activity). The purpose of the Dewhurst 22 to 25 pilot wells is to investigate the potential coal seam gas (CSG) resource of the Gunnedah Basin within PEL 238.

Petroleum exploration wells are classified as a Category 3 activity under the conditions of PEL 238. Category 3 activities require further approval from the Resources Minister in order to carry out the activity.

This Review of Environmental Factors (REF) has been prepared by RPS Australia East Pty Ltd (RPS) at the request of Santos NSW (Eastern) Pty Ltd as the CSG operator on behalf of the titleholders of PEL 238 to assess the environmental impact of Dewhurst 22 to 25. The current titleholders for PEL 238 are Santos NSW Pty Ltd and EnergyAustralia Narrabri Gas Pty Ltd.

This REF is an assessment of the potential environmental impacts of the proposed activity and will assist the Resources Minister in fulfilling his obligations under section 111 of the EP&A Act. The REF addresses the requirements of clause 228 of the *Environmental Planning and Assessment Regulation 2000* and the *ESG2: Environmental Impact Assessment Guidelines* (ESG2 Guidelines) released by the Resources and Energy Division within the Department of Trade & Investment, Regional Infrastructure and Services (DTIRIS) in March 2012 (DTIRIS 2012a). The relevant requirements of the draft *Additional Part 5 requirements for petroleum prospecting: A supplement to ESG2 Environmental Impact Assessment Guidelines* (Department of Planning and Infrastructure (DP&I), 2011) have also been considered in preparing the REF.

1.2 Structure of REF

The structure of the REF, consistent with the ESG2 Guidelines, is as follows:

- Section 1 introduces the proposed activity and provides an overview of the REF.
- Section 2 describes the proposed activity.
- Section 3 describes the site.
- Section 4 describes the existing environment.
- Section 5 discusses the relevant planning legislation associated with the proposed activity.
- Section 6 assesses the potential environmental impacts of the proposed activity and recommends mitigation measures to ensure any impacts are appropriately managed.
- Section 7 summarises the potential environmental impacts of the proposed activity.
- Section 8 concludes the REF.
- Section 9 provides the statement of commitments.

2.0 The proposed activity

2.1 Overview

Santos, for and on behalf of the titleholders of PEL 238, proposes to construct and operate a five well pilot set and associated infrastructure within the Pilliga East State Forest in PEL 238. This will involve drilling two new lateral well sets (Dewhurst 22-23 and Dewhurst 24-25) around an existing core hole (Dewhurst 6) and constructing ancillary infrastructure to manage water and gas during operation of the five well pilot set.

Dewhurst 22 and 24 will consist of single vertical wells, drilled to depths of up to approximately 1005 metres. A tri-stacked and single horizontal well will be drilled at Dewhurst 23 and 25 respectively, to intercept Dewhurst 22 and 24 respectively.

The conversion of the Dewhurst 6 core hole into a vertical production well was approved by the NSW Department of Primary Industry on 3 April 2009 (refer to Appendix 1). This core hole will be worked over and have a pump and surface infrastructure installed to allow it to operate as an appraisal well. These activities were assessed and approved in the letter report dated March 30 2009 entitled *Explanatory Note – Amendment to 2008 PEL 238 Corehole Program B, Dewhurst 5 & 6* (Appendix 1). The approved work over and ancillary activities located on the Dewhurst 6 lease area will be undertaken in conjunction with, but do not form part of, the proposed activity however the gathering system from Monument Road to the lease area is included.

The proposed activity can be described in three stages:

- site preparation and construction
- drilling
- operation.

The works proposed during each stage, and timing for these stages, are summarised in Table 2-1.

Towards the end of operation, an evaluation of two potential post-operation options will be undertaken based on the pilot test results. Depending on the productivity of the wells, they will either be:

1) converted to production wells if sufficient gas is produced (subject to a separate environmental approvals process), or

2) decommissioned and fully rehabilitated if insufficient gas is produced (refer to Section 2.7.9).

The total area of potential disturbance assessed in this REF is up to approximately 6.29 hectares. This includes a lease area of approximately one hectare for each pilot well, four access tracks and gathering system right of way. References to ‘the site’ throughout this REF include the four lease areas, access tracks and right of way.

The proposed activity is described in more detail in section 2.7.

Facilities at Dewhurst 22 form part of a broader water management strategy. Water collected at the pilot wells will ultimately link to a broader flow line network from the wells to storage facilities at Bibblewindi and a treatment facility at Leewood. Both these projects are subject to separate environmental approval processes.

Table 2-1 Summary of proposed activity by stage

Stage	Proposed works	Timing	Duration
Site establishment	▪ constructing four access tracks from Monument Road and Yellow Springs Trail[1] to lease areas (including one creek crossing) ▪ establishing four lease areas up to approximately 1 ha in size each ▪ installing surface infrastructure on the Dewhurst 6 and Dewhurst 22-25 lease areas, including separators, metering skids, power generation equipment, telemetry units, motor control centres and drivers ▪ constructing a gas gathering system parallel to the access tracks (inclusive of Dewhurst 6), Monument Road and Yellow Springs Trail to a flare at Dewhurst 22. ▪ constructing a water gathering system parallel to the gas gathering system with associated piping and pumps at Dewhurst 22. The gathering system extends from the riser located at the edge of the pilot well lease area to the balance tank located at Dewhurst 22.	Third quarter of 2013	14 days
Drilling	▪ drilling two vertical wells (Dewhurst 22 and 24) to a depth of approximately 1005 m ▪ drilling a tri-stacked horizontal well (Dewhurst 23) to intercept Dewhurst 22 ▪ drilling a single horizontal well (Dewhurst 25) to intercept Dewhurst 24	Third quarter of 2013	Up to 40 days
Operation	▪ operating the five well pilot set for the life of PEL 238 or until critical reservoir data is collected ▪ partial rehabilitation of Dewhurst 6, 23, 24 and 25 to well head and essential infrastructure ▪ installing a flare, water balance tank (approximate capacity 40m^3) and pumps at the Dewhurst 22 lease area ▪ continued monitoring of pilot wells and gathering system ▪ maintenance and workover activities.	Fourth quarter of 2013	Up to the life of the PEL

Note

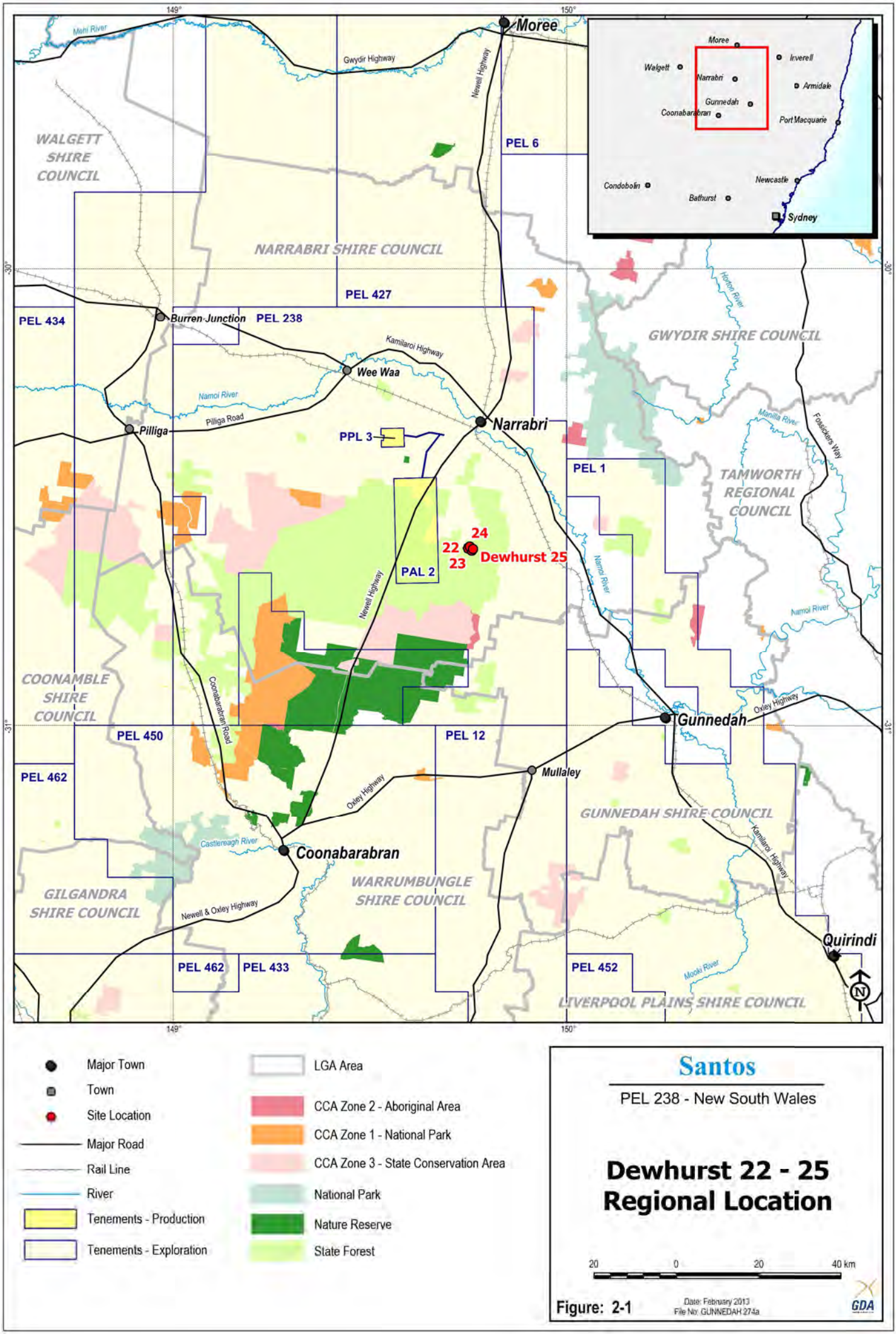
1. Sometimes referred to as Yellow Spring Creek Road

2.2 Regional location context

The site is located in the southern section of PEL 238. PEL 238 covers an area of approximately 7,915 square kilometres and extends across three local government areas (LGAs) including the Narrabri Shire, Warrumbungle Shire and Gunnedah Shire. The site is located within the Narrabri Shire LGA.

The site is located approximately 30 kilometres south and north-west of Narrabri and Boggabri, respectively. The Pilliga East State Forest forms part of a large tract of bushland referred to as the Pilliga Scrub which encompasses numerous protected areas including the Pilliga East State Forest, Bibblewindi State Forest, Pilliga State Conservation Area, Pilliga Nature Reserve, Jacks Creek State Forest, Rutley State Forest and Kerringle State Forest.

Figure 2-1 shows the regional context of the site.


149°
150°
30°
31°
Moree
Mehi River
Gwydir Highway
Newell Highway
WALGETT SHIRE COUNCIL
NARRABRI SHIRE COUNCIL
PEL 6
PEL 427
PEL 434
PEL 238
Burren Junction
Kamilaroi Highway
Wee Waa
Namoi River
Pilliga
Pilliga Road
PPL 3
Narrabri
GWYDIR SHIRE COUNCIL
Horton River
Manilla River
Fossickers Way
PEL 1
TAMWORTH REGIONAL COUNCIL
24
22
23
Dewhurst 25
PAL 2
Newell Highway
Namoi River
Namoi River
COONAMBLE SHIRE COUNCIL
Coonabarabran Road
Oxley Highway
Gunnedah
PEL 450
PEL 12
PEL 462
Mullaley
Oxley Highway
GUNNEDAH SHIRE COUNCIL
Castlereagh River
Coonabarabran
Kamilaroi Highway
WARRUMBUNGLE SHIRE COUNCIL
GILGANDRA SHIRE COUNCIL
Newell & Oxley Highway
Quirindi
PEL 462
PEL 433
PEL 452
Mooki River
LIVERPOOL PLAINS SHIRE COUNCIL
N
Moree
Inverell
Walgett
Narrabri
Armidale
Gunnedah
Coonabarabran
Port Macquarie
Condobolin
Newcastle
Bathurst
Sydney
Major Town
Town
Site Location
Major Road
Rail Line
River
Tenements - Production
Tenements - Exploration
LGA Area
CCA Zone 2 - Aboriginal Area
CCA Zone 1 - National Park
CCA Zone 3 - State Conservation Area
National Park
Nature Reserve
State Forest
Santos
PEL 238 - New South Wales
Dewhurst 22 - 25
Regional Location
20
0
20
40 km
Figure: 2-1
Date: February 2013
File No: GUNNEDAH 274a
GDA

2.3 Petroleum activity context

Santos commenced CSG exploration NSW in 2008. Santos' CSG acreage in NSW covers approximately 62,000 square kilometres in the areas around Narrabri, Boggabri, Gunnedah, Coonabarabran, Quirindi and Scone.

In 2011, Santos acquired Eastern Star Gas' Narrabri Gas Development Project. This included six existing pilots and associated infrastructure within the area around Narrabri (including within PEL 238).

Santos has recently finalised plans for a 50 well drilling program for the Narrabri and Gunnedah area as part of its exploration of the Gunnedah Basin. The drilling program is scheduled to commence in early 2013 and will take two to three years. The program will include up to six pilots and 10 core holes within PEL 238 and Petroleum Assessment Lease (PAL) 2. These activities are required to gather the vital scientific information that will underpin any future decision to progress towards development and production in the area.

The proposed pilot wells are initial exploratory pilot test wells within the southern section of PEL 238. Data collected from the pilot wells will be used to determine the CSG potential within this area of the Gunnedah Basin and whether further assessment or production activities are warranted. Any such activities would be subject to further feasibility and environmental assessment, and obtaining the appropriate government approvals.

2.4 Stakeholder consultation

2.4.1 Approach

Santos recognises the importance of pro-active and effective engagement with communities and stakeholders and is well established within the local community, with a local office in Narrabri and resident employees. Santos has commenced a broad consultation program for planned exploration activities within PEL 238 and PAL 2, and in early 2013 will commence targeted consultation for the proposed project.

Through this consultation, Santos aims to:

- increase overall awareness and understanding of the CSG industry and the proposed activity in particular
- keep landholders, neighbours, residents, local councils and relevant government agencies informed of these activities
- ensure the interests of stakeholders are considered in the project design and implementation
- identify key issues or concerns for the community and address these through the environmental assessment process
- minimise disputes with landowners or other stakeholders.

2.4.2 Stakeholders

2.4.2.1 Forestry NSW as the landowner/manager

The proposed activity is located entirely on land managed by Forestry Corporation of New South Wales (Forestry NSW). Santos holds a Permit to Occupy from Forestry NSW and the State of NSW. The permit to occupy outlines a range of environmental mitigation strategies that Santos must comply with (see Section 2.8).

As part of consultation with Forestry NSW, Santos' Narrabri Operations Manager holds regular meetings with a representative of Forestry NSW. A schedule of upcoming activities was provided to Forestry NSW. This is updated on a monthly basis. The schedule includes activities at Dewhurst 22-25.

2.4.2.2 Other stakeholders

The following stakeholders have also been identified for the proposed activity:

- Narrabri Shire Council
- the Resources Minister
- Department of Trade and Investment (DTIRIS), Division of Resources and Energy (DRE)
- Office of Environment and Heritage
- NSW Office of Water
- neighbouring landowners
- Narrabri Local Aboriginal Land Council (LALC)
- general community
- Community Consultation Committee – Narrabri Shire (Narrabri CCC).

There are no relevant infrastructure authorities or service providers that will be affected by the proposed activity.

The site is located within Coal Authorisation 216, held by DTIRIS on behalf of the Crown. No other authorisation or title holders will be affected by the proposed activity.

2.4.3 Consultation activities undertaken to date

Santos has used a wide range of consultation tools to engage with various stakeholders as part of its overall consultation program for its activities within the Pilliga Forest during the preparation of this REF.

Recent consultation has focussed on engaging with State and local government stakeholders, including DRE, Narrabri Shire Council and Forestry NSW, and local interest/community groups on Santos' broader activities within the region (including PEL 238 and PAL 2).

Approximately four meetings with DRE have been held to discuss the exploration program within PEL 238 and in particular, the regulatory approvals required for this program.

Monthly meetings have been held with the land owner (Forestry NSW) since October 2011. Key issues raised by Forestry NSW specific to Dewhurst 22-25 include the need to:

- provide a current program of activities
- develop a Fire Risk Management plan for activities at Dewhurst 22-25
- assist where required in any emergency that could develop
- provide GIS information on the specific locations of Dewhurst 22-25 so that any Forestry NSW heavy vehicles operating in the same area are aware of the presence of other heavy vehicles.

In conjunction with targeted stakeholder consultation, the wider community were provided information about the broad project scope and the environmental assessment process and invited to contribute feedback.

Questions and concerns raised by the broader community have been addressed through telephone contact (both through the Santos community 1800 line and by individual telephone calls made to the Narrabri Office staff), formal correspondence and on-site meetings where required. These issues for the broader Pilliga Forest activities have been recorded and considered during preparation of the REF.

Broader consultation activities undertaken to date are summarised in Table 2-2.

Table 2-2 Consultation activities

Consultation tool/Activity	Description
Santos project website	Santos maintains a project website which outlines the broad exploration program. The website is regularly updated with project information, photos and frequently asked questions which is general to the NSW coal seam gas project: http://www.santos.com/exploration-acreage/nsw-csg.aspx)
Santos project 1800 number and email address	Santos maintains a free information and enquiries line and project email address (1800 071 278) http://www.santos.com/exploration-acreage/nsw-csg/contact-our-nsw-team.aspx
Santos Narrabri Office and Project Information Centre	Santos has an office and project information centre at 125 Maitland Street, Narrabri which members of the public can visit and request information about the project and particular activities including those to occur at Dewhurst 22-25. The office is attended from 9am to 5pm Monday to Friday.
Community Information Sessions	*Coal seam gas forums.* This has included open days for the community to discuss the exploration activities occurring within the area. Community members have been invited to community forums in the township of Gunnedah where senior Santos personnel have presented information on CSG and been available for the day to answer any questions raised by the community. *Farmer forums* Farmer forums have been held in Narrabri attended by local farmers. *Established community forums* There have been a number of presentations to the wider community including Country Women's Association Narrabri chapter, Narrabri Rotary, Narrabri business chamber and several schools in the PEL 238 and PAL 2 area. Community information sessions will continue through the project.
Stakeholder meetings	*Narrabri Local Aboriginal Land Council* A meeting was held recently with the Narrabri Aboriginal Lands Council to discuss their involvement in due diligence for Cultural Heritage. *Gomeroi native title applicants* A forum was held on 17 January 2013 to discuss the activities occurring within PEL 238 during 2013 and coal seam gas exploration more generally. Thirteen of the nineteen applicants were in attendance as well as the NTSCORP and the Narrabri LALC. *Narrabri Shire Council* A regular monthly meeting is held with the council and at the last meeting with the shire a six monthly look ahead schedule was presented seeking input from the Shire. All senior council staff received personal telephone calls to advice of any media releases prior to any release being made. *Forestry NSW* Monthly meetings have been held with the Forestry NSW - Pilliga Forest Manager since October 2011. Weekly reports are sent by email to the Forest NSW contact person to provide information on weekly activities and the activities proposed for the following week. *DTIRIS, Division of Resources and Energy(DRE)* Approximately four meetings with DRE have been held to discuss the exploration program within PEL 238 and PAL 2, and, in particular, the regulatory approvals required for the broad project. *NSW Office of Water (NOW)* Approximately three meeting with NOW have been held to discuss the exploration program within PEL 238 and PAL 2 and, in particular, water licensing requirements for pilot activities.

Consultation tool/Activity	Description
Targeted mail outs	Affected landholders receive correspondence advising of the future exploration drilling activities in their area, and closer to the date of commencement activities receive a personal telephone call from the locally based land access team.
Advertisements	Advertisements will be placed in the local media (after advising the Narrabri Shire) of the up- coming exploration drilling activities at Dewhurst 22-25
Fact sheets	Fact sheets have been developed explaining the coal seam gas business in New South Wales which are subject to regular update. These are made available on the project website and at open days or individual community meetings.
Narrabri Community Consultation Committee	Santos has established a community consultation committee in Narrabri which meet monthly to discuss upcoming activities on Santos' program of works. Meetings to date have focused on providing an overview of planned petroleum activities and in particular exploration drilling activities.

2.4.4 Consultation outcomes, including influence on design and management of proposed activity

Table 2-3 identifies key outcomes of consultation activities undertaken to date.

Table 2-3 Consultation outcomes

Stakeholder	Issues raised during consultation	How issues addressed
Forestry NSW as the landowner/manager	▪ Santos' activities must comply with regulatory requirements and the permit to occupy. ▪ Santos' must manage the impact to the forest. ▪ A fire risk management plan must be developed	The location of the lease areas and access tracks are influenced by Forestry NSW's requirements. At the monthly meetings held with Forest NSW feedback is sought with modifications to activities made in accordance with the conditions of the Permit to Occupy. These are broadly discussed in Section 2.8 and are reflected in the mitigation strategies.
Narrabri Community Consultation Committee	▪ Concerns about bushfire, impacts to groundwater and how produced formation water is going to be managed. ▪ Particular topics should be discussed at each monthly meeting to inform the committee on the CSG activities being conducted by Santos. – How is coal seam gas extracted from the ground? – How is the drill hole cemented and re-enforced to protect cross flow from aquifers? – In what ways is Santos supporting the local community?	Santos will continue to consult with the Narrabri CCC. A tour of Santos' operations within PEL 238 and PAL 2 by the Narrabri CCC is being scheduled to increase the community's understanding of groundwater issues associated with CSG and the general project activities. Santos has a response procedure to assist the local Country Fire Brigade if there is a bush fire outbreak in the local area. Santos has and will continue to participate in bush fire management under a request from the local community.
Narrabri Shire Council	▪ Requested continued consultation and a schedule of upcoming events.	The Narrabri Shire Council will continue to be consulted and provided with a six monthly look ahead schedule.
Narrabri LALC and Gomeroi native title applicants	▪ Requested more interaction with Santos.	Following the meeting held in January, Santos is working with the indigenous community to establish a process of assessing indigenous heritage beyond the legislative requirements.

2.4.5 Future and ongoing consultation activities

Santos will continue to consult with NSW Forests, the community and stakeholders leading up to and during the proposed activity. Consultation will be in accordance with the ESG2 Guidelines.

This consultation will include:

- newspaper advertisements
- community updates and newsletters
- fact sheets
- community information sessions and display materials
- stakeholder meetings
- email updates to a registered list of interested stakeholders
- continued operation of the project information line, website and email address
- regular project website updates
- written notification to landowners and neighbours
- traffic management notifications
- monthly Narrabri Community Consultation Committee meetings
- continued operation of the Narrabri Office and Information Centre.

Table 2-4 identifies specific consultation activities which will be carried out prior to the proposed activity commencing.

Table 2-4 Specific consultation prior to commencement of proposed activity

Activity	Description	Planned timing
Landowner/manager Forestry NSW	Prior to the commencement of the proposed activity a formal notice of commencement will be sent to Forestry NSW seven days prior to commencement in accordance with the Permit to Occupy. The weekly report send to Forest NSW will outline activities and information on Dewhurst 22-25 as appropriate. Monthly meetings will continue.	Notice of commencement - 7 days prior to commencement of construction Monthly meetings, weekly emails
Neighbouring landowners	Continuing consultation is held with the landholders whose property abuts Forest NSW. Letters will be sent to adjoining landholders to notify of the proposed activity. The letter will include a description of the activities to be undertaken at Dewhurst 22-25. Regular consultation is held with the landholder who is nearest to Forestry NSW on a regular basis. Follow up phone calls will be made to neighboring landowners to ensure that letters have been received and to answer any questions relating to the proposed activity.	14 days prior to the commencement of activities those landholders who adjoin Forest NSW property will be advised of the commencement of activities and any concern.
Narrabri Shire Council	The next meeting with Narrabri Shire is scheduled for early February 2013 when the six month look ahead will highlight the activities to occur at Dewhurst 22-25.	February 2013 14 days prior to the commencement of activities the Shire will be contacted by telephone to confirm that activities are to commence.

Activity	Description	Planned timing
Broader community	At the next Narrabri community consultation Committee the activities to be undertaken at Dewhurst 22-25 will be advised to the Committee. Further, a broader community meeting will be held in Narrabri in February 2013 when the activities to occur at Dewhurst 22-25 will be advised to all attendees. In attendance at the meeting will be experts on geology, drilling, environmental conditions at the site and operational activities.	February 2013 Narrabri community consultation committee
Advertisements	Advertisements will be placed in the local media of the up-coming exploration drilling activities at Dewhurst 22-25. Advertisement proposed for the Narrabri Courier Newspaper describing current and proposed activities for the area.	14 days prior to commencement of construction
Notification to local police	The local police will be notified of the proposed drilling activities and provided with a road traffic plan specifying the route, time and location of the drilling rig.	14 days prior to the drilling rig mobilising to site

2.4.6 Stakeholder complaint and conflict management

Santos' primary approach to conflict management is open and proactive communications with all stakeholders.

The project information line will be maintained throughout the proposed activity. This information line is available 24 hours per day, seven days per week and will be widely promoted on all project communication materials including newsletters, community updates, fact sheets and stakeholder and community letters. Santos aims to resolve all enquiries or complaints received via the information line within two business days.

To manage enquiries or complaints for the proposed activity, Santos will maintain a database of:

- all project related concerns or complaints received from individual members of the community or representative bodies with which we are consulting
- the response provided or action taken
- a system to track notes on progress to resolution.

Santos has a documented complaint management procedure which is communicated to all relevant staff members. This procedure requires that complaints are recorded as soon as they are received and notified to the Chairperson of the Santos NSW Business Complaint Management Committee. Santos has a policy of ensuring that any reportable complaint is communicated to DRE with a plan for resolution within 24 hours of its occurrence. The complaint management procedure includes the following steps:

- complaint/enquiry received via one of the many methods of communication
- capture enquiry and record details
- details to be recorded include time and date the call/email is received, contact name, phone number, and nature of enquiry/complaint and any response provided
- assess and investigate enquiry by the Complaints Committee and escalate if unable to resolve
- update complainant within 24 hours - during the process of investigation the community member is to be kept informed of the progress of the enquiry/complaint and provided with a timeframe (where possible) for responding to them

- finalise the complaint and update records – close out complaint/enquiry and record all communication actions and responses
- reporting – all issues/contacts are outlined in weekly reports to the Santos Management Team.

Santos has well established dispute escalation and resolution processes in place. Where a complaint is not able to be successfully resolved by the Santos NSW Business Complaint Management Committee, the complaint is escalated to Santos senior management for special focus and resolution.

2.5 Justification of the activity

2.5.1 Objectives

The objective of the proposed activity is to drill four pilot wells and undertake ancillary activities to allow operation of a five well pilot set to collect critical reservoir data from this area of PEL 238.

2.5.2 Strategic need

The proposed activity is necessary for the ongoing exploration and evaluation of the hydrocarbon potential in PEL 238, which to date has undergone limited petroleum exploration. Dewhurst 22-25 is a set of pilot wells that is part of a wider exploration program within PEL 238 which will involve up to 10 core holes and up to six pilot well sets over the next two to three years. The construction and operation of these wells will be subject to separate assessment and approval as the detail and specific locations of the wells and infrastructure is developed. Discovery of CSG resources in the area has the potential to increase the state's reserves and revenue from gas, and underpin future exploration and production in the region. Undertaking the proposed activity is essential to the evaluation of the potential resource.

The proposed activity is consistent with the *Strategic Regional Land Use Plan New England North West* (DP&I, 2012) (the SRLUP) which recognises the region's potential for CSG production and identifies the site and surrounding land as having high CSG resources. The SRLUP states that development of the gas industry in the region will bring capital investment and economic benefits, and has the potential to play a significant role in the delivery of reliable energy in a carbon-constrained economy, provide security of supply for domestic gas and alleviate the state's reliance on imported gas.

The SRLUP emphasises the importance of protecting valuable natural environments and agricultural land. Further discussion of potential impacts on biodiversity and agricultural land is provided in sections 6.2 and 6.4 of the REF respectively.

2.5.3 Method and scale

The proposed activity is required as part of Santos' ongoing CSG exploration program within PEL 238, which is planned to include up to 10 core holes and six pilot well sets. The proposed activity will include two vertical and two horizontal pilot wells, access tracks and a gas gathering system.

The two vertical wells (Dewhurst 22 and 24) will be drilled in order to provide the necessary data on the location of the target coal seams. This will permit the accurate installation of the horizontal 'in seam' wells. Dewhurst 22 will be cored to obtain initial coal seam gas content and composition data and also to comply with obligations under PEL 238 to conduct a work program.

The single horizontal well (Dewhurst 25) will be drilled to test for methane concentration and deliverability within the pilot.

The tri-stacked horizontal well (Dewhurst 23) will be drilled to test and assess the technical ability of a triple stacked horizontal well while pumping and producing from three separate coal seams.

At the completion of the drilling process, subsurface pumps and pressure monitoring equipment will be installed and the pilot operated until critical reservoir data is obtained.

Chemicals are required during drilling to control the wells and make drilling more efficient.

2.5.4 Location

The location of the pilot wells is a substantial factor in the evaluation of the potential CSG resource. The pilot well locations were selected based primarily on:

- preliminary geological investigations
- data collected from the existing Dewhurst 6 well that is currently suspended.

The data collected from the pilot wells require a minimum distance within the coal seam and have been positioned accordingly. The site selection process is further discussed in section 2.6.3.

The gathering system that links the four wells is located adjacent to Monument Road and the access tracks to minimise vegetation impacts.

2.5.5 Timing

Drilling of Dewhurst 22 to 25 is scheduled to commence in the third quarter of 2013 due to program commitments. The previously approved drilling of Dewhurst 6 will be undertaken in conjunction with this drilling program.

The duration of operation of the pilot wells at this stage is unknown, but the wells will need to be operated until critical reservoir data is obtained which could take a number of years. It is expected that they will continue to operate throughout the duration of the life of PEL 238.

2.5.6 Consistency with ecologically sustainable development principles

The proposed activity is consistent with the principles of ecologically sustainable development (ESD). ESD is a primary object of the EP&A Act and is defined under section 4 of the EP&A Act as having the same meaning as section 6(2) of the *Protection of the Environment Administration Act 1991,* being:

6(2) for the purposes of subsection (1)(a), ecologically sustainable development requires the effective integration of economic and environmental considerations in decision-making processes. Ecologically sustainable development can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

In the application of the precautionary principle, public and private decisions should be guided by:

(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and

(ii) an assessment of the risk-weighted consequences of various options,

(b) inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations,

(c) conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,

(d) improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,

(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste,

(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

The proposed activity's consistency with these principles is outlined in Table 2-5.

Table 2-5 Consistency of proposed activity with ESD principles

Principle	Proposed activity's consistency
Precautionary principle	A precautionary approach was taken during the site selection process which aimed to avoid significant environmental constraints, thereby minimising the risk of serious or irreversible harm to the environment as a result of the proposed activity. During the environmental assessment process, investigation into a range of issues was carried out to determine the full potential impacts of the proposed activity. This included commissioning groundwater, cultural heritage and ecological technical studies, and drawing on information from technical specialists including geologists, drilling engineers and process engineers. Conservative 'worst case' scenarios, such as a one hectare lease area, were considered as part of the environmental assessment process. A range of mitigation measures will be put in place to minimise or prevent any environmental degradation. Refer to section 6.0.
Intergenerational equity	The proposed activity will not consume significant quantities of non-renewable resources or produce significant quantities of waste that will lead to long term environmental implications. Groundwater will be abstracted but modelling indicates that this will have no impact on the upper aquifers, registered bore users or groundwater dependent ecosystems. Following drilling, the lease areas will reduce in size to approximately twenty by twenty metres with the remainder rehabilitated.
Conservation of biological diversity and ecological integrity	The lease areas were selected to avoid potential impacts to biodiversity and ecological integrity as much as possible. The small area of vegetation required to be removed for the proposed activity will not result in significant impacts to any threatened species, population or ecological community, or their habitat. It is expected that the impacts to vulnerable Pilliga Mouse will be minimal.
Improved valuation, pricing and incentive mechanisms	While clear and widely accepted standards have not yet been established for the application of this principle, Santos acknowledges and accepts the financial costs associated with all the measures required for the proposed activity to avoid, minimise, mitigate and manage potential impacts of the proposed activity.

2.6 Analysis of alternatives

Alternatives to undertaking the work include:

- do nothing
- reduced scale (less well sets)
- alternative location.

2.6.1 Do nothing option

There is limited previous targeted drilling in this area of the Gunnedah Basin that is sufficiently deep for petroleum exploration purposes. The proposed activity is essential to gain knowledge of the gas content, composition and detailed stratigraphic data. A do nothing option will not enable data to be collected.

2.6.2 Reduced scale

Technical studies investigated opportunities to reduce the number of wells required. The provision of combined vertical and horizontal wells combined with a tri-stacked option reduced the well sets to a minimum of two sets (four wells) proximate to Dewhurst 6. There were no other lower impact alternatives to the proposed activity available that will adequately assess the potential gas resource.

2.6.3 Alternative location

The site selection process was influenced by:

- minimum distances from Dewhurst 6 and between the vertical and directional wells
- the need for a minimum of four wells
- underlying geology
- minimising the number of crossings of Spring Creek
- minimising the length of access tracks and the amount of vegetation to be cleared
- minimising hollow bearing tree removal and impact on riparian vegetation

The site was selected based on the principles of impact avoidance and harm minimisation. It was broadly identified by Santos' geologists and refined in consultation with Forestry NSW and with the assistance of cultural heritage, ecological and environmental consultants. Access tracks were located to avoid hollow bearing trees, targeting areas of greatest disturbance.

The presence of Pilliga Mouse habitat was also an important consideration. The Dewhurst 25 lease area was initially located within the Heath community, however this was subsequently relocated to avoid Heath communities to minimise the impact on this species.

Dewhurst 22 was selected as the location of the flare and water transfer facility as it provided the most logical tie in to future infrastructure linking the wells to Bibblewindi ponds. The alternative vertical well, Dewhurst 24 was considered for siting of the flare and water transfer facility however was eliminated as it required crossing of Spring Creek.

2.7 Description of the activity

2.7.1 Overview

The proposed activity can be grouped into three stages; site establishment, drilling and operation. Site establishment includes clearing the lease areas and establishing the access tracks. Construction of the gathering system for operation will also occur at this stage to minimise impacts and reduce the time that construction vehicles are on site. The second stage involves drilling of the four wells including drilling completion works. The approved work over at Dewhurst 6 will be undertaken concurrently. The third stage involves partial rehabilitation of Dewhurst 23, 24 and 25 and establishment of supporting facilities at Dewhurst 22 including well heads, flare and water balance tank. The gathering system constructed in Stage 1 will then be commissioned during Stage 3.

Towards the end of the third stage two potential post-operation options will be evaluated. Depending on the productivity of the wells, they will either be converted to production wells if sufficient gas is produced and therefore subject to a separate environmental approvals process; or decommissioned and fully rehabilitated prior to the expiration of the PEL if considered unviable.

2.7.2 Stage 1 - Site establishment and construction

2.7.2.1 Lease area preparation

Various works will be required to prepare the site for the proposed activity, including preparation of the lease areas, access track construction and positioning the drill rig and associated temporary buildings on site. The major equipment used on site during these activities will be a drilling rig, civil works equipment and associated temporary buildings and vehicles.

During site preparation, there will be some soil disturbance as a level drill pad will need to be constructed at each proposed well lease. The construction of the drill pads will involve earthworks however this is expected to be minimal given the relatively flat topography.

Plastic lined drilling sumps will be constructed on the leases. Temporary venting and flaring facilities will be located at each site during drilling and pump testing, and will be removed at the end of Stage 2. The area to be disturbed for each of the leases is outlined in Table 2-6.

Table 2-6 Approximate areas of disturbance & final level for proposed lease areas

	Disturbance Area	Pad Level
Dewhurst 22	10,000 m^2 (1.00 ha)	RL 299.3 m AHD
Dewhurst 23	10,000 m^2 (1.00 ha)	RL 305.1 m AHD
Dewhurst 24	10,000 m^2 (1.00 ha)	RL 295.5 m AHD
Dewhurst 25	10,000 m^2 (1.00 ha)	RL 301.8 m AHD
Total	**40,000 m^2 (4.00 ha)**	

2.7.2.2 Access tracks

Entry to the lease areas will be constructed off Monument Road (Dewhurst 22, 24 and 25) and Yellow Springs Trail (Dewhurst 23). Access to the lease areas will be provided via four separate access tracks which will require construction. The Dewhurst 24 access track crosses over the ephemeral Spring Creek. The area of vegetation clearing for access tracks is shown in Table 2-7.

Table 2-7 Approximate areas of disturbance & vegetation clearance for proposed access tracks

	Access Track Width	Access Track Length	Total Disturbance Area
Dewhurst 22	10 m	120 m	1,200 m^2 (0.12 ha)
Dewhurst 23	10 m	320 m	3,200 m^2 (0.32 ha)
Dewhurst 24	10 m	290 m	2,900 m^2 (0.29 ha)
Dewhurst 25	10 m	130 m	1,300 m^2 (0.13 ha)
Total			**8,600 m^2 (0.86 ha)**

Potential access track construction works will include:

- Clearing and grading (where required) the access tracks to allow egress of required equipment. Removal of any vegetation will be conducted under the supervision of an appropriately qualified ecologist. Minimum vegetation will be removed to permit access for all required equipment.
- Top dressing the access track with gravel (where required) to reduce dust and provide all weather access
- Installing large aggregate crushed rock consistent with other creek crossings in the area where the access track to Dewhurst 24 crosses Spring Creek

The requirement for any track construction works, will depend on the requirements of the selected contractor and specific drilling rig to be used, and will be determined during the detailed design of the proposed activity to ensure minimal disturbance.

2.7.2.3 Gathering system construction

The proposed water and gas gathering system will comprise of separate buried, low pressure flow lines for water and gas linking the pilot wells to a centralised water and gas management facility ultimately located at Dewhurst 22. Construction of the gathering system will be undertaken during stage 1. The operation of the gathering system is discussed in section 2.7.4.

Figure 2-2 shows the site plan for the proposed activity, including the route for the gathering system, topography contours, Lot and DP number and existing forestry roads. The gathering system will be located within a 10 metre corridor, either within the proposed access tracks or adjacent to the existing roads. By combining the working area for the roads and gathering system, the cumulative area of vegetation impacted by the proposal will be reduced. The gathering system starts and finishes at the riser located at the edge of the lease for each of the lease areas.

The 10 metre corridor will accommodate construction activities and permit the adequate segregation of mulch, topsoil and subsoil stockpiles.

The area to be disturbed and cleared of vegetation for the gathering system is outlined in Table 2-8. This is in addition to the area cleared for the access tracks, which will also be used for the gathering system, outlined in Table 2-7 above.

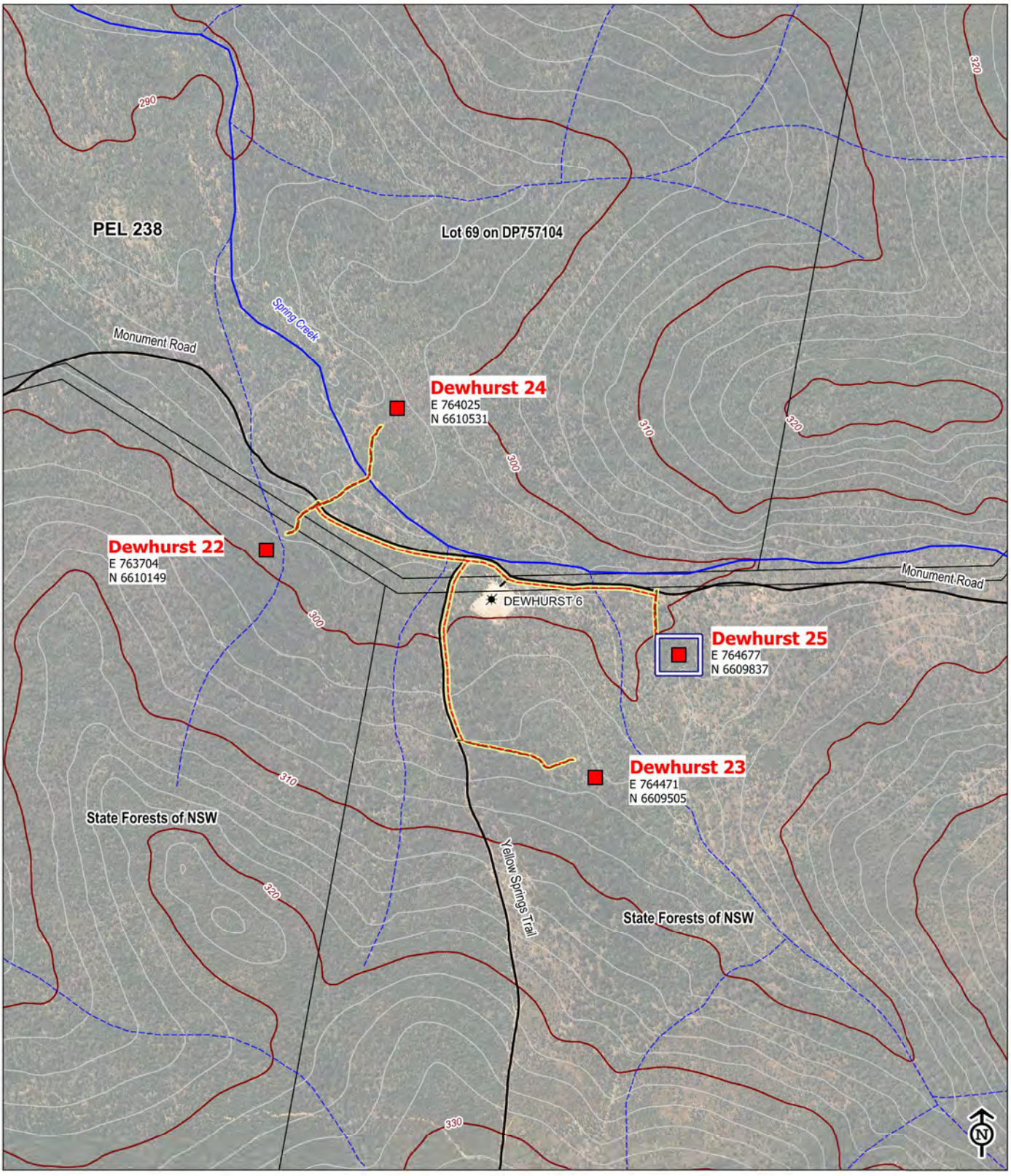
Table 2-8 Approximate areas of additional disturbance & vegetation clearance for proposed gathering system

	Gathering System Width	Gathering System Length	Total Disturbance Area
Dewhurst 6	10 m	20 m	200 m^2 (0.02 ha)
Monument Road	10 m	880 m	8,800 m2 (0.88 ha)
Yellow Springs Trail	10 m	530 m	5,300 m2 (0.53 ha)
Total			**14,300 m^2 (1.43 ha)**

The construction of the gathering system between the pilot wells will require the following activities:

- Surveying the gas and water flow line corridor by a registered surveyor before any preparatory activities take place.
- Clearing and stockpiling vegetation at agreed locations determined during the negotiation of the access agreement with Forestry NSW.
- Ploughing into a common trench using a proprietary pipe installation to a nominal depth of approximately 1000 millimetres. The ploughing technique minimises environmental impact through reducing the width of the corridor and minimising disruption to top soil. The technique also removes the requirement for traditional installation trenches to be formed, dewatering and improves site safety and construction timeframes. The method is as follows:
  - Ripping. The route must be 'ripped' to confirm there is no rock within the gathering system corridor. Where rock is encountered it will be removed and replaced with suitable material that does not present risk of damage to the plough or associated equipment.
  - Fusion bonding. HDPE flowlines are joined using fusion bonding. In preparation of the ploughing works the flowline will be bonded and laid out adjacent to the gathering system route. Typically the entire gathering system length will be bonded together before the ploughing team start work. Up to two kilometres of flowline can be bonded per day.
  - Installation. A blade on the plough forms and clears the laying bed. The machine's movement is accurately guided using GPS technology. The plough's ripper and pipe insertion unit is pulled through the ground and the pipe is continuously laid as the machine moves forward.
  - Reinstatement. The ground closes in naturally following the ploughing. Post installation, a small 'hump' may be created which will be lightly compacted using suitable plant.

Whilst the preferred method of construction is ploughing, there may be some instances where the soil is too rocky and the plough is not suitable. If this does occur, a traditional trench construction approach will be utilised for these short sections. These locations will be determined during the construction phase.



Existing Well
Site Location
Proposed Pipeline
Unsealed Road
Proposed Access Track
Major Drainage
Minor Drainage
Major Contour
Minor Contour
Tenure
Well Lease
Proposed Infrastructure Buffer (10 metre total width)

Santos

PEL 238 - New South Wales

Dewhurst 22 - 25 Site Plan

250 0 250 500 M

Figure: 2-2

Date: February 2013
File No: GUNNEDAH 274b

GDA

2.7.2.4 Lease establishment

The lease areas will be up to approximately 100 by 100 metres in size. Santos is currently reviewing the design of its lease areas to reduce disturbance and minimise environmental impacts of its activities. Lease area establishment has traditionally involved constructing a level pad with cut and fill. Santos is now investigating the feasibility of using industrial matting as an alternative to traditional construction methods.

Given the flat nature of the site, the lease areas for Dewhurst 23, 24 and 25 will likely be established using industrial matting. The industrial matting consists of impervious, non-absorbent material which could be placed directly onto slashed vegetation. This will reduce the need for topsoil removal and earthworks.

Dewhurst 22 will require the use of traditional construction methods as the facilities required for operation are located here and the lease area will remain cleared.

Using the industrial matting method will involve the following activities:

- marking out the extent of the lease area
- slashing and rolling groundcover within lease area
- excavating an environmental pit (54 cubic metres in size) and lining with heavy grade impermeable plastic sheeting at the natural low point on the lease area, for use as secondary containment in the event of a spill
- excavating a standard cellar pit (13.5 cubic metres) in the location of the core hole
- stockpiling spoil from the cellar pit and environmental pit in a designated stockpile area
- installing a standard conductor at the core hole location
- laying industrial matting down to create a continuous solid surface to stand plant, machinery and storage areas on
- fencing the lease area.

Traditional lease construction methods will be used at Dewhurst 22, and only used at the other lease areas if an issue arises with the industrial matting once on site. This would involve the following activities:

- marking out the extent of the lease area
- installing silt fencing down slope of the lease area
- installing silt fencing down slope of a designated stockpile area
- removing topsoil and groundcover using a bulldozer
- grading the lease area, laying and compacting fill
- building a drainage diversion bund upslope of the lease area
- excavating an environmental pit (54 cubic metres in size) and lining with heavy grade impermeable plastic sheeting at the low point on the lease area, for use as secondary containment in the event of a spill
- excavating a standard cellar pit and installing a standard conductor at the core hole location
- fencing the lease area.

Estimated cut and fill volumes for this construction method are identified in Table 2-9 including the size of resultant stockpiles.

Table 2-9 Estimated cut and fill volumes if traditional construction methods used

Lease area	Cut	Fill	Excess to be stockpiled
Dewhurst 22	Approximately 1,100 m^3 topsoil	Approximately 950 m^3 topsoil	Approximately 150 m^3
Dewhurst 23	Approximately 1,050 m^3 topsoil	Approximately 850 m^3 topsoil	Approximately 200 m^3
Dewhurst 24	Approximately 2,450 m^3 topsoil	Approximately 2,200 m^3 topsoil	Approximately 250 m^3
Dewhurst 25	Approximately 700 m^3 topsoil	Approximately 750 m^3 topsoil / gravel	nil

Other activities during establishment of the lease area will include:

- transporting civil works equipment, such as bulldozers, excavators, graders, rollers, a cementing unit, a conductor drilling unit, water trucks, and support and light vehicles, to the lease area
- setting up portable amenities on site
- installing and cementing a 7" conductor casing (typical) at approximately eight to 20 metres depth ahead of the rig arriving on site

2.7.3 Stage 2 - Drilling

2.7.3.1 Drilling rig and equipment set up

The major plant, equipment and temporary buildings to be used during drilling activities will include:

- drilling rig and supporting equipment (such as pipe handler and mud pump)
- surface drilling mud tanks
- metal bins, baskets, skids and sea containers to house equipment
- mechanical vibrating screens
- power generator units
- lighting towers
- site offices
- satellite communication trailers
- containers
- sheds
- flaring facilities
- vent tank.

The plant, equipment and temporary buildings will be transported to the lease area and set up prior to drilling activities. They will remain in place for the duration of the drilling operations. This is estimated between 20 to 40 days (depending on the well profile). A heavy drill rig will move between lease areas followed by a smaller work over rig to run completion equipment into the well. The types of buildings and containers that may be present on the site are shown in the conceptual lease layouts (Figure 2-3).

A vent tank will be installed to capture fluids and gas from the well if required during the drilling process. This tank is a re-enforced steel container, approximately 10 by three metres in size, with internal baffles and piping to allow for the separation of gas and liquids. The tank will be designed to contain any fluids vented. This captured and contained fluid will be removed, as required, and disposed of by a licensed waste disposal company. Minor volumes of methane (CH_4) and carbon dioxide (CO_2) may be emitted from the vent tank from time to time.

Rigging up/down of equipment (i.e. installation and dismantling of rig equipment) is expected to take up to six days per lease (three per rig up, three per rig down).

Other equipment will be required on site during the course of the drilling activities, including wireline trucks, cementing trucks and service company vehicles. These vehicles will exit and enter the site via the access tracks as required.

2.7.3.2 Well design

The wells will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012b). Table 2-10 summaries the key design criteria for each of the wells.

Table 2-10 Well design parameters

Design criteria	Dewhurst 22	Dewhurst 23	Dewhurst 24	Dewhurst 25
Directional	Vertical	Directional	Vertical	Directional
Approximate Depth	1004 m	1070m	1005 m	1070m
Well type	Pilot / Core	Pilot	Pilot	Pilot
Target coal seam	Bohena, Namoi and Parkes	Namoi, Bohena Main and Parkes	Bohena	Bohena
Drilling technique	rotary drilling and coring	rotary drilling and coring	rotary drilling	rotary drilling and coring
Well pair		Dewhurst 22		Dewhurst 24
Number of horizontal lateral wells		3		1
Horizontal length		900 m		900m
Well head pump	progressive cavity pump	electrical submersible pump	progressive cavity pump	electrical submersible pump



REV.	DESCRIPTION	DATE	BY	CHECKED	INITIAL	DATE	APPROVED	INITIAL	DATE
A	ISSUED FOR APPROVAL	26-09-12	BW	BW	BW	26-09-12	ML	ML	26-09-12

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We have the energy.

CONCEPTUAL RIG LAYOUT

SIZE	FSCM NO	DWG NO	REV
A3		7099 – 390 – LAY - 0001	A

SCALE 1 : 300 | SHEET 1 OF 1

2.7.3.3 Drilling process

Drilling and construction of all four wells will involve:

- Drilling an open hole with an approximate diameter of 12-1/4" through alluvial and/or weathered rock material into competent rock (Upper Napperby Formation), known as the coring point.
- Installing 9-5/8" steel casing and cementing in place back to surface. The surface casing will be set 260-280 metres below ground level.
- Installing a blow out preventer (BOP) on top of the casing.
- Drilling out the casing shoe using an 8-1/2" rotary drilling assembly and drilling to the planned depth.
- Installing 7" production casing to the planned total depth.
- Dewhurst 23 and 25 will have +/- 6" holes milled in the casing to facilitate the drilling of the horizontal wells towards their respective targets of Dewhurst 22 and 24.

At Dewhurst 22 where coring will also be conducted, once the initial core point is reached, the rotary drilling assembly will be pulled from the hole and replaced with an 8-1/2" diameter coring assembly to core through selected coal seams and other formations as determined by the geologists.

In the event that drilling is unable to be completed due to geological constraints or other drilling issues, a suitable alternative location will be selected within the existing lease area. DTIRIS will be consulted at this time.

Schematics of the pilot wells are shown in
Figure 2-4 indicating the sub surface cross-section and **Figure 2-5** showing the interaction between a vertical and horizontal well.

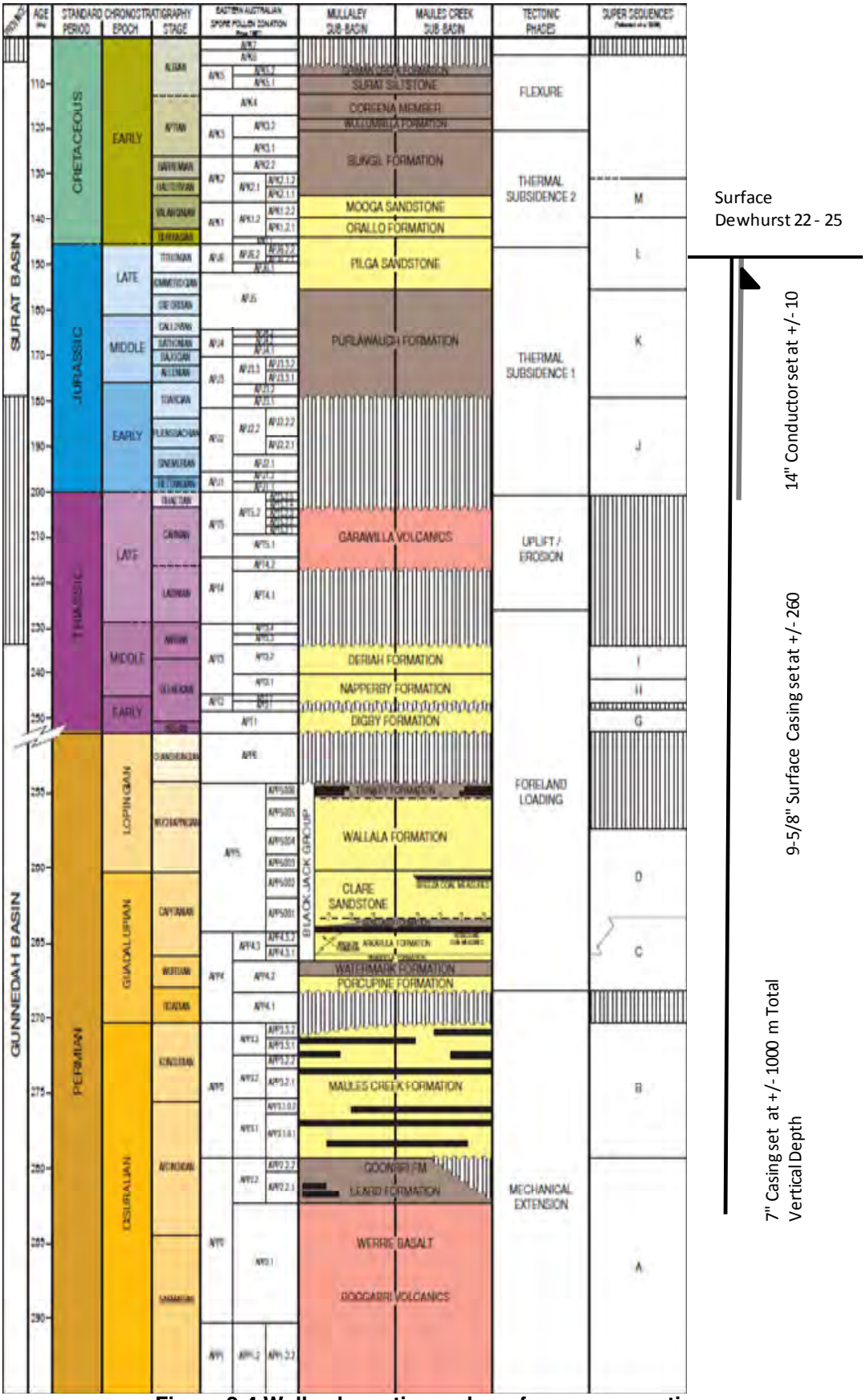


Figure 2-4 Well schematic – sub surface cross section

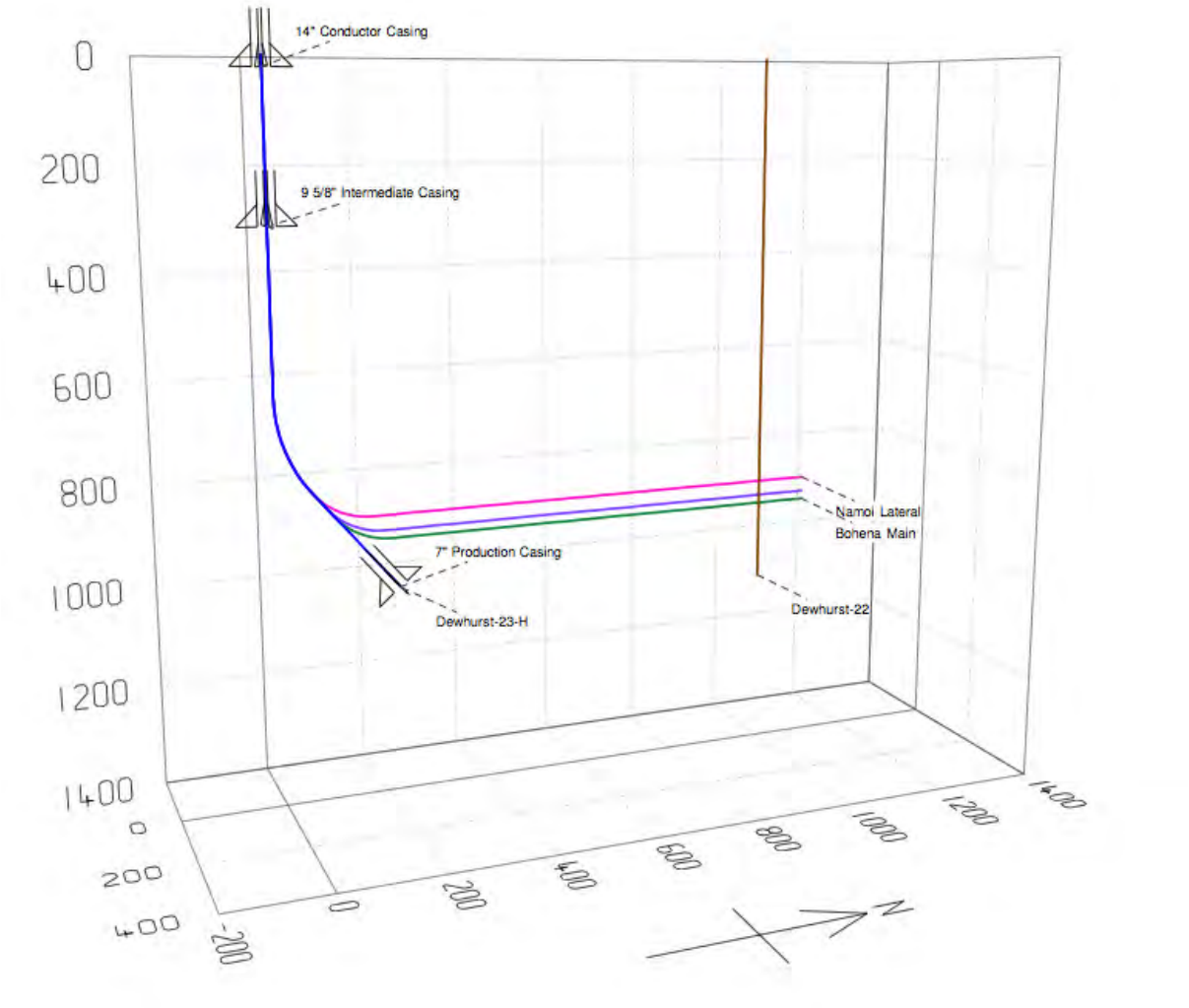


Figure 2-5 Well schematic – indicative example of interaction of directional and vertical pilot wells

2.7.3.4 Drilling mud and additives

During the rotary drilling process, water-based drilling mud is designed to:

- clear rock fragments and other solids (drill cuttings) from the bore hole and bring them to surface
- apply enough pressure against subsurface formations to prevent fluids and gases from flowing into the well
- prevent clays from swelling and keep the bore hole open until casing has been cemented in place
- cool and lubricate the drilling equipment.

Chemicals may be added to the drilling mud, or held as a contingency on site, to facilitate safe and efficient drilling of the pilot wells. The primary additives that may be used are potassium-sulphate and potassium-formate to help control swelling clays. Should these be deemed as unsatisfactory by the Santos Onsite Company Representative (OCR) or the drilling contractor, potassium chloride may be used, which is a proven and more conventional additive. Other chemical additives may be used as weighting agents, viscosifiers or polymers.

Chemicals that may be used or held on site during drilling include:

- K2S04, also known as Potassium Sulphate
- Calcium Chloride 74-77%, also known as Calcium Dichloride
- Xanthan Gum P, also known as Flowzan
- Quickseal Medium, also known as Kwikseal
- Rheopac, also known as Rheopac-RD, Rheopac-LV, Rheopac-R, Drispac-R, Drispac-SL, PAC-R or PAC-L
- JK - 261 / JK-161, also known as CR-650, JK-261 LV, JK-161 LV
- Idcide – 20
- Sodium Bicarbonate
- Citric Acid
- Soda Ash
- Fracseal – Fine
- Sodium Formate
- Defoam – E
- Barite, also known as Rheobar or Aus-Bar.

The Material Safety Data Sheets (MSDS) for these chemicals are provided on the Santos website: http://www.santos.com/exploration-acreage/nsw-csg/reports-and-publications.aspx. The purpose of use, mass, concentration, chemical composition, chemical abstract service numbers and environmental considerations for each chemical, are included in Appendix 2. A MSDS for potassium sulphate based drilling fluid is included in Appendix 3.

Potential sources of make-up water for the drilling mud include the Narrabri's potable town water supply, produced formation water from an operational pilot well in the region, or local industrial licensed water bores. The quality of make-up water will depend on the final source. Formation water is likely to be highly brackish. The data indicates that formation water may be highly brackish and unsuitable for drinking or irrigation.

Chemicals will be mixed with the drilling mud prior to transporting to site. This will reduce the volume of chemicals required to be stored on site during drilling. The drilling mud will be transported to the site in a trailer prior to the commencement of drilling and stored in surface tanks on site. Chemicals on site will be stored in an elevated, bunded trailer for protection in the event of heavy rains or site flooding.

During operations, the drilling mud will mix with naturally occurring rock and soil and return these to the surface. The drilling mud will pass through mechanical vibrating screens to separate out drill cuttings. The liquid component of the drilling mud will flow into the surface tanks for recirculation throughout the drilling process. The drill cuttings will be transferred to metal bins or a lined pit and stored on site until drilling is completed.

Losing drilling fluid is undesirable as it is the primary means of controlling the core hole. In the event that losses are detected, a lost circulation material (LCM) will be mixed into the mud to prevent further losses. LCM is made of cellulose or other natural material and works by blocking the pores in the permeable/fractured rock.

Once drilling of the pilot well set is complete, the drilling mud will be transported back to the treatment and processing facility in Narrabri so it can be reused in future drilling operations. The drill cuttings will be tested to determine the appropriate management and disposal methods. This process is described in section 2.8.1.

2.7.3.5 Cementing

Cementing operations will be in compliance with Section 4.3 of the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012b). The cementing of casing strings will be performed by a recognised professional cementing company who will provide bulk cement facilities, high pressure cementing pumps and mixing pumps to mix and pump the slurries required. The equipment will be operated in a manner that will minimise any spills. Pressure tested steel lines will connect the cementing unit to the well to allow fluids to be pumped to the well and these fluids will be positioned in the well following correctly formulated engineering design and good oilfield practice.

Following completion of cementing, excess fluids and cement slurries will be segregated in steel waste tanks and removed and disposed of by a licensed waste disposal company.

Table 2-11 outlines the expected drilling fluids for each well.

Table 2-11 Estimated drilling fluid transported to and from site

	Dewhurst 22	Dewhurst 23	Dewhurst 24	Dewhurst 25
Drill cuttings generated (m^3)	140	300	140	200
Drilling fluid transported to site (m^3)	225	250	225	225
Drilling fluid transported from rig to Narrabri treatment facility (m^3)	100	150	100	100

2.7.3.6 Casing the well

Once each well has reached the total depth, geophysical wire-line logs will be run over the entire length of the hole to identify major stratigraphic units, intersected coal seam depth and seam thickness. Further down stem tests (or equivalent downhole) evaluation may follow after completion of logging. In the vertical wells, Dewhurst 22 and 24, a combination of steel and fibre glass casing will be run in the hole and pressure cemented ensuring total isolation of the well bore to the surrounding coal seams and any potential aquifers. The combination casing design allows fibreglass to be placed over potential future mineable coal seams whereas steel casing isolates all other non-target rock types in the upper section of the well.

For the directional holes drilled from Dewhurst 23 and 25, the well will intercept the fibreglass casing in the vertical wells over the target coal sequences. Steel 7” casing will be used over the coal seams.

2.7.3.7 Well completion

The wells will be completed using a smaller work over rig. This involves installing the downhole pump assembly and hydraulic drive head (wellhead) with additional support equipment.

Completions will require several days to install the pumping equipment and approximately one day per well to install the pressure monitoring equipment.

2.7.4 Stage 3 - Operation

The proposed water and operations management strategy to accommodate water and gas production will involve the following elements:

- installation of wellhead and metering skids at each of the pilot well locations with associated power generation and telemetry (including at the approved Dewhurst 6)
- commissioning of the water and gas gathering system linking the wells (including Dewhurst 6) to infrastructure located at Dewhurst 22
- installation of facilities at Dewhurst 22 including:
  - » water transfer facilities with a maximum operating capacity of 1000 barrels of water per day per well
  - » installation of a skid flare for the combustion of excess coal seam gas.
- Partial rehabilitation of Dewhurst 6, 23, 24 and 25.

During the pilot test pressures, water volumes, water levels, compositions and gas rates will be monitored. These will be reported in accordance with regulatory obligations.

Data collected on site from the well head and gathering system will be transmitted via a Remote Telemetry Unit (RTU) through the Next G network to Santos offices to enable operations personnel to remotely monitor and control the surface facilities. Security measures will also be installed.

The pilot wells will have automated shutdown systems that are triggered by preset operating envelopes if exceeded are designed to prevent environmental, health or safety risk. Figure 2-6 shows the concept layout for Dewhurst 22.

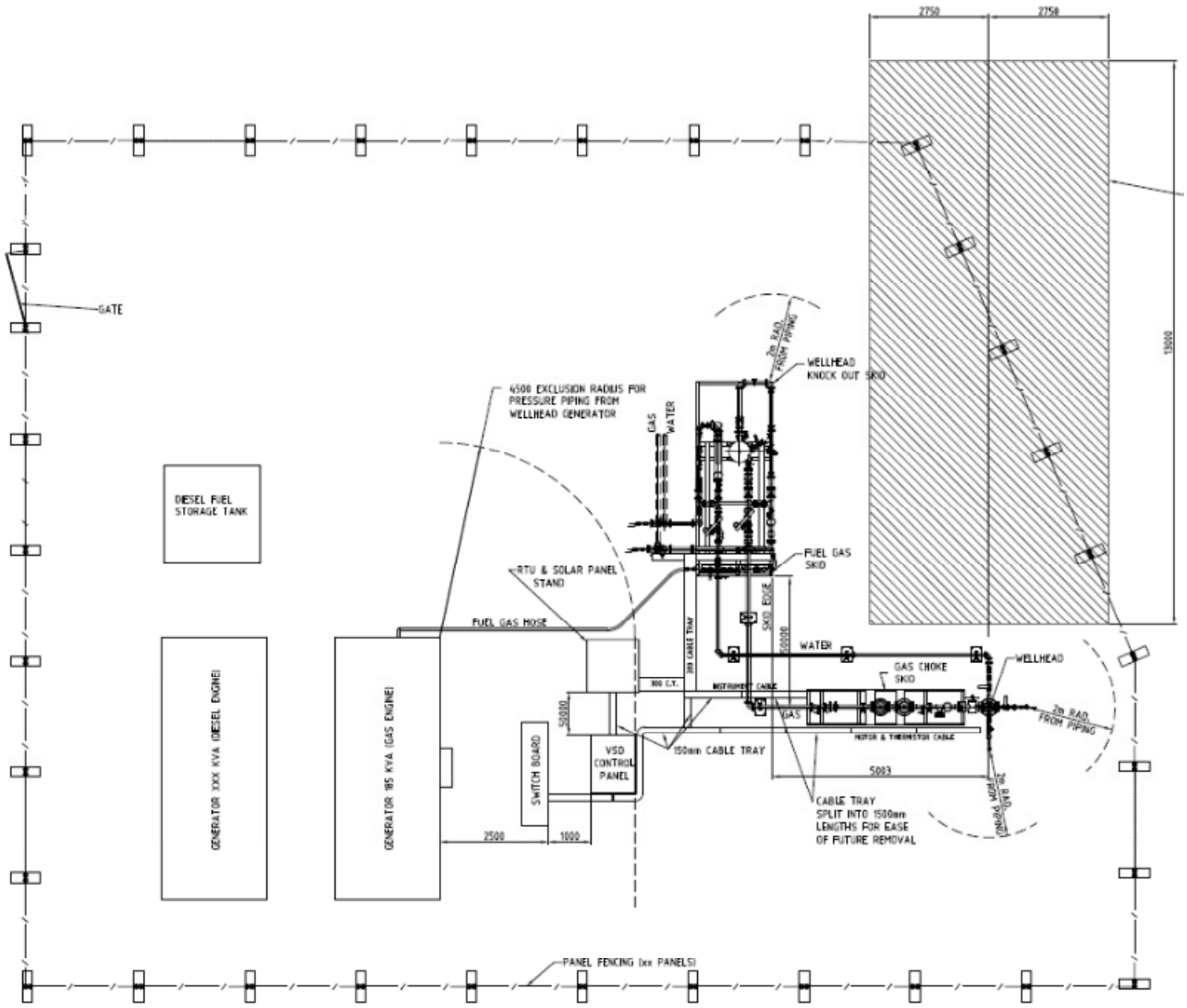


Figure 2-6 Concept arrangement for Dewhurst 22

2.7.4.1 Wellheads and wellhead facilities

The surface facilities at all five wells will be constructed using wellheads similar to the typical arrangement shown in Plate 2-1.

At the surface, each pilot well will be connected to a small separator, operating at low pressure (approximately 275 kPag) to separate any coal seam gas from the incidental water. Both the gas and water will be collected from each well and transferred to the gathering systems.

Gas

Recovered coal seam methane gas will flow up the well annulus separate to the water with the gas stream entering the wellhead knockout pot to remove any entrained water. A portion of the produced gas will be diverted to the local fuel gas skid for conditioning prior to being used within the well site power generators, with the balance flowing to the low pressure gas gathering network and flared.

Backup diesel generators and associated diesel storage tanks (double wall, self-contained steel tank with a vent conforming to AS 1940 and AS 1692) will be stored onsite to ensure suitable power generation capabilities to the site. It is expected that during periods of high fire danger gas may be vented to atmosphere to minimise the risk of ignition sources within the forest and the wells will be remotely isolated in the case of fire.

Water

For the vertical wells (Dewhurst 22 and 24) a progressive cavity pump (PCP) will be installed just below the coal seam and transfer water to the surface through the well tubing. For the directional wells (Dewhurst 23 and 25), an electrical submersible pump (ESP) will be located at the depth of the target coal seams.

The produced water flowing from the wellhead knockout pot will be mixed with the produced water from the PCP / ESP tubing flowline. The combined water stream will then enter the gathering system and flow to facilities at Dewhurst 22.

Plate 2-1 Typical Wellhead Lease



In order to conduct the pilot, water will be extracted from the target seam(s) from both paired pilot wells simultaneously. Total water production from the pilot well set will rise to a rate slightly over 91 megalitres per year within the first 30 days of inception of the pilot, whereupon it will be maintained at an average rate of approximately 96 megalitres per year for the duration of the trial. The water extraction rate is raised steadily over the first 30 days of the trial in order to protect the integrity of the well bore and casing.

The water extraction rate for Dewhurst 6 is predicted to be negligible as a consequence of its central position between the two lateral wells.

Table 2-12 shows the likely produced water composition based on existing water sampling data from the Bohena, Namoi and Parkes coal seams. As a background, rainwater typically has a TDS of 20 milligrams per litre or less. Fresh water from lakes, rivers, and groundwater is more variable, with TDS ranging from 20 milligrams per litre to approximately 1,000 milligrams per litre. Brackish water is, by definition, water with TDS exceeding 1,000 milligrams per litre and ranging as high as that of seawater, at approximately 35,000 milligrams per litre. The below results indicate that the CSG water would be considered in the high brackish range and unsuitable for irrigation or drinking water without treatment.

Table 2-12 Water quality of Bohena, Namoi and Parkes coal seams (based on composite dataset from existing wells)

Parameter	Units	Average	Maximum	Minimum
Total Dissolved Solids TDS	mg/L	14,341	27,429	7,680
Temperature	° C	23.1	25.0	21.4
pH		7.7	8.7	7.0

2.7.4.2 Gathering system operation

Table 2-13 summarises the design parameters for the gathering system.

Table 2-13 Gathering system design parameters

Parameter	Gas gathering system design	Water gathering system design
Diameter	Maximum of 250 mm OD	Maximum of 160 mm OD
Material	High Density Polyethylene (PE100)	High Density Polyethylene (PE100)
Static pressure rating	To AS4130	To AS4130
Depth cover	Minimum 750mm cover	Minimum 750mm cover

2.7.4.3 Water treatment and transfer facilities

Water will be pumped through the gathering system to a balance tank on the Dewhurst 22 lease. It will then be transferred to a suitable location for storage, treatment and beneficial use. It is intended that facilities at Dewhurst 22 will be connected to a water gathering network to allow water to be transferred by pipe to Bibblewindi water handling facility for storage and a new treatment facility at Leewood. Both of these projects are subject to a separate environmental approvals process.

In the event that the water gathering network is not in place or not in operation, water will be trucked to the Bibblewindi facility. It is expected that up to 12 truck movements / day will be generated.

2.7.4.4 Flare system

Any gas surplus to the requirements for onsite power generation will be flared onsite through a flare system installed within the Dewhurst 22 lease area. This will ensure no direct venting of methane to atmosphere for the duration of the production testing. The flare will be of a size capable of consuming up to five million cubic feet of produced gas per day.

The gas flare will be located within the lease with an exclusion zone to mitigate any risk of bushfire. A typical flaring equipment design is shown in Plate 2-2.

The operation of the flare in normal operations is expected to occur intermittently as surplus gases become available. The flare is of a type that combusts methane in the absence of any significant quantities of oxygen and therefore burns with a low intensity, with minimum rates of combustion between 90-95%. Additionally, the flare design is robust and can handle fluctuations in the volumes, gas compositions and meteorological conditions.

Hazardous area classification

A hazardous area classification will be carried out to determine the acceptable radiation limits at the flare and to enable the proper selection and installation of equipment that could be used safely in the vicinity of the proposed flare.

Acceptable radiation limits for various locations at the flare site were determined based on the American Petroleum Industry (API) 521 standard and are outlined in Table 2-14.

Table 2-14 Radiation design limits

Location	Radiation Level kW/m^2
Base of flare stack	9.46
Sterile area boundary	6.31
Nearest plant limit	3.15
Areas where operators are continually exposed	1.58

The classification will be carried out using Santos methodology which has been based on the Australian Standard, AS 60079.10.1 - Classification of Areas – Explosive Gas Atmospheres and other relevant standards and codes. The hazardous area classification has been undertaken with consideration of the standards and codes provided in Table 2-15.

Table 2-15 Standards and codes considered in the hazardous area classification

Australian Standards	
AS/NZS 60079.10.1:2009	Classification of areas – explosive gas atmospheres
AS/NZS 60079.20.1:2012	Electrical Apparatus for Explosive Gas Atmospheres. Part 20: Data for flammable gases and vapours relating to the use of electrical equipment
AS/NZS 2381.1:2005	Electrical equipment for explosive atmospheres – Selection, Installation and Maintenance
International Codes	
IP 15 (Edition 3- July 2005)	Institute of Petroleum, Model Code of Safe Practice in the Petroleum Industry: Part 15, □ Area Classification Code for Installations Handling Flammable Fluids
Santos Design Practices	
1515-67-G002 Rev 1	Design Practice for Hazardous Area Classification

Based on the radiation design limits outlined in Table 2-14 above, a flare exclusion zone will be established around the proposed flare stack to ensure all personnel movement occurred outside the maximum radiation zone of 1.58 kW/m^2 and to ensure that the radiant heat intensity at the separator is maintained below this level. A sterile zone surrounding the flare (i.e. 10 by 10 metres) will also be established.

Table 2-16 summarises the key concept design features of the proposed flare.

Table 2-16 Concept design features of proposed flare

Design feature	Proposed flare
Design flow rate	Up to 5 million standard cubic feet per day (MMSCFD)
Average flow rate	0.25 to 0.75 MMSCFD
Stack height	Up to 5 metres
Exclusion zone (from stack base)	Up to 35 metres
Sterile zone (from stack base)	Up to 10 metres

Flare construction

The construction of the flare system, including exclusion zone of up to 35 metres, will occur within the confines of the Dewhurst 22 lease area. To enable this to occur, construction will occur after the completion of the drilling works at this lease area.

Following site establishment, a HDPE liner will be laid over the proposed sterile zone surrounding the flare and covered with compacted soil and blue metal aggregate. This will ensure protection against heat. No topsoil will be removed.

The flare assembly will then be installed and aboveground piping laid to connect the flare to the separator. Pipe supports every seven metres will be installed to keep the piping in place. Pipe hold down lines will also be installed.

Flare operation

A flow meter will monitor the gas flow rate from the gathering system and then will be safely ignited. The settings of the flare backpressure regulators are able to be modified to suit operational requirements.

The flare will ignite automatically to ensure that all gas is burnt rather than vented to the atmosphere. Flaring operations will occur at low levels as required 24 hours a day seven days per week.

A design feature of the flare installation is a control valve installed upstream of the flare which minimises the pressure drop of the gases in the flare. This design feature reduces noise of the flare operation.

The flare and associated exclusion zone will be fenced with suitably designated fencing and signage for the duration of operation.

Once the flare is no longer required, infrastructure will be removed and the site rehabilitated to its former state.

Table 2-17 summarises the approximate fugitive emissions from the proposed flare.

Table 2-17 Approximate fugitive emission from flaring

Emission	Volume (Mol%)
Nitrogen (N2)	5
Carbon dioxide (CO2)	95
Methane (CH4)	0
Total	100



Plate 2-2 Typical flare assembly

2.7.4.5 Partial rehabilitation of Dewhurst 6, 23, 24 and 25

Once the drilling activities are complete, any surplus lease area is proposed to be rehabilitated to an area of approximately twenty by twenty metres around each well head with appropriate mitigation measures and environmental safeguards implemented to minimise potential impacts. All rehabilitation works will be undertaken with maximum regard to environmental protection and rehabilitation, vegetation, subsoil and topsoil management, weed control, erosion and sedimentation management and revegetation in accordance with the relevant statutory requirements. In addition, the temporary water load out facilities and water tanker turnaround circle will be decommissioned and removed from site.

2.7.5 Site water requirements during construction

Drilling activities will require approximately 0.25 mega litres of water at Dewhurst 22, 24 and 25 respectively; while approximately 0.27 mega litres will be required at Dewhurst 23. Alternatively, production water from pilot wells will be used when available for the preparation of drilling mud. In addition, approximately 0.02 mega litres per day of potable water will be required for facilities on the lease. This will be sourced from Narrabri's town water supply or local industrial licensed water bores and trucked to the site. Water licensing requirements are discussed in section 5.2.8.

2.7.6 Staff and hours of construction

The number of employees present on the site at any one time is expected to be up to 40 persons at the well leases during construction and 10 persons during installation and operation of monitoring equipment. It is not proposed to provide a workers camp on the site, with off-shift drilling crews to be located in nearby accommodation at Narrabri with travel to and from site to be provided.

Construction hours will be subject to negotiation and agreement with Forestry NSW but may be up to 24 hours per day, seven days per week. Personnel movements to and from site will be minimised outside of a single shift change per day but may be necessary during specific activities or in the event of an incident.

2.7.7 Timing and duration

Site preparation and drilling is planned to commence in the third quarter of 2013, subject to approval. The expected duration/timing of the main work phases is identified in Table 2-18.

Table 2-18 Approximate duration of drilling and site activities

Activity	Approximate Duration
Site preparation	14 days
Drilling and completion	15 - 40 days
Operation	For the duration of PEL 238
Rehabilitation	30 days if undertaken (prior to the expiration of PEL 238)

2.7.8 Maintenance

Work over operations using a smaller rig will be required on the pilot wells from time to time for corrosion monitoring, mechanical repairs or other interventions as required. All works will be undertaken within the access tracks and lease area.

Regular maintenance of the gathering system will also be undertaken, as required, often in conjunction with the northern flowline maintenance program. The works will be undertaken within the 10 metre gathering system corridor.

2.7.9 Decommissioning and Rehabilitation

If the decision is made to decommission and rehabilitate the pilot wells post-operation, well abandonment and rehabilitation procedures will be undertaken prior to the expiration of PEL 238 as follows.

2.7.9.1 Well abandonment

The wells will be cemented, plugged and abandoned in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012) and rehabilitated following completion of drilling and testing activities. This will involve:

- sealing the wells from bottom to top by plugging with cement in approximately 200 metre increments
- pressure testing the cement plug across the surface casing shoe to ensure the wells are sealed
- removing the well head at a depth of greater than 1.5 metres below surface and burying.

2.7.9.2 Lease area rehabilitation

The lease areas will be fully rehabilitated within approximately six months of well abandonment where practicable and considering external factors such as the weather and availability of resources.

Rehabilitation works will depend on the method of lease establishment. Rehabilitation activities for both options are identified in Table 2-19.

Table 2-19 Rehabilitation activities

Industrial matting	Traditional lease construction
▪ All plant, equipment, waste materials and temporary buildings will be removed from the site. ▪ Industrial matting will be removed for re-use at another site. ▪ Plastic lining will be removed from the environmental pit and disposed of at an appropriately licensed facility. ▪ The environmental pit will be backfilled and groundcover re-established. ▪ Fencing will be removed from perimeter of lease area.	▪ All plant, equipment, waste materials and temporary buildings will be removed from the site. ▪ Plastic lining will be removed from the environmental pit and disposed of at an appropriately licensed facility. ▪ The environmental pit will be backfilled. ▪ Subsoil will be replaced across the lease area, contoured to the landscape and partially compacted. ▪ Topsoil will be uniformly placed across the lease area, graded to natural levels and partially compacted. ▪ Fencing will be removed from perimeter of lease area. ▪ The lease area will be revegetated according to Forestry NSW requirements. ▪ Weed control will be undertaken.

2.7.9.3 Gathering system rehabilitation

The gathering system will be flushed, capped each end and left in the ground. The surface will be rehabilitated, which will include both natural regeneration and the planting of suitable native perennial grasses and shrubs species that will assist in the stabilisation of the soils as agreed with Forestry NSW.

The rehabilitation will be developed by a suitability qualified ecologist. This plan will include measures to assist in the regeneration of the gathering system corridor, including (but not limited to):

- rehabilitation techniques – native bush regeneration and assisted plantings
- species selection
- seeding and planting techniques
- mulching requirements and techniques
- maintenance and weed control.

2.8 Mitigation strategy

Santos has developed an extensive understanding of the steps and measures that should be taken to prevent or minimise impacts on the environment, human health and safety when undertaking exploration activities, including drilling activities through their experience developed over 50 years. A suite of mitigation measures and a statement of commitments have been developed, as outlined in sections 6 and 9 of this REF, and will be applied when carrying out the proposed activity. The commitments are tailored to CSG exploration activities, and are consistent with many of the principles used in the various guidelines in NSW in relation to biodiversity conservation, Aboriginal cultural and other heritage protection, pollution, noise, dust, stormwater, sediment and erosion control, and waste management measures.

An environmental management plan will be developed prior to works commencing. This will detail requirements for each mitigation strategy. In addition, Santos uses compliance tracking and incident management systems throughout its operations. These internal systems will be applied to monitor performance against the commitments identified in this REF. The statement of commitments in section 9 of the REF will be provided to relevant staff and contractors undertaking the work to ensure compliance with relevant legislation, regulations and the REF.

Climate change is a long-term issue, requiring urgent but informed action to stabilise atmospheric greenhouse gas concentrations. As a global stakeholder in the energy business Santos recognises their social and environmental responsibility to pursue strategies that address the issue of climate change.

Santos is committed to working with government, industry and the community to address climate change with specific focus on addressing energy efficiency, adaptation strategies, the transition to lower emission technologies and reporting transparency.

Santos' Climate Change Policy outlines the organisations approach to climate change and realisation of the vision to 'lower the carbon intensity of its products'. The policy identifies the following commitments:

- Continue to reduce the carbon intensity of Santos' products by focusing on energy efficiency, technology development and by embedding a carbon price in all activities.
- Use energy more efficiently by identifying opportunities to implement energy efficiency projects and report their progress.
- Examine the commercial development of low emission technologies, including storage solutions, which will contribute towards long-term emission reduction targets.
- Pursue no flaring or venting of associated gas, unless there are no feasible alternatives.
- Continue to publicly disclose Santos' greenhouse emissions profile and carefully examine forecast emissions.
- Understand, manage and monitor climate change risk and develop appropriate adaptation strategies for our business.
- Assist governments and engage with other stakeholders on the design of effective and equitable climate change regulations and policy.
- Inform employees about its commitment to climate change and ensure climate change initiatives continue to be implemented.
- Report progress against these commitments to the Board.

Santos has publicly reported its greenhouse gas (GHG) emissions since 2004 with independent assurance provided annually, and as a result has established comprehensive governance processes which will ensure that the emissions associated with the proposed activity will be accurately reported under the *National Greenhouse and Energy Reporting Act 2007* (Cth) (NGER Act). Santos' governance system includes:

- annual independent assurance of GHG emissions
- regular audits in relation to implementation of the Environmental, Health and Safety Management System (EHSMS)
- risk-based internal audits are administered to ascertain conformance with, and effectiveness of the EHSMS Standards
- monitoring and review of energy efficiency opportunities, and
- other audits of compliance with internal policies and procedures related to GHG reduction through the internal audit program.

Santos holds a Permit to Occupy from Forestry NSW. The occupation permit outlines a number of requirements for any works, with key environmental requirements including:

- facilities must be secure and fenced
- Santos cannot place, tip or discharge any material
- there is to be no obstruction to any waterway

- Santos must use best endeavours to limit use of power consuming equipment, water and energy consumption and generation of waste
- Santos must take all reasonable precautions to minimise the risk of fire
- any rehabilitation and seed planting is to be agreed with Forestry NSW
- any cleared vegetation with approval from Forestry NSW must be removed and destroyed
- all new access tracks must be properly constructed and drained to a standard that will provide all weather access for four wheel drive vehicles
- all access tracks must be gated
- all vehicles entering the site must be washed down to mitigate the risk of introducing non-endemic species.

Under clause 5.2.1 of the agreement, consent must be sought from Forestry NSW for any works. This consent can only be sought after the relevant approvals are granted under the EP&A Act.

The mitigation strategy developed addresses all the requirements of the Permit to Occupy.

Detailed strategies for water source protection, waste and noise during the construction and operation phases are provided in sections 2.8.1 and 2.8.2 respectively. They are also covered in the Occupation Permit issued under section 31 of the *Forestry Act 1916* (now repealed).

2.8.1 Construction

2.8.1.1 Water source protection strategy

Surface water protection

Spring Creek is located within close proximity of the site; with the access track to Dewhurst 24 crossing over it and Monument Road running adjacent to it to the south along the section where the gathering system is proposed. Under no circumstances will water be extracted from Spring Creek or other surface waters as part of the proposed activity. This creek and other surface waters will be protected through site water management, drainage and erosion and sediment controls. The site water management principles will be based on:

- minimising surface disturbance
- separating clean and dirty water, including minimising surface water running onto the lease areas
- preventing contaminants from running off the lease area.

Minimising surface disturbance

As the first priority, the site establishment and preparation works will seek to avoid ground disturbance. Use of industrial matting is therefore the preferred lease establishment method, as an alternative to clearing and levelling. Grading of the access track will be avoided wherever possible to reduce surface area disturbance. Instead, the access track will be slashed, watered and rolled (to compress the surface), and topped with gravel (where necessary). Grading of the gathering system corridor will also be avoided where possible, with the vegetation slashed and rocks cleared as necessary.

Separation of clean and dirty water

Where the lease area is to be constructed using traditional methods, a diversion bund will be constructed on the up-slope side of the lease area to divert clean water around the work area. This will reduce the volume of sediment laden water that needs to be managed.

Spill containment and runoff control

Spill kits will be kept on site and any spills will be contained, cleaned up and reported immediately. Any materials contaminated by a spill, such as absorbent pads or soil, will be removed from the site and disposed of at a licensed waste management facility. The lined environmental pit will act as a secondary control measure to capture spilled liquids and ensure these do not leave the site. Contaminated liquid captured in the environmental pit will be removed and disposed of at a licensed waste management facility.

Where traditional lease construction methods are used, an erosion and sediment control plan will be prepared and implemented to minimise site erosion and sediment loads in runoff. Where industrial matting is used, topsoil and vegetation will remain intact and erosion is expected to be minimal.

Water management, drainage, erosion and sediment control measures

Erosion and sediment control will be undertaken in accordance with industry best practice, such as the measures outlined in *Managing Urban Stormwater: Soils and Construction* (Landcom 2004) ('the Blue Book') or the *Best Practice Erosion and Sediment Control Guidelines* (IECA, 2008) (IECA Guidelines). Prior to commencement of work an assessment of the various site conditions will be undertaken and a progressive erosion and sediment control plan will be prepared.

The assessment will consider the following, as a minimum:

- existing soil types (to determine the most appropriate method of control)
- topography
- water
- vegetation
- ecology
- entry and exit points for both drainage and sediment control.

The specific water management, drainage, erosion and sediment control works for each phase of the proposed activity are identified in Table 2-20.

Table 2-20 Water management, drainage, erosion and sediment control measures

Phase	Control measures
Lease area establishment using industrial matting (preferred method)	▪ The extent of the lease area will be delineated on site. ▪ Vegetation will be slashed and compacted. The top soil layer will remain intact. ▪ Areas of industrial matting will be placed on the ground throughout the lease area. ▪ A designated stockpile area will be marked out and silt fencing installed along the down slope perimeter of this area. ▪ All excavated spoil (from the environmental and cellar pits) will be stockpiled in the designated area. ▪ The lined environmental pit will be constructed in the low point of the lease area.
Lease area establishment using traditional methods (if required)	▪ The extent of the lease area will be delineated on site. ▪ Continuous silt fencing will be installed along the down slope perimeter of the lease area. The silt fencing will extend into the ground surface. ▪ A designated stockpile area will be marked out and silt fencing installed along the down slope perimeter of this area. ▪ A drainage diversion bund will be constructed upslope of the lease area to divert clean water around the lease area. ▪ Vegetation, topsoil and spoil will be stripped separately and stockpiled in the designated stockpile area. ▪ The lease area will be graded to a low point where the lined environmental pit will be constructed.
Access track and gathering system construction works	▪ Silt fencing will be installed around the area of disturbance as necessary. ▪ The access track will be topped with gravel.
Stockpiling	▪ Silt fencing will be installed and maintained on the down slope perimeter of all stockpile areas. ▪ Topsoil and subsoil material will be stockpiled separately. ▪ Topsoil and subsoil will be stockpiled at the site for a period of up to approximately six months from release of the drill rig, until partial rehabilitation of the lease area can take place. ▪ Stockpiles will be maintained with a slope of no greater than 2(horizontal): 1(vertical). ▪ Stockpiles will be compacted using the back of an excavator bucket or similar to reduce erosion potential. ▪ Topsoil stockpiles will be maintained at a height no greater than two metres.
Drilling activities and operation of lease area	▪ Water that drains to the cellar pit will be circulated with the drilling mud throughout the drilling process. ▪ Any spilled liquids or contaminated water that is captured in the environmental pit will be removed to a licensed waste facility for treatment or disposal. ▪ The environmental pit will be maintained with a 300 mm freeboard at all times. ▪ Silt fencing will be regularly inspected and maintained.
Rehabilitation	▪ All plant, equipment, waste materials and temporary buildings will be removed from the site. ▪ Any industrial matting will be removed. ▪ Plastic lining will be removed from the environmental and cuttings pits and disposed of at an appropriately licensed facility. ▪ The environmental and cuttings pits will be backfilled. ▪ Fencing will be removed from perimeter of lease area. ▪ Where traditional lease construction methods have been used: – Subsoil will be replaced across the lease area, contoured to the landscape and partially compacted. – Topsoil will be uniformly placed across the lease area, graded to natural levels and partially compacted. ▪ Weed control will be undertaken.

Groundwater protection

Potential groundwater impacts and mitigation measures are identified in section 6.1.3 of the REF.

The proposed activity will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS 2012b) and will minimise potential groundwater impacts. Overbalanced drilling techniques will be used to ensure that water is not lifted during drilling. A driller that holds the relevant qualifications as defined by the NSW Office of Water will manage the drilling of the top hole and until the surface casing is set, cemented and pressure tested. This will ensure that the appropriate knowledge of water legislation and regulation in NSW and technical skills are employed to avoid impacts to groundwater sources.

During drilling, the circulating drilling mud will establish a wall cake and maintain pressure on the various aquifers intercepted. This will prevent the ingress of groundwater to the pilot well and discharge of groundwater to the surface. It will also limit the ingress of drilling mud into the aquifers to the immediate vicinity of the pilot well.

At the completion of drilling, the hole will be cased with pipe and cemented into place. This will provide a solid barrier to prevent any future ingress, mixing or discharge of groundwater and cross contamination of aquifers.

While there is minimal risk of impacts to aquifers as a result of the proposed activity, Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within three kilometres of the site to undertake groundwater monitoring prior to drilling, to establish baseline conditions, and on completion of drilling, to determine if there are any impacts. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and quality observations in the field, and sampling for analysis by an accredited laboratory.

2.8.1.2 Waste reduction and management strategy

The proposed activity will produce a number of waste streams. Waste will predominantly be generated during the site preparation and drilling phases including:

- any civil works associated with the lease area construction (if traditional lease construction methods used) and access track upgrade works
- drilling activities
- site clean up
- partial rehabilitation (where traditional lease construction methods used)
- general waste from contractors and personnel on site.

The main waste types and estimated volumes generated during site establishment and drilling activities are identified in Table 2-21.

Table 2-21 Estimated waste volumes

Waste	Estimated volume
General site waste, such as packaging materials, scrap metal and chemical/fuel/oil containers and domestic waste	20 m^3
Sewage waste[1]	2 m^3/month
Mud contaminated cement slurry	115 m^3
Drilling mud	450 m^3

Table note: 1. No camp facilities will be located on site. Toilet facilities will be located on site for persons working on site.

The most significant waste types and volumes will be generated during drilling. The management approach for drilling mud and solids (cuttings) has aimed to reduce waste to landfill as much as possible.

Drilling fluids will be mixed at the Narrabri fluids treatment facility prior to being transported to site. This will reduce wastes associated with mixing chemicals on site (such as chemical containers).

During drilling, used fluids will be separated into liquids and solids and mud will be continuously reused throughout the drilling process. At the end of drilling there will be a residual volume of mud which will be returned to a licensed treatment facility in Narrabri for processing so that it can be reused at the next well to be drilled on the program. There will be a residual amount of waste from this treatment facility which will eventually need to be disposed of at a licensed waste facility.

It is expected that drill cuttings will consist of excavated natural material and can be used in site rehabilitation under the *Excavated Natural Material Exemption 2012* (ENM exemption) issued by the EPA on 19 October 2012. Drill cuttings will be tested to determine whether they comply with the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (Waste) Regulation 2005* and the ENM exemption and whether they can be reused or require off-site disposal.

Sampling and analysis of drill cuttings will be undertaken in accordance with *Australian Standard 1141 Methods of Sampling and Testing Aggregates* and will include tests for:

- metals (mercury, cadmium, lead, arsenic, chromium, copper, nickel and zinc)
- electrical conductivity
- pH
- Total Polycyclic Aromatic Hydrocarbons
- Total Petroleum Hydrocarbons
- Benzo(a) pyrene
- Total Chlorinated Hydrocarbons
- percentage component of rubber, plastic, bitumen, paper, cloth, paint and wood.

Drill cuttings determined to comply with the ENM and applicable regulations will be used for backfilling or site shaping during rehabilitation of the site. This will reduce the need to import additional fill and will reduce material which may otherwise go to landfill.

If testing determines that the drill cuttings exceed the limits set by the excavated natural material exemption, a contractor licensed to transport trackable wastes, with the appropriate waste tracking certificates, will remove them from the site. Any such cuttings will be disposed off site at an appropriately licensed waste facility.

Wastes requiring on-site storage will be placed within lidded skip bins in a designated waste transfer point within the lease area prior to transportation for disposal. Regulated waste will be collected by licensed contractors for off-site disposal. General and recyclable waste will be transported to local council landfill and recycling facilities.

An indicative waste inventory and proposed management for each waste type is provided at Appendix 4.

Prior to commencement of the proposed activity, a waste management plan will be developed based on the waste reduction hierarchy of avoid, reduce, reuse, recycle, recover, treat and dispose.

The waste management plan will identify:

- types of waste generated
- waste management processes and procedures for each waste stream
- waste transport requirements
- monitoring requirements
- audit and inspection requirements
- record keeping and reporting requirements.

Other waste management measures are identified in section 6.1.7.

2.8.1.3 Noise management strategy

The proposed activity will generate noise, particularly during drilling and cementing activities, which may occur up to 24 hours per day, seven days per week. A quantitative noise assessment of drilling activities has been undertaken by Noise Measurement Services in accordance with the *Interim Construction Noise Guideline* (ICNG) (DECC 2009) (refer Appendix 5). The results of the noise assessment are discussed in section 6.1.8 of the REF.

Noise impacts will be managed in accordance with the ICNG and OEH requirements. The management approach will include:

- consultation with potentially affected receivers
- monitoring of noise impacts
- implementation of feasible and reasonable work practices
- complaint management and response.

The nearest potentially affected sensitive noise receiver is a group of two residential dwellings and associated infrastructure just over three kilometres to the north north-west of Dewhurst 24 lease area. Due to its remote location, it is unlikely that noise generated by the proposed activity will be audible at these residential receivers. Users of the Forest, such as bushwalkers, picnickers and Forestry NSW staff, may be affected by noise and vibration during the works. Forestry NSW will be notified of the proposed activity prior to commencing works. This will include details of the timing and duration of noise generating activities.

Santos will aim to maintain noise levels at the rating background level (RBL) plus 10 dB(A) during standard working hours (7am to 6pm Monday to Friday and 8am to 1pm Saturday) and the RBL plus 5 dB(A) outside of standard working hours. The RBL at the site is assumed to be no more than 30 dB(A), based on the noise assessment (Appendix 5) by Noise Measurement Services.

Noise testing of the drilling rig will be carried out prior to its arrival on site to confirm predicted noise levels.

Where noise levels are likely to exceed the RBL plus 10 dB(A) during standard working hours, or the RBL plus 5 dB(A) outside of standard working hours, feasible and reasonable work practices will be implemented to reduce noise levels. Such practices may include:

- training contractors to operate plant and equipment in ways that minimise noise generation
- scheduling deliveries to occur during day time hours where practicable
- inspecting and maintaining equipment to ensure it is in good working order
- reducing throttle setting and turning off equipment when not in use.

In the event of a noise complaint, the source of the noise will be investigated. Where necessary, Santos will offer to conduct noise monitoring from the proposed activity at the affected receiver. If it is determined that noise levels are unacceptable, further feasible and reasonable work practices or mitigation measures will be implemented.

2.8.2 Operation

2.8.2.1 Water source protection

During operation, groundwater abstracted from each well will pass through a separator to a gathering system linking the four wells to surface facilities at Dewhurst 22.

Pressure gauges will be fitted to both lines and monitored remotely through a Supervisory Control and Data Acquisition (SCADA) system. Should pressure change due to a leak, the pilot wells will be shut down immediately and the affected area investigated.

Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within three kilometres of the site to undertake groundwater monitoring during operation of the pilots, to determine if there are any impacts to aquifers. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and quality observations in the field, and sampling for analysis by an accredited laboratory.

2.8.2.2 Waste reduction and management strategy

The main waste stream during operation is the associated water produced from the wells. This will be collected at the well heads and pumped to a balance tank at Dewhurst 22. Water will then be transferred to a facility for treatment, beneficial reuse and/or disposal.

Subject to a separate REF, the northern flow lines will link facilities at Dewhurst 22 to the facility at Bibblewindi for storage and ultimate treatment at a new facility at Leewood. In the event that the northern flowlines are not in place water will be moved by road to an appropriate facility for treatment.

2.8.2.3 Noise management strategy

During operation noise will be limited to the occasional combustion of gas through a flare or vehicles visiting the site, and pumping of water between the wells and gathering system. The flare control valve installed upstream of the flare reduces noise of the flare operation.

Cumulative noise levels will be very low, with the noise assessment concluding that the operation of the pilot wells should not be audible at the nearest sensitive receivers (refer to Appendix 5); and accordingly a specific strategy to manage noise has not been developed.

However, should a noise complaint be received, noise levels will be investigated.

2.9 Access arrangements

The proposed activity is to be undertaken on land dedicated as State Forest managed by Forestry NSW. Works within the Pilliga East State Forest are undertaken in accordance with the Occupation Permit issued under section 31 of the *Forestry Act 1916* (now repealed). The Occupation Permit constitutes an access agreement with Forestry NSW under the *Petroleum (Onshore) Act 1991*.

2.10 Other approval requirements

Assessment and determination of the proposed activity under Part 5 of the EP&A Act, and approval under the *Petroleum (Onshore) Act 1991*, is required before the activity can commence. A water access licence (WAL) under the Water Management Act 2000 (WMA) is also required; refer to section 5.2.8 for further details.

No other approvals are required. Refer to section 5 for further details

3.0 The site

3.1 Site description and plan

The site is located within the Pilliga East State Forest off monument Road, approximately 30 kilometres south of Narrabri, within Crown Land.

The coordinates of the four pilot wells are identified in Table 3-1.

Table 3-1 Coordinates (MGA zone 55) for Dewhurst 22 to 25 pilot wells

Name	Easting	Northing
Dewhurst 22	763704	6610149
Dewhurst 23	764471	6609505
Dewhurst 24	764025	6610531
Dewhurst 25	764677	6609837

Each pilot well will be located in the centre of a lease area of up to approximately one hectare.

The following photographs illustrate the site.



Plate 3-1 Dewhurst 22



Plate 3-2 Dewhurst 23



Plate 3-3 Dewhurst 24

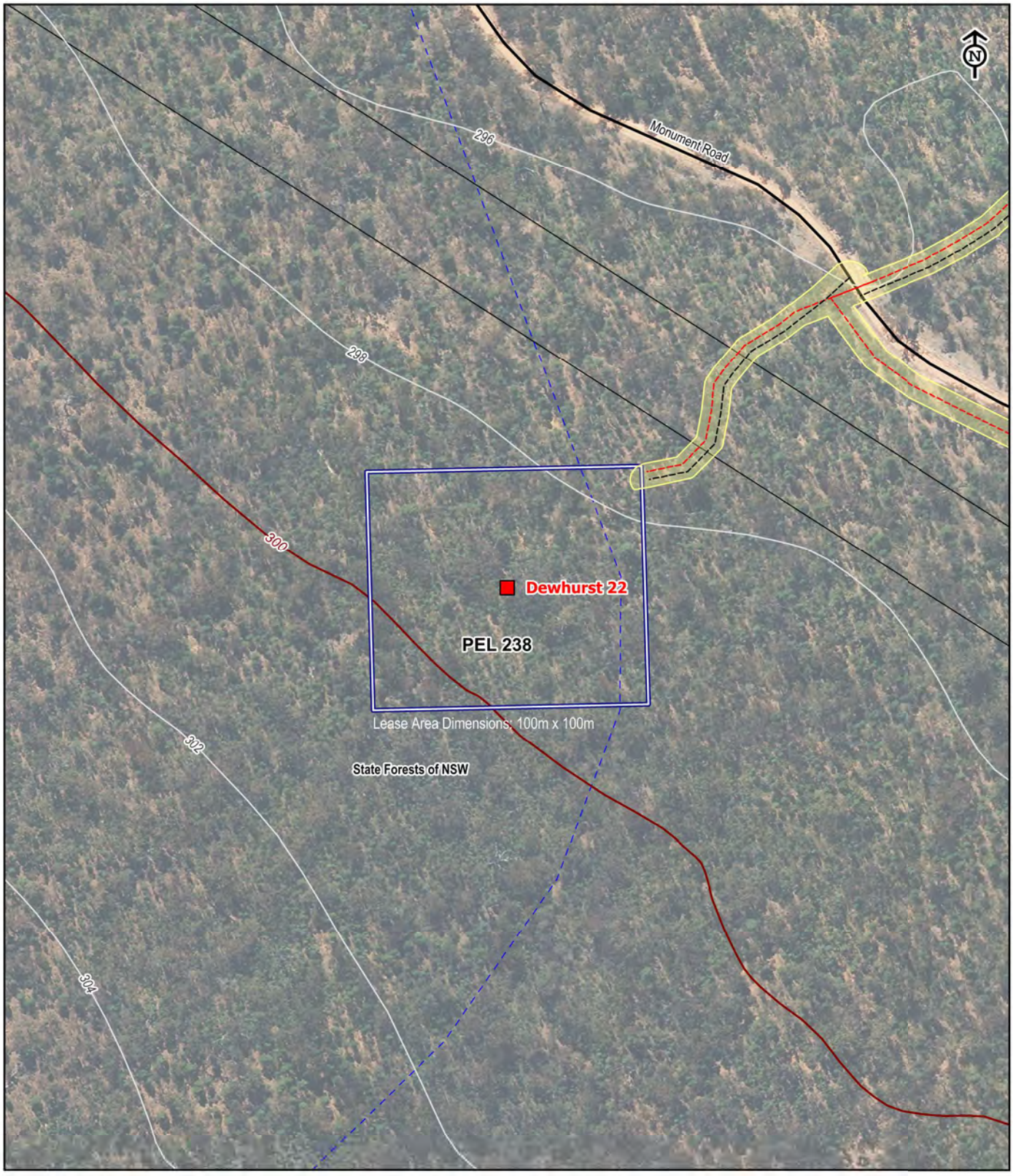


Plate 3-4 Dewhurst 25



Plate 3-5 Monument Road

The lease areas are shown at Figures 3-1 to 3-4.



Site Location
Proposed Pipeline
Proposed Access Track
Unsealed Road
Major Contour
Minor Contour
Creek
Minor Drainage
Lease Area (100m x 100m)
Tenure Boundary
Proposed Infrastructure Buffer (10 metre total width)

Santos

PEL 238 - New South Wales

Dewhurst 22 Lease Area

25 0 25 50 75 m

Figure: 3-1

Date: February 2013
File No: GUNNEDAH 274c

GDA



Site Location

Proposed Pipeline

Proposed Access Track

Unsealed Road

Major Contour

Minor Contour

Creek

Minor Drainage

Lease Area (100m x 100m)

Tenure Boundary

Proposed Infrastructure Buffer (10 metre total width)

Santos

PEL 238 - New South Wales

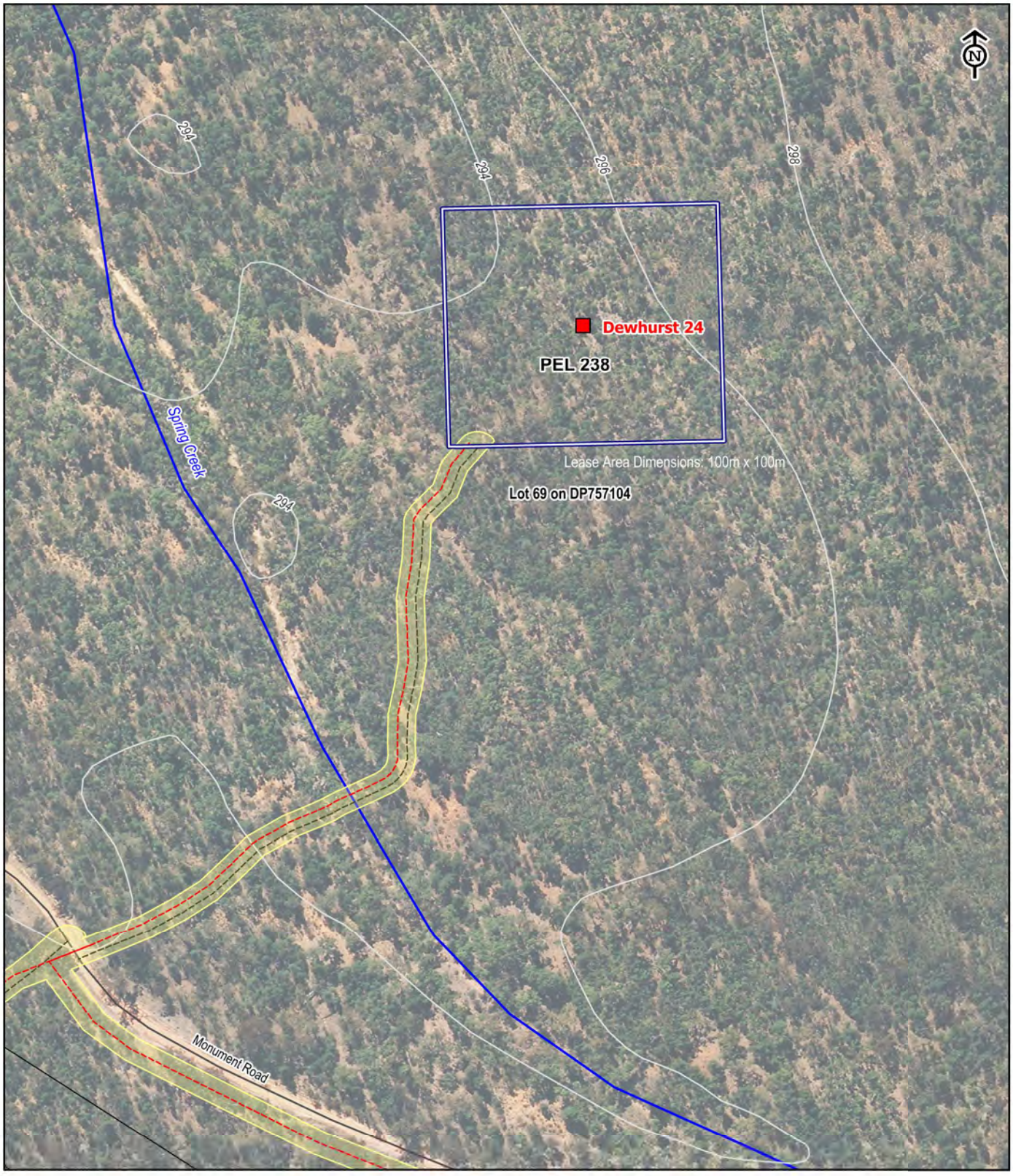
Dewhurst 23 Lease Area

50 0 50 M

Figure: 3-2

Date: February 2013
File No: GUNNEDAH 274d

GDA



Site Location
Proposed Pipeline
Proposed Access Track
Unsealed Road
Major Contour
Minor Contour
Creek
Minor Drainage
Lease Area (100m x 100m)
Tenure Boundary
Proposed Infrastructure Buffer (10 metre total width)

Santos

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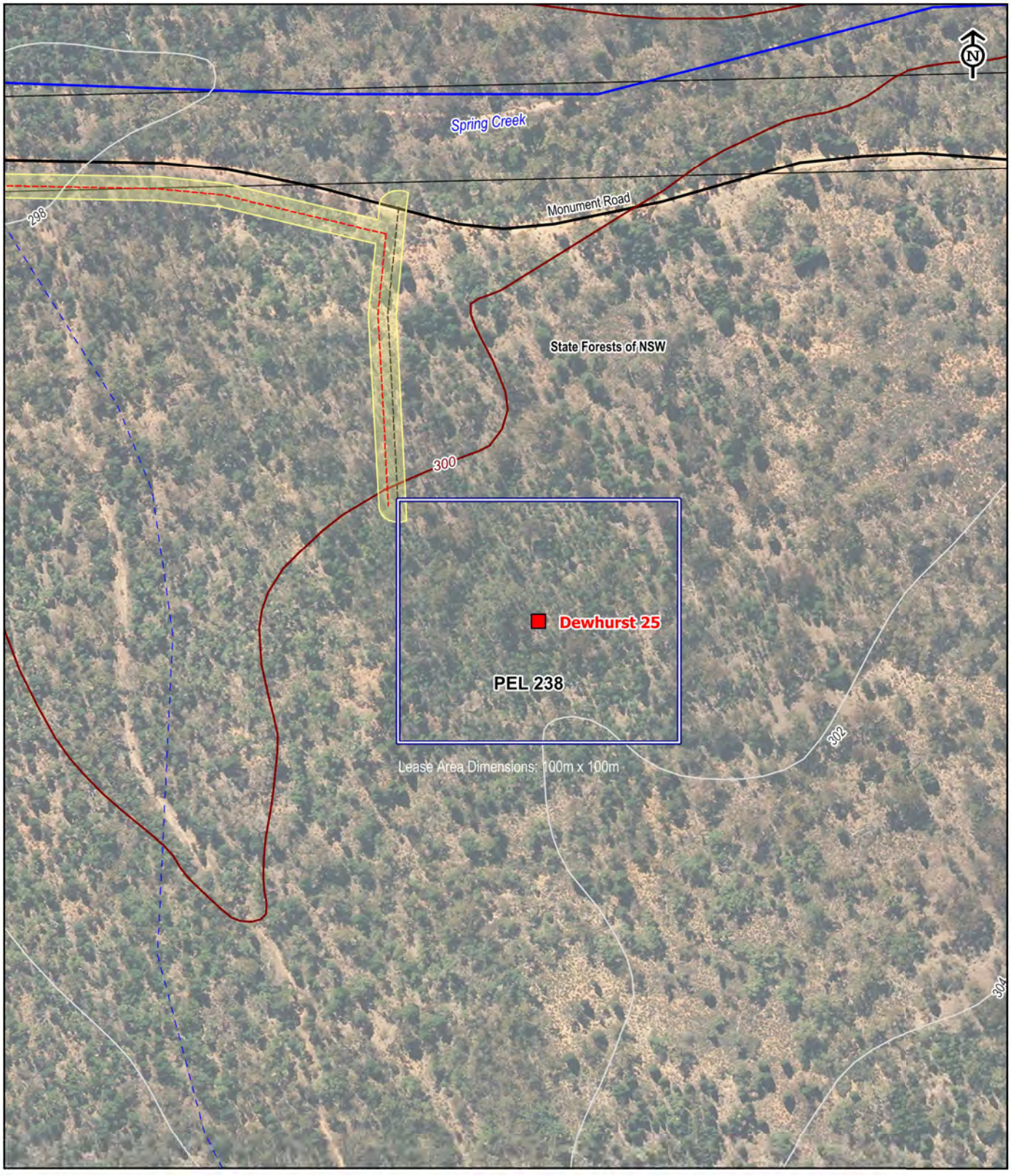
Dewhurst 24 Lease Area

25 0 25 50 75 m

Figure: 3-3

Date: February 2013
File No: GUNNEDAH 274e

GDA



Site Location
Proposed Pipeline
Proposed Access Track
Unsealed Road
Major Contour
Minor Contour
Creek
Minor Drainage
Lease Area (100m x 100m)
Tenure Boundary
Proposed Infrastructure Buffer (10 metre total width)

Santos

PEL 238 - New South Wales

Dewhurst 25 Lease Area

25 0 25 50 75 m

Figure: 3-4

Date: February 2013
File No: GUNNEDAH 274f

GDA

4.0 Existing environment

4.1 General description

4.1.1 Climate and weather

The closest Bureau of Meteorology (BoM) weather station to the site is Narrabri (Rosewood Farm) (station 053103), however it provides only sparse rainfall data from 1979 to 2012 and no temperature data. The BoM weather station considered the most representative of the site is Narrabri West Post Office (station 053030, opened 1891); while Narrabri Airport AWS (station 054038) is the closest station to the site with recent temperature statistics (Narrabri West Post Office statistics end at 2002). The local climate can be regarded as semi-arid due to hot summers and mild winters. The average daily maximum temperature is 26.5°C, while the average daily minimum temperature is around 11.7°C (BoM, 2012). Annual rainfall is 659.7 mm and is known to range between 297.4mm (lowest record) and 1012.1mm (highest record). Rainfall is summer dominant with approximately 40 per cent of rainfall occurring between December and February.

As shown in Table 4-1, based on mean temperature records the warmest month is January and the coolest month is July. October receives the greatest rainfall and April the least.

Table 4-1 Mean climate data

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Max Temp (°C)	33.8	33.2	31.2	27.3	22.5	18.7	18	19.8	23.4	30.1	33	33
Mean Min Temp (°C)	19.3	19.1	16.4	11.9	8.3	5.2	3.7	4.6	7.6	11.7	14.8	17.7
Mean Rainfall (mm)	82.3	62.1	56.8	38.9	47.9	48.2	46.3	41.1	42.5	82.9	61.8	78.3

4.1.2 Topography

The regional topography is characterised by flat to very flat (approximately 1:1000), gently sloping land with little or no vertical relief.

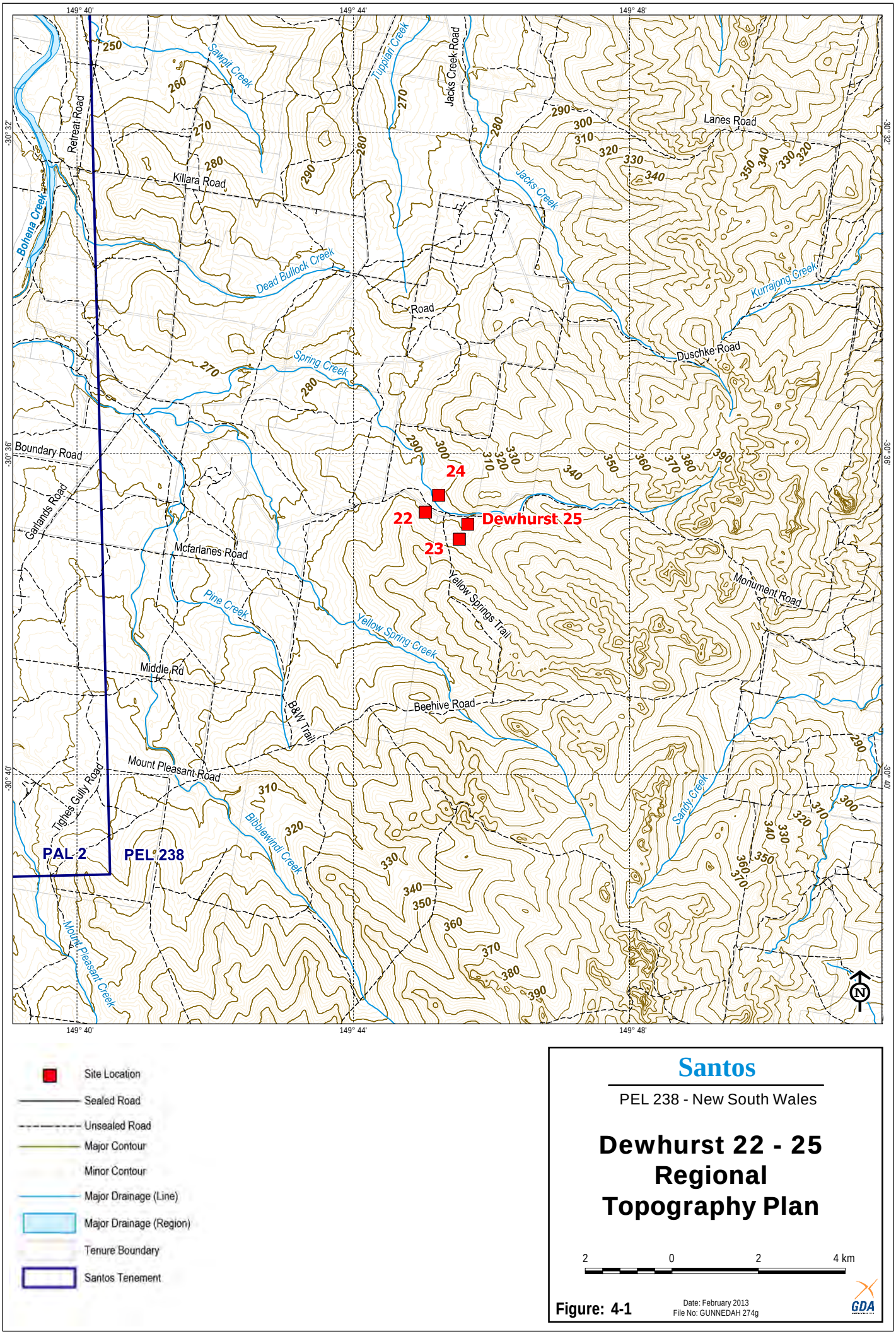
The proposed site is relatively flat. Individual topographic characteristics of each lease area are as follows:

- Dewhurst 22 lease area – generally slopes in a north east direction, with elevations ranging between approximately 298 and 301 metres (AHD).
- Dewhurst 23 lease area – generally slopes in a north east direction, with elevations ranging between approximately 303.5 and 306.5 metres (AHD).
- Dewhurst 24 lease area – predominantly slopes in a south west direction, however the south east corner of the lease area is also slightly raised so the lowest point occurs to the north west. Elevations range between approximately 294.5 and 298 metres (AHD).
- Dewhurst 25 lease area – generally slopes in a north west direction, with elevations ranging between approximately 300.7 and 302.7 metres (AHD).

Table 4-2 summarises average site crossfall and Figure 4-1, the topography.

Table 4-2 Site crossfall

	Average site crossfall
Dewhurst 22	1 in 50
Dewhurst 23	1 in 50
Dewhurst 24	1 in 40
Dewhurst 25	1 in 70


149° 40'
149° 44'
149° 48'
-30° 32'
-30° 36'
-30° 40'
Retreat Road
Killara Road
Bohena Creek
Sawpit Creek
Tuppiari Creek
Jacks Creek Road
Jacks Creek
Lanes Road
Dead Bullock Creek
Road
Spring Creek
Kurrajong Creek
Duschke Road
Boundary Road
Garlands Road
Mcfarlanes Road
Pine Creek
Yellow Springs Trail
Monument Road
Yellow Spring Creek
Middle Rd
B&W Trail
Beehive Road
Mount Pleasant Road
Tighes Gully Road
Bibblewindi Creek
Sandy Creek
Mount Pleasant Creek
PAL 2
PEL 238
24
22
Dewhurst 25
23
N
Site Location
Sealed Road
Unsealed Road
Major Contour
Minor Contour
Major Drainage (Line)
Major Drainage (Region)
Tenure Boundary
Santos Tenement
Santos
PEL 238 - New South Wales
Dewhurst 22 - 25
Regional
Topography Plan
2
0
2
4 km
Figure: 4-1
Date: February 2013
File No: GUNNEDAH 274g
GDA

4.1.3 Vegetation

Three vegetation communities occur within the study areas:

- Narrow-leaved Ironbark Woodland
- Heath
- Rough barked apple Riparian Woodland

4.1.3.1 Narrow-leaved Ironbark Shrubby Woodland

The primary vegetation community within the site, occurring within the Dewhurst 22 to 24 lease areas and along the associated access tracks is narrow-leave ironbark shrubby woodland. The community is generally in good condition, and is considered to be remnant. This community is commensurate with the Ironbark Shrubby Woodland of the Pilliga Area, Brigalow Belt South, however it does not constitute any threatened ecological community listed under either the *Threatened Species Conservation Act 1995* (TSC Act) or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The canopy (comprising 25 per cent coverage) is dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*) with Dirty Gum (*Eucalyptus chloroclada*) and White Cypress (*Callitris glaucophylla*) commonly occurring. A secondary canopy layer occurs (with 40 per cent coverage), and is dominated by White Cypress, with Dirty Gum and Bulloak (*Allocasuarina luehmannii*) commonly occurring. The understorey is comprised of two shrub layers. The primary shrub layer (comprising 40 per cent coverage) consists of predominantly Bulloak, Mudgee Wattle (*Acacia spectabilis*), *Allocasuarina diminuta*, and Carol's Wattle (*Acacia caroleae*). The secondary shrub layer (30 per cent coverage) includes a variety of native shrub species. Ground cover is sparse, with grasses, herbs and forbs totalling approximately 35 per cent. Grasses are sparse, with few species observed.

4.1.3.2 Heath

This vegetation community occurs within the Dewhurst 25 lease area and access track. While a small portion of this community along the Dewhurst 25 access track has been recently cleared, overall condition is considered good. This community is similar in composition to Ironbark – Brown Bloodwood – Black Cypress Pine heathy woodlands, however it does not constitute any threatened ecological community listed under either the TSC Act or the EPBC Act.

An emergent layer (less than 20 per cent coverage) is present, and is dominated by Dirty Gum. A sparse primary shrub layer occurs, dominated by Cough Bush (*Cassinia laevis*), with a cover of approximately 20 per cent. The secondary shrub layer of this community is comprised of dense heathland vegetation dominated by Common Fringe-myrtle (*Calytrix tetragona*), *Acacia* species and *Dodanea* species with approximately 70 per cent coverage. Ground cover is sparse, comprising approximately 30 per cent herbs and forbs.

4.1.3.3 Rough-barked Apple Riparian Woodland

This vegetation community occurs within the Dewhurst 24 lease area and access track, as well as along Monument Road. The community is generally in good condition, and is considered to be remnant. This community is commensurate with the Rough-barked Apple – Blakely's Red Gum Riparian Grassy Woodlands, Brigalow Belt South and Nandewar. While it can be commensurate with the EPBC Act listed White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands (Box-Gum Grassy Woodlands and Derived Grasslands), and the TSC Act White Box Yellow Box Blakely's Red Gum Woodland (Box-Gum Woodland), an assessment against the listing criteria determined that this community is not an EPBC Act or TSC Act listed community (refer to section 4.3.1).

The canopy (comprising 35 per cent coverage) is dominated by Rough Barked Apple (*Angophora floribunda*) with occasional Dirty Gum, Brown Bloodwood (*Acacia trachyphloia*) and Blakely's Red Gum (*E. blakelyi*) occurring. A sparse secondary canopy occurs, dominated by White Cypress, with a cover of approximately 10 per cent. The primary shrub layer ranges in cover from 30 to 50 per cent, while a low, sparse secondary shrub layer also occurs, with cover averaging 10 per cent. The ground cover comprised approximately 15 per cent herbs and forbs, and five per cent native grasses. Grasses observed include *Aristida calycina*, *Erargrostis* sp, and Kangaroo Grass (*themeda triandra*).

4.1.4 Soils

An Agricultural Impact Statement (AIS) (Appendix 6) for the proposal included investigations into soil landscapes, soil fertility, and soil limitations.

The soils across the region vary depending on the local sediment source. Duplex soils comprising fine, sandy loam topsoil overlaying harsh, clay subsoils are present in the region. These soils are typical of those derived from the Pilliga Sandstone and are described as highly siliceous (Norris, 1996).

The soil landscapes underlying the site and surrounds is designated as Cubbo Uplands, Coghill Alluvial Plains and Bugaldie Uplands according to the NSW (Mitchell) Landscapes (DECC 2002).

The Cubbo Uplands soil landscape is characterised by:

- thin discontinuous soils with stony, sandy profiles and low nutrients on sandstone ridge tops
- texture-contrast soils with harsh clay subsoils down slope
- deep sands with yellow earthy profiles, harsh grey clays, or more texture-contrast soils with a greater concentration of soluble salts in the valley floors.

The Coghill Alluvial Plains soil landscape is characterised by:

- long gentle slopes broken by sandy abandoned stream channels, patches of heavy grey clay and contemporary incised stream channels
- deep texture-contrast soils with harsh clay subsoils, grey clay with gilgai.

The Bugaldie Uplands soil landscape is characterised by:

- thin discontinuous soils with stony, sandy profiles and low nutrients on ridge tops
- texture-contrast soils with harsh clay subsoils down slope
- deep uniform or gradational yellow-brown sands on the valley floors.

According to the *Draft Inherent Soil Fertility mapping of the New England – North West region* (OEH 2012), the inherent soil fertility of the overall site and its surrounds is moderately low to low.

Soil characteristics of the property indicate that the study area is considered to have moderate to severe limitations, as the features listed in Table 4-3 limit agricultural productions.

Table 4-3 Soil limitations of the Dewhurst 22 – 25 site

Soil Landscape	Salinity	PAWC*	Stoniness	Soil Depth	Nutrients	Sodicity
Coghill Alluvial Plains	-	✓	✓	✓	✓	✓
Cubbo Uplands	✓	✓	✓	✓	✓	-
Bugaldie Uplands	-	✓	✓	✓	✓	✓

*PAWC – Plant available water capacity

A search of the contaminated land record database maintained by the OEH indicated records of seven contaminated sites within the Narrabri Shire LGA. None of these sites are located near the proposed activity. The site is undeveloped and within the Pilliga East State Forest. As such, it is highly unlikely that there will be any previous uses of the land that will have resulted in contamination.

4.1.5 Geology

PEL 238 is located in the central portion of the Gunnedah Basin where Jurassic and Cretaceous Surat Basin sediments unconformably overlie Permo Triassic Gunnedah Basin sediments. The Gunnedah Basin, covers an area of more than 15,000 square kilometres and is defined in structural terms as being bounded to the east by the Hunter-Mooki Thrust Fault System and the New England Fold Belt, and to the west by the Lachlan Fold Belt onto which the Gunnedah Basin sediments gradually onlap.

Metavolcanics, meta-sediments and minor ignimbritic volcanics of the Lachlan Fold Belt form much of the basement under the western part of the Gunnedah Basin and the Rocky Glen Ridge. Widespread Late Carboniferous and Early Permian mafic lavas were succeeded by paralic-lacustrine environments with sediments of the Leard and Goonbri Formations deposited. This was followed by low energy fluvial conditions in which the coal measures of the Maules Creek Formation were deposited.

An Early Permian transgression then inundated the area and deposited shallow marine para-conglomerate, sandstone and siltstone of the Porcupine and lower Watermark Formations and culminating in the deposition of the upper Watermark Formation marine claystone.

The Black Jack Group was deposited in a major delta system with a dominantly northeast sediment source from the New England region. A minor westerly provenance associated with the emergence of the Lachlan Fold Belt is also apparent. The New England provenance of the lower Black Jack Group resulted in generally quartz lithic and arkosic sandstones with limited reservoir potential. The sandstones were deposited in a lower delta plain/marginal marine environment.

Deposition of the lower Black Jack Group sediments was followed by an episode when marine conditions affected the Gunnedah Basin, with the deposition of sandstones of poor to fair reservoir quality. Deposition of the western derived quartzose sandstones was followed by very widespread coal swamp conditions depositing the thick Hoskissons Coal seam that is readily correlated across the Basin. The thickness of the Hoskissons Coal ranges from less than one metre in the west to more than 12 metres in the north and to 18 metres in the south-east.

Late Permian volcanic activity and tectonism to the east resulted in renewed deposition of more lithic sediments with an easterly provenance and consequently the upper Black Jack Group has only limited potential for reservoir development. A period of tectonism, uplift and erosion of variable intensity throughout the Basin followed Late Permian deposition. The end of the Permian is marked by a major regional unconformity.

A basal conglomerate that has been derived from the New England Fold Belt marks the Digby Formation. This unit thickens towards the east and onlaps onto the older sediments and basement to the west. Reservoir quality is generally poor due to a tight sandstone matrix. Thick near-shore marine shales of the overlying Napperby Formation are considered a potential seal to any hydrocarbons reservoir in the Digby Formation.

Unconformably overlying the Napperby, the Jurassic age Purlawaugh Formation is fluvial dominated, generally consisting of thinly interbedded carbonaceous claystone, siltstone and thin coal seams. There can be abundant carbonaceous fragments with thin beds of flint and clay. Within the Purlawaugh Formation there is development of intra-formational aquitards deposited in meandering river/lacustrine system.

The Pilliga Formation conformably overlies the Purlawaugh Formation. The Pilliga Formation is described as medium to very coarse grained, well sorted, angular to subangular quartzose fluvial sandstone. Minor interbedded mudstone, siltstone and fine grained sandstone and coal. The Pilliga Formation is the major aquifer in the northern Gunnedah Basin.

The stratigraphy of the Surat and Gunnedah Basin is shown in Figure 4-2.

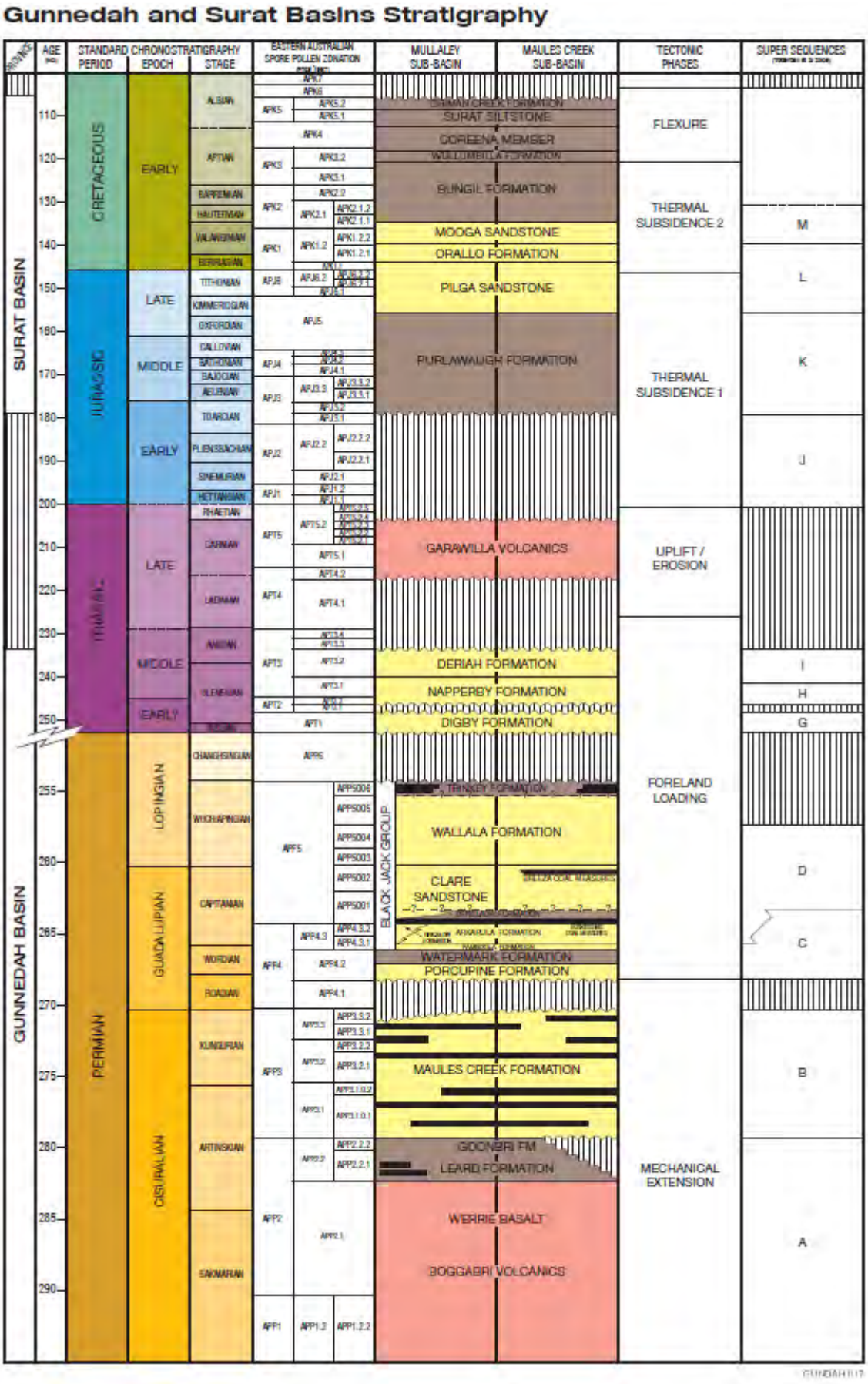


Figure 4-2 Stratigraphy of the Gunnedah Basin

4.1.6 Land use

The site is located within the Pilliga East State Forest, which is Crown Land managed by Forestry NSW. The State Forest covers an area of approximately 160,000 hectares, and provides publicly accessible roads and tracks which are used for recreational activities such as bushwalking and bird watching.

The nearest sensitive receivers to the site is a group of two residential dwellings and associated infrastructure just over three kilometres to the north north-west of Dewhurst 24 lease area. The next nearest dwelling is located approximately four kilometres to the north of this lease area.

The *New England North West Strategic Regional Land Use Plan* (DoP&I 2012) identifies the site and surrounding land as having high CSG resources and underground coal exploration potential. Both CSG and coal mining are growing industries in the region with numerous existing CSG wells, and a number of existing mines located within 100 kilometres of the site. PEL 238 is overlaid with mining titles, and the site itself is located within coal authorisation 216 (AUTH 216) held by DTIRIS on behalf of the Crown. Refer to Figure 4-3.

The dominant land use in the Namoi catchment is sheep and cattle grazing which accounts for 61 per cent of land use by area. Wheat, cotton and other broad acre crops are grown along the alluvial floodplains. Approximately 1,120 square kilometres of the Lower Namoi Catchment was irrigated in the year 2000. Of this, around 800 square kilometres was used for cotton production (CSIRO, 2007).

The site is not located within land mapped as biophysical strategic agricultural land (SAL) under the SRLUP. Based on the broad-scale mapping provided in the SRLUP, the nearest biophysical SAL is located approximately eight kilometres south east of the site. Refer to Figure 4-4. Given the location of the activity within the Pilliga East State Forest, the impact on agricultural land is negligible.

The site has been mapped as having Class 4 and 5 land and soil capability (LSC) (OEH 2012). Class 4 and 5 lands are characterised as being associated with moderate to severe limitation, and severe limitation, respectively. These lands are generally not capable of sustaining high impact land uses (e.g. cropping) unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Lower impact land uses (e.g. grazing) can be managed by readily available practices.

The site is not located within an Environmentally Sensitive Area of State Significance, as defined under State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (Mining SEPP)(Table 4-4).

Table 4-4 Environmentally sensitive areas

Is the proposed activity located on or within any of the following:	Yes/No
Coastal waters of the State	No
Lands protected under SEPP 14 – Coastal Wetlands?	No
Lands protected under SEPP 26 – Littoral Rainforests?	No
Aquatic reserves dedicated under the *Fisheries Management Act 1994* or a marine park under the *Marine Parks Act 1997*?	No
Wetland areas dedicated under the Ramsar Wetlands Convention?	No
A World Heritage Area declared under the World Heritage Convention?	No
Land identified in an environmental planning instrument as being of high Aboriginal cultural significance?	No
An area reserved or dedicated under the *National Parks and Wildlife Act 1974*?	No
Land, places, buildings or structures listed on the State Heritage Register?	No
Is the proposed activity located within land reserved or dedicated within the meaning of the *Crown Lands Act 1989* for preservation of flora, fauna, geological formations or for other environmental protection purposes?	No
Land identified as being critical habitat under the *Threatened Species Conservation Act 1995* or Part 7A of the *Fisheries Management Act 1994*?	No

4.1.7 Availability of services

Monument Road is an unsealed vehicle track which leads east from the Newell Highway, approximately 20 kilometres from the site. It provides an east west connection through the Pilliga Forest. It is predominantly used by Santos and Forestry NSW staff and some local land owners.

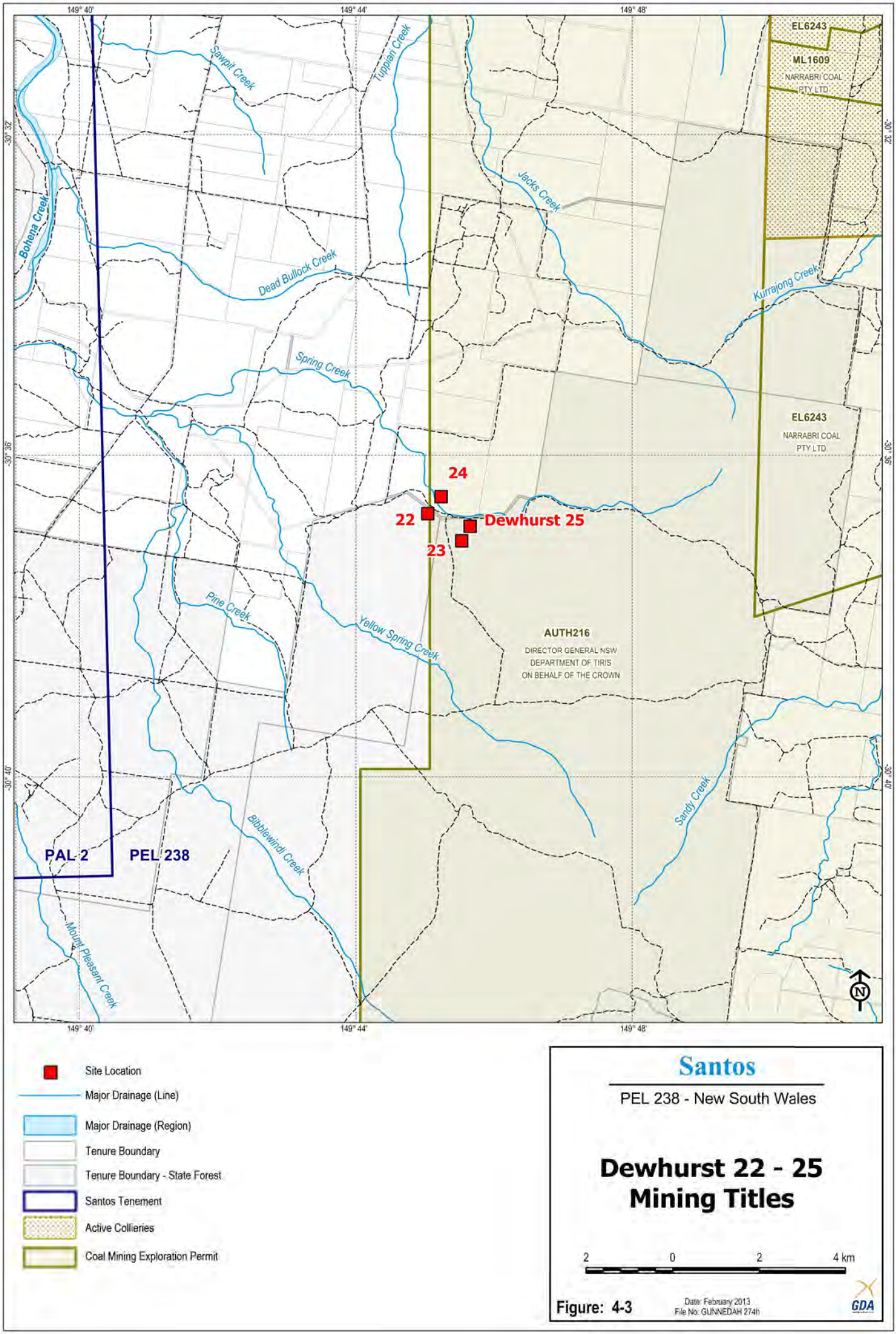
Yellow Springs Trail is a local forest track, also unsealed, and provides a north south link between Monument Road and an unnamed forest track to the south.

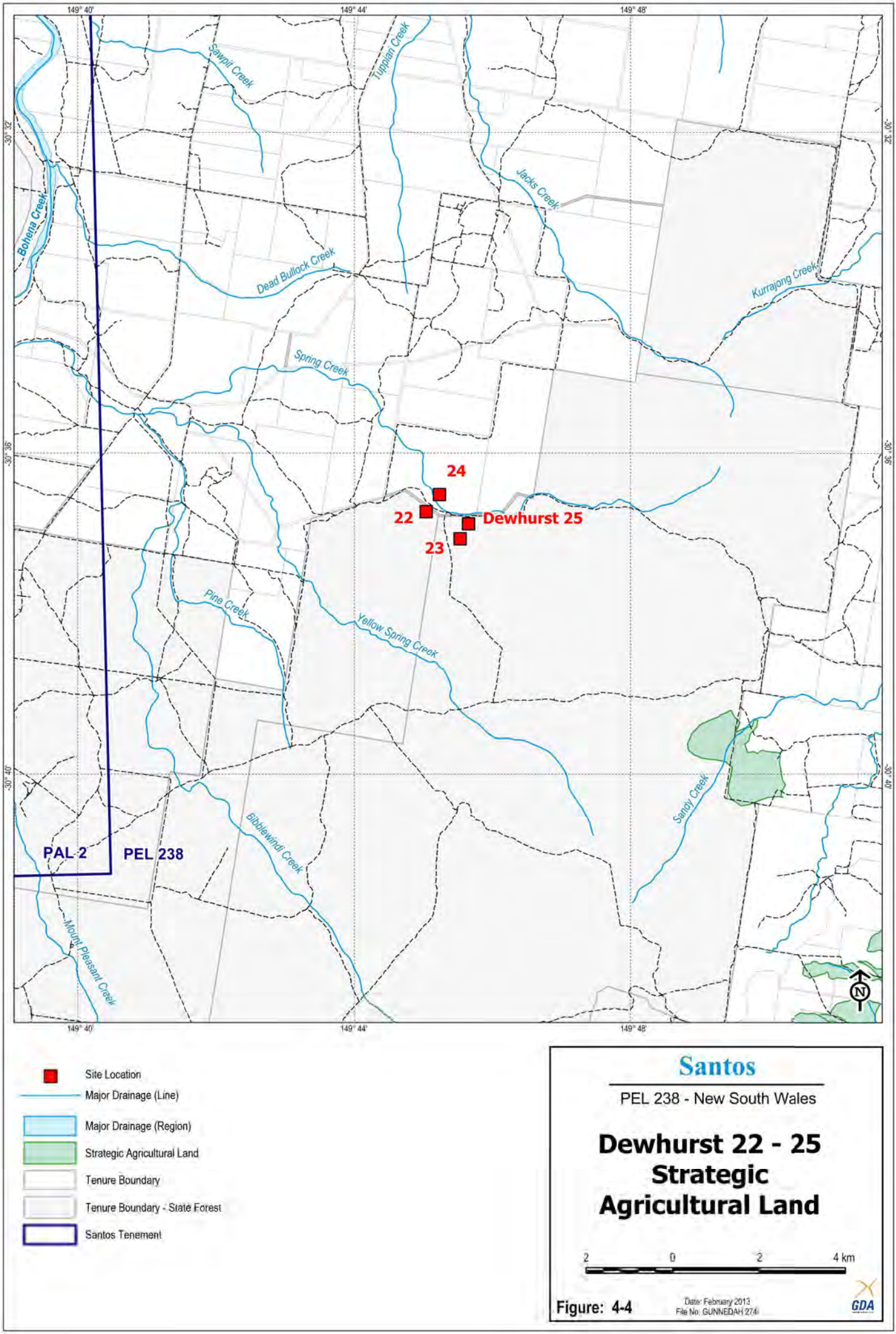
The Newell Highway, national route 39, is a two-way two lane highway stretching from the Victorian to the Queensland border. Locally the highway links Narrabri and Coonabarabran.

Six licensed groundwater bores are located within five kilometres of the proposed lease area (NSW Government 2012). The registered bores are all located at least 2.5 kilometres north of the Dewhurst 24 lease area, with details as follows:

- GW059958 (maximum depth 66.0 metres) – authorised purpose is domestic/stock (water bearing zone is located within Pilliga sandstone at depth 52.0 to 65.0 metres).
- GW038774 (maximum depth 76.2 metres) – authorised purpose is domestic/stock (located within the Southern Recharge groundwater source of the Great Artesian Basin).
- GW003587 (maximum depth 72.5 metres) – intended purpose is domestic/stock (water bearing zone is located within Pilliga sandstone at depth 69.1 to 69.8 metres).
- GW969324 (maximum depth 71.0 metres) – authorised purpose is domestic/stock (located within the Southern Recharge groundwater source of the Great Artesian Basin).
- GW055085 (maximum depth 65.0 metres) – intended purpose is domestic/stock (water bearing zone is located within Pilliga sandstone at depth 55.5 to 65.0 metres).
- GW002169 (maximum depth 54.8 metres) – intended purpose is domestic/stock (water bearing zone is located within sandstone at depth 53.3 to 54.9 metres).

It is not planned to extract any water from these bores for drilling or construction purposes.No known telecommunication, power, water or other services occur at the site or within the Monument Road road reserve.


149° 40'
149° 44'
149° 48'
-30° 32'
-30° 36'
-30° 40'
EL6243
ML1609
NARRABRI COAL PTY LTD
Sawpit Creek
Tupplari Creek
Bohena Creek
Jacks Creek
Dead Bullock Creek
Kurrajong Creek
Spring Creek
EL6243
NARRABRI COAL PTY LTD
24
22
Dewhurst 25
23
Pine Creek
Yellow Spring Creek
AUTH216
DIRECTOR GENERAL NSW
DEPARTMENT OF TIRIS
ON BEHALF OF THE CROWN
Sandy Creek
Bibblewindi Creek
PAL 2
PEL 238
Mount Pleasant Creek
N
Site Location
Major Drainage (Line)
Major Drainage (Region)
Tenure Boundary
Tenure Boundary - State Forest
Santos Tenement
Active Collieries
Coal Mining Exploration Permit
Santos
PEL 238 - New South Wales
Dewhurst 22 - 25
Mining Titles
2
0
2
4 km
Figure: 4-3
Date: February 2013
File No: GUNNEDAH 274h
GDA


149° 40'
149° 44'
149° 48'
-30° 32'
-30° 36'
-30° 40'
Sawpit Creek
Tupplan Creek
Jacks Creek
Bohena Creek
Dead Bullock Creek
Kurrajong Creek
Spring Creek
24
22
Dewhurst 25
23
Pine Creek
Yellow Spring Creek
Sandy Creek
Bibblewindi Creek
PAL 2
PEL 238
Mount Pleasant Creek
N
Site Location
Major Drainage (Line)
Major Drainage (Region)
Strategic Agricultural Land
Tenure Boundary
Tenure Boundary - State Forest
Santos Tenement
Santos
PEL 238 - New South Wales
Dewhurst 22 - 25
Strategic
Agricultural Land
2
0
2
4 km
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Date: February 2013
File No: GUNNEDAH 274
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4.1.8 Air and noise

As discussed at section 4.1.6, there are few sensitive air and noise receptors surrounding the site. The closest is a group of two residential dwellings and associated infrastructure just over three kilometres to the north north-west of Dewhurst 24 lease area. The next nearest dwelling is located approximately four kilometres to the north of this lease area.

Regional air quality is likely influenced by mining activities, grazing, land clearing and soil preparation, sowing and harvesting of crops, vehicle and heavy machinery movements, bushfires, burn-offs and use of combustion heaters. There are no OEH air quality monitoring stations within the local vicinity of the site; however, the primary air pollutants of concern within the Narrabri region are likely to be dust (particulate matter PM_{10}) caused by mining operations, transport of coal and farming activities such as ploughing, and fine particulates ($PM_{2.5}$) from vehicle emissions.

Birds, animals and insects, wind in trees, rural activities and occasional vehicles travelling along Monument Road influence background noise levels at the site.

Baseline noise monitoring has been conducted at the site by Noise Measurement Services as part of the noise assessment for the REF (Appendix 5). The assessment concluded that, in the absence of insects and winds the background noise levels recorded are below 30 dBA. This level is the minimum Rating Background Level (RBL) considered in NSW under the NSW Industrial Noise Policy (INP) (EPA, 2000). A RBL of 30 dB(A) is typical of rural areas and has been assumed for the purposes of noise assessment.

4.2 Surface and groundwater sources

4.2.1 Surface water catchment

The site is located within the Namoi River catchment which covers an area of approximately 42,000 km^2 stretching from Woolbrook in the east to Walgett in the west. The catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south and the Nandewar Ranges and Mount Kaputar to the north. Major tributaries of the Namoi River include Coxs Creek and the Mooki, Peel, Cockburn, Manilla and Macdonald rivers, all of which join the Namoi River upstream of Boggabri with Pian, Narrabri, Baradine and Bohena Creeks joining below Boggabri (NCMA, 2012).

Given the dominant use of the land in the Namoi catchment being for grazing and both dryland and irrigated cropping (refer Section 4.1.6) surface water quality within the catchment is likely to be influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2012).

The subject site is located within the Bohena sub-catchment of the Namoi River catchment. The Bohena sub-catchment covers an area of approximately 830 square kilometres south of Narrabri and is the northern extension of the Borah sub-catchment. The Bohena sub-catchment is drained by Bohena, Cowallah and Bibblewindi creeks (NCMA, 2012).

The issues within the sub-catchment include soil erosion, biodiversity conservation, water quality and riparian management.

Bohena Creek and its tributaries are ephemeral, generally flowing for short periods following significant rainfall or prolonged wet periods. Baseflow in these creeks are insignificant. Bohena Creek remains dry for extended periods between runoff events, sometimes for periods in excess of 12 months. It contributes little inflow to the Namoi under normal conditions; however during protracted wet conditions, significant flood inflows to the Namoi can be generated.

The Namoi Water Quality Project 2002-2007 (Mawhinney 2011) incorporated a surface water monitoring station on Bohena Creek at the Newell Highway, downstream of the confluence with Bibblewindi Creek (station number 419905). The frequency of sampling throughout the program's five year life was once a month, however over the course of the five year monitoring period, a total of only five samples were collected at this site, always following heavy rainfall in the catchment area. This reflects the ephemeral nature of the water courses in this area. Details of the water quality measured at this sampling location on Bohena Creek are provided in Table 4-5.

Table 4-5 Water quality measured on Bohena Creek (station number 419905) from 2002 - 2007

Parameter	Minimum	Maximum	Median
EC (µS/cm)	148	327	185
Turbidity (NTU)	17	130	76
Total Phosphorus (mg/L)	0.061	0.107	0.073
Total Nitrogen (mg/L)	0.32	0.91	0.62

4.2.2 Site drainage and local surface waters

Figure 4-5 shows the drainage in the vicinity of the site. The closest watercourses to each lease area are as follows:

- Dewhurst 22 lease area – an unnamed ephemeral tributary of Spring Creek is located within the lease area (drainage line was not discernible on-ground during the site inspection); Spring Creek is located approximately 210 metres to the north east.
- Dewhurst 23 lease area – an unnamed ephemeral tributary of Spring Creek is located approximately 50 metres to the north east.
- Dewhurst 24 lease area – Spring Creek is located approximately 75 metres to the south west. In addition the access track crosses over the creek itself (refer to Plate 4-1)
- Dewhurst 25 lease area – an unnamed ephemeral tributary of Spring Creek is located approximately 80 metres to the west.

In addition, Spring Creek runs adjacent along the northern side of Monument Road along a section where the proposed gathering system is located. The gathering system will be located on the southern side of Monument Road, away from Spring Creek; however it will cross over two unnamed tributaries of it.

Spring Creek is a tributary of Bibblewindi Creek, which flows into Bohena Creek. According to Eco Logical (2009), both Bibblewindi and Bohena Creek are considered to be third/fourth order streams (using the Strahler stream classification system) which exhibit generally good landscape condition.

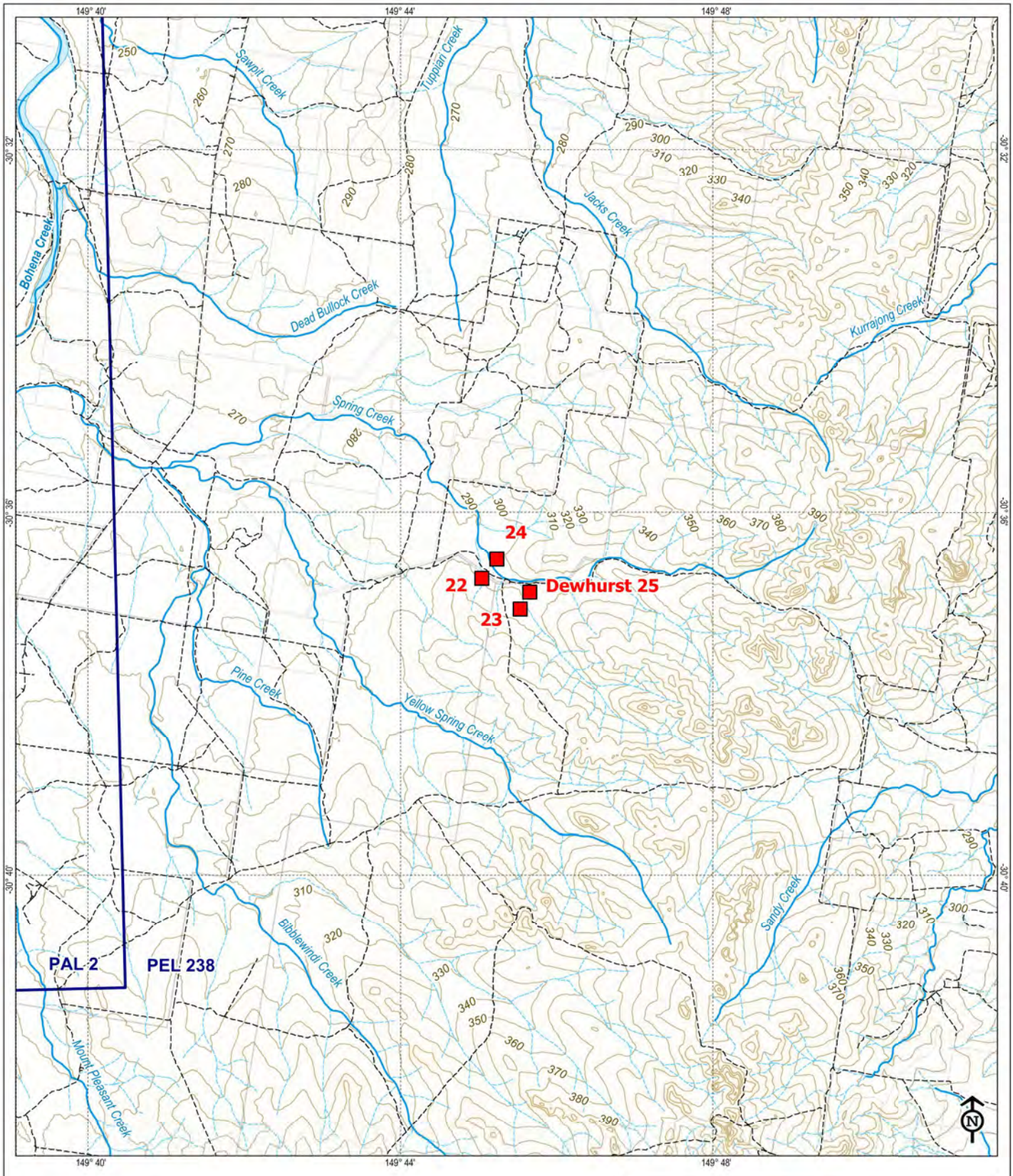
The location of the proposed activity is within the Pilliga Outwash landscape unit as described in Lampert and Short (2004). An aggradational landscape of low lying, undulating alluvial sediments, the outwash is traversed by a number of south to northwest trending drainage lines, many being abandoned paleochannels. Most sediment within the water courses of this landscape is derived from upstream Pilliga Sandstone plateaus or as a result of reworking of the broad outwash plain.

According to Lampert and Short (2004), both Bibblewindi and Bohena Creeks, are representative of the 'low sinuosity, sand' river style. This river style does not retain surface water between flows. The channel will go through phases of incision, expansion and lateral migration and then recover through bench formation. Overbank flows, which occur every one to two years, activate flood channels, dissipating flow energy onto the floodplains.

Spring Creek is a relatively undisturbed second order water course (as defined under the Water Management Act 2000, using the Strahler System). During the site inspection, in November 2012, no water was observed to be flowing or pooled within the creek channel. The channel bed was covered with a thin layer of leaf litter, providing evidence that creek does not flow often, is highly ephemeral and does not provide suitable habitat for fish or other aquatic organisms. Significant channel erosion was sighted approximately 20 metres downstream from the proposed crossing, giving evidence that soils within the channel are highly erodible.



Plate 4-1 Spring Creek



Site Location

Major contour

Minor Contour

Major Drainage (Line)

Minor Drainage

Major Drainage (Region)

Santos Tenement

Santos

PEL 238 - New South Wales

Dewhurst 22 - 25 Regional Drainage Plan

2 0 2 4 km

Figure: 4-5

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4.2.3 Groundwater sources

Groundwater in the Namoi River catchment supports the irrigation industry and also provides the water supply for many towns and intensive industries. There are a total of 700 groundwater license holders in the Namoi River catchment (NOW, 2011). The Upper Namoi and Lower Namoi Alluvium form the principal aquifers of the Namoi River Catchment and are heavily used for irrigation (Schlumberger Water Services, 2012). The Namoi catchment is licensed to provide over 343,000 mega litres of groundwater entitlement per year.

According to the relevant water sharing plans for the region, the site does not sit within any mapped Upper Namoi and Lower Namoi Alluvium. However, according to AGE (2006) there are alluvial aquifers associated within Bohena and Bibblewindi Creeks, with minor thin veneers of alluvium in some tributary creeks. The alluvium of Bohena Creek and major tributaries consist of clean, medium to coarse quartz sands which are up to about six metres thick. The alluvial sands form elongated deposits confined to the creek alignment and have an estimated average width of about 60 metres along Bohena Creek.

The water table in the alluvium of Bohena Creek varies from surface level following periods of creek flow, to an estimated two metres below surface level during dryer periods (AGE 2006). It is considered that groundwater in the alluvium is perched on the finer grained sedimentary deposits of the Blythesdale Group, as the water level in the deeper Pilliga Sandstone aquifer is 20 to 30 metres below ground level in the area.

Recharge of the alluvium occurs primarily from infiltration of surface water during creek flow events and to a lesser degree by direct infiltration of rainfall on the sand deposits. Groundwater flow is to the north along the creek channel, with discharge eventually to the Namoi River and/or the major alluvial aquifers associated with the river.

The main aquifers surrounding the site are associated with underlying basement rock units, and include the following:

- Southern Recharge groundwater source, under the Water Sharing Plan for the NSW Great Artesian Basin Groundwater Sources.
- Gunnedah-Oxley Basin MDB buried groundwater source, under the Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources
- Lachlan Fold Belt MDB buried groundwater source, under the Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources

The Great Artesian Basin (GAB) also underlies the site. The GAB covers 1.7 million square kilometres and contains 8,700 million mega litres of artesian water. It consists of sedimentary sequences with layers of porous and permeable sandstones which alternate with low permeability shales, siltstones and mudstones. Aquifers of the GAB are unsuitable for irrigation use due to high levels of sodium; however, water from these aquifers is generally suitable for domestic and town water supply (GABCC, 1998).

Groundwater recharge takes place chiefly along the south and eastern fringe of the GAB. Groundwater enters the main Pilliga Sandstone aquifer directly through exposed outcrop, or at lesser rates, via overlying strata where there is potential for downward groundwater movement (DWE 2009). The Pilliga Sandstone outcrops in the vicinity of the site, and underlies the area at a relatively shallow depth (20 to 30 metres). The Southern Recharge groundwater source, in which the site lies, is characterised by better quality groundwater than other zones of the GAB.

The Gunnedah-Oxley Basin MDB Groundwater Source covers a subcrop area of 2,860,000 hectares. It is the Permian and Triassic rocks associated with the Gunnedah Basin, and the overlying younger Jurassic and Cretaceous rocks associated with the Oxley Basin. The Gunnedah-Oxley Basin extends from the Mount

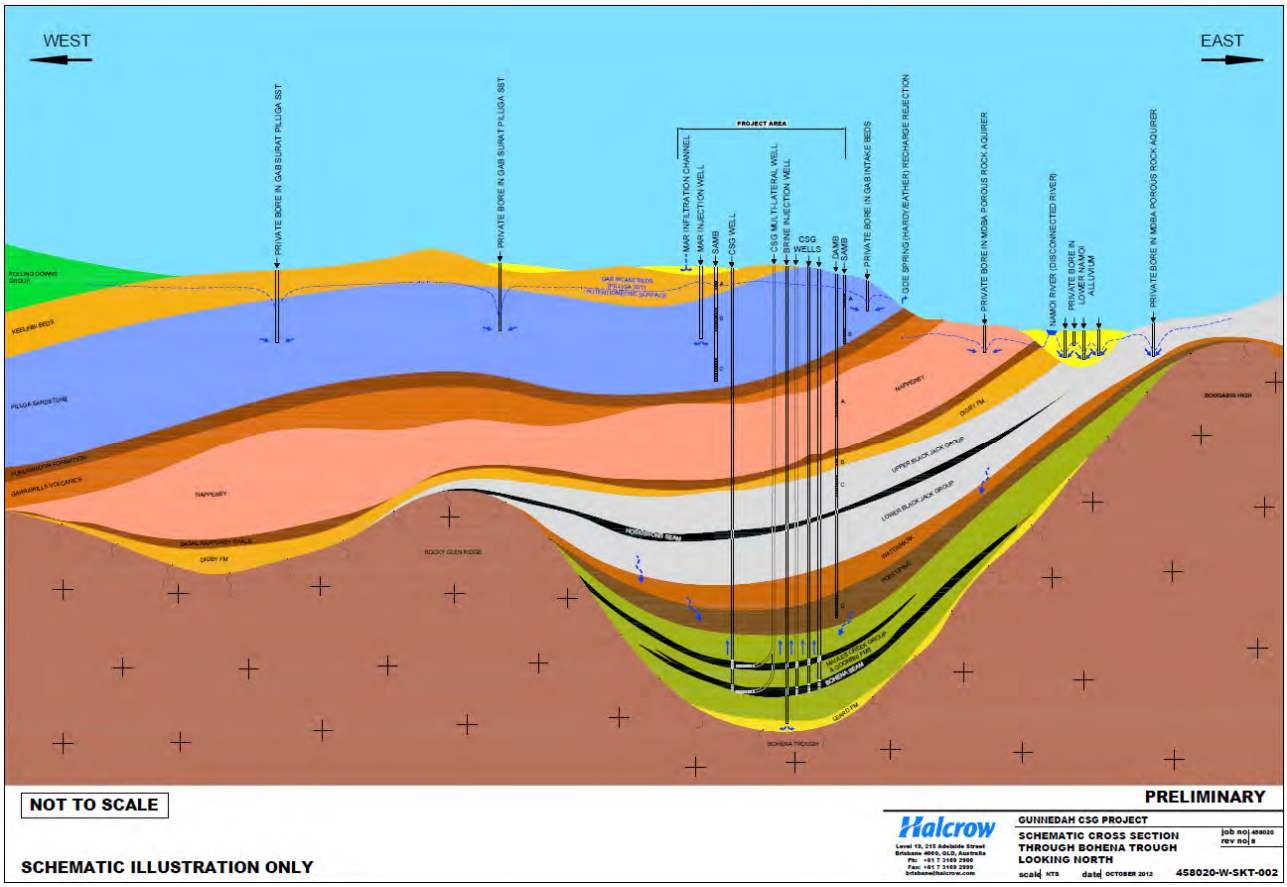
Coricudgy Anticline (separating it from the Sydney Basin), the Hunter-Mooki Thrust to the east (forming the eastern boundary between the Gunnedah-Oxley Basin and the New England Fold Belt), the Lachlan Fold Belt to the west and a structural high to the north of Narrabri (NOW 2012a).

The consolidated formations (e.g. hard rock aquifers) of the Gunnedah Basin comprise interbedded coals, sandstone and siltstones and are not considered major groundwater sources. These formations may be categorised into the following hydrogeological units (AGE 2006):

- Hydrogeologically 'tight' and hence very low yielding to essentially dry sandstone and lesser siltstone and shale that comprise the majority of the strata; or
- Low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

The primary target CSG bearing formations for this proposed development are the lower Permian coals between the upper Maules Creek formation and lower Maules Creek formation as shown in Figure 4-6.

The Lachlan Fold Belt MDB Groundwater Source covers an area of 16,722,000 hectares. It consists of Cambrian to Lower Carboniferous rock successions, located deeper than the targeted CSG bearing formations. The eastern margin is truncated by the present coastline in the south and is overlapped by the Permo-Triassic succession of the Sydney Basin and its northern equivalents; the northern margin is overlaid by the Mesozoic Great Artesian Basin succession; the southern margin is truncated by the present Tasmanian coastline, and is overlaid by Permian and younger successions. The western margin is largely covered by the mainly Cainozoic Murray Basin successions (NOW 2012b).



Source: Dewhurst 22-25 Technical Pilot, Halcrow (2012)

Figure 4-6 Schematic cross section through the Bohena trough (not to scale)

Groundwater will be produced during operation of the pilot wells as discussed in section 6.1.3. Water produced (approximately 96 ML/yr) will be captured at each well head and transferred via the water gathering system to a balance tank at Dewhurst 22. The saline water will then be transferred to an appropriate treatment facility (subject to a separate REF) to be treated for beneficial re-use and/or disposal through the northern flow line (subject to a separate REF). In the event that the northern flow line is not yet operation, the saline water will be trucked to the treatment facility.

4.2.4 Water sharing plans

The following Water Sharing Plans (WSPs) apply to water sources within the site and surrounds:

- WSP for the Namoi Unregulated and Alluvial Water Sources 2012
- WSP for the NSW Great Artesian Basin Groundwater Sources 2008
- WSP for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011
- WSP for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011.

4.2.5 Drinking water catchment

The site is not located within a drinking water catchment however surface water would filter to groundwater which may be used for drinking water in the surrounding areas. The project will be managed to ensure that there are no impacts on groundwater used for drinking water. These mitigation measures are detailed at sections 6.1.2 and 6.1.3.

4.2.6 Management controls to mitigate impacts to water sources

During operation, the proposed activity is expected to extract approximately 96 mega litres of groundwater per year from the Gunnedah-Oxley Basin MDB groundwater source under the NSW MDB Porous Rock Groundwater Source WSP. The share component of water access licences within the Gunnedah-Oxley Basin MDB groundwater source is 16,197 unit shares. One unit share is equal to one mega litre of water or lower amount as a result of growth in extraction response. Santos currently holds a 20 unit share aquifer access licence entitlement for this groundwater source and will seek further entitlement to cover the expected extraction volume prior to operating the pilots.

The management controls that would be implemented to avoid, minimise or mitigate impacts to water sources; and monitor impacts are outlined in section 2.8.

4.3 Threatened species, populations and ecological communities

An Ecological Assessment of the proposed activity was prepared by RPS and is attached at Appendix 7. The Ecological Assessment included:

- database searches, including the EPBC Act Protected Matters Search Tool and Atlas of NSW Wildlife, for threatened species, populations and ecological communities within 10 kilometres of the site
- review of aerial photography and National Vegetation Information Systems mapping within the vicinity of the site
- a preliminary ecological field survey on 19 September 2012
- a detailed ecological assessment between 8 October and 12 October, including detailed flora and fauna surveys
- an additional flora survey was conducted on 24 January 2013.

The assessment described the site habitat as characterised by woodland and heath communities that provide distinctly unique resources and niches for native fauna. Both habitat types are generally in good condition with disturbances limited to logging for forestry, clearing of roads and minor impacts associated with introduced fauna and weeds.

The findings of the assessment are outlined below.

4.3.1 Ecological Communities

Seven Threatened Ecological Communities (TEC) listed under the EPBC Act were identified as potentially occurring within the locality of the study area as part of the EPBC Protected Matters Search Tool, including:

- Brigalow (*Acacia harpophylla* dominant and co-dominant)
- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions
- Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia
- Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland
- Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions
- Weeping Myall Woodlands
- White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands.

As outlined in Section 4.1.3, the Rough-barked Apple Riparian Woodland can be commensurate with the White Box – Yellow Box – Blakely's Red Gum Grassy Woodland TEC. However, as Blakely's Red Gum does not dominate or co-dominate this community, and a shrub layer with a cover of greater than 30 per cent occurs, it is not considered to be a TEC under the EPBC Act.

Nine Endangered Ecological Communities (EEC) listed under the TSC Act were identified as occurring within the study area, based on known or predicted communities occurring within the Namoi CMA (NSW Atlas of Wildlife Search). These include:

- Brigalow within the Brigalow Belt South, Nandewar, and Darling Riverine Plains Bioregions
- *Cadellia pentastylis* (Ooline) community in the Nandewar and Brigalow Belt South Bioregions
- Coolibah-Black Box Woodland of the Darling Riverine Plains and Brigalow Belt South bioregions
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Cobar, Peneplain, Nandewar and Brigalow Belt South Bioregions
- Inland Grey Box Woodland in the Riverina; NSW South Western Slopes; Cobar Peneplain; Nandewar and Brigalow Belt South Bioregions
- Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions
- Native Vegetation on Cracking Clay Soils of the Liverpool Plains
- Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandawar Bioregions
- White Box - Yellow Box - Blakely's Red Gum (Box – Gum) Woodland.

As outlined in Section 4.1.3, the Rough-barked Apple Riparian Woodland can be commensurate with the White Box - Yellow Box - Blakely's Red Gum (Box – Gum) Woodland EEC. However, given the presence of a dense shrub layer, and the low density of Red Gum in this community, this community is not considered to be an EEC under the TSC Act.

4.3.2 Flora

4.3.2.1 Threatened Species

Threatened species database searches indicated records for six threatened flora species listed under the EPBC Act and/or TSC Act. These species and their threat status are identified in Table 4-6. None of the threatened flora species were identified within the site or surrounds despite targeted searches being carried out during the ecological field survey. No regionally significant flora was identified within the site.

Table 4-6 Threatened flora species records within 10 km of site

Species	Listing[1]		Identified during field survey
	TSC Act	EPBC Act	
Coolabah bertya (*Bertya opponens)*	V	V	No
Philotheca ericifolia	-	V	No
Native Milkwort (*Polygala linariifolia)*	E	-	No
Rulingia procumbens	V	V	No
Cobar Greenhood Orchid *(Pterostylis cobarensis)*	V	V	No
Tylophora linearis	V	E	No

Table note: 1. E = endangered, V = vulnerable

4.3.2.2 Weeds

The EPBC Protected Matters Search Tool identified five weeds of national significance (WoNS) as potentially occurring in the study area, namely:

- African Boxthorn (*Lycium ferocissimum*)
- Radiata Pine (*Pinus radiata*)
- Blackberry (*Rubus fruticosus aggregate*)
- Willows (*Salix* spp.)
- Athel Pine (*Tamarix aphylla*).

No WoNS were observed within the study area during the ecological field surveys in Spetember and October 2012 and January 2013.

One listed noxious weed, Prickly Pear, was identified within the site. Prickly pears (includes all *Opuncta* species other than *O. ficus-indica*) are a Class 4 weed under the *Noxious Weeds Act 1993*. This means that the growth and spread of the weed must be controlled according to the measures specified in a management plan published by the local control authority, and the plant may not be sold, propagated or knowingly distributed.

4.3.3 Fauna

4.3.3.1 Threatened Species

Threatened species database searches and an assessment of likelihood of occurrence indicated that 26 threatened fauna species listed under the EPBC Act and/or TSC Act a were identified as known, likely or possibly occurring in the 10 kilometre buffer study area of the site based on habitat preference and known species distribution. These species are identified in Table 4-7.

Table 4-7 Threatened fauna species with potential to occur within 10 km of site based on presence of suitable habitat

Species	Listing[1]		Identified during field survey
	TSC Act	EPBC Act	
Regent Honeyeater (*Anthochaera Phrygia)*	CE	E	No
Glossy Black Cockatoo (*Calyptorhynchis lathami*)	V	-	No
Brown Treecreeper (*Climacteris picumnus victoriae*)	V	-	No
Varied Sittella (*Daphoenositta chrysoptera*)	V	-	No
Little Lorikeet (*Glossopsitta pusilla*)	V	-	No
Swift Parrot (*Lathamus discolor*)	E	E	No
Malleefowl (*Leipoa ocellate)*	E	V	No
Hooded Robin (*Melanodryas cucullata cucullata*)	V	-	Yes
Turquoise Parrot (*Neophema pulchella*)	V	-	Yes
Barking Owl (*Ninox connivens*)	V	-	No
Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)	V	-	Yes
Speckled Warbler (*Pyrrholaemus sagittatus*)	V	-	Yes
Diamond Firetail (*Stagonopleura guttata*)	V	-	No
Masked Owl (*Tyto novaehollandiae*)	V	-	No
Eastern Pygmy-possum (*Cercartetus nanus*)	V	-	No
Large-eared Pied Bat (*Chalinolobus dwyeri)*	V	V	No
Little Pied Bat (*Chalinolobus picatus*)	V	-	No
Spotted-tailed Quoll (*Dasyurus maculatus*)	V	E	No
Black-striped Wallaby (*Macropus dorsalis*)	E	-	No
South-eastern Long-eared Bat (*Nyctophilus corbeni)*	V	V	No
Koala (*Phascolarctos cinereus)*	V	V	No
Pilliga Mouse (*Pseudomys pilligaensis*)	V	V	Yes
Squirrel Glider (*Petaurus norfolcensis*)	V	-	No
Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*)	V	-	Yes
Pale-headed Snake (*Hoplocephalus botorquatus*)	V	-	No
Border Thick-tailed Gecko (*Uvidicolus sphyrurus)*	V	V	No

Table note: 1. CE = critically endangered, E = endangered, V = vulnerable, M = Migratory

One threatened species listed under both the EPBC Act and TSC Act, and a further five threatened species listed under the TSC Act were identified within the site or surrounds during the ecological field surveys in September and October 2012 and January 2013. These included:

- Grey-crowned Babbler (*Pomatostomus temporalis*) – TSC Act
- Turquoise Parrot (*Neophema pulchella*) – TSC Act
- Speckled Warbler (*Pyrrholaemus sagittatus*) – TSC Act
- Hooded Robin (*Melanodryas cucullata* – TSC Act
- Pilliga Mouse (*Pseudomys pilligaensis*) – EPBC and TSC Act
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) – TSC Act.

4.3.3.2 Migratory Species

The EPBC Protected Matters Search Tool indicated that 12 migratory species listed under the EPBC Act were identified as potentially occurring within a 10 kilometre radius of the site. An assessment of likelihood of occurrence was completed for each species, based on habitat preference and known species distribution (refer to Appendix 7). The assessment confirmed that three species are likely to occur on site:

- Rainbow Bee-eater (*Merops ornatus*)
- White-throated Needletail (*Hirundapus caudacutus)*
- Regent Honeyeater (*Xanthomyza phyrgia*).

No migratory species were observed during the ecological field survey.

4.3.3.3 Introduced Species

During the ecological field survey four feral animals were recorded in the study area, namely Goat (*Capra hircus*), Red Fox (*Vulpes vulpes*), Rabbit (*Oryctolagus cuniculus)* and Hare (*Lepus europaeus*). Signs of Pig (*Sus scrofa*) presence (e.g. diggings and rooting) were also recorded in surrounding areas. It is also considered likely that Cat (*Felis catus*) occur within the study area.

4.3.3.4 Habitat Values

The study area contains a diversity of habitats including heath, woodland and riparian ecosystems fulfilling habitat requirements for a range of species. These habitats consist of, and provide, various quality (condition) habitats and resources (e.g. foraging and breeding niches) for native flora and fauna, including:

- small, medium and large tree hollows
- flowering Eucalypts
- fallen / felled timber, including hollow-bearing logs
- ephemeral waterways including semi-permanent waterholes
- a ground layer comprising under-storey vegetation and coarse leaf litter
- dense shrub layer comprised of flowering heath species
- mistletoe within the canopy layer
- roost trees.

Two broad habitat types were identified in the study area, woodlands and heath. In addition to the floristic composition of these habitat types and the food resources which they may provide to native fauna species (e.g. fruiting and/or flowering trees, water), both of these broad habitat types may also contain elements which fulfil a range of requirements for various native fauna species. For example, elements such as fallen woody debris/ logs, hollow bearing trees, flowering plants and waterholes fulfil important foraging, sheltering and nesting requirements for amphibians, birds, reptiles and mammals.

Detailed descriptions of the specific habitat values and distribution of the woodlands and heath communities are provided in the Ecological Assessment (Appendix 7).

4.4 Aboriginal cultural heritage

The proposed activity will require the disturbance of up to approximately 6.29 hectares of land. As the site is located within the Pillaga Forest previous disturbances have been variable, as the area has been subjected to varying levels of forestry, fires, grazing and mining exploration.

A due diligence cultural heritage investigation of the site was carried out in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010* (DECCW 2012) (refer to Appendix 8). This investigation included a desktop review of the environmental and archaeological contexts of the site and surrounding area, a search of the Aboriginal Heritage Information Management Systems (AHIMS) database maintained by OEH, and an archaeological field survey on 18 and 19 September 2012, with a subsequent survey on 24 January 2013.

The AHIMS search results indicated that there are no previously recorded Aboriginal heritage sites or previously declared Aboriginal places within one kilometre of the site (refer to Appendix 8 for search results). A review of previous literature indicated a number of sites within the broader Narrabri region, but none were located in close proximity to the proposed activity.

No Aboriginal heritage sites, objects or culturally modified trees were identified during the archaeological field survey. There is potential for Aboriginal objects to have been located in the vicinity of the site, as it is within 200 metres of waters (Spring Creek). However, the surveyed section of the creek did not contain any evidence of Aboriginal objects or sites. In addition, past land uses such as grazing, land clearance and other agricultural and commercial pursuits may have damaged and/or destroyed any remnant evidence of any occupation. It is therefore reasonable to conclude, in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010*, that there are no known Aboriginal objects or a low probability of objects occurring at the site.

Aside from Spring Creek, no other sensitive landscape features, such as sand dune systems, ridge lines, cliff faces, caves or rock shelters, were identified during the field survey, which indicate the likely existence of Aboriginal objects within the vicinity of the site.

4.5 Native Title

As PEL 238 was granted prior to the commencement of the *Native Title Act 1993* (Cth), there is no further need to comply with the *Native Title Act* for the conduct of the proposed activity

4.6 Historic cultural and natural heritage

Database searches indicated that there are no items of National Heritage significance within or in near proximity to the site. No items listed NSW State Heritage Register (or of State significance) occur within the site and no European heritage items listed under the Narrabri Local Environmental Plan 2012 (Narrabri LEP) occur in, or near the site. Several European heritage items of local or state significance listed under the Narrabri LEP or Commonwealth Register of National Estate occur within the Narrabri LGA. However, these are not located in the vicinity of the proposed activity.

No relics or items of European cultural heritage value were recorded on the site during the archaeological field survey.

5.0 Regulatory context

5.1 Commonwealth legislation

5.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) provides for the protection of certain Matters of National Environmental Significance (MNES) listed under the EPBC Act, which include:

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

Under the EPBC Act, approval is required from the Australian Government Minister for Sustainability, Environment, Water, Population and Communities (Commonwealth Minister) for any action that will have or is likely to have a significant impact on a MNES, or on the environment of Commonwealth land or on the environment if the action is proposed to be taken by a Commonwealth agency (known as a 'controlled action').

A person proposing to take an action that may be a controlled action must refer the proposal to the Commonwealth Minister for determination as to whether the proposed action is a controlled action. A person proposing to take an action that the person thinks is not a controlled action may nevertheless refer the proposal to the Commonwealth Minister for the Commonwealth Minister's decision on whether or not the action is a controlled action. If the Commonwealth Minister determines that the proposed action is a controlled action, the action is subject to the assessment and approval processes under the EPBC Act. If the proposed action is not a controlled action, approval under the EPBC Act is not required and the action may be undertaken in accordance with the referral.

An EPBC Act Protected Matters Search Report was generated for a 10 kilometre radius surrounding the site to determine whether any MNES are likely to be affected the proposed activity. In addition, an Ecological Assessment was prepared to determine whether the proposed activity will be likely to impact on any nationally listed threatened species or ecological communities, or migratory species. The Ecological Assessment is contained in Appendix 7.

An assessment of the proposed activity against MNES is provided in section 6.7. The proposed activity will be unlikely to impact on any MNES, or the environment on Commonwealth land and is not proposed to be taken by a Commonwealth agency. One Commonwealth listed threatened species, the Pilliga Mouse (*Pseudomys pilligaensis)*, was recorded on site. An assessment of significance was undertaken for this species in accordance with the EPBC Act and *EPBC Act Policy Statement 1.1 - Significant Impact Guidelines Matters of National Environmental Significance* (DEWHA, 2009) which concluded that a significant impact is unlikely. However, Santos will lodge a referral to the Commonwealth Minister under the EPBC Act.

5.2 NSW legislation

5.2.1 Petroleum (Onshore) Act 1991

The *Petroleum (Onshore) Act 1991* (Petroleum Act) regulates the onshore exploration for and production of petroleum. Under the Petroleum Act, petroleum means:

(a) any naturally occurring hydrocarbon, whether in a gaseous, liquid or solid state, or

(b) any naturally occurring mixture of hydrocarbons, whether in a gaseous, liquid or solid state, or

(c) any naturally occurring mixture of one or more hydrocarbons, whether in a gaseous, liquid or solid state, and one or more of the following, that is to say, hydrogen sulphide, nitrogen, helium, carbon dioxide and water,

and includes any substance referred to in paragraph (a), (b) or (c) that has been returned to a natural reservoir, but does not include coal or oil shale or any substance prescribed to be a mineral for the purposes of the Mining Act 1992.

The holder of an exploration licence has the right to prospect for petroleum on the land comprised in the licence. The proposed activity will be undertaken within the area of PEL 238 granted under the Petroleum Act. Under PEL 238, the following categories of works can be undertaken:

Category 1

- development to which clauses 10(1) and 10(2) of the Mining SEPP apply.

Category 2

- development to which clause 10(2) of the Mining SEPP applies that is not on land to which clause 10(1) applies;
- construction of an access way such as a track or road;
- construction and use of boreholes; and
- seismic surveys.

Category 3

- construction and use of petroleum wells;
- prospecting operations and water management infrastructure required to be carried out in accordance with an approved Produced Water Management Plan;
- fracture stimulation;
- installation of gas gathering and pipeline infrastructure;
- any prospecting operation resulting in a cumulative surface disturbance exceeding a total of five hectares within the exploration license area; and
- any other prospecting operations not listed in Category 1 prospecting operations or Category 2 prospecting operations.

The proposed activity falls under Category 3. Under Condition 2 of PEL 238, the licence holder is required to obtain approval from the Minister prior to carrying out any Category 2 or Category 3 prospecting operations on the exploration licence area. The licence holder is required to comply with the conditions of any approval granted by the Minister. A Surface Disturbance Notice, REF and Agricultural Impact Statement are required for all Category 3 prospecting operations.

This REF is being submitted in accordance with Condition 2 of PEL 238.

5.2.2 Environmental Planning and Assessment Act 1979

5.2.2.1 Overview

Development in NSW is assessed and approved under either Part 4 or Part 5 of the EP&A Act. Development is assessed under Part 5 if:

- the relevant environmental planning instruments provide that the development does not require development consent;
- the development is not exempt development;
- the development is either carried out by a determining authority or requires the approval of a determining authority; and
- the development has not previously been approved under Part 4 of the EP&A Act.

The proposed activity falls within the Narrabri Shire LGA. The site is zoned as RU3 Forestry under the *Narrabri Local Environmental Plan 2012* (Narrabri LEP). The proposed activity is permissible without consent under the Narrabri LEP as the activity is authorised under the *Forestry Act 2012*.

The Mining SEPP aims 'to provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of [NSW]'. Clause 6 of the Mining SEPP provides that development for the purposes of petroleum exploration may be carried out without development consent. Clause 6 applies despite the provisions of the Narrabri LEP. Condition 2 of PEL 238 required the licence holder to obtain further approval from the Resources Minister prior to carrying out a Category 3 prospecting operation. The Resources Minister is the determining authority for the purposes of Part 5 of the EP&A Act. The proposed activity is not within three kilometres of any other petroleum wells within PEL 238 and therefore clause 7 of the Mining SEPP which relates to development that is permissible with consent is not relevant.

The proposed activity will not be carried out on an environmentally sensitive area of State significance or land on which the following instruments apply: *State Environmental Planning Policy (Major Developments) 2005*, *State Environmental Planning Policy No 14 – Coastal Wetlands* and *State Environmental Planning Policy No 26 – Littoral Rainforests*.

5.2.2.2 Assessment under Part 5 of the EP&A Act

Under Part 5 of the EP&A Act, a determining authority is required to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity (section 111 duty).

The determining authority must consider, among other things, the effect of the proposed activity on critical habitat and any protected fauna or protected native plans within the meaning of the *National Parks and Wildlife Act 1974*, and in the case of threatened species, populations or ecological communities, and their habitats, whether there is likely to be a significant effect on those species, population or ecological communities or those habits.

The determining authority is also required to determine whether an Environmental Impact Statement (EIS) or Species Impact Statement (SIS) is required. In deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats, section 5A of the EP&A Act requires the following factors to be taken into account (the 'seven part' test of significance):

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,

(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

  (i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

  (ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

(d) in relation to the habitat of a threatened species, population or ecological community:

  (i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

  (ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

  (iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

This REF has been prepared to assist the determining authority in meeting its obligations under section 111 of the EP&A Act. In particular, the "seven part" test has been applied to the proposed activity in Appendix 7 of the REF. The REF concludes that the proposed activity is not likely to significantly affect the environment or threatened species, populations or ecological communities or their habitats.

5.2.2.3 Narrabri Local Environmental Plan 2012

For the reasons discussed above, the proposed activity does not require development consent under Part 4 of the EP&A Act. However, consideration has nevertheless been given to the relevant RU3 Forestry zone objectives under the Narrabri LEP.

The proposed activity is a non-forestry use that will not restrict the use of other land for forestry purposes. The natural resource base relied upon by the industry within the area will not be significantly affected by the proposed activity. The proposed activity will not affect the development of forestry or forestry-related enterprises in the area nor will it result in the fragmentation or alienation of resource lands. The proposed activity will not result in conflict between land uses within the RU3 Forestry zone or land uses within adjoining zones. Therefore, the proposed activity is considered to be a suitable activity within the RU3 Forestry zone.

5.2.3 Threatened Species Conservation Act 1995

The TSC Act sets the framework for the listing of threatened species, populations and ecological communities, and key threatening processes in NSW, and the preparation and implementation of recovery plans and threat abatement plans.

The TSC Act also provides a mechanism for applying for and obtaining licences to take actions, which could result in harm to a threatened species, population or ecological community, or their habitat, or damage to critical habitat.

As discussed above, section 5A of the EP&A Act lists seven factors that must be taken into account in determining the significance of a potential impact on 'threatened species, populations or ecological communities (or their habitats)' listed under the TSC Act (refer to section 5.2.2). The assessment of significance (7-part test) is used to determine whether activities are 'likely' to cause 'a significant impact' on threatened biota and thus whether an SIS is required.

The Ecological Assessment prepared for the proposed activity identified a number of threatened species and ecological communities as having the potential to occur on the site. A total of 18 assessments of significance were undertaken for ten birds, seven mammals, and one reptile (refer to Appendix 7). The application of the 7-part test concluded that there is not likely to be a significant effect on threatened species, populations, or their habitats arising from the proposed activities.

5.2.4 National Parks and Wildlife Act 1974

5.2.4.1 Threatened species

Part 8A of the *National Parks and Wildlife Act 1974* (NPW Act) regulates the undertaking of activities, which may impact on threatened species, populations and ecological communities listed under the TSC Act and their habitats.

The NPW Act provides that a person must not harm any animal that is a threatened species, population or ecological community, pick any plant which is part of a threatened species, population or ecological community, damage any critical habitat or damage any habitat of a threatened species, population or ecological community without a licence being obtained under the NPW Act or TSC Act or unless another exception applies.

However, it is a defence to a prosecution for contravening any of those requirements where the action was essential for the carrying out of an activity in accordance with an approval of a determining authority under Part 5 of the EP&A Act where the determining authority has complied with Part 5. This REF has been prepared to assist the determining authority to comply with Part 5 of the EP&A Act (refer to section 5.2.2).

5.2.4.2 Aboriginal cultural heritage

The NPW Act conserves places, objects and features of significance to Aboriginal people.

It is an offence under the NPW Act to:

- harm or desecrate an object that the person knows is an Aboriginal object except in accordance with an Aboriginal heritage impact permit (AHIP)
- harm or desecrate Aboriginal objects and Aboriginal places except in accordance with an Aboriginal heritage impact permit or where the person can show they exercised due diligence to reasonably determine that no Aboriginal object will be harmed.

A cultural heritage assessment of the site was prepared in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010* (DECCW 2012). The assessment determined that the proposed activity will not impact on any known Aboriginal objects or places. Provided that the mitigation measures identified in sections 6.5 and 6.6 are carried out, impacts to any unknown Aboriginal objects or places should be avoided. Therefore, an AHIP is not required for the proposed activity.

5.2.5 Protection of the Environment Operations Act 1997

One of the primary objectives of the *Protection of the Environment Operations Act 1997* (NSW) (POEO Act) is to 'protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development'. The POEO Act requires environmental protection licences (EPLs) be obtained for the carrying out of 'scheduled activities' or to pollute waters.

The proposed activity does not involve a 'scheduled activity'. Accordingly, an EPL is not required.

The proposed activity will involve the transport of a trackable waste listed under Schedule 1 of the POEO Act. This will be carried out by a waste contractor with the appropriate EPL.

5.2.6 Fisheries Management Act, 1994

One of the objectives of the *Fisheries Management Act 1994* is to 'conserve key fish habitats'. A policy definition of the term 'Key Fish Habitat' (KFH) was developed to guide the compilation of key fish habitat maps. KFH is defined to include all marine and estuarine habitats up to highest astronomical tide level (that is reached by 'king' tides) and most permanent and semi-permanent freshwater habitats including rivers, creeks, lakes, lagoons, billabongs, weir pools and impoundments up to the top of the bank.

The Department of Infrastructure and Investment (I&I NSW) uses the Strahler stream classification system to give waterways an 'order' according to the number of additional tributaries associated with each waterway (Strahler, 1952). This system provides a measure of system complexity and therefore the potential for fish habitat to be present. I&I NSW recognises third order streams and above as likely to display valuable fish habitat, and hence could support viable fish populations.

Small headwater creeks and gullies (known as first and second order streams), that only flow for a short period after rain are generally excluded from the definition of 'key fish habitat', as are farm dams constructed on such systems. Unmapped gullies and first and second order streams (based on the Strahler method of stream ordering) are determined from the largest scale topographic map produced for the area concerned (ie use 1:25,000 rather than 1:50:000 and use 1:50:000 rather than 1:100,000 and include all depicted streams).

Spring Creek is defined as a second order stream which flows ephemerally and consequently aquatic ecology has not been assessed in detail.

5.2.7 Heritage Act 1977

One of the main objectives of the *Heritage Act 1977* (Heritage Act) is to encourage the conservation of the heritage of NSW. The site is not listed on the State Heritage Register under the Heritage Act.

The Heritage Act also prevents impacts on 'relics', which are defined as:

any deposit, artefact, object or material evidence that:

(a) relates to the settlement of the area that comprises New South Wales, not being Aboriginal settlement, and

(b) is of State or local heritage significance.

Under the Heritage Act, it is an offence to disturb or excavate any land knowing or having reasonable cause to suspect that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed unless the disturbance or excavation is carried out in accordance with an excavation permit. No items of heritage significance listed under either the Narrabri LEP 2012 or on the NSW State Heritage Register occur on the site. A number of items of local and State heritage significance occur within the Narrabri LGA, however these are not located in close proximity to the site.

5.2.8 Water Act 1912 and Water Management Act 2000

The *Water Act 1912* (Water Act) and *Water Management Act 2000* (WMA) are the key pieces of legislation regulating access and impacts to surface and groundwater resources in NSW. Where a water sharing plan is in place, the WMA governs the issuing of water access licences (WALs) and water management and activity approvals. As water sharing plans are in place for the surface and groundwater sources at or surrounding the site, the WMA applies to the proposed activity.

5.2.8.1 Aquifer interference approval

Under section 91F of the WMA, it is an offence to carry out an aquifer interference activity without an aquifer interference approval. An aquifer interference activity includes the penetration, interference or obstruction of flows within an aquifer or to take or dispose of waters from an aquifer.

However, section 91F of the WMA does not currently apply. This is because the provisions contained in Divisions 1 and 1A of Part 3 of Chapter 3 of the WMA (including section 91F) have not become operative under section 88A. Section 88A provides that Part 3 of Chapter 3 applies to each part of the State or each water source and each type or kind of approval that relates to that part of the State or that water source that is declared by proclamation.

At the time of this REF, no proclamation has been made declaring that Part 3 of Chapter 3 of the Act applies in relation to aquifer interference approvals.

Accordingly, an aquifer interference approval will not be required for the proposed activity.

5.2.8.2 Water sharing plans

Water sharing plans (WSPs) are designed to provide long-term environmental protection and sustainability of the surface water and groundwater resources as well as directing how water will be allocated and shared among the various water users. WSPs apply the goals and principles of the *NSW State Groundwater Policy* at a local and regional level.

The WMA provides for a system of assessment and licensing and approvals relating to the equitable take of water from water sources, in addition to works and activities occurring within or affecting these water sources. Each WSP sets out Water Sharing Rules and Management Rules for aquifer interference activities within each water source that operate under these water management principles.

The proposed activity will have to comply with the rules developed for the affected water sources within the relevant water sharing plans outlined above.

5.2.8.3 Water access licences

Under Part 2 of Chapter 3 of the WMA, it is an offence to take water from a source regulated by the WMA unless in accordance with a water access licence (WAL). A water licence is required (unless an exemption applies) where any aquifer interference activity causes:

- the removal of water from a water source
- the movement of water from one part of an aquifer to another part of an aquifer
- the movement of water from one water source to another water source.

Water used for the construction and operation of the proposed activity will be sourced from Narrabri's potable town water supply or local industrial licensed water bores and trucked to the site. Alternatively, production water from pilot wells will be used when available for the preparation of drilling mud.

A WAL is also required for the taking of groundwater, whether for consumption or incidentally, unless an exemption applies. Any new mining and petroleum exploration activities that take more than three mega litres per year from groundwater sources will need to hold a WAL.

Through the course of undertaking the pilot trial over the life of the PEL, the volume of water extracted from the Gunnedah-Oxley Basin MDB Buried Groundwater Source by the Dewhurst 22-25 wells (excluding Dewhurst 6) is predicted to be approximately 288 megalitres over the first three years, and 96 megalitres per year for the remaining life of the PEL. Santos will need to obtain a WAL to account for this water take.

5.2.8.4 Flood work approval

Under section 90 of the WMA, a flood work approval is required to construct and use flood work at a specified location. Flood work is defined within the WMA and includes a work (such as a barrage, causeway, cutting or embankment) in the vicinity of a river or within a floodplain (as declared under the WM Regulation) that is of such a size or configuration that it is likely to have an effect on the flow of water to or from a river or the distribution or flow of floodwater in times of flood. Clause 13 of Schedule 9 of the WMA Act provides that any land that was designated as a floodplain under Part 8 of the Water Act is taken to be a floodplain for the purposes of the WMA Act.

There are a number of floodplains declared under the Water Act located nearby but not on the site. The closest is the Namoi River: Carroll to Boggabri floodplain located approximately 30 kilometres to the south east. The proposed activity is considered unlikely to affect the flow of water to or from any river, or the distribution or flow of floodwaters. Therefore, a flood work approval is not required for the proposed activity.

5.2.8.5 Controlled activity approval

Under section 91E of the WMA, it is an offence to carry out a controlled activity in, on or under waterfront land without a controlled activity approval for that activity. Waterfront land is taken to mean land within 40 metres of a water body. Controlled activities include the removal of vegetation or material, or deposition of material.

Clause 39 of the WM Regulation provides that activities specified in Part 2 of Schedule 5 of the regulation are exempt from requiring controlled activity approvals under the WMA. Part 2 of Schedule 5 includes any activity carried out in accordance with a right in force under the Petroleum Act. Therefore, a controlled activity approval is not required for the proposed activity.

6.0 Potential environmental impacts and mitigation

This section of the REF addresses the potential environmental impacts associated with the proposed activity and identifies mitigation measures to ensure any impacts are appropriately managed.

Potential impacts have been categorised in accordance with the ESG2 Guidelines. Impact categories include:

- negligible
- low adverse
- medium adverse
- high adverse
- positive.

6.1 Physical and chemical aspects

6.1.1 Soil quality and land stability

6.1.1.1 Potential impacts

Likely impact on soil quality or land stability

Erosion

The proposed activity may require vegetation clearing, top soil removal and earthworks for establishment of the lease areas and construction of the access tracks and gathering system corridors. The total area of disturbance will be up to approximately one hectare for each of the lease areas, up to approximately 0.86 hectares for the access tracks and up to an additional 1.43 hectares for the gathering system. Any topsoil and spoil generated during site preparation activities will be stockpiled on site for the duration of site preparation, drilling, testing and completion activities until rehabilitation of the site occurs. A large part of the gathering system follows existing roads in areas that are already disturbed.

The proposed disturbance to the ground surface is greater than the current nature and condition of the site and surrounding landscape, and as such it may be sensitive to disturbance. However, historically the site may have been subject to varying disturbances, including forestry activities, fires, grazing and mining exploration.

While each of the lease areas are relatively flat, any vegetation clearing and earthworks will increase the site's erosion potential and may result in loss of topsoil/spoil, and sedimentation of waterways, particularly Spring Creek. Potential impacts to surface waters are further discussed in section 6.1.2.

Incomplete or inadequate rehabilitation of the site could create long term erosion and land stability issues.

Drilling activities will produce drilling fluid and drill cuttings. These materials are unlikely to present an erosion hazard as drilling mud and cuttings will be contained in surface tanks, metal bins or lined pits.

Delivery trucks and personnel vehicles exiting the sites may track sediments onto Monument Road. Erosion and sedimentation will be reduced through the measures identified in section 6.1.1.2.

Potential erosion impacts are greatest during the site establishment, drilling and construction phases of the activity. During operation, erosion would be limited to the personnel and vehicles accessing the site.

Contamination

During site establishment, construction and drilling, the proposed activity could result in soil contamination as a result of spilled or leaked chemicals (such as drilling fluid additives), fuel or oil. Spills or leaks could occur during handling, use, storage or transit of chemicals, fuels and oils. Spills or leaks may also occur during refuelling or maintenance of plant or equipment.

There is minimal risk of soil contamination occurring due to the use of drilling mud as this will be water-based and will contain non-toxic additives. Drilling mud and cuttings are therefore unlikely to be contaminated.

Measures to reduce the risk of contamination as a result of the proposed activity are identified in section 6.1.1.2.

During operation, the groundwater lifted from the coal seam will flow to a balance tank to be stored temporarily prior to transfer to the water treatment facility. Water will ultimately be transferred via flowlines to future facilities (subject to separate a REF process). In the event that the flowlines are not constructed prior to operation of the pilot wells, water will be transferred by road to the existing facility at Bibblewindi.

The balance tank will be bunded to 100 per cent capacity to minimise impacts of any spillage.

There is potential for an uncontrolled discharge to the environment during road water transport. Although unlikely, if this were to occur, there could be localised contamination impacts. It is expected however that these impacts will be small (largest water truck capacity 23 cubic metres), localised and short term.

There is also a risk that a line failure could occur within the gathering system that transfers lifted groundwater between the wells to the balance tank at Dewhurst 22. Water pressure within the pipes is monitored remotely and should this occur, operation of the well will be suspended until the problem is rectified. The extent of the impact will also be small, localised and short term.

Impacts to structural integrity, land instability or subsidence are not expected.

6.1.1.2 Mitigation measures

The management process for drilling mud and cuttings, described in section 2.8.1 of the REF, will safeguard against contamination of the site. The following measures will be implemented to minimise potential impacts to soils and reduce the risk of contamination:

Site establishment and construction

- Where the lease area is constructed using traditional methods (instead of using industrial matting), topsoil and other soil horizons will be stripped, handled and stockpiled separately.
- Excess spoil generated during site preparation activities will be stockpiled on site and used as backfill during site rehabilitation. No uncontaminated soil or spoil will be removed from the site.
- Stockpiles will be managed according to best management practices such as the measures outlined in *Managing Urban Stormwater: Soils and Construction* (Landcom 2004) ('the Blue Book') or the *Best Practice Erosion and Sediment Control Guidelines* (IECA, 2008) (IECA Guidelines).
- Erosion and sediment controls will be implemented where necessary during site preparation activities, including lease area construction and any upgrades to the existing access track, 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.

- A diversion bank will be constructed to direct water around the area of disturbance.
- A sediment fence will be installed at the downstream limit of disturbance area.

Drilling

- The quantity of chemicals, fuels and oils stored on site will be minimised, where practicable.
- All additives, chemicals, fuels and oils stored on site will be kept in an appropriately secured, bunded storage facility in accordance with the relevant MSDS.
- An MSDS register of all chemicals used or stored on site will be maintained.
- Maintenance of vehicles, plant and equipment will occur off site at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance on site.
- Refuelling of plant and equipment will occur in a designated, bunded area, at least 40 metres from the nearest waterway.
- A spill kit will be available on site and personnel will be trained in its use.
- A vacuum truck will be on standby 24 hours a day to travel to the site if required
- Any spills or leaks will be contained and cleaned up immediately using the spill kit. Contaminated material (such as contaminated soil or absorbent materials) will be contained and removed from site for disposal at a licensed waste facility.
- Plant and equipment will be inspected daily to ensure these are properly maintained.

Operation

- Ongoing management and maintenance of remaining infrastructure on site will occur, including water transfer area and well heads.
- The gathering system water pressure will be monitored
- The site will be rehabilitated in accordance with section 2.7.9 of the REF.

6.1.1.3 Impact categorisation

Table 6-1 provides an analysis of the potential impacts on soil quality and land stability.

Table 6-1 Soil quality and land stability impact categorisation

Analysis of impact	Comment
Size	Up to approximately 6.29 hectares will initially be cleared with top soil stockpiled. Lease areas for Dewhurst 23 to 25 will reduce following completion of initial drilling activities from approximately 1 hectare to 0.04 hectares and the topsoil used to rehabilitate the site. The entire lease area at Dewhurst 22 will be retained during operation as this area will contain the flare and water balance tank. Following construction of the gathering system, the surface area will be rehabilitated and natural overland flow restored.
Scope	Soil erosion may occur for stockpiles and generally across the lease area. Soil contamination from chemical or oil spills during site establishment and drilling activities
Intensity	Site is relatively flat and soil erosion impacts are expected to be minimal. Any water leakage from the gathering system will have only a small localised impact.

Analysis of impact	Comment
Duration	Stockpiled top spoil will remain for up to 6 months following completion of drilling activities. Site establishment and drilling activities approximately 54 days per well.
Level of confidence in predicting impacts	High, provision of erosion controls including drainage bunding, controls on the size and slope of the stockpiles and controls to manage any spills will minimise any impact to soil quality and stability.
Level of reversibility of impacts	Impacts are likely to be minimal with mitigation measures in place and reversible
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.1.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising soil quality and land stability impacts and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: *Managing Urban Stormwater*: Soils and Construction (Landcom 2004) ('the Blue Book') *Best Practice Erosion and Sediment Control Guidelines* (IECA, 2008) (IECA Guidelines)
Level of public interest	The level of public interest regarding potential impacts on soil quality and land stability matters is considered to be low to moderate. The general public maintains an interest in ensuring that the works would not result in adverse impacts on the environment.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact on soil quality or land stability.
Impact category	Based on the analysis of the impact above, the potential for impact upon soil quality and land stability would be negligible to low adverse.

6.1.2 Water body, watercourse, wetland and natural drainage systems

6.1.2.1 Potential impacts

Likely effect on a waterbody, watercourse or wetland or natural drainage system

Impacts to water bodies can be grouped as follows:

- Redirection of flow – this is likely to be minor but will occur during site establishment and drilling when drainage bunding will be put in place to manage surface run off from the lease area or impacts from any spills. The levelling of the site will also impact overland flows.
- Changes to the area, volume or flow of a water body – unlikely for surface water, groundwater is assessed separately in section 6.1.3. The access track for Dewhurst 24 will cross Spring Creek.
- Actual or likely pollution of waters – possible as a result of spills.

As discussed in section 6.1.1, any vegetation clearing, earthworks and stockpiling activities required for lease establishment will increase the erosion potential of the site. This may result in increased sediment loads in surface runoff, which could increase turbidity and suspended sediment loads of receiving waters including Spring Creek and the Bohena Creek system. Runoff is not expected to be significant given the flat nature of the site and moderate average rainfall.

Under the Fairfull and Witheridge classification method, Springs Creek would best be described as a Class 4 watercourse (unlikely fish habitat). A Class 4 watercourse is defined as a named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools after rain events. The recommended crossing type for a Class 4 watercourse is a culvert, causeway or ford.

Erosion and sediment controls will be utilised to minimise the potential for sediment migration to nearby drainage lines. Erosion and sediment control structures may include silt fences, diversion drains, and maintenance of down slope buffer zones. Contour banks around the proposed sumps will minimise any overland flow entering the sumps.

In the case of the proposed drilling sump, a plastic liner will be used to ensure there is no leakage to the surrounding environment. The liner will be removed after drilling with the water re-used or taken to a licensed facility for disposal.

There is potential for drilling mud to be spilled due to overflow of surface tanks or as a result of tank failure, during the drilling process, or during transit to and from the site. This could result in pollution of Spring Creek or other waterways with sediment and other contaminants, but this is considered unlikely. In the event of an incident, appropriate measures to contain and remediate areas of impact will be initiated.

Water for the drilling, access track and lease build activities will be sourced from town water or a producing well, rather than a natural/local surface water body.

There is potential for chemicals, fuels or oils used or stored on site to leak or spill and enter drainage lines or Spring Creek and degrade local water quality. Litter from personnel on site may enter waterways and degrade water quality.

Pollutants or wastewater could be discharged to Spring Creek or other waterways during general site activities such as vehicle washing or dust suppression.

Surface runoff will be captured through site bunding along the lease area.

During operation the groundwater lifted from the coal seam will need to be stored temporarily and disposed of in accordance with the proposed water management strategy. An uncontrolled discharge to the environment could occur during road water transport. If this were to occur, there could be localised impacts to surface water. The extent of the impact will be small, localised and short term.

Potential surface water impacts are greatest during the site establishment, construction and drilling. During operation, potential surface water impacts would be limited to any leakage from the gathering system.

Water Quality and River Flow Objectives have been defined for uncontrolled streams within the Namoi catchment. The relevant objectives and how the proposed activity will achieve these objectives are outlined in Table 6-2.

Table 6-2 Relevant Water Quality and River Flow Objectives

Relevant Water Quality and River Flow Objective	Description of objective	How proposed activity will meet objective
Aquatic ecosystems	*Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term*	The site will be managed to ensure that no 'dirty' water is discharged to Spring Creek or drainage lines and that existing salinity, turbidity and pH levels of surface waters are maintained.
Visual amenity	*Aesthetic qualities of waters*	The site will be managed to ensure that no 'dirty' water, oil/fuel or debris is discharged to Spring Creek or drainage lines. The proposed activity is unlikely to introduce aquatic pests or weeds. Vehicle cleaning procedures will ensure that other weed species are not introduced to waterways.
Livestock water supply	*Protecting water quality to maximise the production of healthy livestock*	The groundwater impact assessment determined that the aquifers which may be used for livestock water supply would not be impacted upon by the proposed activity. The well will be constructed in accordance with industry standards and will isolate aquifers.
Irrigation water supply	*Protecting the quality of waters applied to crops and pasture*	The groundwater impact assessment determined that the aquifers which may be used for irrigation water supply would not be impacted upon by the proposed activity. The well will be constructed in accordance with industry standards and will isolate aquifers.
Homestead water supply	*Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing*	The groundwater impact assessment determined that the aquifers which may be used for domestic water supply would not be impacted upon by the proposed activity. The well will be constructed in accordance with industry standards and will isolate aquifers.
Drinking water - Disinfection only, or Drinking water - Clarification and disinfection Drinking water - Groundwater	*Refers to the quality of drinking water drawn from the raw surface and groundwater sources before any treatment*	The proposed activity does not involve the drawing of drinking water from raw surface or groundwater sources.
Protect pools in dry times	*Protect natural water levels in pools of creeks and rivers and wetlands during periods of no flows*	The proposed activity will not involve extraction from any surface waters.
Protect natural low flows	*Protect natural low flows*	The proposed activity will not involve extraction from any surface waters.
Maintain wetland and floodplain inundation	*Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems*	The proposed disturbed area is only approximately 6.29 hectares in size and will not alter flooding patterns.

Relevant Water Quality and River Flow Objective	Description of objective	How proposed activity will meet objective
Manage groundwater for ecosystems	*Maintain groundwater within natural levels and variability, critical to surface flows and ecosystems*	The groundwater impact assessment determined that the aquifers which may feed groundwater dependent ecosystems and base flows would not be impacted upon by the proposed activity. The well will be constructed in accordance with industry standards and including isolation of aquifers.

6.1.2.2 Mitigation measures

The measures identified in section 6.1.1.2 will minimise impacts to surface water and the site will be rehabilitated in accordance with section 2.7.9 of the REF. The following additional measures will be implemented:

Site establishment and construction

- Contaminated waters will be contained and where necessary disposed of at an appropriate facility.
- Sediment fences and traps will be installed so as to prevent soil loss or sedimentation.
- Where applicable maintenance of roads, drains, bund walls, contour and diversion banks to occur. All drainage structures will be maintained for the life of the development.
- The crossing of Spring Creek will be designed to minimise erosion of the beds and changes to overland flow velocities.

Drilling

- Drilling mud will be contained in surface tanks which will be regularly inspected and maintained.
- Over-balanced drill techniques will be used to prevent formation fluid from rising through the well to the surface.
- Drilling mud will be transported to and from the site by an appropriately licensed contractor as outlined in section 2.8.1 of the REF.
- Fuel and lubricants will be stored on site only when necessary and maintained off site whenever possible.
- Contaminated liquid captured in the environmental pit will be removed to a licensed waste facility that is able to accept liquid waste for disposal or treatment.
- All areas storing or handling fuel, fuel using equipment, and chemicals will be bunded in accordance with Australian Standard 1940 – 2004; The Storage and Handling of Flammable and Combustible Liquids.
- The maintenance and cleaning of vehicles and other equipment or plant will be carried out in areas from where the resultant contaminants cannot be released into any waters.

Operation

- Proposed rehabilitation (section 2.7.9) will ensure pre-operational quality or better, to minimise sediment erosion.

6.1.2.3 Impact categorisation

Table 6-3 provides an analysis of the potential impacts on waterbodies, watercourses, wetlands and natural drainage systems.

Table 6-3 Surface water impact categorisation

Analysis of impact	Comment
Size	Small - Spring Creek is located 75m from Dewhurst 24 and 125 m from Dewhurst 22. The creek is ephemeral in nature.
Scope	Localised - Surface water quality could be impacted by spills or sediment erosion.
Intensity	Low - Water contamination, if it occurs will be as a result of small spills or leaks that will be relatively contained. Changes to overland flows are minimal as existing area is relatively flat
Duration	Short term – The likelihood of impact will only occur during site establishment and drilling.
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period.
Level of reversibility of impacts	With the implementation of the mitigation measures proposed above and the use of water based drilling mud and non-toxic additives, the reversibility of the impacts is considered to be high.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.2.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising impacts on waterbodies, watercourses, wetland and natural drainage systems and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: Australian Standard 1940 – 2004; The Storage and Handling of Flammable and Combustible Liquids. Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla.
Level of public interest	The level of public interest relating to potential impacts on waterbodies, watercourses, wetland and natural drainage systems matters is considered to be high, as water quality is a major issue that has been consistently raised at a number of forums and communication activities. The general public maintains an interest in ensuring that the works would not result in adverse impacts on the environment.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact on waterbodies, watercourses, wetland and natural drainage systems.
Impact category	Although the activity will occur within a sensitive area (i.e. soils with potential salinity or sodicity problems), given the small scale of the proposed activity, provided that the identified mitigation measures are implemented, a negligible to low adverse impact on waterbodies, watercourses, wetland and natural drainage systems is expected.

6.1.3 Groundwater

A Groundwater Impact Assessment has been undertaken by Halcrow and is provided in Appendix 9. The key findings are outlined below.

6.1.3.1 Potential impacts

Likely effect on a waterbody, watercourse or wetland or natural drainage system

Groundwater impacts apply partially during drilling (aquifer interference) but mostly during operations.

During drilling, groundwater aquifers will be intersected. However these will be cased off and cemented to isolate any water transfer between aquifers. During operation lifting of water is proposed from the Bohena, Namoi and Parkes seams.

Impacts during drilling

Potential impacts to groundwater associated with drilling and well installation may result from drilling, well installation or abandonment if not carried out correctly.

Potential impacts of drilling in mixed multi-aquifer systems include:

- creating an artificial connection between water-bearing formations that bypasses aquitards (low permeability layers which restrict groundwater flow) or aquicludes (geological formations through which no groundwater flows) resulting in cross contamination of aquifers
- contamination of the aquifers by drilling fluids or mud if these are lost in the formation
- groundwater discharging to the surface, which might cause flooding or impact on surface water quality depending on the discharge and receiving water qualities.

Groundwater contamination could occur due to spills of oil, fuels or chemicals if not cleaned up appropriately.

The key risk associated with drilling and well installation include creating an artificial connection between water bearing formations that bypasses aquitards and aquicludes and loss of drilling fluid into the formation resulting in the degradation of water quality. Potential impacts associated with improper drilling, well installation or well abandonment include depressurisation and/or cross contamination of groundwater resources due to leakage within the borehole and changes to groundwater quality from drilling fluid. Human consumptive uses and aquatic ecosystems are at risk from these potential impacts. These impacts are rated as minor and are considered unlikely to occur due to the proposed well installation method (which is in accordance with *NSW Coal Seam Gas Code of Practice Well Integrity*) and based on the results of numerical modelling.

Impacts to upper layers during operation

The alluvial groundwater sources of the upper and lower Namoi alluvium (NSW upper and lower Namoi groundwater source water sharing plan (WSP)) are considered to be highly productive in the context of the Aquifer Interface Policy (AIP). Groundwater modelling has indicated that there will be no decline in the water table or change in flux within these alluvial aquifers as a result of the operation of the activity.

The porous rock groundwater source of the Great Artesian Basin (GAB) Surat Pilliga sandstone (NSW GAB groundwater source WSP) is considered a highly productive porous rock groundwater source in the context of the AIP. Groundwater modelling has indicated that there is also no decline in ground water level or change in flux within this aquifer during operation.

Impacts to the coal seam aquifer

The porous rock groundwater source of the Gunnedah Basin (NSW MDB porous rock groundwater source WSP) is considered a less productive porous rock groundwater source in the context of the AIP. As the targeted coal seams falls within the lower parts of this water source, changes in flux at the lower levels will comprise aquifer interference under the aquifer interference policy.

The Gunnedah Basin comprises a number of layers with differing impacts identified through the modelling simulating pilot well operation:

- Triassic strata of the Digby, Napperby and Deriah formation will have no decline in the ground water level or change in flux
- Permian strata of the Black Jack Group will have no decline in the ground water level or change in flux
- Maules Creek Group will be impacted as this contains the target coal seam aquifers.

Registered users

There are six registered bores within 2.5 kilometre of the proposed activity. These bores abstract water from the lower Namoi alluvium and the Pilliga Sandstone. The Pilliga Sandstone of the Surat Basin is considered the lowest (and most easterly) intake beds of the Great Artesian Basin (GAB). None of these layers will be impacted by the proposed activity (construction and operation).

Groundwater Dependant Ecosystems

Two high priority groundwater dependant ecosystems (GDEs) are identified in the vicinity of the project, Hardy's Spring and Ether Spring. These are hydrogeologically associated with the Pilliga sandstone. As there is no impact to the Pilliga sandstone, there is expected to be no impact on the GDE's.

6.1.3.2 Mitigation measures

The measures identified in section 6.1.1.2 will minimise potential impacts to groundwater. In addition, the following mitigation measures will be implemented to minimise potential impacts on groundwater sources:

Site establishment and construction

Nil

Drilling

- The wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS 2012b).
- A driller that holds a license under the National Water Drillers Licensing Accreditation Scheme will be on site during drilling of the top hole and until the surface casing is set, cemented and pressure tested. During this time, there will be 24 hour coverage by one person working the day shift and on call at site during the night.
- A NOW hydrogeologist will be notified at least 28 days prior to the commencement of drilling.
- Drilling and installation operations, well control, waste management and abandonment procedures for the pilot wells will be in accordance with accepted industry practices and in accordance with the processes outlined in this REF.
- Excessive drilling mud losses will be cured by loss circulation material (cellulose material such as sawdust or other benign naturally occurring substances, as required) to ensure most fluids return to the surface.

- Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within three kilometres of the site to undertake groundwater monitoring prior to drilling, to establish baseline conditions, and on completion of drilling, to determine if there are any impacts. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and quality observations in the field, and sampling for analysis by an accredited laboratory.

Operation

- The wells will be decommissioned as soon as they are no longer required.
- Data will be collected from the wells to measure permeability of the various strata.
- Pressure gauges will be installed adjacent to the pilot wells with monitoring points to assess impacts on overlying formations.
- The quality of incidental water lifted during proposed activities will be monitored daily and the results provided to the relevant authorities on a weekly basis.
- Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within three kilometres of the site to undertake groundwater monitoring during operation of the pilots. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and quality observations in the field, and sampling for analysis by an accredited laboratory.

6.1.3.3 Impact categorisation

Table 6-4 provides an analysis of the potential impacts on groundwater.

Table 6-4 Groundwater impact categorisation

Analysis of impact	Comment
Size	The total water likely to be abstracted is approximately 288 ML over three years and 96 ML/yr over the remaining life of the PEL (including from Dewhurst 6).
Scope	There is negligible change in flux or drawdown in the upper layers. GDE's and registered bore users will not be impacted.
Intensity	Low – impacts are negligible
Duration	Short term – Water extraction will occur over a sufficient period to provide three months continuous data at stabilised extraction rates. This requires the pilot to be active for up to three years.
Level of confidence in predicting impacts	High confidence and knowledge based on detailed groundwater modelling that has been undertaken, as well as previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period.
Level of reversibility of impacts	Medium, any movement of groundwater between aquifers will naturally rebalance over time
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.3.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising impacts on groundwater and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: NSW Coal Seam Gas Code of Practice Well Integrity (DTIRIS 2012b)
Level of public interest	The level of public interest relating to potential impacts on groundwater is considered to be moderate, particularly as registered bore users will have an interest in impact to groundwater. The general public maintains an interest in ensuring that the works would not result in adverse impacts on the environment.

Analysis of impact	Comment
Requirement for further information on the impacts of the activity or mitigation	Additional modelling as water production data becomes available will be undertaken. This will further refine impacts to the deeper targeted aquifers.
Impact category	Although the activity will occur within a sensitive area (i.e. groundwater recharge area), given the small scale of the proposed activity, provided that the identified mitigation measures are implemented, a negligible to low adverse impact on groundwater is expected.

6.1.4 Flooding

6.1.4.1 Potential Impacts

Likely change on flood or tidal regimes, or activity to be affected by flooding

The proposed activity is unlikely to significantly affect the distribution or flow of floodwaters. Some grading will occur at the lease areas however given the existing topography is relativly flat, changes are minimal.

The site is not located within a floodplain.

The access track to Dewhurst 24 will cross Spring Creek. Large aggregate gravel will be placed at the crossing to minimise impact to natural flowlines.

There is potential that during a flood event, plant, equipment and temporary buildings stored within the lease area could be washed away or eroded. This would potentially result in damage to construction equipment or release of sediments and/or contaminants into Spring Creek or other local drainage lines.

The site is not located near the coast and therefore would not affect tidal regimes.

6.1.4.2 Mitigation measures

Site establishment and construction

- Weather forecasts will be monitored and in the event that prolonged, severe wet weather or flooding is predicted, works will cease and plant, machinery and any chemicals will be secured and bunded. This will also occur during drilling

Drilling

- The environmental pit will be maintained with a minimum freeboard of 300 millimetres at all times.

Operation

Nil

6.1.4.3 Impact categorisation

Table 6-5 provides an analysis of the potential impacts that could be caused by flooding.

Table 6-5 Flooding impact categorisation

Analysis of impact	Comment
Size	Site is not located within a flood plain, any flooding that will occur will be the result of localised heavy rains
Scope	Impacts will be localised
Intensity	Small - any impacts will be small and short term
Duration	Short term – site will only be impacted in heavy rains
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period.
Level of reversibility of impacts	With the implementation of the proposed mitigation measures it would be unlikely that there would be any adverse impacts however any impacts would be easily reversible.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.4.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising impacts from flooding have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	With the implementation of the proposed mitigation measures, the proposed activity would comply with all relevant standards, plans or policies.
Level of public interest	The level of public interest relating to flooding is low.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact from flooding.
Impact category	Based on the analysis of the impact above, the potential for flood impact would be negligible

6.1.5 Coast process and coastal hazards

Likely effect on coastal processes and coastal hazards, including those under projected climate change conditions

The site is not located near the coast and therefore would not affect coastal processes or hazards, including tidal regimes.

6.1.5.1 Mitigation measures

Nil.

6.1.5.2 Potential impact category

Nil. Coastal processes and coastal hazards would not be affected by the proposed activity.

6.1.6 Hazardous substances and chemicals

6.1.6.1 Potential impacts

Use, storage or transport of hazardous substances or use or generation of chemicals which may build up residues in the environment

The proposed activity will require the use of chemicals, fuels and oils, particularly during drilling activities, as described in section 2.7.3 of the REF. While these substances are not highly hazardous, potential impacts may occur due to their improper use, transport or storage, or in the event of an incident. Such impacts could include outbreak of fire, increasing risk to people, environment and property, or pollution of land, water or air, affecting quality. Moving vehicles, plant and machinery may also introduce a potential hazard to the site, which may have safety implications due to the accidental ignition by vehicles or machinery.

Drilling mud, containing a number of chemical additives, will be used during drilling as described in section 2.7.3 of the REF. A chemical fact sheet, identifying environmental considerations for each of the chemicals to be used during drilling, is included in Appendix 2. The majority of chemicals would have no impact on the environment. Some of the chemicals to be used may have consequences to the environment if not used, stored or disposed of appropriately. However, the risk to the environment is considered to be low as chemicals will be stored on site in small quantities. Chemicals will be stored off the ground in an elevated trailer. The proposed activity will be short term and all chemicals will be used and disposed of in accordance with the relevant MSDS.

The risk to human health as a result of the chemicals is also considered to be low as site workers will wear and use the appropriate personal protective equipment and no members of the public will be able to enter the work area. Waste will be disposed of appropriately in accordance with relevant legislation.

Any dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008.*

No chemicals with added benzene, toluene, ethylbenzene, and xylenes (BTEX) will be used.

The impacts associated with spills and associated mitigation measures are covered in the discussion on soil quality (Section 6.1.1) and surface water quality (Section 6.1.2)

6.1.6.2 Mitigation measures

The measures identified to address soil quality and surface water quality will minimise potential impacts and risks associated with the use of hazardous substances and chemicals. In addition, the following mitigation measures will be implemented:

Site establishment and construction

Nil

Drilling

- Chemicals and potentially hazardous substances will be used and stored according to regulatory requirements including the *Work Health and Safety Act 2011*.
- Any dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008*.

Operation

Nil

6.1.6.3 Impact categorisation

Table 6-6 provides an analysis of the potential impacts from the use of hazardous substances and chemicals.

Table 6-6 Hazardous substances and chemicals impact categorisation

Analysis of impact	Comment
Size	The potential for impacts associated with chemical and hazardous substance use can be appropriately managed with the identified mitigation measures. The volume of lubricants and additives utilised for the proposed drilling and maintenance activities is small and comprise of non-toxic water-based products.
Scope	Use of hazardous substances and chemicals would be generally limited to drilling activities.
Intensity	With the implementation of the proposed mitigation measures, potential impacts would be low and over a relatively short period.
Duration	The proposal is for a temporary duration and all drilling fluids will be removed and disposed of at an appropriately licensed facility at completion of drilling and testing works, minimising the risk for impact.
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period.
Level of reversibility of impacts	It is unlikely that impacts would occur. However in the event that there were any impacts, reversibility and rehabilitation could be low to high depending on the incident that occurred.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.6.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising risk of impact from use of hazardous substances and chemicals and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: Work Health and Safety Act 2011. Dangerous Goods (Road and Rail Transport) Act 2008.
Level of public interest	The level of public interest regarding the use of hazardous substances and chemicals is likely to be moderate to high. The general public maintains an interest in ensuring that the works would not result in adverse impacts on the environment.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact from hazardous substances or chemicals.
Impact category	Based on the analysis of the impact above, the potential for impact upon soil quality and land stability would be negligible to low.

6.1.7 Gaseous, liquid and solid waste and emissions

6.1.7.1 Potential impacts

Generation or disposal of gaseous, liquid or solid wastes or emissions

Waste

The proposed activity will generate a number of waste streams, as identified in section 2.8.1 and Appendix 4 of the REF. Where possible waste will be reduced or recycled with waste separated into bins on the lease area to facilitate transfer to appropriate treatment facilities. Specific reuse activities will be put in place for drilling fluids and cuttings.

Potential impacts associated with the generation and disposal of these wastes include:

- leaching of chemicals and other pollutants into groundwater, soils or surface water
- pollution or contamination of land or water due to inappropriate disposal of waste, lack of suitable containment of waste
- littering of the site, surrounding properties or surface waters due to lack of suitable containment of waste

- odours caused by improper storage or treatment of putrescible waste
- addition to landfill.

It is expected that drill cuttings will consist of excavated natural material and can be used in site rehabilitation under the excavated natural material ENM exemption issued by the EPA on 19 October 2012. Drill cuttings will be tested to determine whether they comply with the *Protection of the Environment Operations Act 1997* and the *Protection of the Environment Operations (Waste) Regulation 2005* and the ENM exemption and whether they can be reused or require off-site disposal.

During operation, saline water abstracted from the aquifer will be captured at the wellhead and transferred through the water capture system to Dewhurst 22. The water will then be stored in a balance tank prior to transfer for treatment.

Emissions

Emissions include greenhouse gasses (GHG) and other pollutants that may impact on localised air quality.

The main air pollutants that impact air quality are associated with vehicle, plant and machinery exhaust emissions impacting on air quality including fine particulates ($PM_{2.5}$), carbon monoxide, oxides of nitrogen, carbon dioxide and hydrocarbons. These pollutants generally dissipate with distance from the source and are unlikely to affect surrounding sensitive receptors given the distance to these receptors.

Scope 1 air emissions (direct GHG) from the proposed activity will include:

- Flaring of coal seam gas.

  Flaring will be the primary source of GHG emissions for the proposed activity. It is estimated that around 90% of the produced CSG will be flared (the remainder will be used for on-site power generation). Flaring of gas will result in a net reduction of the GHG emissions when compared to venting. When the gas is flared methane is consumed in the process resulting in a significantly lower emission than from direct release to the atmosphere (methane has 21 times the global warming potential (GWP) of carbon dioxide). Consistent with Santos' Climate Change Policy, venting and flaring will only be employed where there is no feasible alternative.
- Fugitive emissions associated with the gathering system and drilling activities

  Minor amounts of gas will be lost to the atmosphere during well development and operation, as well as from the gas gathering pipeline network and associated equipment.

  When drilling, venting and flaring may be required when:

  - Disposing of air and any produced CSG (when air drilling)
  - Production testing the well
  - Drill stem testing
  - In an emergency well control situation.

  Venting and flaring rates, durations and volumes can vary significantly and depend on whether the well is drilled with air or mud, the number of gas zones and the distance between the zones. Air drilled holes require flaring once the top gas zone has been penetrated. If mud drilling is adopted, no gas is flared or vented except in an emergency or if gas is unexpectedly produced during drill stem testing. Santos intends to drill all the wells using water based mud which will minimise venting and flaring requirements during this phase of the operation.

  Fugitive emissions have been calculated based on:

  - 1.2×10^{-3} tonnes of carbon dioxide equivalent (CO_2-e) per tonne gas throughput for the gathering

system, in accordance with the *National Greenhouse and Energy Reporting (Measurement) Determination* 2008

- 0.2 tonnes methane (CH_4) / drilling day for mud degassing (converted from 70% methane and accounting for GWP of 21), in accordance with the *API Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry*

These emissions are expected to be incidental however have been included in the estimate for completeness.

- Emissions from on-site power generation

  Some of the produced CSG will be used for electricity generation at the drill sites. This will reduce the sites dependence on diesel fuel for generation, and reduce the amount of gas sent to flare.

- Exhaust emissions from site-based vehicle movements, plant and machinery

  GHG are emitted when fuel is combusted in vehicles, plant and machinery. These emissions are expected to be negligible.

- Clearing of vegetation

  Trees and other vegetation metabolise carbon and store a portion of it as permanent, woody biomass as they grow. When vegetation is cleared the stored carbon is typically lost to the atmosphere as carbon dioxide (CO_2) along with small amounts of carbon monoxide (CO) and CH_4. Vegetation clearing has been minimised where possible as discussed in Section 6.2.

Scope 2 (indirect GHG) emissions will not occur as there will be no purchases of electricity from the grid.

Scope 3 emissions have not been considered at this time.

Table 6-7 provides a summary of estimated emissions. These values have been calculated based on estimated gas flow rates for the first twelve months. The calculation for the flare is based on the design capability of the equipment rather than the expected generated gas levels and is therefore conservative.

Table 6-7 Estimated GHG Emissions

Component	Tonnes / CO_2-e / day
Flare [1]	13.2 – 39.5
Mud degassing [2]	4.3
On-site power generation	1.6 – 4.8
Fugitive emissions	0.02 – 0.05
Plant and equipment	Negligible
Vegetation clearing	Negligible
Maximum	**14.8 – 44.4**

Notes
1. Emissions associated with the flare will not occur until after the gathering system is operational and drilling has finished.
2. per drilling days, up to 40 days

The REF has assessed overall impacts for the proposed activity based on operation for the life of PEL 238. It is however expected that the flare would not operate for the same period in line with Santos policy to pursue no flaring or venting of associated gas unless there are no feasible alternatives.

Emissions will be monitored and reported in accordance with legislative requirements.

The primary risk associated with GHG emissions are their potential contribution to New South Wales and Australian GHG profiles.

Australia's GHG Inventory for 2010 (http://ageis.climatechange.gov.au/) is provided in Table 6-7. The table shows the maximum expected emissions for the proposed activity over a 12 month period. The potential GHG contribution of the proposed activity with regard to Australia's existing GHG profile is very minor, being in the region of 0.0028% and 0.01% of the National and State emissions profiles respectively.

Table 6-8 Comparison to Australian and NSW Emissions

	GHG Emissions (Tonnes CO_2-e)
Australian Emissions (2010)	560,773,000
NSW Emissions (2010)	157,435,000
Maximum Estimated Project Emissions	16,000

Notes
1. based on most conservative estimate of 44.4 tonnes / CO_2-e / day

Other air emission associated with the operation of combustion equipment (such as for the flare and the generation sets), are expected to dissipate with distance from the source. As the closest sensitive receiver is in excess of three kilometres from the proposed activity, impacts are expected to be negligible, with no increased risk to health or amenity.

The flare has been designed to ensure that complete gas combustion occurs, and therefore impacts to air quality are minimised. Bushfire risk is discussed in section 6.3.1.

6.1.7.2 Mitigation measures

The waste management strategy described in section 2.8 will be implemented for the proposed activity. In addition, the following measures will be carried out to minimise waste and potential impacts associated with waste generation and disposal:

Site establishment and construction

- A waste management plan will be prepared prior to construction.
- Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation.
- Appropriate waste receptacles will be provided on site including covered rubbish bins for disposal of domestic wastes. These will remain during drilling activities.

Drilling

- Waste materials will be separated, classified and managed in accordance with the *Waste Classification Guidelines Part 1: Classifying Waste* (DECCW 2009).
- Drilling mud will be managed according to the process described in section 2.8.1.
- All wastes will be removed from the site at the completion of drilling for recycling or disposal at an appropriately licensed facility.
- The type and volume of all waste removed from the site will be recorded.
- Portable toilets will be provided on site and will be regularly serviced by a licensed contractor.
- All staff and contractors will be made aware of waste management procedures during the site induction

- All staff and contractors will be made aware of waste management procedures during the site induction and through toolbox talks.
- Chemical, fuel and oil containers will be managed according to the MSDS or manufacturers' directions to avoid potential impacts to the environment or human health.

Operation

- Produced water will be transferred to an appropriate water treatment facility to be treated for beneficial reuse or disposal.

The following measures will be implemented to minimise impacts on air quality and reduce GHG emissions:

Site establishment and construction and drilling

- All wells to be drilled using water based mud that will minimise venting and flaring requirements
- The area of disturbance will be limited to the minimum required to carry out the proposed activity safely and efficiently.
- Vehicles, plant and equipment will be regularly maintained to ensure they are in good operating condition.
- Vehicles, plant and machinery will be turned off when not in use rather than left idling.
- Use energy efficient equipment and processes where possible

Operation

A portion of the produced CSG will be diverted for on-site power generation, reducing the need to use diesel on the site, and reducing gas to flare.

6.1.7.3 Impact categorisation

Table 6-7 provides an analysis of the potential impacts from the production of gaseous liquids, solid waste and emissions.

Table 6-9 Gaseous, liquid and solid waste and emissions categorisation

Analysis of impact	Comment
Size	Estimated waste – 20 m^3 general waste, 2 m^3/month sewage waste. Following reuse on site, drilling waste transferred to treatment facility 450 m^3. Produced water during operation average 96 ML /yr Emissions – minimal, pollutants generally dissipate with distance from the source and are unlikely to affect surrounding sensitive receptors. Flare designed to ensure that ignition and complete gas combustion occurs. Contribution to state and national GHG emissions approximately 0.0028% and 0.01% respectively
Scope	Waste – localised, waste will be sorted on site and transported to the appropriate facilities for treatment and disposal. Drilling fluid will be separated and reused on site where possible. Emissions - localised, closest sensitive receiver located over 3km from source, Greatest proportion of GHG emissions likely to come from flare at Dewhurst 22.
Intensity	With the implementation of the proposed mitigation measures, potential impacts would be low and over a relatively short period. GHG impacts are longer term however the extent of emissions is relatively small.
Duration	Short / medium term – Flare installed at Dewhurst 22 for the life of the pilot wells, any leakage from the gathering system will be identified immediately and the well shut down. Waste will only be generated during site establishment and drilling activities.

Analysis of impact	Comment
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period.
Level of reversibility of impacts	Low
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.7.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising risk of impact from generation or disposal of gaseous, liquid or solid wastes or emissions and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: POEO Act and POEO (Waste) Regulation. Waste Classification Guidelines Part 1: Classifying Waste (DECCW 2009). National Greenhouse and Energy Reporting Act (2007) (Cth) Other audits of compliance with internal policies and procedures related to GHG reduction through the internal audit program.
Level of public interest	The level of public interest is likely to be moderate to high. The general public maintains an interest in ensuring that the works would not result in adverse impacts on the environment.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact from waste and emissions.
Impact category	Potential impacts associated with gaseous liquids, solid waste and emissions can be appropriately managed with the identified mitigation measures. GHG emissions generated by the proposed activity will not significantly contribute to State or National greenhouse gas emissions given the scale and temporary nature of the proposed activity. A negligible to low adverse impact is expected.

6.1.8 Dust, noise, odours, vibration and radiation

6.1.8.1 Potential impacts

Emission of dust, odours, vibration, or radiation in the proximity of residential/urban area or other sensitive locations

Dust

Dust will be generated during clearing, access track and well lease excavation and drilling and will vary depending on weather conditions.

Excessive dust from the proposed activities could potentially disrupt the pollination cycle and ability of native plants to regenerate (i.e. germination, revegetation and re-colonisation of existing plants).

Odours

Methane (CH_4) in its natural form is odourless. Carbon dioxide (CO_2) in low concentrations is also odourless. No impact is expected.

Vibrations

Vibration from the proposed activity, particularly during earthworks and drilling, would be limited to the site and immediate surrounds. It is not expected that vibration would impact on the nearest residential receivers, located in excess of three kilometres from the activity, or the amenity or structures of surrounding properties.

Radiation

There would not be any radiation generated by the proposed activity.

Emission of noise in the proximity of residential/urban area or other sensitive locations

A Noise Impact Assessment has been undertaken by Noise Measurement Services and is provided in Appendix 5. The key findings are outlined below.

In accordance with the recommendations in the Interim Construction Noise Guidelines (ICNG), the construction activities for mining projects are to be assessed under the *NSW Industrial Noise Policy* (INP) (EPA 2000). Therefore, the operational noise criteria to be achieved are the intrusive noise criterion and sleep disturbance criterion under the INP. This is based on the rating background level plus 5 dB(A). This is LAeq 35 dB(A). The duration of works associated with a well site is up to 40 days, with the greatest noise emissions (drilling) limited to approximately one week.

Table 6-10 summarises the results of noise modelling and expected impacts to sensitive receivers. It indicates that in all scenarios the criteria of less than LAeq 35 dB(A) will be met.

Table 6-10 Summary of predicted noise levels dB(A) (LAeq)

Scenario	Residence 1	Residence 2	Residence 3	Residence 4
Distance from activity[1]	3,370 m	3,430 m	4,070 m	5,730 m
Drilling activity during calm weather	24	23	20	<15
Drilling activity with southerly winds	34	33	30	15
1 well in operation in calm conditions	<15	<15	<15	<15
4 wells in operation in calm conditions	<15	<15	<15	<15
1 well in operation with southerly winds	17	17	<15	<15
4 wells in operation with southerly winds	21	21	18	

Note: Distance to Dewhurst 24

The noise emissions from the operation of the 5 pilot wells together (inclusive of Dewhurst 6), under temperature inversion 'F' conditions, is calculated at approximately 18 dB(A) LAeq, at 5 kilometres from the wells. Level F inversion conditions are typical of rural areas and represents stable atmospheric conditions typically occurring at night.

The drilling stages may be audible at night when the background levels drop to around 20 dB(A). The activity, however, is of short duration and noise mitigation to the mud-pump (the main source of noise) will reduce further any audible sound.

The operation of the pilot wells will not be audible at any of the residences.

It is unlikely that the nearest sensitive receivers will be affected by noise from construction vehicles travelling along the access track, or any access track upgrade works given the distances from these receivers to the site. Notwithstanding, any impacts will be temporary and will be managed through consultation with the landowners as identified in section 2.4.

Noise as a result of vehicles, machinery and drilling may deter native fauna from utilising the study area and immediate surrounding areas as habitat. The proposed activities could affect the migration and dispersal ability of native fauna particularly in relation to vehicular movements. The proposed activities may result in increased noise and light pollution which has the potential to disrupt the breeding cycle and the foraging and roosting behaviour of some native fauna species.

6.1.8.2 Mitigation measures

The following measures will be implemented to reduce the impact of dust:

Duration of project

- Dust will be suppressed as required by spraying water along the access tracks and lease areas.
- If necessary, the access tracks will be sealed to prevent excessive dust emissions.
- Site speed limits will be imposed to minimise dust generated by vehicle movements.

The noise management strategy outlined in section 2.8 will be implemented. Further, the following measures will be implemented to manage potential noise impacts of the proposed activity:

Site establishment and construction

- Consultation with Forestry NSW and the nearest sensitive receivers will be carried out in accordance with section 2.4 of the REF.
- Where noise levels exceed LAeq 35 dB(A), feasible and reasonable work practices will be implemented to achieve the noise affected level. Further noise monitoring will be carried out to determine the effectiveness of mitigation measures.
- In the event of a noise complaint, the effectiveness of noise mitigation measures will be assessed and additional feasible and reasonable measures will be implemented, where necessary.

Drilling

- Prior to arriving on site, source noise levels of the drilling rig will be confirmed to verify noise impacts and confirm the management approach.

Operation

Nil

6.1.8.3 Impact categorisation

Table 6-11 provides an analysis of the potential impacts caused by the generation of dust, noise, odours, vibration and radiation.

Table 6-11 Dust, odours, noise, vibration or radiation categorisation

Analysis of impact	Comment
Size	Dust – dust will occur during site establishment although this is expected to be minimal Noise – generated noise will be within acceptable guidelines (LAeq 35 dB(A))
Scope	Dust will be confined to the access tracks and lease areas proximate to construction activities. Sensitive receivers are located in excess of three kilometres from the nearest well.
Intensity	It is expected that any impacts would be minor and can be mitigated to ensure existing amenity is maintained.
Duration	Short term – noise and dust impacts are greatest during site establishment and drilling.

Analysis of impact	Comment
Level of confidence in predicting impacts	High confidence and knowledge based on Santos' prior experience with similar drilling activities and findings of noise assessment prepared by Noise Measurement Services. Refer to Appendix 5.
Level of reversibility of impacts	There would be no on-going impacts on the amenity of nearby receivers. Therefore, the reversibility of impact is of negligible consequence.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.1.8.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in maintaining the existing amenity of nearby receivers and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: NSW Industrial Noise Policy (INP) (EPA, 2000) Interim Construction Noise Guideline (ICNG) (DECC, 2009).
Level of public interest	The level of public interest regarding dust, noise, odour, vibration and radiation impacts is relatively low. The general public, particularly nearby residences, maintain an interest in ensuring that the works would not result in loss of amenity.
Requirement for further information on the impacts of the activity or mitigation	None
Impact category	Potential impacts associated with noise and vibration can be appropriately managed with the identified mitigation measures. A low adverse impact is expected. Impacts from dust, odour and radiation would be negligible.

6.2 Biological

6.2.1 Potential impacts

An ecological assessment has been undertaken by RPS and is provided in Appendix 7. The key findings are outlined below. The impact of crossing Spring Creek is discussed in section 6.1.2.

Vegetation to be cleared or modified (including vegetation of conservation significance)

Construction activities will require the removal of approximately six hectares of vegetation. This will include the clearing of trees with small hollows, removal of old stockpiles of felled vegetation, and disturbances to understorey vegetation and ground cover such as leaf litter and fallen bark. Table 6-12. summarises vegetation type and amount cleared.

Table 6-12 Summary of vegetation removal

Vegetation community	Clearing required (ha)[1]	Area in the immediate vicinity (ha)[1,2]	% of community removed [3]	Habitat associated threatened species [4]
Narrow leaved ironbark woodland	4.96	370	1.3	Grey-crowned babbler, hooded robin, turquoise parrot, speckled warbler
Riparian woodland	1.02	75	1.4	Pilliga mouse, Grey-crowned babbler, hooded robin, turquoise parrot, speckled warbler
Heath	0	80	0	Pilliga mouse, grey-crowned babbler, hooded robin, turquoise parrot, speckled warbler
Total	**5.98**			

Notes:
1. Values are approximate only.
2. Overall Community refers to the total area of each community within the study area defined in the ecological assessment (Appendix 7)
3. % of community removed refers to clearing undertaken in comparison to overall community in the study area
4. Only species recorded in the study area are included

A range of short-term impacts may result from the proposed activity as a result of vegetation removal, topsoil disturbance and other construction activities. However these impacts will be temporary and relatively minor. The site is located within an area that has been disturbed by land management practices associated with forestry, historical clearing and damage from pigs, but is in generally good ecological condition.

Some hollow bearing trees will be removed as a result of the proposed activity. These trees provide viable nesting, roosting and/or breeding resources for native birds, arboreal mammals and some reptile species. They provide breeding habitat for a range of threatened species that are known, or potentially occur in the study area, including Little Lorikeet, Masked Owl, South-eastern Long-eared Bat, and Turquoise Parrot.

However, the remainder of the broader area provides an abundance of hollow bearing trees that contain viable nesting, roosting and/or breeding resources. The potential removal of hollow bearing trees is not considered to be significant as it is considered unlikely that hollow dependant fauna will be adversely impacted by the proposed activities and should be able to relocate successfully into hollow bearing resources that are present throughout the adjacent habitats.

There will be a temporary disruption of nesting, breeding and/or sheltering behaviour of some reptiles and ground dwelling mammals, however, the disruption is likely to be minimal in extent and these habitat resources will be relocated to adjacent habitats within the broader area.

Likely effect on threatened flora or fauna species, populations, or their habitats, or critical habitat; or an endangered ecological community or its habitat.

Threatened flora and fauna species (impacts under the TSC Act)

Section 5A of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of proposed activities on 'threatened species, populations or ecological communities (or their habitats)' listed under the TSC Act. The Assessment of Significance (7-part test) (AOS) is used to determine whether there is likely to be a significant effect on threatened species, populations or ecological communities, or their habitats and thus whether a SIS is required.

Assessment of significance were completed for the threatened species populations and ecological communities that are known to occur, or considered likely to occur within the study area. A total of 18 AOS were undertaken for ten birds, seven mammals, and one reptile.

The application of the 7-part tests concluded that there is not likely to be a significant effect on threatened species, populations, or their habitats arising from the proposed activities. Table 6-13 provides a summary of assessment of significance of potential impacts.

Table 6-13 Summary of Assessment of Significance for TSC Act listed species

Species	Common Name	TSC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
Fauna species recorded in the study area				
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	▪ Loss of habitat ▪ Modification to ground habitat	Significant impact unlikely
Neophema pulchella	Turquoise Parrot	V	▪ Loss of habitat, particularly hollow bearing trees and ground covers ▪ Potential for increased predation	Significant impact unlikely
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	▪ Loss of woodland habitat ▪ Disturbance to movement patterns as they are unable to cross open areas ▪ Disturbance or removal of nests	Significant impact unlikely
Pseudomys pilligaensis	Pilliga Mouse	V	▪ Disturbances due to noise and light ▪ Disturbances throughout clearing activities	Significant impact unlikely.
Pyrrholaemus sagittatus	Speckled Warbler	V	▪ Loss of woodland habitat, particularly understorey vegetation ▪ Disturbances to nests, often located on the ground ▪ Potential for increased predation of nest sites	Significant impact unlikely
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	▪ Loss of woodland habitat ▪ Loss of roosting sites	Significant impact unlikely
Fauna species considered likely to occur				
Anthochaera phrygia/ Xanthomyza phrygia	Regent Honeyeater	CE	▪ Loss of woodland habitat and flowering Eucalypts ▪ Disturbances due to noise and light	Significant impact unlikely
Cercartetus nanus	Eastern Pygmy-possum	V	▪ Loss of habitat ▪ Loss of hollow-bearing trees ▪ Disturbances due to noise and light	Significant impact unlikely
Chalinolobus picatus	Little Pied Bat	V	▪ Loss of woodland habitat ▪ Loss of roosting sites	Significant impact unlikely

Species	Common Name	TSC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	▪ Loss of woodland habitat ▪ Disturbances to fallen timber ▪ Loss of hollow-bearing trees required for nesting	Significant impact unlikely
Daphoenositta chrysoptera	Varied Sittella	V	▪ Loss of habitat ▪ Disturbances to nests	Significant impact unlikely
Glossopsitta pusilla	Little Lorikeet	V	▪ Loss of habitat, particularly riparian habitat ▪ Loss of hollow-bearing trees ▪ Loss of flowering Eucalypts	Significant impact unlikely
Macropus dorsalis	Black-striped Wallaby	E	▪ Loss of dense woody or shrubby habitat ▪ Vehicle strike	Significant impact unlikely
Ninox connivens	Barking Owl	V	▪ Loss of habitat ▪ Loss of nesting sites (hollow-bearing trees)	Significant impact unlikely
Nyctophilus corbeni	South-eastern Long-eared Bat, Corben's Long-eared Bat	V	▪ Loss of woodland habitat and hollow-bearing trees ▪ Disturbances due to noise and light	Significant impact unlikely
Phascolarctos cinereus	Koala	E	▪ Loss of secondary food trees ▪ Vehicle strike ▪ Disturbances due to noise and light	Significant impact unlikely
Tyto novaehollandiae	Masked Owl	E	▪ Loss of habitat ▪ Loss of nesting sites (hollow-bearing trees) ▪ Vehicle strikes	Significant impact unlikely
Hoplocephalus bitorquatus	Pale-headed Snake	V	▪ Loss of habitat, particularly riparian vegetation ▪ Removal of loose-barked trees ▪ Vehicle strike	Significant impact unlikely

Threatened flora and fauna species (impacts under the EPBC Act)

While no listed flora species were recorded in the study area, five species have the potential to occur based on habitat available. An assessment of significance was not considered necessary, as targeted searches for these flora species did not record these species within the study area, and an initial assessment of potential for impact determined that significant impacts are considered unlikely.

One vulnerable fauna species, the Pilliga Mouse, was recorded in the study area. While no additional threatened fauna species were recorded in the study area, it is considered possible that a further three bird species, four mammal species and one reptile species occur. An assessment of significance for each of the fauna species whose occurrence is considered to be 'likely' has been undertaken in accordance with the EPBC Act and *EPBC Act Policy Statement 1.1 - Significant Impact Guidelines Matters of National Environmental Significance* (DEWHA, 2009). Table 6-14 provides a summary of the significant impact assessments.

Table 6-14 Summary of EPBC Act Impact Assessment for Threatened Fauna Species

Species	Common Name	EPBC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
Recorded in the Study Area				
Pseudomys pilligaensis	Pilliga Mouse	V	▪ Disturbances due to noise and light ▪ Disturbances throughout clearing activities	Significant impact unlikely
Considered to Likely Occur				
Xanthomyza phrygia	Regent Honeyeater	E	▪ Loss of woodland habitat and flowering Eucalypts ▪ Disturbances due to noise and light	Significant impact unlikely
Phascolarctos cinereus	Koala	V	▪ Loss of secondary food trees ▪ Vehicle strike ▪ Disturbances due to noise and light	Significant impact unlikely
Nyctophilus corbeni	South-eastern Long-eared Bat, Corben's Long-eared Bat	V	▪ Loss of woodland habitat and hollow-bearing trees ▪ Disturbances due to noise and light	Significant impact unlikely

Notwithstanding a significant impact is unlikely, given the presence of pilliga mouse, Santos is preparing a referral to the Commonwealth Minister and will lodge this prior to Resources Minster's determination of the proposed activity.

Key threatening process

The EPBC Act and TSC Act provide for the identification and listing of key threatening processes (KTP). KTP are defined as a threatening process 'if it threatens or may threaten the survival, abundance, or evolutionary development of a native species or ecological community' (SEWPaC, 2012).

KTP under the EPBC Act and TSC Act that are relevant to the proposed activities are discussed in Table 6-15.

Table 6-15 Summary of key threatening processes

Key threatening process	Relevance to proposed activity
EPBC Act / TSC Act	
Competition and land degradation by feral European Rabbits	While Rabbits were observed within the study area, it is not anticipated that the proposed activities will increase opportunities for increase to the Rabbit population.
Competition and land degradation by unmanaged goats	While goats were observed within the study area, it is not anticipated that the proposed activities will result in an increase in population. Mitigation measures may be required at the completion of the project to ensure rehabilitation activities are not disturbed by unmanaged goats
Dieback caused by the root-rot fungus (Phytophthora cinnamomi)	There exists the potential for the importation of this pathogen on unclean vehicles and plant machinery.
Land clearance / removal of native vegetation	Vegetation clearing will be required. Approximately 6 ha of vegetation will be removed to facilitate the construction of four wells and associated access tracks.
Predation by European Red Fox	Red fox were observed in the study area. It is considered unlikely that the proposed activities will result in increased predation by European Red Fox, given the relatively limited amount of clearing proposed, in comparison to habitat available in the surrounding areas.
Predation by feral cats	Feral cats were not observed in the study area, but are considered likely to occur. If waste is not managed on site, there is the potential for an increase in the feral cat population.
Predation, habitat degradation, competition and disease transmission by feral Pigs	Evidence of feral pigs was observed in the study area. It is considered unlikely that the proposed activities will result in increased predation, habitat degradation, and competition or disease transmission.
TSC Act	
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	The proposed activity will not result in high frequency fires. Fire prevention strategies will be outlined in the REF.
Removal of dead wood and dead trees	Some dead wood in the form of hollow logs and fallen woody debris will be disturbed by the proposed activities, but these habitat resources will be relocated elsewhere in the study area.
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	Some disturbance is proposed to a creek located to the south of Dewhurst 24. To ensure no alteration to natural flow regimes, works will be undertaken to prevent erosion of banks, and timed to correspond with the dry season. Refer to the REF.
Predation and hybridisation by feral dogs, (Canis lupus familiaris)	Feral dogs were not observed in the study area, but are considered likely to occur. It is considered unlikely that the proposed activities will result in increased predation from feral dogs.
Loss of hollow-bearing trees	Hollow-bearing trees will be removed to facilitate construction. Where hollow-bearing trees occur adjacent to leases, they will be retained. The hollow bearing trees to be removed will be placed into adjacent habitats as hollow logs and woody debris.
Invasion of native plant communities by exotic perennial grasses	There exists the potential for the invasion of native woodland and grassland communities by exotic perennial grass species, transferred via vehicles and site machinery.

Potential to endanger, displace or disturb fauna (including fauna of conservation significance) or create a barrier to their movement?

The proposed activity will result in the clearing of viable habitat from the affected area (lease area, access track and gathering system). This habitat provides foraging, breeding, roosting and sheltering resources that may currently be utilised by all the faunal groups identified in the study area. This will result in the displacement of native fauna across the study area. Displaced fauna will need to relocate into adjacent habitats, which will place short-term pressure on the available resources within these habitats.

The degree of displacement within the study area and the intensity of pressure placed on adjacent habitats are minimal based on the percentage of habitats to be lost in comparison to what will be retained in the study area.

The impact on the migration and dispersal ability of native flora and fauna, like most of the other impacts, is species specific. Species, which are less mobile (e.g. reptiles and amphibians), residents (e.g. some birds) or species whereby the habitat to be removed forms an important component of the overall habitat area, are those that will be most likely impacted.

The proposed activity is unlikely to fragment or isolate areas of vegetation or impose a significant barrier to the migration and dispersal ability of native biota. Mobile species such as microbats, medium to large mammals and woodland birds will not be impacted by the proposed activities.

The less mobile smaller species are also unlikely to be significantly impacted, as the area/ extent of habitats to be cleared is small in comparison to the area of habitats to be retained across the study area.

Likely impact on an ecological community of conservation significance

Three vegetation communities occur within the study area. Narrow-leaved Shrubby Ironbark Woodland is the dominant community within the study area with Heath and Riparian Woodland also occurring. None of these communities are commensurate with any of the seven TECs or nine EECs that were identified during the desktop assessment.

Therefore any impact on an ecological community of conservation significance is considered unlikely.

Likely threat to the biological diversity or ecological integrity of an ecological community

Impacts to biological diversity are negligible as the area impact is relatively small, the activity is temporary in nature and edge effects and severance of fauna corridors will not occur.

Likely introduction of noxious weeds, vermin, feral species or genetically modified organisms into an area

The proposed activity has the potential to introduce weeds to the site or spread existing weeds throughout the site or surrounding area. Soil, seed or vegetation attached to plant, machinery, vehicles or personnel may transfer weeds to or from the site. Activities such as clearing and earthworks may create favourable conditions for weeds and encourage weed growth. Weed cover within the impacted area is very low with only one noxious weed (prickly pear) observed in very low densities.

6.2.2 Mitigation measures

The site will be rehabilitated in accordance with section 2.7.9 of the REF. In addition, the following measures will be implemented to minimise impacts on flora and fauna:

Site establishment and construction

- Clearing of habitat trees will be avoided where possible
- Disturbance areas will be minimised where possible during the design process
- While clearing or disturbance to vegetation occurs, a fauna spotter/catcher will be on site to supervise works
- 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. Fauna sensitive clearing techniques will be implemented, including vibrating the bucket on large trees (particularly hollow-bearing trees) prior to clearing, and dismantling large trees
- The site boundary will be clearly demarcated to ensure that plant and vehicles keep within the approved area of disturbance.
- Plant and machinery will be cleaned of any soil, seed and vegetation prior to being transported to the site in accordance with legislative requirements.
- Prior to earthworks, noxious weeds present on the site will be removed or treated with herbicide to help prevent or reduce their spread.
- Clearing will commence in areas of low weed infestation and move towards area of high weed infestation where practicable.
- Weed monitoring will occur throughout site preparation, drilling, completion and rehabilitation activities. Weed removal will be carried out as necessary.
- Cleared weed species will be stockpiled separately and removed off site. Weed material will not be re-used during site rehabilitation.
- In the event that the proposed activity needs to extend outside the site, a qualified ecologist will undertake further inspection.

Drilling

Nil

Operation

- The site will be rehabilitated in accordance with section 2.7.9 of the REF.

6.2.2.1 Impact categorisation

Table 6-16 provides an analysis of the potential biological impacts.

Table 6-16 Biological impacts categorisation

Analysis of impact	Comment
Size	Approximately six hectares will be cleared. Four EPBC listed and 18 TSC listed fauna species are either known or considered likely to occur on site but with a significant impact considered unlikely. There are no threatened flora species that are known or considered likely to occur.
Scope	Localised - impacts are confined to the local area. It is expected that all affected species will relocate to adjacent vegetated areas. Any hollow logs will also be relocated.
Intensity	Small - any impacts will be small and short term. The area impacted is proportionally small.
Duration	Medium term. Areas will require clearing however following completion of works the area will be rehabilitated. Partial rehabilitation will occur as soon as practically possible. For Dewhurst 23, 24 and 25 this will occur at the completion of drilling with all remaining well set surface facilities located at Dewhurst 22.
Level of confidence in predicting impacts	High. An ecological assessment has been undertaken by appropriately qualified ecologists.
Level of reversibility of impacts	High, impacts will be minimal with mitigation measures implemented. Any affected fauna will be relocated to adjacent areas. Partial rehabilitation will occur.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.2.2 have been developed based on Santos' prior experience with similar activities and recommendations of the ecological assessment. These measures would be effective in minimising biological impacts and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	With the implementation of the proposed mitigation measures, the proposed activity would comply with all relevant standards, plans or policies.
Level of public interest	High, a number of environmental stakeholders have raised impacts to flora and fauna as a key issue.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted biological impacts.
Impact category	Based on the analysis of the impact above, the potential for biological impacts would be low to medium adverse.

6.3 Community

6.3.1 Potential Impacts

Likely effect on existing community services or infrastructure

The proposed activity is unlikely to significantly impact on any community services and infrastructure.

Contractors and employees required for the proposed activity may be sourced from outside the local area and are likely to be housed in purpose built temporary accommodation camps (DA 457/2013) located at 1919 Westport Road. There may be some required accommodation in Narrabri or other surrounding areas although this would be minimal.

As the number of workers is relatively small (around 40 at its peak) social infrastructure in the local towns is also expected to accommodate the temporary workforce.

Traffic volumes will increase on Monument Road and the northern part of Yellow Springs Trail, particularly during site establishment and drilling however these roads are not heavily utilised by the local community and there are no local residents with frontage to the roads.

During operation, the well sites will be visited daily. Although not intended, in the event that the proposed water flow lines are not operational, traffic will also be generated to remove produced water from the site. In this scenario, approximately 12 trucks per day would be expected to visit the Dewhurst 22 lease area.

Movements associated with operations (inclusive of trucks) will easily be accommodated within the existing infrastructure.

The proposed activity will not impact on any water supply services, travelling stock routes, processing facilities, or railways required for agricultural enterprises.

Effect on sites of importance to the local or broader community for their recreational or other values or access to these sites

There are no sites of community importance located in the vicinity of the activity.

Lease areas will be fenced during site establishment, drilling and operations reducing access to some parts of the Pilliga Forest although this represents less than 0.0025 per cent of the available Forest.

Likely effect on economic factors

The proposed activity will provide economic benefits for Narrabri and the surrounding region through the introduction of a temporary workforce, potential increase in demand for accommodation in Narrabri or other surrounding areas, and purchasing of material supplies which could provide economic benefits to flow-on businesses.

No existing agricultural jobs will be lost as a direct result on the proposed activity, nor will the proposed activity result in a loss of agricultural employment opportunities in the Narrabri Shire region. Therefore, the proposed activities will not result in a loss of agricultural employment opportunities on the site or in the Narrabri Shire LGA.

The exploration and development of gas reserves will have significant wider economic benefits to the NSW economy and is encouraged through policy guidance. The development of pilot wells is essential in determining the nature and composition of the Narrabri gas field and to inform future production.

Likely impact on the safety of the community

Minor increases in traffic will occur along Monument Road and the surrounding road network, particularly during site preparation and drilling. This traffic will be unlikely to result in road safety issues.

The proposed activity will introduce a potential hazard to the site, such as moving vehicles, plant and machinery, and chemicals, fuels and oils. This could have safety implications for Forestry NSW or neighbours.

Overall, the potential impacts from hazards are considered to be low.

Potential to cause a bushfire risk

Fire plays a major role in the ecology of the Pilliga scrub, with many plant species depending on fire to regenerate. However in unfavourable conditions fire can be extremely intense, destroy entire ecosystems, spread very quickly and threaten nearby properties. The magnitude of historical Pilliga bushfires correlates with the El Nino Southern Oscillation phenomena, with El Nino (dry) years having the most severe fires (NPWS 2006). In 1997 a major fire burned almost half the Pilliga scrub, while an extremely dry winter and spring in 2006 saw a number of large fires develop. More recently, there were large fires in early 2013.

Bushfire needs to be considered from two perspectives:

- the management activities required should a fire occur
- the risk that the proposed activity contributes to the lighting of a fire due to the presence of flammable substances and potential for accidental ignition by vehicles or machinery.

In the event of a bushfire, all activities will cease, wells will be capped (during drilling) or shut in remotely during operation. This includes the wells, flare and gathering system. A bushfire management plan will be prepared prior to operation.

The flare located at Dewhurst 22 is designed to limit the risk of ignition. Acceptable radiation limits for various locations at the flare site were determined based on the American Petroleum Industry (API) 521 standard and AS 60079.10.1 - Classification of Areas – Explosive Gas Atmospheres.

Within the sterile zone, a HDPE liner will be laid covered with 300 millimetres of compacted soil and blue metal aggregate. This will ensure protection against heat and minimise the risk of ignition.

Likely impacts on the visual or scenic landscape

The site is not visible from private landholder properties adjacent to the State Forest. The presence of plant, equipment and stockpiles during the proposed activity will result in visual clutter in the immediate area and may detract from the scenic qualities of the area for vehicles that happen to use Monument Road. During operation the well heads and related surface infrastructure may also be visible from Monument Road but will appear similar to other existing wells in the area.

The flare will not be visible from any sensitive recievers.

6.3.2 Mitigation measures

6.3.2.1 Mitigation measures

The consultation activities outlined in section 2.4 of the REF will be implemented. The site will be rehabilitated in accordance with section 2.7.9 of the REF. Further, the following measures will be implemented to reduce community impacts:

Duration of the project

- Works will be conducted in accordance with landowner requirements as outlined in the Occupation Permit under the *Forestry Act 2012.*

Site establishment and construction

- Site safety protocols, incident management and emergency procedures will be implemented during the construction and drilling works.
- The site will be kept in a clean and tidy manner during site preparation, drilling activities and operation of

the pilot wells.

Operation

- All new access tracks will be retained for the ongoing use of Forestry NSW.
- The lease areas will be fenced and within Dewhurst 22, the flare will have a secondary 1.8 metre high fence.
- A bushfire management plan will be developed prior to construction
- A fire risk management plan will be developed prior to construction
- Hazard classification mapping will be updated prior to commencement of construction

6.3.2.2 Impact categorisation

Table 6-17 provides an analysis of the potential impacts on the community.

Table 6-17 Community impacts categorisation

Analysis of impact	Comment
Size	The impact will be minimal, the temporary workforce is small and will be accommodated within existing social infrastructure. Risks to safety including bushfire will be minimised through design.
Scope	Localised - impacts are confined to the local area Extensive - The proposed activity contributes to the evaluation of gas reserves and the long-term economic benefits to the local and NSW economy.
Intensity	Small - any impacts will be small and short term
Duration	Short term – the workforce is greatest during site establishment and drilling. During operation, the proposed activity will be visited daily generating one vehicle movement.
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period.
Level of reversibility of impacts	There would be no on-going impacts on the community. Therefore, the reversibility of impact is of negligible consequence.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.3.2 have been developed based on Santos' prior experience with similar activities. These measures would be effective in minimising risk of impact to the community and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: American Petroleum Industry (API) 521 AS 60079.10.1 - Classification of Areas – Explosive Gas Atmospheres Other standards as outlined in Table 2-15.
Level of public interest	The level of public interest regarding impacts on the community is low to moderate. The general public maintains an interest in ensuring that the works would not result in adverse impacts on the environment or the community.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact on the community.
Impact category	Potential impacts to community services, infrastructure or sites of importance are considered to be negligible. The proposed activity will result in economic benefits to the wider community. With the implementation of mitigation measures, potential amenity and public safety impacts will be negligible.

6.4 Natural resources

6.4.1 Potential Impacts

Potential to result in the degradation of an area reserved for conservation purposes

The proposed activity does not impact on any conservation zones. Works will be undertaken within the Pilliga East State Forest. The impact of this has been considered in biological impacts (Section 6.2) and community uses (Section 6.3).

Likely effect on the use of, or the community's ability to use, natural resources

There would be minimal effect on the community's ability to use natural resources.

The proposed activity will temporarily prohibit conservation and forestry activities on up to approximately 6.29 hectares during site establishment and drilling and less than 1.98 hectares during operation within the Pilliga East State Forest. This represents a small portion of the total size of this State Forest (160,000 hectares).

The proposed activity will not impact on any biophysical SAL or Critical Industry Clusters (CIC) defined under the SRLUP. An Agricultural Impact Statement (AIS) has been prepared for the proposed activity and is included in Appendix 6.

As the proposed activity lies within a State Forest, it will not prohibit any agricultural production within the region, nor will any permanent land capability reduction of agricultural resources occur. It will also not impact on any transport infrastructure, water supply services or processing facilities required for agricultural enterprises.

Therefore, the proposed activity will not significantly affect the use of, or the community's ability to use, agricultural resources and production within neighbouring properties or the Narrabri Shire LGA as a whole.

The site is not located within a drinking water catchment however surface water would filter to groundwater which may be used for drinking water in the surrounding areas. The project will be managed to ensure that there are no impacts on groundwater used for drinking water.

Use, wastage, destruction or depletion of natural resources including water, fuels, timber, or extractive materials?

The proposed activity will not impact on existing coal mining operations. There is no known coal mines planned for the site. The pilot wells will pose no threat to future coal mining operations.

As discussed in sections 6.1.1, 6.1.2 and 6.1.3, the proposed activity has the potential to impact on soils, and surface and groundwater sources. None of these impacts are expected to have consequences for agricultural enterprises reliant on these resources. The proposed activity may also contribute to the spread of weeds or plant and soil diseases, particularly *Phytopthora.* These potential impacts will be managed through the measures identified in this REF.

Natural resources required for the proposed activity include fill material to build the lease area at Dewhurst 25 (approximately 50 cubic metres) and diesel and petroleum fuels for operation of plant and machinery. Fill will be sourced from a local licensed quarry. Quantities of fuel (both diesel and petroleum) for operation of plant and machinery will not be significant.

6.4.2 Mitigation measures

The following measures will be implemented to minimise potential impacts on natural resources:

Duration of the project

- All plant and machinery delivered to the site will be cleaned of foreign soil in accordance with legislative requirements with respect to weed management.

Site establishment and construction

- Construction personnel will be trained in pest control and hygiene procedures.

Drilling

- Fuel will be used as efficiently as possible through appropriate work behaviour (e.g. switching off equipment when not in use).
- The well will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity*.

Operation

- nil

6.4.2.1 Impact categorisation

Table 6-18 provides an analysis of the potential impacts on natural resources.

Table 6-18 Natural resources impact categorisation

Analysis of impact	Comment
Size	The impact will be minimal, approximately 6.29 hectares of Pilliga East State Forest will be impacted during site establishment and drilling reducing to less than 1.98 hectares during operation. There will be no impact on agricultural land.
Scope	Localised - impacts are confined to the local area
Intensity	Small - any impacts will be small and short term
Duration	Short term – Natural resources will be impacted mostly during site establishment and drilling (up to 40 days). Following the initial activities, the site will be rehabilitated in accordance with the agreement between Santos and Forestry NSW.
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period and the findings of the Agricultural Impact Statement at Appendix 6.
Level of reversibility of impacts	There would be no on-going impacts on natural resources. Therefore, the reversibility of impact is of negligible consequence.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.4.2 have been developed based on Santos' prior experience with similar activities and the findings from the Agricultural Impact Statement. These measures would be effective in minimising potential impact on natural resources and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	The following standards, plans and policies will be adhered to: NSW Coal Seam Gas Code of Practice Well Integrity.
Level of public interest	High, impacts to the Pilliga East State Forest have been an area of concern for the community
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of impact on the community.

Analysis of impact	Comment
Impact category	In the context of the total conservation area within the region, the temporary and minor loss of available land for conservation is considered to be negligible with the implementation of mitigation measures. Potential impacts on agricultural and natural resources will be negligible.

6.5 Aboriginal cultural heritage

6.5.1 Potential impacts

Disturbance of ground surface or culturally modified trees

Up to approximately 6.29 hectares of ground surface would be disturbed.

No culturally modified trees were identified on site during the archaeological survey. It is considered unlikely that any will be located during the works due to past disturbance of the site.

Known aboriginal objects or places

No aboriginal objects or sites were identified on site during the archaeological survey. It is considered unlikely that any will be located during the works due to past disturbance of the site. Specific mitigation measures will be carried out to limit potential impacts on any unknown Aboriginal sites or objects.

Landscape features

According to the *2010 Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* (DECCW 2010) the site possesses sensitive landscape features, as the proposed activity occurs within 200 metres of waters. These sensitive landscape features may indicate the presence of Aboriginal objects. Although a number of creek lines run within close proximity to the Dewhurst 22-25 lease areas, these are located outside of the lease area boundaries. Spring Creek, which the Dewhurst 24 access track crosses, is considered to be a sensitive landscape feature; however upon inspection it did not contain any evidence of Aboriginal objects or sites.

The site is located within the vicinity of a number of predominantly ephemeral creek lines. However given previous land disturbance and the distance from larger, more permanent water sources, it is reasonable to conclude, in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010*, that there are no known Aboriginal objects or a low probability of objects occurring at the site, and thus unlikely that harm will occur to Aboriginal objects.

Avoidance opportunities

No avoidance opportunities are possible.

Native title and other agreements

See section 4.5.

6.5.2 Mitigation measures

The following measures will be implemented to reduce potential impacts on Aboriginal heritage:

Site establishment, construction and drilling

- Project staff and contractors will be made aware of their statutory obligations to protect under the NPW Act and the Heritage Act, through the site induction and toolbox talks.
- Where practicable, vegetation will be cut rather than bulldozed to reduce disturbance to the ground surface.
- All works will be undertaken to comply with Part 6 of the NPW Act.
- If any previously unidentified Aboriginal sites are identified during works, then works in the immediate area will cease, the area will be cordoned off and the OEH Enviroline 131 555 will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed managed.
- In the event that skeletal remains are uncovered, then works in the immediate area will cease, the area will be cordoned off and the NSW Police Coroner will be contacted to determine if the material is of Aboriginal origin. If determined to be Aboriginal, the OEH Enviroline 131 555 and relevant Aboriginal stakeholders will be contacted to determine an action plan for the management of the skeletal remains prior to works re-commencing.
- In the event that the proposed activity needs to extend outside the site, a qualified archaeologist will undertake further inspection.

Operation

Nil

6.5.2.1 Impact categorisation

Table 6-19 provides an analysis of the potential impacts on Aboriginal cultural heritage.

Table 6-19 Aboriginal cultural heritage impact categorisation

Analysis of impact	Comment
Size	Small - no cultural objects, sites or landscapes identified within the site
Scope	Localised - small area of ground disturbance at each well
Intensity	Activity is low impact over a short duration. Area of impact is relatively small.
Duration	Short term, potential impacts will only occur during site establishment or initial drilling.
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period and the findings of the Aboriginal and European Cultural Heritage Due Diligence Assessment at Appendix 8.
Level of reversibility of impacts	Low, if a site is disturbed or artefact destroyed impact is not reversible however site has been identified as low risk of finding any unidentified sites or objects.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.5.2 have been developed based on Santos' prior experience with similar activities and the findings from the Aboriginal and European Cultural Heritage Due Diligence Assessment. These measures would be effective in minimising potential impact on natural resources and have been included within the statement of commitments for the proposed activity at section 9.0.
Ability of the impacts to comply with standards, plans or policies	Mitigation measures include training on statutory obligations under NPW Act and the Heritage Act
Level of public interest	The level of public interest regarding Aboriginal cultural heritage is moderate. The general public maintains an interest in ensuring that the works would not result in adverse impacts on Aboriginal cultural heritage.

Analysis of impact	Comment
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of Aboriginal cultural heritage impact.
Impact category	Provided the identified mitigation measures are carried out, potential impacts on Aboriginal cultural heritage will be negligible

6.6 European cultural heritage impacts

6.6.1 Potential impacts

The proposed activity will not impact on any known European cultural heritage items or places. There is potential for relics or other items of European heritage value to be uncovered during clearing and excavation works although this is very unlikely.

Impact on places, buildings, landscapes or moveable historic heritage items

No places, buildings, landscapes or moveable items will be affected.

Likely effect on vegetation of cultural landscape value to be affected (e.g. gardens and settings, introduced exotic species, or evidence of broader remnant land uses)

No vegetation of cultural landscape value will be affected.

6.6.2 Mitigation measures

If any previously unidentified potential European cultural heritage material is identified during construction or drilling, then works in the immediate area will cease, the area will be cordoned off and the OEH Heritage Branch will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed and managed.

6.6.2.1 Impact categorisation

Table 6-20 provides an analysis of the potential impacts on European cultural heritage.

Table 6-20 European cultural heritage impact categorisation

Analysis of impact	Comment
Size	Small - no places, buildings, moveable items, vegetation or landscapes identified within the site
Scope	Localised - small area of ground disturbance at each well
Intensity	Activity is low impact over a short duration. Area of impact is relatively small.
Duration	Short term, potential impacts will only occur during site establishment or initial drilling.
Level of confidence in predicting impacts	High confidence and knowledge based on previous exploration activities, including drilling activities, undertaken by Santos over a 50 year period and the findings of the Aboriginal and European Cultural Heritage Due Diligence Assessment at Appendix 8.
Level of reversibility of impacts	Low, if a site is disturbed or artefact destroyed impact is not reversible however site has been identified as low risk of finding any unidentified sites or objects.
Ability to manage or mitigate the impacts	The proposed mitigation measures at section 6.6.2 have been developed based on Santos' prior experience with similar activities and the findings from the Aboriginal and European Cultural Heritage Due Diligence Assessment. These measures would be effective in minimising potential impact on natural resources and have been included within the statement of commitments for the proposed activity at section 9.0.

Analysis of impact	Comment
Ability of the impacts to comply with standards, plans or policies	Mitigation measures include training on statutory obligations under NPW Act and the Heritage Act
Level of public interest	The level of public interest regarding European cultural heritage is low to moderate. The general public maintains an interest in ensuring that the works would not result in adverse impacts on European cultural heritage.
Requirement for further information on the impacts of the activity or mitigation	No additional information is required to confirm the predicted level of European cultural heritage impact.
Impact category	Provided the identified mitigation measures are carried out, potential impacts on European cultural heritage will be negligible

6.7 Matters of National Environmental Significance

The proposed activity will impact MNES as detailed in Table 6-21.

Table 6-21 Matters of National Environmental Significance

MNES	Overview
World Heritage Properties	The proposed activity is not located in or within close proximity to a World Heritage area.
National Heritage Places	The proposed activity is not located in close proximity to a National Heritage Place.
Wetlands protected by international treaty (the RAMSAR convention)	The proposed activity is not located within or upstream of a RAMSAR listed wetland area.
Nationally listed threatened species and ecological communities:	Five Threatened Ecological Communities (TEC) listed under the EPBC Act were identified as potentially occurring within the locality of the study area although none were identified during the field survey. The TEC's include: ▪ Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions ▪ Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia ▪ Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland ▪ Weeping Myall Woodlands ▪ White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands. Additionally, two EEC's listed under the TSC Act are known to occur and have equivalent TEC listing under the EPBC act. These include: ▪ Brigalow (Acacia harpophylla dominant and co-dominant) ▪ Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions. The Rough-barked Apple Riparian Woodland can be commensurate with the White Box – Yellow Box – Blakely's Red Gum Grassy Woodland TEC. However, as Blakely's Red Gum does not dominate or co-dominate this community, and a shrub layer with a cover of greater than 30 per cent occurs, it is not considered to be a TEC under the EPBC Act. No listed flora species were recorded in the study area, however five species have the potential to occur based on habitat available. An assessment of significance was not considered necessary, as targeted searches for these flora species did not record these species within the study area, and an initial assessment of potential for impact determined that significant impacts are considered unlikely. One vulnerable fauna species, Pilliga mouse was recorded in the study area. While no additional threatened fauna species were recorded in the study area, it is considered possible that a further three bird species, four mammal species and one reptile species could occur. The assessment concluded that no significant impact is anticipated. A referral to the Commonwealth Minister is under preparation.

MNES	Overview
Migratory species	Three migratory bird species listed under the EPBC Act were identified having the potential to occur on site including the rainbow bee-eater, white throated needle tail and regent honeyeater. The regent honey eater was also assessed under threatened fauna species as having a significant impact but unlikely. The remaining two species were initially considered however impacts were considered unlikely.
Commonwealth marine areas	The proposed activity will not impact any Commonwealth marine areas.
Great Barrier Reef Marine Park	The proposed activity will not impact the Great Barrier Reef Marine Park.
All nuclear actions	The proposed activity does not involve a nuclear activity.

6.8 Cumulative impacts

6.8.1 Potential impacts

The Narrabri Shire is recognised for its coal seam gas and mining resources. A number of mining exploration and production licences cover the area.

Existing mining occurs at the Whitehaven coal mine approximately 28 kilometres south of Narrabri and Boggabri Coal mine, approximately 15 kilometres north of Boggabri. The Whitehaven coal mine has commenced an approval process to support a 20 year mine life with a production of three million tonnes per annum. Expansion plans for both mines include a rail spur and coal handling facility. These will not impact the proposed activity.

A number of existing exploration and production wells are located within PEL 238, PAL 2 and PPL 3. These are in varying stages with some active, some suspended and others abandoned and rehabilitated, or awaiting rehabilitation. Existing wells and their purpose within PAL 2, PEL 238 and PPL 3 are summarised in Table 6-22.

Table 6-22 Existing Wells within PEL 238

Purpose	PAL 2	PEL 238	PPL 3
Coal	-	66	-
Gas	-	1	11
Oil and Gas	2	2	-
UNAS	-	2	-
CSG	48	47	1
Total	50	118	12

Santos is proposing a 50 well drilling program scheduled over three years commencing in 2013 to explore the Gunnedah Basin gas reserve. At this stage, the extent of the project within PEL 238 (inclusive of PAL 2) is expected to include:

- up to 10 core holes
- up to six pilot well sets.

The construction and operation of these wells will be subject to separate assessment and approval as the detail and specific locations of the wells and infrastructure is developed. Dewhurst 22- 25 is one of the first pilot well sets proposed as part of this program.

The cumulative impacts of the proposed activity with the wider exploration program within PEL 238 are considered in Table 6-23.

Table 6-23 Cumulative impacts

Area of impact	Comment
Physical and chemical aspects	The proposed activity is temporary and of a minor nature. The lease area will be partially rehabilitated following completion of the pilot wells. There will be some cumulative impacts with work over activities at Dewhurst 6 although these are expected to be minimal. The proposed drilling program currently assumes three rigs that have the potential to operate concurrently. Apart from Dewhurst 6, no drilling is expected in the vicinity of the proposed activity and cumulative impacts would be minimal.
Biological	The proposed activity will remove trees with small hollows, old stockpiles of felled vegetation and disturbance to understorey vegetation and ground cover. Dewhurst 6 has already been cleared as part of previous works under a separate REF process. Other wells may be located in the Pilliga forest and where possible, these will be located in more disturbed areas. Lease areas have been minimised and access tracks and flow lines located adjacent to infrastructure corridors. Vegetation cleared represents around 2% or less of communities within the area.
Community	The proposed drilling program currently assumes three rigs that have the potential to operate concurrently. The number of employees present within the region associated with construction and drilling works, could be approximately 70-100 personnel. There is the potential for these employees to utilise local community social infrastructure, such as accommodation, retail and other services. The local townships of Narrabri, Wee Waa and Coonabarabran are expected to accommodate the additional short term workforce. Therefore, cumulative impacts on the community are expected to be negligible.
Natural resources	The proposed activity will involve minimal use of natural resources, including agricultural land. Cumulative impacts on natural resources will be negligible.
Cultural heritage impacts	The results of cultural heritage due diligence assessments indicate that the proposed activity is highly unlikely to impact on any cultural heritage. Therefore cumulative cultural heritage impacts are considered highly unlikely.
Groundwater	A regional groundwater model was developed that includes an assumption of 390 wells inclusive of the four pilot wells proposed. The modelling indicated that there will be negligible impact to the upper aquifers, GDE's and registered bore users. Wells will be constructed in accordance with industry regulations, therefore no contamination of shallow groundwater sources is expected. As the proposed activity was included as part of the regional modelling, no further cumulative impacts are expected.

There are five Santos-operated CSG-related wells within five kilometres of Dewhurst 22 to 25 – Dewhurst 3, 5, 6 and 7, and Parkes 3). Dewhurst 6 is located in the centre of the Dewhurst 22 to 25 configuration. Four of these wells (Dewhurst 3, 5, 6 and 7) have maintenance work over operations planned for Quarter 2 and 3, 2013. There is a small chance these operations will occur during the drilling of Dewhurst 22 to 25, however they will only be undertaken one at a time (not concurrently).

Any community concern over these issues will be addressed through ongoing consultation with affected landowners and the wider community.

Cumulatively, the proposed activity and other coal mining and CSG activities will stimulate the local and regional economies but could also result in increased pressure on labour resources, temporary and permanent accommodation, road infrastructure and telecommunications. Santos is committed to working with local governments to ensure that these issues are addressed appropriately.

6.8.2 Mitigation measures

Santos will work with the relevant local governments, including Narrabri Shire Council for this activity, to ensure issues relating to increased pressure on labour resources, temporary and permanent accommodation, road infrastructure and telecommunications are addressed appropriately at a strategic level.

7.0 Summary of potential impacts

The potential impacts associated with the proposed activity are summarised in Table 7-1.

Table 7-1 Summary of potential impacts

Aspect	Potential impacts	Potential impact category (with mitigation measures)
Soil quality and land stability	▪ disturbance of up to approximately 6.29 ha of land ▪ soil erosion and loss of topsoil or spoil ▪ land contamination in event of a leak or spill	Negligible to low adverse
Surface water	▪ sedimentation of surface waters due to increased erosion ▪ contamination of surface waters in event of a leak or spill ▪ pollution/contamination of surface waters in event of flooding and inundation of the site	Negligible to low adverse
Groundwater	▪ groundwater contamination due to mixing of aquifers, loss of drilling mud into the formation or inappropriate management of spills ▪ total water abstracted over 3 years, approximately 288 ML; then approximately 96 ML/yr for the remaining life of the PEL. ▪ negligible change in flux or drawdown in the upper layers, no impact to registered bore users or groundwater dependant ecosystems.	Negligible to low adverse
Flooding	▪ area not within flood prone land	Negligible
Coastal process and costal hazards	▪ proposed activity not near a coastline	N/A
Hazardous substance and chemical use	▪ land, water or air pollution, or fire, from improper use of hazardous substances or chemicals	Negligible to low adverse
Gaseous, liquid and solid waste and emissions	▪ management of saline groundwater produced during operation of the pilot wells ▪ generation and disposal of various wastes ▪ contamination of groundwater, soils or surface water from illegal dumping or leaching of waste ▪ litter due to lack of suitable waste containment odours from improper storage or treatment of putrescible waste ▪ generation of greenhouse gas emissions	Low adverse
Dust, noise, odours, vibration and radiation	▪ generation of dust and other particulates ▪ generation of noise, particularly during drilling activities which may occur up to 24 hours per day	Negligible to low adverse
Biological	▪ removal of up to approximately 6 ha of vegetation, 4.96 ha narrow-leaved ironbark woodland and 1.02 ha riparian woodland ▪ temporary disruption to breeding cycle, roosting, sheltering and foraging behaviour of fauna species ▪ minor impacts on Pilliga mouse	Low to medium adverse

Aspect	Potential impacts	Potential impact category (with mitigation measures)
Community	▪ pressure on temporary accommodation in Narrabri area ▪ minimal generation of traffic on Monument Road and Yellow Springs Trail. ▪ temporary reduced amenity for neighbours from noise, dust and visual impacts ▪ introduction of hazard (construction activities, gathering system and flare)with potential safety implications	Negligible
Economic issues	▪ economic benefits to Narrabri and surrounding region ▪ ongoing use of upgraded access track to benefit of Forestry NSW	Positive
Natural resources	▪ impact to Pilliga East State Forest ▪ no impact to agricultural land ▪ use of minor quantities of natural resources including fill material and fuels	Negligible
Aboriginal cultural heritage	▪ disturbance of unknown Aboriginal objects	Negligible
European cultural heritage impacts	▪ disturbance of unknown European heritage items	Negligible

On balance, the proposed activity will have negligible to low adverse impacts on the environment and community. There would be medium adverse impacts on biological aspects. These impacts will be temporary and of a small scale and can be mitigated through the measures identified in this REF.

7.1 Clause 228 Factors

Clause 228 of the *Environmental Planning and Assessment Regulation 2000* outlines a number of factors that must be taken into consideration in assessing an activity under Part 5 of the EP&A Act. An assessment of the clause 228 factors is provided in Table 7-2.

Table 7-2 Clause 228 factors

Factor	Impact
Any environmental impact on a community	Minor short term. Impacts will be short term and localised. There are no residential properties within three kilometres of the site. The nearest residential dwellings are located approximately 3.37 km, 3.43 km, 4.07 km and 5.73 km from the site. The proposed activity will generate additional traffic but this will be unlikely to significantly impact the local road network. Impacts associated with the proposed activity will be virtually imperceptible to the wider community.
Any transformation of a locality	Minor short term. There will be a localised and non-permanent visual impact on the immediate vicinity of the pilot wells for the duration of the program. This impact will be significantly reduced once the lease area is partially rehabilitated and completely reversed once the flare and water transfer facility is decommissioned and final rehabilitation of the site is complete.
Any environmental impact on the ecosystems of the locality.	Minor short term Three vegetation communities and habitats occur within the study area. Narrow leafed shrubby ironbark woodland is the dominant community with heath and riparian woodland also occurring. None of these communities are commensurate with any of the seven TECs or nine EECs that were identified during the desktop assessment.
Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality	Negligible. The proposed activity will reduce the aesthetic values of the site temporarily but will be have no long term effects on the scenic qualities of the landscape.
Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations	Nil. No locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations occur within or near the site.
Any impact on the habitat of protected fauna (within the meaning of the National Parks and Wildlife Act 1974)	Medium short term. The site provides foraging habitat for a range of protected fauna species within the meaning of the NPW Act. While the proposed activity will involve the removal of approximately 6.29 ha of potential habitat the impacts of this will be minor as there is sufficient alternative foraging habitat within the wider locality and the majority of the site will be rehabilitated on completion of the works. Fauna surveys identified 50 bird species, 19 mammal species and 11 reptile species within the study area. One threatened species listed under the EPBC Act and six threatened species listed under the TSC Act were recorded. These were all assessed as having a significant impact but unlikely. The activity will result in the loss of 1.02 ha of Pilliga mouse habitat (riparian woodland). Proportionally, this is relatively minor compared to the available habitat in the immediate area.
Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air	Nil. The proposed activity will not endanger any species of animal, plant or other form of life, whether living on land, in water or in the air.

Factor	Impact
Any long-term effects on the environment	Nil. The proposed activity will have no long-term effects on the environment. Well installation will be undertaken in accordance with relevant legislation and best practice guidelines to ensure no aquifer interference. There will be no impact to the upper aquifers. Rehabilitation of the site will occur.
Any degradation of the quality of the environment	Minor short term. There is potential for minor short term environmental degradation as a result of air and noise emissions during the works, or from the accidental release of contaminants to the environment.
Any risk to the safety of the environment	Minor short term. The proposed activity may result in short term potential risks to the safety of the environment due to incidents and spills. The flare will be designed with an appropriate clearance zone.
Any reduction in the range of beneficial uses of the environment	Nil. The proposed activity will not result in any reduction in the range of beneficial uses of the environment.
Any pollution of the environment	Minor sort term. The proposed activity may result in short term potential risk of pollution of the environment due to incidents and spills or as a result of air or noise emissions.
Any environmental problems associated with the disposal of waste	Nil. Drill cuttings will be allowed to dry onsite and disposed of at an appropriate licensed facility. All other wastes generated by the proposed activity will be collected, classified and removed from site for recycling, disposal or disposal at a licensed waste facility if required. Given the short term nature of the proposed activity, only minor quantities of waste will be produced.
Any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply	Minor short term. Resources required for the proposed activity are not in limited supply in the area.
Any cumulative environmental effect with other existing or likely future activities	Nil. The proposed activity would not result in any cumulative environmental effects given the minor and short term nature of the proposed activity. This is discussed further at section 6.8.
Any impact on coastal processes and coastal hazards, including those under projected climate change conditions	Nil. The site is not located near the coast and therefore would not affect coastal processes or hazards.

8.0 Conclusion

This REF has been prepared to assess the potential environmental impacts of drilling four petroleum exploration pilot wells, known as Dewhurst 22, Dewhurst 23, Dewhurst 24 and Dewhurst 25, and carrying out ancillary activities within the Pilliga East State Forest along Monument Road, approximately 30 kilometres south of Narrabri, NSW. The purpose of the proposed activity is to investigate the potential CSG resource of the Gunnedah Basin within PEL 238.

The proposed activity is temporary and minor in scale. The site of the proposed activity has been selected to avoid significant environmental and heritage constraints, and reduce impacts to the surrounding community. The potential impacts of the proposed activity have been assessed and can be managed through the identified mitigation measures. On balance, the proposed activity will have a negligible to low adverse impact on the environment and community.

The proposed activity is not likely to significantly affect the environment or any threatened species, populations or ecological communities, their habitats or critical habitat. Habitat for the Pilliga mouse listed as vulnerable under the EPBC Act will be removed (approximately one hectare) however this is proportionally small when compared to the available good quality habitat in the immediate area. Consequently, impacts are expected to be minor. The proposed activity does not require preparation of an EIS.

The proposed activity will be referred to SEWPaC. The referral is under preparation.

9.0 Statement of commitments

Table 9-1 provides a statement of commitments for the proposed activity.

Table 9-1 Statement of commitments

Item	Commitment
Activity type and location	*Site Establishment and construction* ▪ constructing four access tracks from Monument Road to lease areas (including one creek crossing) ▪ establishing four lease areas up to approximately 1 ha in size each ▪ installing surface infrastructure on the Dewhurst 6 and Dewhurst 22-25 lease areas, including separators, metering skids, power generation equipment, telemetry units, motor control centres and drivers ▪ constructing a gas gathering system parallel to the access tracks (inclusive of Dewhurst 6), Monument Road and Yellow Springs Trail to a flare at Dewhurst 22. The gathering system extends from the riser located at the edge of the pilot well lease area to the balance tank located at Dewhurst 22. ▪ constructing a water gathering system parallel to the gas gathering system with associated piping and pumps at Dewhurst 22. *Drilling* ▪ drilling two vertical wells (Dewhurst 22 and 24) to a depth of approximately 1005 m ▪ drilling a tri-stacked horizontal well (Dewhurst 23) to intercept Dewhurst 22 ▪ drilling a single horizontal well (Dewhurst 25) to intercept Dewhurst 24 ▪ operating the five pilot well set for the life of PEL 238 or until critical reservoir data is collected. *Operation* ▪ partial rehabilitation of Dewhurst 6, 23, 24 and 25 to well head and essential infrastructure ▪ installing a flare, water balance tank (capacity 40m^3) and pumps at the Dewhurst 22 lease area ▪ continued monitoring of pilot wells and gathering system ▪ maintenance and workover activities.
Hours of operation	Hours of operation will be negotiated with the landowner and may be up to 24 hours a day, seven days a week.
Activity duration	Duration of PEL 238
Proposed commencement date	Works will commence in the first quarter of 2013.
Maximum area of disturbance	up to approximately 6.29 ha
Rehabilitation commitments and timeframes	Partially rehabilitation will occur within six months of completion of the pilot wells for Dewhurst 23, 24 and 25, where practicable. The site will be rehabilitated to its pre-operational condition or better as agreed with Forestry NSW. If the site is determined to be unviable for conversion into production, final rehabilitation will occur prior the expiration of PEL 238.
Community consultation	Community consultation will be undertaken in accordance with Table 2-4 of section 2.4.5 of the REF.
Complaint management	Complaint management will be dealt with in accordance with Santos protocols outlined in section 2.4.6

Item	Commitment
Soil quality and land stability	*Site establishment and construction* ▪ Where the lease area is constructed using traditional methods (instead of using industrial matting), topsoil and other soil horizons will be stripped, handled and stockpiled separately. ▪ Excess spoil generated during site preparation activities will be stockpiled on site and used as backfill during site rehabilitation. No uncontaminated soil or spoil will be removed from the site. ▪ Stockpiles will be managed according to best management practices such as the measures outlined in *Managing Urban Stormwater: Soils and Construction* (Landcom 2004) ('the Blue Book') or the *Best Practice Erosion and Sediment Control Guidelines* (IECA, 2008) (IECA Guidelines). This will include: » Erosion and sediment controls will be implemented where necessary during site preparation activities, including lease area construction and any upgrades to the existing access track, 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. » A diversion bank will be constructed to direct water around the area of disturbance. » A sediment fence will be installed at the downstream limit of disturbance area. *Drilling* ▪ The quantity of chemicals, fuels and oils stored on site will be minimised, where practicable. ▪ All additives, chemicals, fuels and oils stored on site will be kept in an appropriately secured, bunded storage shed in accordance with the relevant MSDS. ▪ An MSDS register of all chemicals used or stored on site will be maintained. ▪ Maintenance of vehicles, plant and equipment will occur off site at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance on site. ▪ Refuelling of plant and equipment will occur in a designated, bunded area, at least 40 metres from the nearest waterway. ▪ A spill kit will be available on site and personnel will be trained in its use. ▪ A vacuum truck will be on standby 24 hours a day to travel to the site if required ▪ Any spills or leaks will be contained and cleaned up immediately using the spill kit. Contaminated material (such as contaminated soil or absorbent materials) will be contained and removed from the site for disposal at a licensed waste facility. ▪ Plant and equipment will be inspected daily to ensure these are properly maintained. *Operation* ▪ Ongoing management and maintenance of remaining infrastructure on site will occur, including water transfer area and well heads. ▪ The gathering system water pressure will be monitored ▪ The site will be rehabilitated in accordance with section 2.7.9 of the REF. Partial rehabilitation will occur for Dewhurst 23 to 25 following drilling activities reducing the cleared area to 20m by 20m around the well head. This will include: » All plant, equipment, waste materials and temporary buildings will be removed from the site.

Item	Commitment
	» Plastic lining will be removed from the environmental pit and disposed of at an appropriately licensed facility. » The environmental pit will be backfilled. » Subsoil will be replaced across the lease area, contoured to the landscape and partially compacted. » Topsoil will be uniformly placed across the lease area, graded to natural levels and partially compacted. » Fencing will be removed from perimeter of lease area. » The lease area will be revegetated according to Forestry NSW requirements. » Weed control will be undertaken.
Water body, water course, wetland and natural drainage systems	*Site establishment and construction* ▪ Contaminated waters will be contained and where necessary disposed of at an appropriate facility. ▪ Sediment fences and traps will be installed so as to prevent soil loss or sedimentation. ▪ Where applicable maintenance of roads, drains, bund walls, contour and diversion banks to occur. All drainage structures will be maintained for the life of the development. ▪ The crossing of Spring Creek will be designed to minimise erosion of the beds and changes to overland flow velocities. *Drilling* ▪ Drilling mud will be contained in surface tanks which will be regularly inspected and maintained. ▪ Over-balanced drill techniques will be used to prevent formation fluid from rising through the well to the surface. ▪ Drilling mud will be transported to and from the site by an appropriately licensed contractor as outlined in section 2.8.1 of the REF. ▪ Fuel and lubricants will be stored on site only when necessary and maintained off site whenever possible. ▪ Contaminated liquid captured in the environmental pit will be removed to a licensed waste facility that is able to accept liquid waste for disposal or treatment. ▪ All areas storing or handling fuel, fuel using equipment, and chemicals will be bunded in accordance with Australian Standard 1940 – 2004; The Storage and Handling of Flammable and Combustible Liquids. ▪ The maintenance and cleaning of vehicles and other equipment or plant will be carried out in areas from where the resultant contaminants cannot be released into any waters. *Operation* ▪ Proposed rehabilitation (section 2.7.9) will ensure pre-operational quality or better, to minimise sediment erosion combined with mitigation measures for soil quality and land stability.

Item	Commitment
Groundwater	*Site establishment and construction* Nil *Drilling* ▪ The wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS 2012b). ▪ A driller that holds a license under the National Water Drillers Licensing Accreditation Scheme will be on site during drilling of the top hole and until the surface casing is set, cemented and pressure tested. During this time, there will be 24 hour coverage by one person working the day shift and on call at site during the night. This will ensure that the appropriate knowledge of water legislation and regulation in NSW and technical skills are employed to avoid impacts to groundwater sources. ▪ A NOW hydrogeologist will be notified at least 28 days prior to the commencement of drilling. ▪ Drilling and installation operations, well control, waste management and abandonment procedures for the pilot wells will be in accordance with accepted industry practices and in accordance with the processes outlined in this REF. ▪ Excessive drilling mud losses will be cured by loss circulation material (cellulose material such as sawdust or other benign naturally occurring substances, as required) to ensure most fluids return to the surface. ▪ Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within three kilometres of the site to undertake groundwater monitoring prior to drilling, to establish baseline conditions, and on completion of drilling, to determine if there are any impacts. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and quality observations in the field, and sampling for analysis by an accredited laboratory. *Operation* ▪ The wells will be decommissioned as soon as they are no longer required. ▪ Data will be collected from the wells to measure permeability of the various strata. ▪ Pressure gauges will be installed adjacent to the pilot wells with monitoring points to assess impacts on overlying formations. ▪ The quality of incidental water lifted during proposed activities will be monitored daily and the results provided to the relevant authorities on a weekly basis. ▪ Santos will make reasonable endeavours to seek permission (from landowners) to access registered groundwater bores within three kilometres of the site to undertake groundwater monitoring during operation of the pilots. Where access to bores is granted (and the bore is functioning), monitoring will include water level measurements and quality observations in the field, and sampling for analysis by an accredited laboratory.

Item	Commitment
Flooding	*Site establishment and construction* ▪ Weather forecasts will be monitored and in the event that prolonged, severe wet weather or flooding is predicted, works will cease and plant, machinery and any chemicals will be secured and bunded. This will also occur during drilling *Drilling* ▪ The environmental pit will be maintained with a minimum freeboard of 300 millimetres at all times. *Operation* Nil
Hazardous substance and chemical use	*Site establishment and construction* Nil *Drilling* ▪ Chemicals and potentially hazardous substances will be used and stored according to regulatory requirements including the *Work Health and Safety Act 2011*. ▪ Any dangerous goods will be transported according to regulatory requirements under the *Dangerous Goods (Road and Rail Transport) Act 2008*. *Operation* Nil
Gaseous, liquid and solid waste emissions	*Site establishment and construction* ▪ A waste management plan will be prepared prior to construction. ▪ Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation. ▪ Appropriate waste receptacles will be provided on site including covered rubbish bins for disposal of domestic wastes. These will remain during drilling activities. ▪ The area of disturbance will be limited to the minimum required to carry out the proposed activity safely and efficiently. ▪ Vehicles, plant and equipment will be regularly maintained to ensure they are in good operating condition. ▪ Vehicles, plant and machinery will be turned off when not in use rather than left idling. ▪ Use energy efficient equipment and processes where possible *Drilling* ▪ Waste materials will be separated, classified and managed in accordance with the Waste Classification Guidelines Part 1: Classifying Waste (DECCW 2009). ▪ Drilling mud will be managed according to the process described in section 2.8.1. ▪ All wastes will be removed from the site at the completion of drilling for recycling or disposal at an appropriately licensed facility.

Item	Commitment
	▪ The type and volume of all waste removed from the site will be recorded. ▪ Portable toilets will be provided on site and will be regularly serviced by a licensed contractor. ▪ All staff and contractors will be made aware of waste management procedures during the site induction and through toolbox talks. ▪ Chemical, fuel and oil containers will be managed according to the MSDS or manufacturers' directions to avoid potential impacts to the environment or human health. ▪ All wells to be drilled using water based mud that will minimise venting and flaring requirements *Operation* ▪ Produced water will be transferred to an appropriate water treatment facility to be treated for beneficial reuse or disposal. ▪ A portion of the produced CSG will be diverted for on-site power generation, reducing the need to use diesel on the site, and reducing gas to flare.
Dust, noise, odours, vibration and radiation	*Duration of project* ▪ Dust will be suppressed as required by spraying water along the access tracks and lease areas. ▪ If necessary, the access tracks will be sealed to prevent excessive dust emissions. ▪ Site speed limits will be imposed to minimise dust generated by vehicle movements ▪ Where noise levels exceed LAeq 35 dB(A), feasible and reasonable work practices will be implemented to achieve the noise affected level. Further noise monitoring will be carried out to determine the effectiveness of mitigation measures. ▪ In the event of a noise complaint, the effectiveness of noise mitigation measures will be assessed and additional feasible and reasonable measures will be implemented, where necessary. *Site establishment and construction* ▪ Consultation with Forests NSW and the nearest sensitive receivers will be carried out in accordance with section 2.4 of the REF. *Drilling* ▪ Prior to arriving on site, source noise levels of the drilling rig will be confirmed to verify noise impacts and confirm the management approach. *Operation* Nil

Item	Commitment
Biological	*Site establishment and construction* ▪ Clearing of habitat trees will be avoided where possible ▪ Disturbance areas will be minimised where possible during the design process ▪ while clearing or disturbance to vegetation occurs, a fauna spotter/catcher will be on site to supervise works ▪ Hollow logs removed from the disturbance areas are to be relocated in habitats adjacent to the lease areas under supervision from the fauna spotter/catcher. Fauna sensitive clearing techniques will be implemented, including vibrating the bucket on large trees (particularly hollow-bearing trees) prior to clearing, and dismantling large trees ▪ The site boundary will be clearly demarcated to ensure that plant and vehicles keep within the approved area of disturbance. ▪ Plant and machinery will be cleaned of any soil, seed and vegetation prior to being transported to the site in accordance with legislative requirements. ▪ Prior to earthworks, noxious weeds present on the site will be removed or treated with herbicide to help prevent or reduce their spread. ▪ Clearing will commence in areas of low weed infestation and move towards area of high weed infestation where practicable. ▪ Weed monitoring will occur throughout site preparation, drilling, completion and rehabilitation activities. Weed removal will be carried out as necessary. ▪ Cleared weed species will be stockpiled separately and removed off site. Weed material will not be re-used during site rehabilitation. ▪ In the event that the proposed activity needs to extend outside the site, a qualified ecologist will undertake further inspection. *Drilling* Nil *Operation* ▪ The site will be rehabilitated in accordance with section 2.7.9 of the REF and mitigation measures described in soil quality and land stability.
Community	*Duration of the project* ▪ Works will be conducted in accordance with landowner requirements as outlined in the Occupation Permit issued under the Forestry Act 1916. *Site establishment and construction* ▪ Site safety protocols, incident management and emergency procedures will be implemented during the construction and drilling works. ▪ The site will be kept in a clean and tidy manner during site preparation, drilling activities and operation of the pilot wells. *Operation* ▪ All new access tracks will be retained for the ongoing use of Forestry NSW. ▪ The lease areas will be fenced and within Dewhurst 22, the flare will have a secondary 1.8 metre high fence.

Item	Commitment
	▪ A bushfire management plan will be developed prior to construction ▪ A fire risk management plan will be developed prior to construction ▪ Hazard classification mapping will be updated prior to commencement of construction
Natural resources	*Duration of the project* ▪ All plant and machinery delivered to the site will be cleaned of foreign soil in accordance with legislative requirements with respect to weed management. *Site establishment and construction* ▪ Construction personnel will be trained in pest control and hygiene procedures. *Drilling* ▪ Fuel will be used as efficiently as possible through appropriate work behaviour (e.g. switching off equipment when not in use). ▪ The well will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity*. *Operation* Nil
Aboriginal cultural heritage	*Site establishment, construction and drilling* ▪ Project staff and contractors will be made aware of their statutory obligations to protect under the NPW Act and the Heritage Act, through the site induction and toolbox talks. ▪ Where practicable, vegetation will be cut rather than bulldozed to reduce disturbance to the ground surface. ▪ All works will be undertaken to comply with Part 6 of the NPW Act. ▪ If any previously unidentified Aboriginal sites are identified during works, then works in the immediate area will cease, the area will be cordoned off and the OEH Enviroline 131 555 will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed and managed. ▪ In the event that skeletal remains are uncovered, then works in the immediate area will cease, the area will be cordoned off and the NSW Police Coroner will be contacted to determine if the material is of Aboriginal origin. If determined to be Aboriginal, the OEH Enviroline 131 555 and relevant Aboriginal stakeholders will be contacted to determine an action plan for the management of the skeletal remains prior to works re-commencing. ▪ In the event that the proposed activity needs to extend outside the site, a qualified archaeologist will undertake further inspection. *Operation* Nil
European cultural heritage	▪ If any previously unidentified potential European cultural heritage material is identified during construction or drilling, then works in the immediate area will cease, the area will be cordoned off and the OEH Heritage Branch will be contacted. A suitably qualified archaeologist will be contacted so that the site can be assessed and managed.
Cumulative	▪ Santos will work with relevant local governments, including Narrabri Shire Council for this activity, to ensure issues relating to increased pressure on labour resources, temporary and permanent accommodation, road infrastructure and telecommunications are addressed appropriately at a strategic level.

Terms and abbreviations

Term/abbreviation	Meaning
Abandonment	Decommissioning the well. A process which involves shutting down the well and rehabilitating the site.
AHIMS	Aboriginal Heritage Information Management System
Annulus	The space between the wellbore and surrounding pipe.
Aquiclude	Compacted geological formations through which no groundwater flows.
Aquitard	Low permeability formation which restricts the flow of groundwater.
Blow out preventer	One of several valves installed in a wellhead to prevent the escape of pressure either in the annular space between the casing and the drill pipe or in the open hole during drilling, completion and work over operations.
BoM	Bureau of Meteorology
BOP	Blow out preventer
Casing	A pipe placed in a well to prevent the wall of the hole from caving in and to prevent movement of fluids from one formation to another.
Casing collar	Coupling between two joints.
Casing coupling	Tubular section of pipe that is threaded inside and used to connect two joints of casing.
Casing head	A heavy flanged steel fitting connected to the first string of casing. It provides a housing for slips and packing assemblies.
Cementing	The application of a liquid slurry of cement and water to various points inside and outside the casing.
Cementing head	Component fitted to the bore for the use of cementing.
Cement plug	Portion of cement placed at some point in the wellbore.
Coring	Process of cutting a vertical, cylindrical sample of the formations.
CSG	Coal Seam Gas
DAMB	Deep aquifer monitoring bore
Drill fluid/mud	Circulating fluid that can lift cuttings from the wellbore to the surface and to cool down the drill bit.
DTIRIS	Department of Investment, Trade, Regional Infrastructure and Services
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
flux	rate of volume flow across a unit area (m3·s−1·m−2)
kPag	Kilopascal gauge
LGA	Local government area
ML	Mega litres
MNES	Matter of National Environmental Significance
MSDS	Materials Safety Data Sheets
NV Act	Native Vegetation Act 2003
NOW	NSW Office of Water
OEH	Office of Environment and Heritage
Packer	Piece of down hole equipment that consists of a sealing device. Used to block the flow of fluids through the annular space between the pipe and the wall of the wellbore.
PEL	Petroleum Exploration Licence
Plug	Any object or device that blocks a hole or passageway.

Term/abbreviation	Meaning
POEO	*Protection of the Environment Operations Act 1997*
REF	Review of Environmental Factors
SEPP	State Environmental Planning Policy
TSC Act	*Threatened Species Conservation Act 1995*
Surface casing	A drilled and cemented pipe used to provide blow-out protection, to seal off water/hydrocarbon sands and prevent the loss of circulation. Also used to seal off water sands, weak formations and/or lost circulation zones. In some cases surface and intermediate casing requirements are provided by the same string.
WAL	Water access licence
Wall cake	Low permeability 'skin' around the wall of the hole.
Wellhead	The system of spools, valves and associated adapters that provide pressure control for production.
WMA	Water Management Act 2000
WSP	Water Sharing Plan

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Appendix 1

Dewhurst 6 approval letter and explanatory note

NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Now incorporating Department of Mineral Resources
ABN 51 734 124 190-003

Mr Tim Donnan
Environmental Officer
Eastern Star Gas Limited
GPO Box 4526
Sydney NSW 2001

Dear Mr Donnan,

PEL238: Amendment to 2008 Corehole Program B, Dewhurst 5 & 6

I refer to your letter of 30 March 2009 requesting amendment to the approved drilling of Dewhurst 6 from a corehole to a vertical production well.

The amendment as described has been assessed and is unlikely to result in any significant change to the environmental impacts previously assessed and approved by DPI. In accordance with Condition 1 of PEL 238 granted under the provisions of the *Petroleum (Onshore) Act 1991*, the titleholder is hereby granted approval to conduct the Dewhurst 5 & 6 drilling program as amended, subject to the conditions of the existing DPI approval dated 12 June 2008 and the condition under.

CONDITION

General condition

1. The works must be carried out at the location(s) and in accordance with the methods contained in:
   - REF 2008 PEL 238 Corehole Program B, Dewhurst 5 & 6 dated April 2008, as amended by
   - The explanatory information on the review of environmental factors dated 30 March 2009 from Eastern Star.

No increase in security is warranted.

Should you wish to discuss any details of this approval, please contact me directly on (02) 4931 6705

Yours Sincerely,

Greg Summerhayes
Principal Environmental Officer

DATE:.....3 April 2009.....

Environmental Sustainability Branch
516 High Street Maitland NSW 2320
PO Box 344 Hunter Region Mail Centre NSW 2310

www.dpi.nsw.gov.au
Tel: 02 4931 6605
Fax: 02 4931 6790

Monday March 30, 2009

Greg Summerhayes
Principal Environmental Officer
Environmental Sustainability Branch
Mineral Resources Division
Department of Primary Industries
PO Box 344 Hunter RMC
NSW 2310

Dear Greg,

RE: Explanatory Note - Amendment to 2008 PEL238 Corehole Program B Dewhurst-5 and 6 (approved)

Please find the following explanatory note considering the likely implications of modifying the approved Dewhurst Corehole Program B Dewhurst-5 and 6. The proposal involves the adjustment of operations at the Dewhurst-6 location from a corehole to a vertical production well. The proposed location defined for Dewhurst-6 in the original application will remain unchanged.

It is expected the change in operations will not create any further significant environmental impacts than those previously mentioned in the REF document. The major effect on the surrounding environment at Dewhurst-6 will be the drilling pad size. Eastern Star Gas (hereafter referred to as ôESGõ) propose to change the drilling pad size from the originally planned 50 metre by 50 metre pad (0.25 hectares), to a larger 80 metre by 80 metre (0.64 hectares) pad for placement of the Lucas Drilling rig. It is the view of ESG that the environmental impact related to the slight increase in area will be negligible.

Please find following a short discussion of the key environmental issues aligned with the proposed amendments and the extent to which the current approval is sufficient to account for any such impacts. Please call if you require any further information.

Kind Regards,

Peter Jaeger
Environmental Officer

Eastern Star Gas Limited
ABN 29 094 269 780

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51 Pitt Street
Sydney NSW 2000
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Introduction

Factor	REF Section	Description
Primary Objectives	2.2	The objective of the production well at Dewhurst-6 is alike to the submitted REF. Through drilling the vertical production well, the results gathered will give an enhanced indication of baseline parameters (as stated in section 2.2). This will provide improved substantial evidence to help facilitate the reserves certification process across the Maules Creek formation.
Description of the Activity	2.3	The drilling activities at Dewhurst-6 will include the following changes: • Preparation of a 80 metre by 80 metre (0.64 hectare) pad; • Placement of the Lucas Drilling rig and ancillary equipment; • The drilling of a production well at Dewhurst-6; • The suspension of the well as a future production asset;

Assessment and Prediction of Environmental Factors

Factor	REF Section	Description
Land	4.3.1 4.3.2 4.3.3 4.3.4 4.3.5	Access: A major objective of ESG operations within Forests NSW Lands is to use existing roads and tracks as far as practicable. The extensive system of roads and tracks crossing the Bibblewindi State Forests permits safe and efficient access. Any damage to existing roads/access caused by the drilling and operations activity remains the responsibility of ESG and will be rectified as soon as practicable at the discretion of Forestry NSW. Well Pad Construction: The well pad construction will require a larger land area for the placement Lucas Drilling rig. It will be an 80 metre by 80 metre pad (0.64 hectares) which will be designed to provide a stable and level platform for the drilling rig and associated equipment to operate safely. Drainage: It is expected sufficient drainage is present at the Dewhurst-6 location to limit requirements for drainage to be installed, as stated in the REF. It is viewed by ESG that the change in rig will not have a significant impact on the drainage requirements. Initial Rehabilitation and Site Restoration: Rehabilitation and restoration of the Dewhurst-6 location will follow the strategy defined in the REF. When drilling operations cease, the 80 metre by 80 metre site will be fenced with an appropriate 5 strand (or equivalent) stock proof fence and lockable gate.

		Subsurface Impacts: Protection of the subsurface environment is an important consideration in the drilling of hydrocarbon wells. The intersection of over/undercharged aquifers from surface to total depth presents various issues to the drilling of wells as does the intersection of gas bearing formations. In these terms, a number of important features of the drilling process provide physical protection to subsurface aquifers, surface equipment and personnel from the higher pressures experienced as the well deepens whilst also preventing the inflow of water into the well bore and the loss of drilling fluids into permeable formations. The main functions of a drilling fluid are to cool and lubricate the drill bit, provide a mechanism to carry drill cuttings up and out of the well bore, keep the annular bore hole space clean and óbalanceô the hydraulic pressures exerted on the bore hole as vertical depth increases. To maintain ideal conditions during the drilling of the wells, the mud program typically employed by ESG for the drilling of Coal Seam Gas wells in this area consists of: • A high viscosity, mid weight mud for the surface to approximately 100 metre vertical depth (surface casing) where water bearing formations are typically overcharged and will readily flow into the well bore; and • A low to mid viscosity, minimum weight mud from the surface casing shoe to the base of intermediate casing (650-750 metres) and then onto total depth. The low weight mud program for the deeper drilling is designed to minimise damage to production target. The mud system is bentonite based and readily forms an impermeable layer or ófilter cakeô on the surface of the open hole which: • Retards the inflow of water into the well bore from overcharged aquifers or formations; and • Prevents the loss of drilling fluids into undercharged aquifers or porous formations. Whilst some exchange of fluids is inevitable in the lead up to the formation of the filter cake or where the mud system is too low in weight (or óunder balancedô), the gain or losses of fluids is readily controllable and is unlikely to result in the loss/generation of any significant volumes of water or fluids.

		Further, long term protection of the subsurface environment from petroleum well operations is afforded by the installation and cementing of steel casing into the open hole once the well has reached total depth. Casing is left in place over the entire depth of the well further limiting the likelihood of fluid exchange and aquifer contamination. Plugging and Abandonment Procedures: The Dewhurst-6 production well will be suspended and a wellhead will be installed for future re-entry. Prior to the cessation of production operations and the initiation of plugging and abandonment procedures, a notification of the plan of abandonment will be provided to the NSW Department of Primary Industries (Mineral Resources) for approval. As per standard oil field practice, a dry hole marker or such surface preparations indicating the well location will be installed in the final stages of abandonment in a manner which is appropriate for both the local land uses and in accordance with department regulations.
Air	4.1.1 4.1.2	Fugitive Dust Generation: The dust generated by the mobilisation of the drilling and ancillary equipment to and from a location is generally no greater than localised traffic movements. In the event that the roads are excessively dry and soft and where mobilisation may be expected to generate excessive amounts of dust, a water truck will be deployed to water the roads before and during the move to location. It is expected the change from a corehole program to a vertical production well program will have no additional impacts. Noise Impacts: All of the equipment used for mobilisation and supply of power to the drill rig are modern, well maintained and have noise attenuation apparatus fitted as standard. The drilling activity will occur across a 24 hour shift cycle with crew changes occurring at 12 pm and 12 am. The location of the Dewhurst-6 site is in excess of 6 kilometres to the east of the nearest inhabitation and the mobilisation of equipment and personnel and its operation is unlikely to result in any measureable noise impacts on existing point source receptors such as homes and businesses.

Water	4.2.1	Impacts on localised water courses: No impacts are likely to be introduced onto localised creeks and water courses through the Dewhurst-6 drilling program. Mud containment onsite will involve an integrated mud sump/cuttings ditch with dimensions of approximately 6 metres by 3 metres by 3 metres. The sump will be located adjacent to the drilling rig and accept all mud returns and rock cuttings from the well during drilling. The issue of mud containment and potential risks of land and groundwater contamination (e.g. percolation through walls/base of sump, accidental discharge (overtopping) during rainfall etc.) has been reviewed along with risk assessments carried out by Lucas/ESG prior to the commencement of drilling: • The risk of contamination of groundwater from the percolation of drilling fluids from the unlined surfaces of mud/cuttings sumps is very low. The use of natural clay products (Bentonite, Barites etc) during the early stages of drilling work as effective sealants of cut surfaces. Furthermore, the drilling fluids utilised during later drilling do not generally present a risk of contamination given the relative concentrations of salt (i.e. KCl, NaCl) additives of less than 5 percent. The risk of a mud sump/cuttings overtopping due to excessive well discharge or inflow from a rainfall event is low. The risk assessment process undertaken by Lucas/ESG identifies this as a potential risk and provides a response mechanism of manual pump-out where any danger of overtopping is identified by the drilling supervisor. Source: Water sourced will be from the sites stated in the REF.
Flora	4.5.1 4.5.2	Background Information: As stated in REF. Assessment of Significant Effects: The significant effects identified in the REF will have a larger scope due to the increase in the area of the drill pad from 0.25 hectares to 0.64 hectares. It is ESGs expectation that the recovery and rehabilitation procedure will mitigate any significant impact of the increase in impacted area.

		Weed Species: As stated in REF.
Fauna	4.6.1	Background Information: As stated in REF. Field Surveying and Assessment Reporting: Field surveys carried out to date in the adjacent PAL2 have occurred on four separate occasions, the full results of which are contained within the aforementioned impact assessment reports. In summary, the impact assessments conducted to date conclude that: • Critical habitat as listed in the Register of Critical Habitat kept by the Director General of Department of Environment and Conservation does not occur in the study area; • No threatened ecological fauna communities or fauna populations listed on the schedules of the TSC Act occur in the study area; • The cumulative study area is not potential habitat as defined in SEPP44 (Koala Habitat Protection); • Many of the species identified during surveying are avian species with sufficiently large home ranges that, when combined with the extent of the regionally common *E. crebra* dry open forest habitat identified by Elks, is unlikely to result in any long term, significant impacts any species or community in the Pilliga East State Forests; • Activities on this scale are such that habitat is not likely to become fragmented or isolated from other areas of habitat within the Pilliga Scrub; • Sufficient mitigative action can be taken to limit the impact of the proposal on the hollow dependant species identified by Kendall; • The proposed activity will not impact on habitat favoured by the Pilliga Mouse *Pseudomys pilligaensis* which includes recently burnt gullies, areas containing an understorey of kurricabah (*Acacia burrowii*) with a bloodwood (*Corymbia trachyphloia*) overstorey; and • Habitat for the listed microbats is widespread and common in the study area, locality, and region.
Cultural Heritage	4.7	As stated in REF.
Waste Management	4.4.1 4.4.2	Drilling Fluid and Cutting Disposal: At the completion of the drilling activity, the fluids contained within the sumps will be pumped out and disposed of in the lined evaporation pond at Bohena 3. This process will assist in the natural drying out of muds settling in the pits, at which time the excavation will be

		backfilled. The cuttings generated during drilling will be left in situ. The term ódrill cuttingô describes the material generated from the drilling activity once removed from the drilling fluids. Varying is size depending on the type of drill bit employed, the cuttings can range in size from coarse sand like material to >5 millimetres in diameter. ESG exclusively uses PDC (polycrystalline diamond compact) bits that generate cuttings of a size similar to very coarse sand (<3 millimetres). Putrescible Waste Disposal: Day to day materials and putrescible wastes will be collected in rubbish cages located on the drilling site for the duration of the activity and will be serviced by a licensed waste contractor from Narrabri. A portable toilet will be located onsite and maintained by services from Narrabri.
Greenhouse Gas Impacts		It is planned that there will be no venting at the Dewhurst-6 well and consequently greenhouse gas impacts are considered to be negligible. The well will be suspended and a wellhead will be installed for future re-entry.
Chemical and Hazardous Substance Management		The consumption and storage of potentially hazardous materials including fuels, oil based lubricants and drilling fluid additives is addressed in the generic risk assessment carried out by ESG and Lucas Drilling. The following mitigation strategies have been devised to limit the incidental risks of land or water contamination from materials stored on the drill site for the duration of the activity: • Mud tanks will be employed for the mixing of drilling fluids and longer term storage (*not to be confused with mud pits/sumps); • Ablution facilities equipped with 3 separate black water tanks to extend the capacity in the event of limitations on services access to site; • Drilling fluid additives (dry) stored in covered/weather proof trailer; • Bunded trailers designed to AS/NZS used for fuel and chemicals storage; and • Spill kits located at frequent locations across the drill site
Conclusions	7	ESG remain confident that the proposed change to include a vertical production well will not create any long term, detrimental environmental impacts likely to alter the operational environment or the surrounding region.

		It is the opinion of ESG that the impacts created by the proposed activity when considered alongside the mitigation strategies in place will create no long term effect on the localised and regional environment.

Appendix 2

Chemical fact sheet

CHEMICAL FACT SHEET - SANTOS ENERGY NSW DRILLING OPERATIONS

Rheochem Trade Name	Other Trade Names	Material / Chemical Description	Chemical Abstract Service Number/s	Other Industries	HAZCHEM ? (Code)	Toxicity	Environmental Considerations	Independent BTEX Tested	Handling (Consult MSDS for handling and PPE)	Unit Size	Typical Concentration used (kg/m³)	Max Kept on Site (kg)	Basic Function	Purpose / Use
K2S04	Potassium Sulphate, K2SO4	Sulphuric Dipotassium Salt, Sulphate of Potash, Potash of Sulfur, Arcanite	7778-80-5	Fertiliser for chloride sensitive crops.	No	Low, moderate if coming into contact with eyes.	None	YES - No detectable levels of BTEX recorded	Avoid Inhaling Dust. Store in well ventilated area.	25 kg Sack	36.0 - 52.0	240	Clay Inhibitor	Helps to keep the drilled clays dry and less sticky.
Calcium Chloride 74-77%	Calcium Dichloride	Calcium Chloride	10043-52-4	Used to de-ice roads. Food grade versions are used in canned vegetables and electrolyte in sports drinks Medicine - Intravenous drips	Yes	Moderate irritant to Eyes, Skin (can cause rash), Inhalation	Salinity	YES - No detectable levels of BTEX recorded	Avoid Skin, Eyes and Lung Exposure.	25 kg Sack	2.80	40	Cement Accelerator	To speed up setting of cement and reduce waiting time.
Xanthan Gum P	Flowzan	Corn Based biopolymer (polysaccharide)	11138-66-2	Food grade version sare used as binders and thickeners.	No	Low	None	YES - No detectable levels of BTEX recorded	Avoid Inhalation	25 kg Sack	1.4 - 5.7	80	Viscosifier	Thickens the mud so it can carry the drilled rock out of the hole.
Quickseal Medium	Kwikseal	Cellophane / Wood / Nutshells	not available	-	No	Low	None	YES - No detectable levels of BTEX recorded	Avoid Inhaling Dust. Store in well ventilated area.	18.1 kg Sack	14.2 - 28.5	50	Lost Circulation Material	Deposits against the wall of the hole to prevent or reduce mud lost down the hole.
Rheopac	Rheopac-RD, Rheopac-LV, Rheopac-R, Drispac-R, Drispac-SL, PAC-R, PAC-L	Poly Anionic Cellulose	9004-32-4, 7647-14-5, 2836-32-0	Poly-anionic cellulose or PAC is derived from Carboxymethyl cellulose (CMC) where the food grade version is used in the manufacture of icecream. Non-food uses include KY Jelly, toothpaste,diet pills etc.	No	Low	Low Biodegradability	YES - No detectable levels of BTEX recorded	Avoid Inhalation	25 kg Sack	1.4 - 3.4	80	Fluid Loss Control	Reduces the amount of fluid seepage from the mud into the ground which can cause the hole to become sticky, unstable and less productive.
JK - 261 / JK-161	CR-650, JK-261 LV, JK-161 LV	PHPA (Partially Hydrolised Poly Acrylamide)	25085-02-3	Water treatment, paper manufacture, soil treatment material. Food grade version is used in potable water	No	Low	None	YES - No detectable levels of BTEX	Avoid Inhalation	25 kg Sack	1.4 - 3.4	40	Clay Inhibitor	Helps to keep the drilled clays dry and less sticky.
Idcide - 20		Tetrakis Hydroxymethyl Phosponium Sulfate (THPS)	55566-30-8	Biodegradable and non-bioaccumalative microbiocide.	No	Low to Moderate irritant for Skin, to Inhale or Ingest. Severe irritant in contact with eyes.	Toxic to microorganisms in short term, but biodegradable and non-bioaccumlative	YES - No detectable levels of BTEX recorded	Liquid Product. Contain if spilled.	20 kg Drum	0.28 - 0.71	16	Biocide	To prevent micro-organisms from attacking the mud and to stop the sump from going green and starting to smell.
Sodium Bicarbonate	Generic Product	Sodium Hydrogen Carbonate (NaHC03)	144-55-8	Food grade version is a major ingredient of Baking Soda.	No	Low	None	YES - No detectable levels of BTEX recorded	Avoid Inhalation	25 kg Sack	0.71	48	pH Control / Cement Treatment	Treatment against cement contamination of the drilling mud.
CITRIC ACID	Generic Product	-	77-92-9	Food grade version is used for flavouring in beverages, jams, jellies and candy.	Yes (N/A)	Low. Slight irritant to eyes and skin or if inhaled or ingested.	None	YES - No detectable levels of BTEX recorded	Avoid Skin, Eyes and Lung Exposure	25 kg Sack	0.71	40	pH Control / Stuck Pipe	to reduce pH, or to mix in a Citric SAPP pill if the drillpipe gets stuck in the hole.
SODA ASH	Generic Product	Sodium Carbonate (Na2C03)	497-19-8	Food grade version used in water treatment for hardness. Manufactuirng of Glass. General cleanser.	No	Slightly Corrosive - Irritant	pH	YES - No detectable levels of BTEX recorded	Avoid Inhalation	25 kg Sack	0.71	48	Hardness Treatment	Control of Calcium Hardness.
Fracseal - Fine		Micronised Cellulose fibre	Not available	Paper	No	Low	None	YES - No detectable levels of BTEX recorded	Avoid Inhaling Dust. Store in well ventilated area.	11.3 kg Sack	14.2 - 28.5	35	Lost Circulation Material	Deposits against the wall of the hole to prevent or reduce mud lost down the hole.
Sodium Formate	Sodium Formate	Formic Acid, Sodium Salt	141-53-7	Food grade version is used as a Preservative and Anti-bacterial ingredient	No	Moderate irritant - The substance is toxic to lungs, mucous membranes. Very hazardous in case of ingestion. Hazardous in case of skin contact of inhalation	Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.	Sample Testing ongoing	Keep away from heat. Keep away from sources of ignition. Do not breathe dust.	25 kg Sack	13.7 - 18.2	240	Weighting Agent, Clay Inhibitor	To provide weight in the fluid and provide some clay inhibition.
DEFOAM - E	-	Polyoxyethylene polyoxypropylene block copolymer	64742-95-6, 64742-88-7	-	No	Low to moderate irritant if in contact with eyes. Over exposure may irritate nose and throat.	Not readily biodegradable	YES - No detectable levels of BTEX recorded	Liquid Product. Contain if spilled.	25 L Drum	0.08	32	Defoaming Agent	Prevent foaming of mud and problems with pumps.
Barite	Rheobar, Aus-Bar	Barite, Barium Sulfate. Naturally occurring, insoluble mineral.	14808-60-7, 7727-43-7	Medical - eg passed through digestive system to X-Ray digestive problems. Used in the manufacture of paper and paint.	No	Low	None	YES - No detectable levels of BTEX recorded	Avoid Inhaling Dust. Store in well ventilated area.	25 kg Sack	142 - 180	Standby	Weighting Material	To prevent hole collapsing and high pressure gas or water from escaping (ie "Blowout"). Legal Requirment for "Well Control".

Appendix 3

MSDS for Potassium Sulphate Polymer Drilling Fluid

RHEOCHEM

MATERIAL SAFETY DATA SHEET

Product Name **POTASSIUM SULPHATE POLYMER DRILLING FLUID**

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Supplier Name	**RHEOCHEM LTD**
Address	11 Alacrity Place, Henderson, WA, AUSTRALIA, 6166
Telephone	+61 8 9410 8200
Fax	+61 8 9410 8299
Emergency	1800 127 406 (Australia); 011 64 3 3530199 (International)
Web Site	http://www.rheochem.com.au/
Synonym(s)	K2SO4 DRILLING FLUID
Use(s)	DRILLING FLUID • DRILLING FLUID ADDITIVE
SDS Date	28 Sep 2011

2. HAZARDS IDENTIFICATION

NOT CLASSIFIED AS HAZARDOUS ACCORDING TO SAFE WORK AUSTRALIA CRITERIA

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE

UN No.	None Allocated	**DG Class**	None Allocated	**Subsidiary Risk(s)**	None Allocated
Packing Group	None Allocated	**Hazchem Code**	None Allocated		

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Ingredient	Formula	CAS No.	Content
WATER	H2O	7732-18-5	>85%
POTASSIUM SULPHATE	K2-S-O4	7778-80-5	3-10%
BARITE	Not Available	Not Available	1-5%
NON HAZARDOUS INGREDIENTS	Not Available	Not Available	<2%
CELLULOSE	Not Available	Not Available	0.5-1.5%
XANTHAN GUM	Not Available	Not Available	<0.5%

4. FIRST AID MEASURES

Eye	If in eyes, hold eyelids apart and flush continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre, a doctor, or for at least 15 minutes.
Inhalation	If inhaled, remove from contaminated area. Apply artificial respiration if not breathing.
Skin	If skin or hair contact occurs, remove contaminated clothing and flush skin and hair with running water. Continue flushing with water until advised to stop by a Poisons Information Centre or a doctor.
Ingestion	For advice, contact a Poison Information Centre on 13 11 26 (Australia Wide) or a doctor (at once). If swallowed, do not induce vomiting.
Advice to Doctor	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flammability Non flammable. May evolve toxic gases if strongly heated.

Fire and Explosion Treat as per requirements for Surrounding Fires: Evacuate area and contact emergency services. Remain upwind and notify those downwind of hazard. Wear full protective equipment including Self Contained Breathing Apparatus (SCBA) when combating fire. Use waterfog to cool intact containers and nearby storage areas.

Extinguishing Prevent contamination of drains or waterways.

Hazchem Code None Allocated

6. ACCIDENTAL RELEASE MEASURES

Spillage If spilt (bulk), use personal protective equipment. Contain spillage, then cover / absorb spill with non-combustible absorbent material (vermiculite, sand, or similar), collect and place in suitable containers for disposal. Prevent spill entering drains or waterways. CAUTION: Spill site may be slippery.

7. STORAGE AND HANDLING

Storage Store in a cool, dry, well ventilated area, removed from oxidising agents, heat or ignition sources and foodstuffs. Ensure containers are adequately labelled, protected from physical damage and sealed when not in use. Check regularly for leaks or spills. Large storage areas should have appropriate ventilation systems.

Handling Before use carefully read the product label. Use of safe work practices are recommended to avoid eye or skin contact and inhalation. Observe good personal hygiene, including washing hands before eating. Prohibit eating, drinking and smoking in contaminated areas.

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Exposure Stds No exposure standard(s) allocated.

Biological Limits No biological limit allocated.

Engineering Controls Avoid inhalation. Use in well ventilated areas.

PPE Wear splash-proof goggles and rubber or PVC gloves. When using large quantities or where heavy contamination is likely, wear: coveralls. In a laboratory situation, wear: a laboratory coat.



9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	VISCOUS WHITE TO OFF-WHITE LIQUID	**Solubility (water)**	NOT AVAILABLE
Odour	CHARACTERISTIC ODOUR	**Specific Gravity**	1 to 1.2 (Approximately)
pH	8.5 (Approximately) (10% solution)	**% Volatiles**	NOT AVAILABLE
Vapour Pressure	NOT AVAILABLE	**Flammability**	NON FLAMMABLE
Vapour Density	NOT AVAILABLE	**Flash Point**	NOT RELEVANT
Boiling Point	> 100°C	**Upper Explosion Limit**	NOT RELEVANT
Melting Point	NOT AVAILABLE	**Lower Explosion Limit**	NOT RELEVANT
Evaporation Rate	NOT AVAILABLE		
Autoignition Temperature	NOT AVAILABLE	**Decomposition Temperature**	NOT AVAILABLE
Partition Coefficient	NOT AVAILABLE	**Viscosity**	NOT AVAILABLE

10. STABILITY AND REACTIVITY

Chemical Stability	Stable under recommended conditions of storage.
Conditions to Avoid	Avoid heat, sparks, open flames and other ignition sources.
Material to Avoid	Incompatible with oxidising agents (eg. hypochlorites).
Hazardous Decomposition Products	May evolve toxic gases if heated to decomposition.
Hazardous Reactions	Polymerization is not expected to occur.

11. TOXICOLOGICAL INFORMATION

Health Hazard Summary	Low toxicity - low irritant. This product may present a hazard with direct eye contact or prolonged skin contact. Chronic effects are not anticipated.
Eye	Low irritant. Contact may result in irritation, lacrimation and redness.
Inhalation	Low irritant. Over exposure may result in irritation of the nose and throat, with coughing.
Skin	Low irritant. Prolonged or repeated contact may result in mild irritation, rash and dermatitis.
Ingestion	Low toxicity. Ingestion of large quantities may result in nausea, vomiting and gastrointestinal irritation.
Toxicity Data	POTASSIUM SULPHATE (7778-80-5) LD50 (Ingestion): 6600 mg/kg (rat) LDLo (Ingestion): 750 mg/kg (woman) LDLo (Subcutaneous): 3000 mg/kg (guinea pig) TDLo (Ingestion): 750 mg/kg (woman)

12. ECOLOGICAL INFORMATION

Environment	Limited ecotoxicity data was available for this product at the time this report was prepared. Ensure appropriate measures are taken to prevent this product from entering the environment.

13. DISPOSAL CONSIDERATIONS

Waste Disposal	For small amounts, absorb with sand, vermiculite or similar and dispose of to an approved landfill site. For larger amounts, contact the manufacturer for additional information.
Legislation	Dispose of in accordance with relevant local legislation.

14. TRANSPORT INFORMATION

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE

Shipping Name	None Allocated				
UN No.	None Allocated	**DG Class**	None Allocated	**Subsidiary Risk(s)**	None Allocated
Packing Group	None Allocated	**Hazchem Code**	None Allocated		

15. REGULATORY INFORMATION

Poison Schedule	A poison schedule number has not been allocated to this product using the criteria in the Standard for the Uniform Scheduling of Drugs and Poisons (SUSDP).
AICS	All chemicals listed on the Australian Inventory of Chemical Substances (AICS).

16. OTHER INFORMATION

Additional Information	ABBREVIATIONS: ACGIH - American Conference of Industrial Hygienists. ADG - Australian Dangerous Goods. BEI - Biological Exposure Indice(s). CAS# - Chemical Abstract Service number - used to uniquely identify chemical compounds. CNS - Central Nervous System. EC No - European Community Number. HSNO - Hazardous Substances and New Organisms. IARC - International Agency for Research on Cancer. mg/m³ - Milligrams per Cubic Metre. NOS - Not Otherwise Specified. pH - relates to hydrogen ion concentration using a scale of 0 (high acidic) to 14 (highly alkaline).

ppm - Parts Per Million.
RTECS - Registry of Toxic Effects of Chemical Substances.
STEL - Short Term Exposure Limit.
SWA - Safe Work Australia.
TWA - Time Weighted Average.

HEALTH EFFECTS FROM EXPOSURE:
It should be noted that the effects from exposure to this product will depend on several factors including: frequency and duration of use; quantity used; effectiveness of control measures; protective equipment used and method of application. Given that it is impractical to prepare a ChemAlert report which would encompass all possible scenarios, it is anticipated that users will assess the risks and apply control methods where appropriate.

PERSONAL PROTECTIVE EQUIPMENT GUIDELINES:
The recommendation for protective equipment contained within this ChemAlert report is provided as a guide only. Factors such as method of application, working environment, quantity used, product concentration and the availability of engineering controls should be considered before final selection of personal protective equipment is made.

Report Status

This document has been compiled by RMT on behalf of the manufacturer of the product and serves as the manufacturer's Safety Data Sheet ('SDS').

It is based on information concerning the product which has been provided to RMT by the manufacturer or obtained from third party sources and is believed to represent the current state of knowledge as to the appropriate safety and handling precautions for the product at the time of issue. Further clarification regarding any aspect of the product should be obtained directly from the manufacturer.

While RMT has taken all due care to include accurate and up-to-date information in this SDS, it does not provide any warranty as to accuracy or completeness. As far as lawfully possible, RMT accepts no liability for any loss, injury or damage (including consequential loss) which may be suffered or incurred by any person as a consequence of their reliance on the information contained in this SDS.

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SDS Date 28 Sep 2011

End of Report

Appendix 4

Indicative waste inventory

Waste	Regulated / trackable	Action	Reduce	Reuse	Recycle	Landfill
Chemicals						
Chemical waste	Yes	Return excess to supplier wherever possible. Triple rinse containers and empty for recycling.	●		●	
Contaminated soils						
Contaminated soils – hydrocarbons	Yes	Contact environmental professional for advice.	●			
Contaminated soil – other	Yes	Contact environmental professional for advice.	●			
Drilling Wastes						
Drill Cuttings	Both	Sample and classify for reuse or disposal. Where re-used, store in bins and skips or if disposed transfer to licensed waste disposal facility.	●	●		●
Drill Fluids – K2SO4 Based	Yes	Classify and store onsite in tanks for transport to batching facility for re-use and/or licensed disposal.	●	●		
Drill Fluids – KCl Based	Yes	Classify and store onsite in tanks for transport to batching facility for re-use and/or licensed disposal	●	●	●	
Electrical and Electronic						
Electrical - batteries - dry	Yes	Place in recycling container at Council's waste transfer station	●		●	
Electrical – batteries – wet	Yes	Place in recycling container at Council's waste transfer station	●		●	
Electrical – electronic and electrical equipment	No	Place in recycling container at Council's waste transfer station	●	●	●	
Electrical – toner and print cartridges	No	Place toner into original cardboard box for transport to accredited toner cartridge collector.	●	●	●	
General						
General – cardboard	No	Ensure cardboard is clean and has no plastic or other contaminants. Place into receptacle for collection by the waste contractor.			●	
General – litter	No	Place into receptacle for collection by the waste contractor.	●			●
General – paper	No	Ensure paper is segregated disposed into recycling bins.	●		●	
General – paper food packaging	No	Ensure packaging is disposed into general waste bins. If packaging is labelled with recycling symbol, segregate into recycling bins.			●	●
General – food scraps	No	Food scraps are to be disposed of into the designated bin on site. Bin to be emptied into the worm farm for the Narrabri Operations Centre.	●		●	
Glass						
Glass – general	No	Ensure glass jars/bottles are rinsed of contents. Store on site in designated recycle bin.			●	

Waste	Regulated / trackable	Action	Reduce	Reuse	Recycle	Landfill
Glass – fluorescent tubes	No	Place intact tubes in old tube boxes where available prior to delivery fluorescent tube box located within the Narrabri Operations Centre.	●	●	●	
Hazardous						
Hazardous – filters – air, dust, paper	Yes	Air filters vehicles are to be cleaned out using an air pressure hose so that they may be re-oiled and refitted to the vehicle. Return directly to supplier where possible.	●	●		
Metals						
Metals – aerosol cans	No	Ensure aerosol cans are empty and store on site in designated recycle bin prior to disposal			●	
Metals – aluminium cans	No	Store on site in designated recycle bin prior to removal to appropriate recycling facility.	●		●	
Metals – copper and aluminium (other than cans)	Yes	Store on site prior to disposal in metal bin at Councils waste transfer station .			●	
Metals – steel drums – empty - damaged	No	Ensure all steel drums are empty (<1% product), clearly labelled and accompanied with an MSDS if appropriate. Return directly to supplier where possible or place on pallet at waste transfer area	●		●	
Metals – steel drums – empty – good condition	No	Ensure all steel drums are empty (<1% product), clearly labelled and accompanied with an MSDS if appropriate. Return directly to supplier where possible or place on pallet at waste transfer area		●	●	
Metals – steel – scrap	No	Small off-cuts are to be cleaned of any oils/lubricants before being placed in bin, ensure large scrap metal items are removed from any site.			●	
Oils						
Oils – oil filters	Yes	Drain filters of excess oil prior to disposal. Place in oily waste bins prior to disposal off site.			●	
Oils – oily rags	Yes	Ensure oily rags are not mixed with clean rags. Place in oily waste bins prior to disposal off site.			●	
Oils – waste oil	Yes	Ensure waste oil is contained before placing into designated storage tank.			●	
Plastics						
Plastics – drums (empty)	No	Ensure drums are cleaned appropriately and chemical labels are removed for re-use. Return directly to supplier where possible.	●	●	●	
Plastics – packaging	No	Classify into recyclable or general waste and store in appropriate bins prior to disposal at waste transfer station			●	●
Plastics – PET containers	No	Store in recycle bin on site prior to disposal at waste transfer station			●	
Rubber						
Rubber – other	No	Return directly to supplier where possible. Ensure remaining rubber items are placed in container at waste transfer area.		●	●	
Rubber – tyres and tubes	Yes	Ensure that un-usable tyres are returned to supplier, remaining tyres are placed on pallets at waste transfer			●	●

Waste	Regulated / trackable	Action	Reduce	Reuse	Recycle	Landfill
		area				
Sewerage						
Septic waste	Yes	Effluent removed by licenced contractor.		●		
Wood and Garden Waste						
Wood/garden – wood – general	No	Place in recycling area at waste transfer area			●	
Wood/garden – wood – pallets	No	Return directly to supplier where possible. Ensure remaining pallets are stored at waste transfer area.			●	
Other						
Other – concrete	No	Place in general waste bins on site.			●	
Other – personal protective equipment	No	Place in general waste bins on site.		●		●

Appendix 5

Noise and Vibration Assessment
Noise Measurement Services

NOISE MEASUREMENT SERVICES

Noise and Vibration Assessment

Drilling, Construction and Operation of Pilot Wells

Santos Limited

Pilliga State Forest

Narrabri NSW

Report 2228-DPW 6 February 2013

DOCUMENT CONTROL PAGE

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0	29/11/2012	Draft Report for Review		BT
1	3/12/2012	Report; review additions	MF	BT
2	4/12/2012	Additional well, updates, review		BT
		comments included		
2A	6/12/2012	Sound power table D1		BT
3	6/2/2013	Revised Dewhurst well locations		BT

Copy No(s)	Rev No	Destination
1pdf	3	RPS Australia East
2	3	Noise Measurement Services

REPORT FOR RPS Australia East

CONTACT Sigrid

Signed



Dr Bob Thorne
(Principal)

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This Report by Noise Measurement Services Pty Ltd is prepared for a particular Client and is based on the agreed objective, scope, conditions and limitations as may be stated in the Executive summary. The Report presents only the information that Noise Measurement Services Pty Ltd believes, in its professional opinion, is relevant and necessary to describe the issues involved. The Report should not be used for anything other than the intended purpose and should not be reproduced, presented or reviewed except in full. The intellectual property of this Report remains with Noise Measurement Services Pty Ltd. The Client is authorised, upon payment to Noise Measurement Services Pty Ltd of the agreed Report preparation fee, to provide this Report in full to any third party.

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EXECUTIVE SUMMARY

Noise Measurement Services Pty Ltd was commissioned by RPS Australia East consulting to Energy NSW - Santos to complete an environmental noise assessment for the drilling, construction and operation of pilot wells which can be used to support the Review of Environmental Factors (REF) for the Dewhurst 6, 22 – 25 pilot wells, as well as REF's for other pilot wells within the Pilliga. The scope of works in this Report is:

- Establishing the existing background sound levels in the vicinity of the proposed Dewhurst 6, 22-25 pilot wells;
- Establishing the environmental noise criteria that would apply to the drilling, construction and operation of the pilot wells;
- Predicting the environmental noise levels due to the construction and operation of the proposed pilot wells at noise sensitive receivers (residences); and
- Assessing the noise related impacts, if any, at noise sensitive receivers (residences).
- Measures for noise mitigation of any noise source are not part of this scope of works.

The noise criteria to be achieved are the Intrusive noise criterion and sleep disturbance criterion under the Industrial Noise Policy. The Rating Background Level plus 5 dB(A) and is established as LAeq 35 dB. The duration of works associated with a well site is in the order of weeks, with the greatest noise emissions (drilling) limited to approximately one week. In this context the drilling is similar to short-term construction noise and the appropriate assessment guidelines are detailed in the *Interim Construction Noise Guideline.*

Table ES1: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated at the residential façade

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	26	36	16	21	24	29	22
R2	3430	25	36	16	21	23	29	22
R3	4070	23	32	<15	19	21	27	21
ML1-R4	5730	16	17	<15	16	<15	18	17
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

The noise emissions from the operation of the 5 pilot wells together, under temperature inversion 'F' conditions, is calculated at approximately 18 dB(A) LAeq, at 5 km from the wells.

It is concluded that the drilling stages may be audible at night when the background levels drop to around 20 dB(A). The activity, however, is of short duration and noise mitigation to the mud-pump (the main source of noise) will reduce further any audible sound.

It is concluded that the operation of the pilot wells should not be audible at any of the residences identified in this assessment.

Glossary

Ambient sound

All sounds in a locality or “soundscape” from distant and nearby sources or activity including traffic, bird song, vegetation movement in the breeze, and so on.

Assessment Background Level (ABL).

The Assessment Background Level is the single figure background level representing each assessment period (day, evening and night) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (LA90) for each period.

Background sound pressure level (LA90,T), L90

Commonly called the "L90" or "background" level and is an indicator of the quietest times of day, evening or night. The L90 level is calculated as the noise level equalled and exceeded for 90% the measurement time. The level is recorded in the absence of any noise under investigation. The level is not adjusted for tonality or impulsiveness. Also known as the background “noise” level.

Character of the environment

The *character of the environment* is often assessed by third-octave or narrow band analysis of the ambient sound. Sounds may be characterised, for example, as “bangs”, “hum noise”, “plant sounds”, and “high frequency sounds”. The assessment is required to determine intrusive noise, tonality or annoying character.

Equivalent Continuous or time average sound pressure level (LAeq,T), Leq

Commonly called the "Leq" level it is the logarithmic average noise level from all sources far and near and is referenced to a specific measurement time interval; e.g. 1-hour. The level can be adjusted for tonality.

LA10.

The LA10 level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the LA10 level for 90% of the time. The LA10 is a common noise descriptor for environmental noise and road traffic noise.

INP

New South Wales Industrial Noise Policy, EPA 2000

NMS

Noise Measurement Services Pty Ltd

Rating Background Level (RBL)

The overall, single-figure, background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24-hout period used for the assessment of background level [in NSW]). This is defined as the median value of all the day evening or night assessment background levels.

1.0 INTRODUCTION

1.1 Project Location

The proposed activity will occur within the Pillaga East State Forest along Monument Road (the Forest), south of Narrabri, within PEL 238. Santos will conduct the activities for and on behalf of the titleholders of PEL 238 and is working with Forests NSW, who manages the Forest, to establish a land access agreement.

Noise Measurement Services Pty Ltd was commissioned by RPS Australia East consulting to Energy NSW - Santos to complete an environmental noise assessments for the drilling, construction and operation of the Dewhurst 6, 22 – 25 pilot wells. The proposed pilot well locations are illustrated in Plates 1.1.1 and 1.1.2. The gathering corridor is 10 metres in width. The initial size of each pilot well drill pad is 100 metres by 100 metres. The area reduces to approximately 10 metres by 10 metres when the pilot well alone is operational. (The gathering system operational works for the wells is calculated as part of the overall noise emissions).

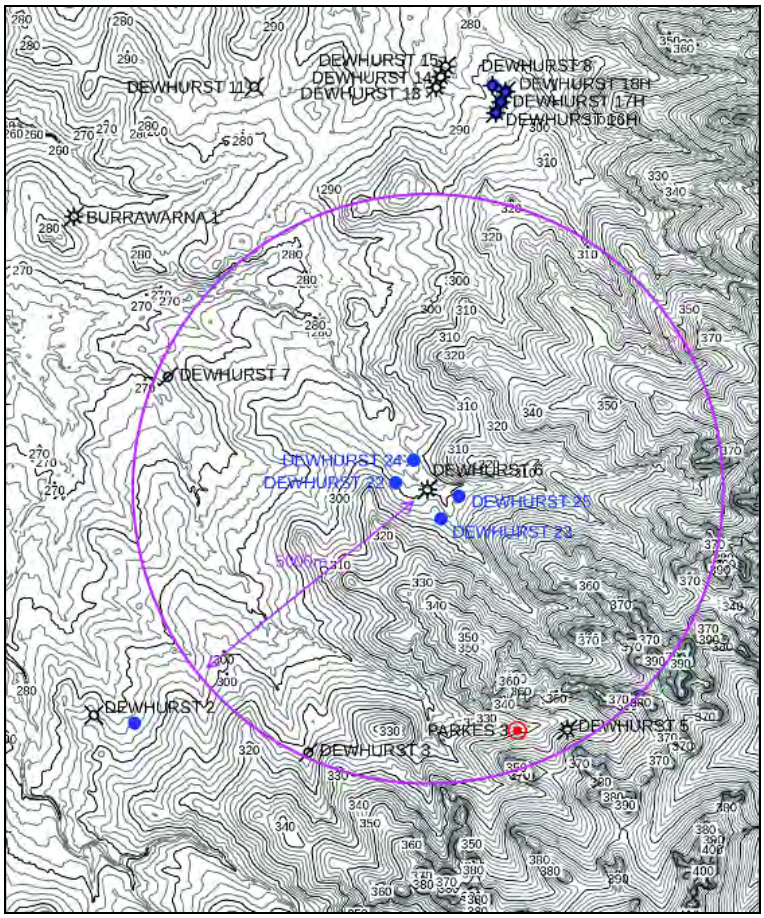


Plate 1.1.1: Location of pilot wells Dewhurst 6, 22 – 25.

The gas flare and water storage facility will be situated at Dewhurst 22. Future infrastructure will link the gathering system to the Bibblewindi ponds.

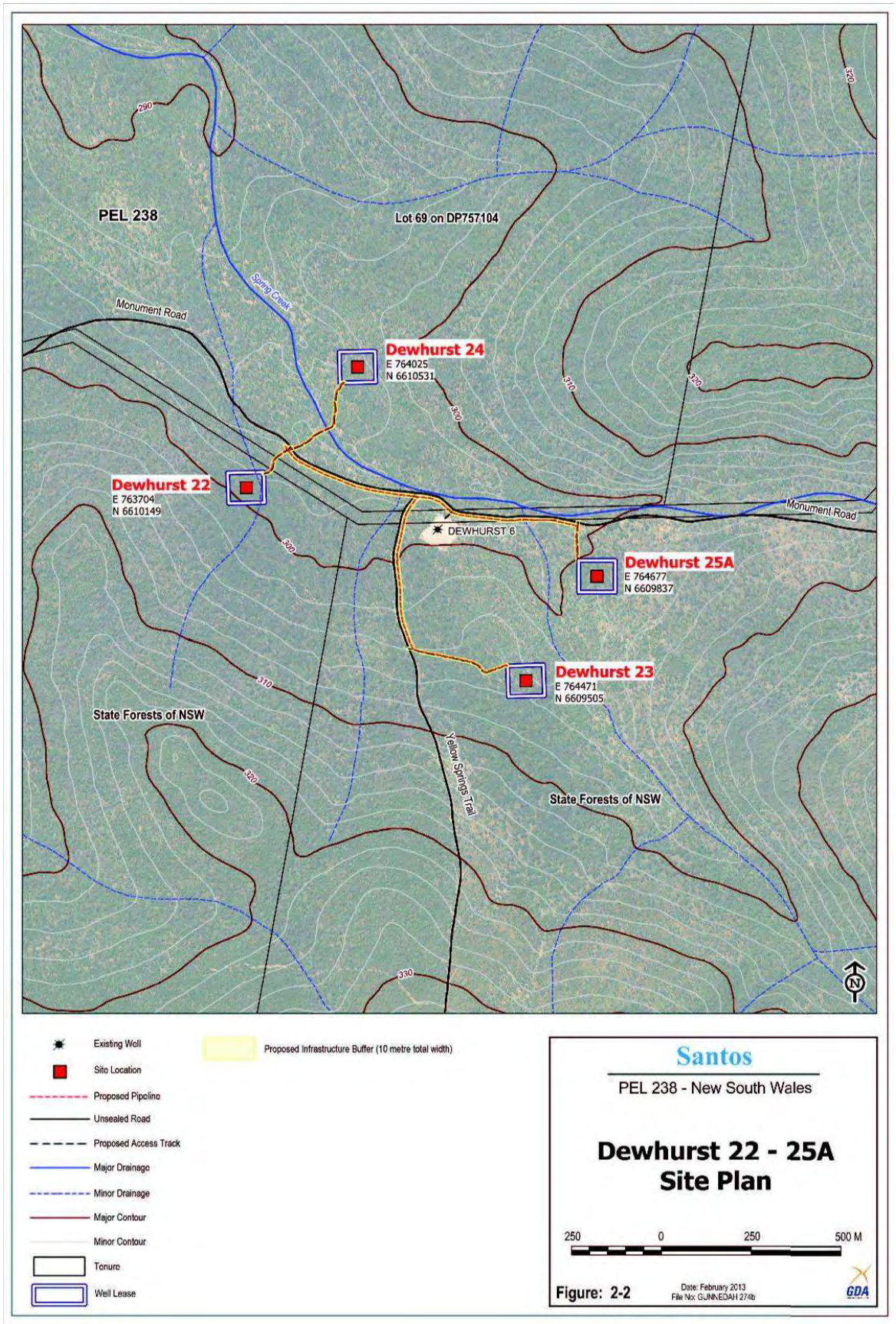


Plate 1.1.1: Location of existing Dewhurst 6 well, pilot wells Dewhurst 22 – 25A and gathering system (red/yellow lines).

1.2 Project Description

This Report considers the noise emissions from coal seam gas (CSG) well development and operation of the pilot wells.

1.2.1 Well development

CSG Well Development is undertaken in stages and operational noise potentially impacting on nearby noise sensitive receivers may include:

- Scouting - a relatively quiet activity, the only noises that should be expected are from vehicles travelling to the site and general conversation.
- Well site preparation – following location of the well site, general construction activities such as excavation and trenching take place to prepare the site, or well pad, for drilling.
- Well drilling – during gas well drilling activities, increases in noise and vibration can be expected in the surrounding area. This noise and vibration is temporary but is generated on a 24 hour continuous basis. Noise emitting equipment used includes the drilling rig, electricity generators for pumps and lighting, pumps, PA system, cementing process, truck and vehicle movements.
- Well completion – site rehabilitation enables the drilled well to be converted into a producing well. Flaring can create a noise for a short period of time. Noise is from the power generator, pump and compressor, and flaring. Trucks remove water and gas with associated vehicle noise. There is some noise during site rehabilitation and periodic well maintenance.
- Installation of the gas and water gathering systems – noises associated with this include the operation of earthmoving and trenching equipment, pipe unloading and lowering pipe into the trenches, backfilling the trench and associated truck engine sounds.

While earthmoving works are undertaken mostly using conventional construction plant such as excavators and graders, drilling processes involve specialised plant such as high-performance compressors and drilling machinery. The equipment used for the mobilisation and powering of the drilling rigs have mufflers installed on their respective power plants and prime movers. Sound from plant and equipment may be audible at night, however, depending on the activities taking place.

1.2.2 Drilling activities

Well drilling involves the following general stages-

- Drilling involves the removal of material by rotary drilling to create the well. The primary noise sources during this operation are the drilling rig engine and the mud pump, each of which operates at moderate to high revs. The greatest noise levels are produced when the rig experiences high torque as result of drilling through hard rock. In addition to the above sources, sound can also be radiated from resonances in the drill pipe and/or the derrick. This is most prominent under high torque loads.
- Tripping involves the removal of the drill pipe and bit from the well (i.e. making a trip). During this stage the drill rig engine operates at moderate revs and the mud pump operates at low revs. Some banging can occur from the placement of drill pipe onto the pipe bins though this is minimised by the pipe-handler/pipe bin design and can be nullified by careful operation. The noise emissions from this stage are reduced compared with drilling.

- Running casing involves inserting metallic casing into the well. The noise emissions from this stage are similar to “tripping”.
- Cementing the casing involves the injection of high-pressure cement outside the metallic casing to secure the well. Noise emissions from the drill rig during this stage are similar to “tripping”, with low-moderate drill rig engine revs and mud pump revs. In addition to the drill rig noise emissions, a high-pressure concrete truck is required during this stage. Noise levels from the concrete truck are significant and thus overall site noise emissions during this stage are similar to drilling, though the directional characteristic differs. The high-pressure concrete truck, cement truck and water cart are only in position adjacent to the rig during the cementing process (i.e. not during drilling etc.).
- These drilling and casing operations are repeated multiple times with decreasing hole and casing diameters until the desired well depth is reached. The depth of each cycle, and consequently the duration of each cycle varies, though it is often in the order of several hundred meters for vertical wells, requiring typically in the order of 1-2 days for each cycle.

The drill rigs used for coal seam gas wells typically emit noise from the operation of:



Figure 1.2.2.1: Typical drilling rig

- Diesel motor/s for the rig‘s operation;
- The mud pump that pumps drilling mud through the drill pipe and brings the cuttings to the surface then circulates the mud into tanks or ground sumps for reuse;
- Fitting and uplifting drill stems and fixing with an iron roughneck, that tightens the pieces of drill stem together as the hole is drilled deeper;
- Small pumps for water removal; and
- Generators to power ancillary lighting and office air conditioning equipment.

Noise emissions from the drilling rig encompasses different drilling modes the potential noise impacts are assessed at various distances from the rig. Noise measurements and predictions are generally for four different operational modes:

- Open hole drilling;
- Running casing;
- Cementing; and
- Core drilling.

The sound levels from various items of plant such as the mud pump, lighting rigs, various generators, pumps and items of mobile plant have been included in the noise assessments. The calculated sound power levels and calculated noise emission levels from typical plant are detailed in Annex A and summarised in Part 4.

1.2.3 Wellhead for water and gas extraction

To extract the gas from the coal seam, the gas and CSG water is pumped to the surface, where the CSG water and free and entrained gas is directed to a separator at the well head to reduce the amount of gas going to the water gathering system and minimise the amount of water going to the gas gathering system. Water gathering systems drain to low points in the topography and the collected water goes to tanks or to flow-lines to a water treatment facility. Each wellhead has separation and gas and water metering facilities. Gas and water from the wells is collected by the gathering systems linking the wells to centralised gas production facilities. The typical facilities at a CSG well are illustrated in Figures 1.2.3.1 to 1.2.3.3:

- A wellhead through which the gas and CSG water is brought to the surface;
- A pump that lifts the CSG water to the surface;
- A power supply to drive the water pump; and
- A wellhead separator with CSG control devices.

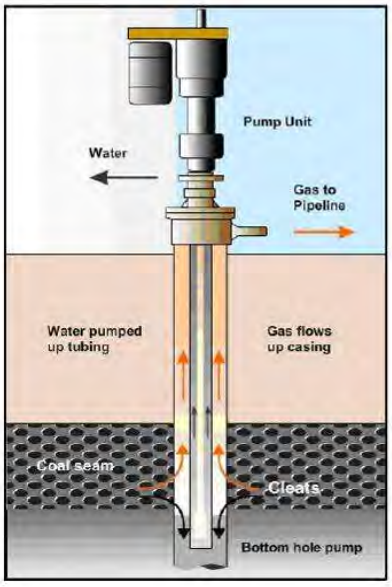
Well head pumping power is generally supplied by a modular gas fired or diesel electric power generation unit located adjacent to the well head. The power generation system and controls provide power for the artificial lift system within the well. As the well pressure declines, a small compressor may be required at the wellhead to ensure that maximum recovery of available gas is achieved. A pump may also be required to maintain water transfer. Flaring happens when there is gas build up and can occur at any time day or night ("24/7").



Figure 1.2.3.1 - Typical wellhead for extraction of gas and CSG water from coal seams



Figure 1.2.3.2: Typical flare assembly



The on-site plant includes:

- Wellhead with progressing cavity pump (PCP, vertical wells at Dewhurst 6, 22 and 24) or down-hole electric submersible pump (ESP, lateral wells at Dewhurst 23 and 25) installed
- Gas fired gensets (2 x 185 kVa) with diesel backup generators (where applicable)
- Plant control panel
- Wellhead choke skid
- Wellhead knockout skid (includes gas and liquid metering skid)
- Gas flow monitoring device; Vortex Meters or Multivariable Transmitter (MVT) units
- Liquid flow monitoring via a Magnetic Water Flow meter device
- Remote Telemetry Unit
- Flow line risers
- Transfer tank
- Transfer pumps.
- Flare at Dewhurst 22

Figure 1.2.3.3: illustration of coal seam gas extraction pump unit

A portion of the produced gas is diverted to the local fuel gas skid for conditioning prior to being used within the well site power generators, with the balance being sent into the LP gas gathering network and flared. Backup diesel generators and associated diesel storage tanks will be stored onsite to ensure suitable power generation capabilities to the site. Any gas surplus to the requirements for on-site electricity generation will be flared on-site at Dewhurst 22 through a skid mounted or equivalent flare system.

1.2.4 Site preparation and rehabilitation

Site preparation consists of clearing the site (100m x 100m) and installing the various ponds and facilities. On-site plant will include excavators and trucks to move over-burden and to stock-pile soil for rehabilitation. Trucks will bring in metal for base-course and this is spread either by bulldozer or grader or both. Other vehicles will bring in the facilities and small plant. Maintenance vehicles (4WD vehicles) will be on-site at twice per day. Vehicles will travel along the access tracks Monument Road and Yellow Spring Creek Road. A water and gas collection system linking the 5 wells runs parallel to the access tracks.

1.2.5 Timing and Duration of Activities

The overall on-site activities are expected to take approximately 3 months and the main phases of work are identified in Table 1.2.5.1

Table 1.2.5.1 Duration of on-site activities

Activity	Approximate Duration	12hr or 24 hr
Site Preparation	14 days	12
Drilling* and completion	15 – 40 days	12
** drilling and cementing as a stand-alone process*	*3 – 7 days within the above time*	*24*
Operation of wellhead	12 months	12
Rehabilitation	14 days	12

The number of people on-site at any one time is expected to be 40 staff during construction and 10 staff during installation and operation of the monitoring equipment. Crews will be located in Narrabri and travel to

site. The standard working hours are 7:00 am to 6:00 pm. The number of 4WD vehicle movements is expected to be approximately between 10 and 20 at these hours.

1.3 Sensitive Receptors

Three noise sensitive receptors (i.e. residences R1 to R3) are within 5 km of the Dewhurst 22 – 25 pilot wells and one residence is a little further way, as shown in Plate 1. Plate 1 also shows the ambient noise monitoring locations (ML1 and ML2). There is a residence at location ML1. The location of the Dewhurst 22-25 pilot wells is shown on Plate 1 and in more detail on Plate 2. The location of the residences and measurement locations in this report are given in Table 1.3.1 by latitude and longitude.

Table 1.3.1 Residential and Measurement Locations

Location	Easting	Southing
Residence 1	149°44' 36"	30°34' 55"
Residence 2	149°44' 31"	30°34' 42"
Residence 3	149°45' 05"	30°34' 20"
Residence 4 and ML1	149°41' 38"	30°36' 26"
ML2	149°41' 59"	30°38' 54"
ML3 (to the north of the Project area)	149°41' 07 "	30°21' 49"
ML4 (to the north of the Project area)	149°41' 07 .47"	30°22' 06"

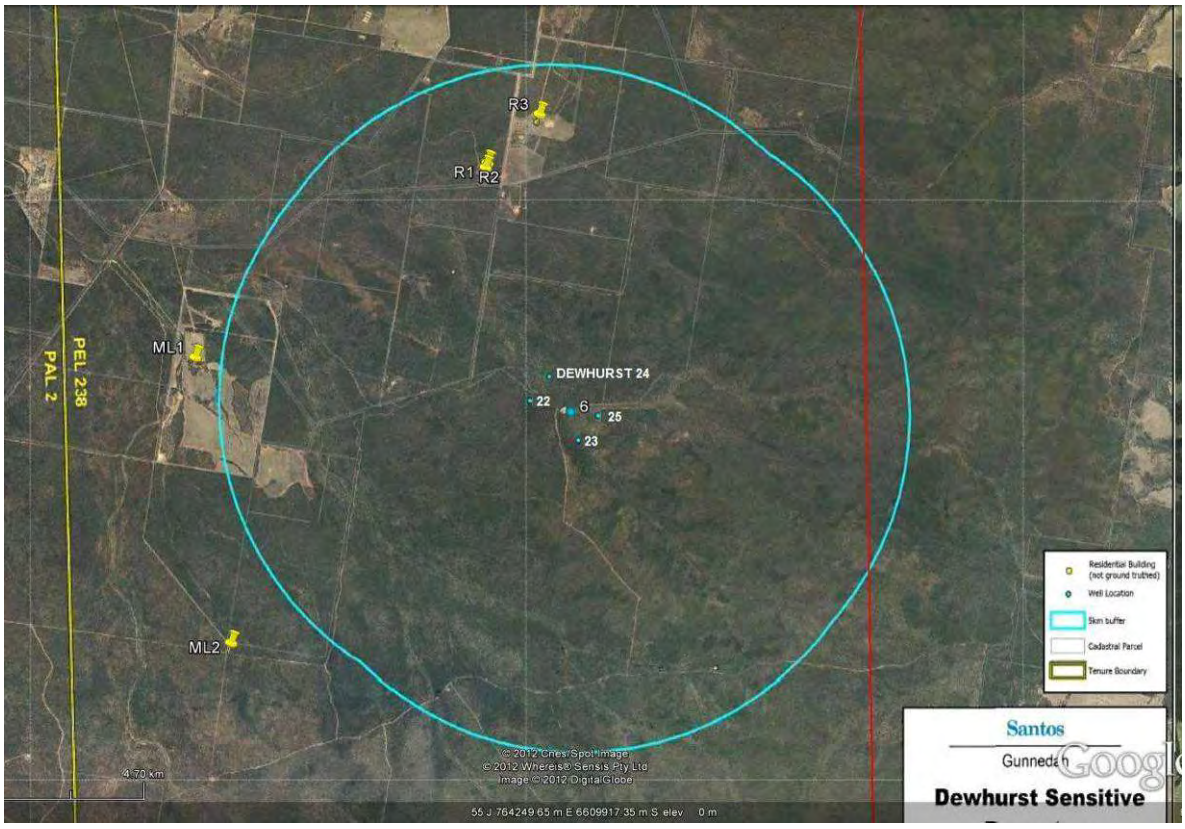


Plate 1.3.1: Residences (R1-R3), noise monitoring locations ML1, ML2) and Dewhurst pilot well locations

1.4 Noise Assessment Method

The basic concept of determining whether or not the noise from petroleum and gas activities is likely to cause intrusive noise impacts is to compare the existing noise levels to the expected noise levels from the proposed activities. The operational noise assessment was conducted in accordance with the Industrial Noise Policy (INP) published by the NSW EPA in 2000.

The determination compared the background sound levels calculated to the Industrial Noise Policy (the average of the minimum sound levels without the petroleum and gas activities) to the measured sound level at a potentially affected sensitive residence when the petroleum and gas activities are being carried out. Further operational noise levels were calculated to other residences potentially affected. Noise modelling creates different scenarios, including a scenario of worst case meteorological conditions. While different scenarios can be calculated through a noise model, it will rarely be possible to factor in all possible situations that may present themselves over time with accuracy. For this reason, assumptions must be made in applying the noise model. The calculation methods are detailed in Annex C.

The model identifies the preparation, drilling and 5 pilot well noise sources that could impact on residences. A residence may be affected by noise emissions from two or more operational wellheads. Therefore multiple noise sources are calculated.

The ambient noise level at a residence consists of the natural sound levels from wind in trees, insects, animal, rural activity, household activity noise. When the drilling occurs or the wellheads are in operation an additional sound is added to the natural environment. This is defined as the intrusive noise (or component noise) and is defined as the source noise only (i.e. without the contribution of background noise).

We conclude that, in the absence of insects and winds the background sound levels are below 30 dBA. This level constitutes the minimum Rating Background Level (RBL) considered in NSW under the NSW Industrial Noise Policy (INP, EPA 2000) and other policies/guidelines that refer to the determination of background noise levels detailed in the INP. The measured ambient sound levels are recorded in Section 2.

An RBL of 30 dBA would be expected in rural areas and so this is considered appropriate for derivation of indicative noise level criteria in this instance.

Intrusive Noise

The Intrusive Noise Criterion is determined as the Rating Background Level (RBL) plus 5 dB(A), measured as the time-average LAeq sound level over 15 minutes.

Sleep Disturbance

The Sleep Disturbance Criterion is determined as 40 dB(A), façade-affected per Table 2.1 of the INP measured as the time-average LAeq sound level over 15 minutes.

2.0 Ambient Noise Monitoring

2.1 Noise monitoring locations

In order to establish the existing noise environment within and adjacent to the Project area, ambient noise monitoring was conducted at two locations, ML1 and ML2 in November 2012. The selected locations are considered to be representative of the noise sensitive receptors within the Project area. In addition, two monitoring locations (ML3 and ML4) just to the north of the Project area are included as these give representative rural noise levels for June 2012. The measurement locations are shown graphically in Plate 2.1.1 and 2.1.2. The selection of noise monitoring locations was based on consideration of noise sensitive locations (residential properties) and other noise sources which may influence the noise measurements.

Plate 2.1.1: Aerial photograph showing ML1 and ML2 (November 2012). ML1 is located close to a Residence.

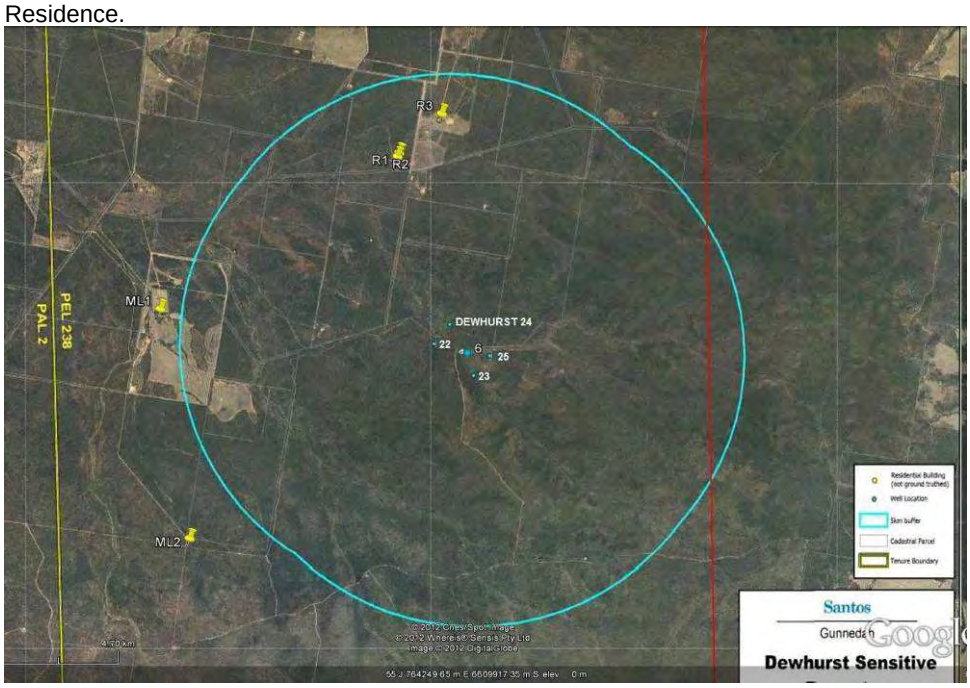


Plate 2.1.2: Aerial photograph showing ML3 and ML4 (June 2012). ML4 is located close to a residence.



The following photographs illustrate the various sound measurement locations for the survey.

Photo 2.1: View of noise logger location ML1 including weather station and residential dwelling behind.



Photo 2.2: View of noise logger ML2.



Photo 2.3: View of noise logger ML3 (June 2012 Survey).



Photo 2.4: View of noise logger ML4 (June 2012 Survey).



2.2 Instrumentation

The two-week unattended noise logging was conducted using Larson Davis 831 sound analyser instruments, designated as Class 1 under Australian Standard *AS IEC 61672.1-2004 Electroacoustics - Sound level meters - Specifications* as having an accuracy suitable for field use. The long-term noise loggers were calibrated before and after the measurements with a drift in calibration not exceeding ±0.5 dB. Each sound level meter was calibrated before and after the measurements with a Rion NC73 calibrator and the drift in calibration not exceeding ±0.5 dB. Each sound level meter used for this assessment has current a calibration certificate.

2.3 Meteorological data

Weather data for the area was sourced from the Bureau of Meteorology's Narrabri Airport weather station (Annex C) to wind speed and direction over a 12-month period and during the monitoring. A Davis weather station was installed at one of the measurement locations in order to record ground-level meteorological data. As required by the INP guidelines, extraneous noise events and noise data adversely affected by weather, e.g. rain, were excluded. The recorded weather data was recorded every 15 minutes and the data is summarised in Table 2.3.1. All the 15 minutes samples are displayed in 6-hour blocks. The noise data is unaffected by adverse weather.

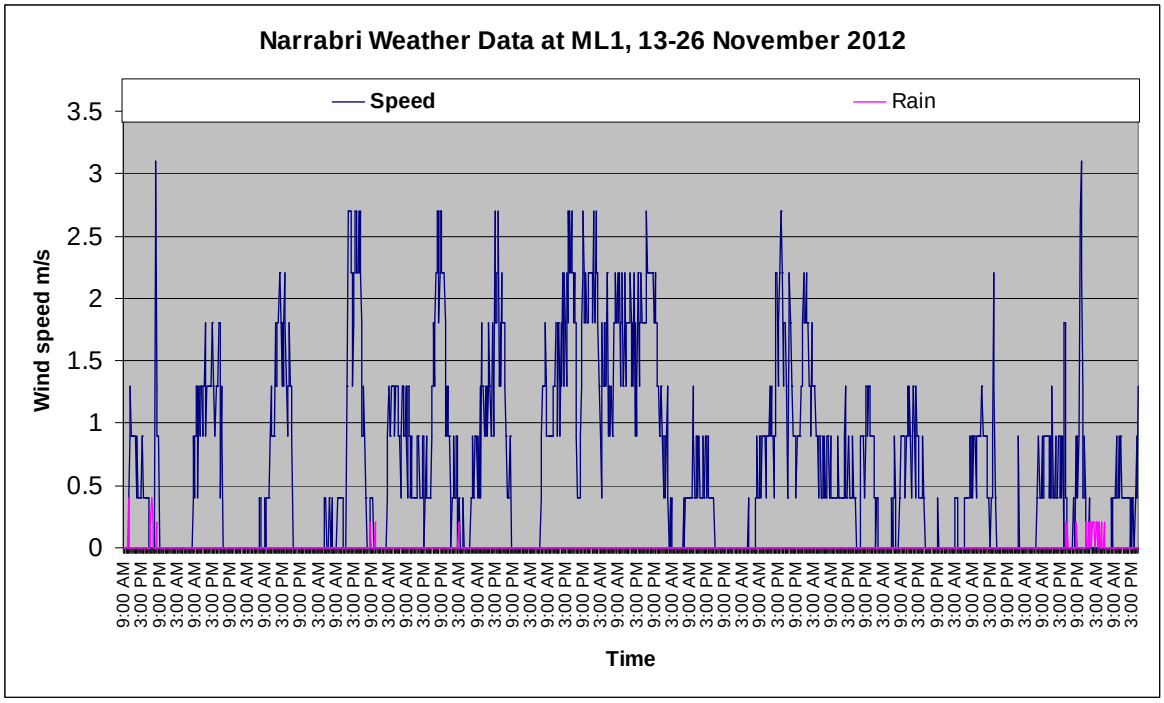


Figure 2.3.1 Weather data at Narrabri during the monitoring in November 2012

2.4 Unattended continuous noise monitoring

In order to assess the background and ambient noise levels at the site, in the absence of plant operating and in accordance with the *NSW Industrial Noise Policy 2000,* a series of surveys were taken on site, generally in accordance with Australian Standard AS1055.1:1997 - 'Acoustics-*Description and measurement of environmental noise - Part 1: General procedures'*.

The microphone at each location was 1.35m above ground level. A Davis weather station was also employed during the survey to record wind and rain information, in order that days with excessive wind or rain noise could be identified and excluded. Two loggers were used to continuously measure background noise levels between Tuesday 13 November 2012 and Tuesday 27 November 2012 (refer to Figure 3). The results of the noise monitoring were processed in accordance with the procedures contained in the INP. Additionally, sound levels recorded to the north of the Project area have been reviewed and noted as they relate to different time of year and have different background levels that will be similar to the Dewhurst location.

The noise logger measured the noise level over the sample period and the L_{A1}, L_{A10}, L_{A90}, L_{Amax} and L_{Aeq} sound levels recorded every 15 minutes. The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample period respectively.

The noise logger at location ML2 failed after 3 days. This was an instrument failure.

2.5 Rating Background Noise Levels

The background sound levels calculated to the Industrial Noise Policy are presented in the following tables. The levels were measured in continuous 15 minute intervals from 14 to 26 November 2012. The data is correlated to 15-minute wind and rain data. There were no events (rain or avearge wind speeds above 5m/s) requiring data to be excluded. This data is available for a more precise analysis if necessary.

The L_{A90} is taken as the background noise level. The Assessment Background Level (ABL) is established by determining the lowest tenth-percentile level of the L_{A90} noise data acquired over each period of interest. The background noise level or Rating Background Level (RBL) representing the day, evening and night-time assessment periods is based on the median of individual ABLs determined over the entire monitoring duration.

The RBL is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the background level. The L_{Aeq} is the average energy sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

A summary of the calculated RBLs (L_{A90}) and existing ambient noise levels (L_{Aeq}) is presented in the following tables. The calculated ABLs and existing L_{Aeq} ambient noise levels for each noise monitoring location for each assessment period (day, evening and night) are presented following.

Where the rating background level is found to be less than 30 dB(A) the RBL is are set to 30 dB(A).

Table 2.1: Ambient noise levels at Residence (ML1); RBL (Median LA90)

	Day	Evening	Night
Wed 14 Nov	33.7	37.2	36.7
Thu 15 Nov	33.7	32.6	37.4
Fri 16 Nov	32.8	35.0	35.5
Sat 17 Nov	28.6	30.6	33.4
Sun 18 Nov	28.4	32.7	32.7
Mon 19 Nov	27.4	35.6	25.7
Tue 20 Nov	33.4	34.8	35.2
Wed 21 Nov	27.9	29.2	27.3
Thu 22 Nov	30.2	30.3	30.2
Fri 23 Nov	28.7	30.0	35.3
Sat 24 Nov	32.1	30.6	41.0
Sun 25 Nov	33.4	59.1	38.5
Mon 26 Nov	35.4	36.3	40.9
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**32**	**33**	**35**

Table 2.2: Ambient noise levels background location (ML2); RBL (Median LA90)

	Day	Evening	Night
Wed 14 Nov	28.0	35.7	16.6
Thu 15 Nov	27.4	30.4	15.6
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**28**	**33**	**16**

Note: the measurements are truncated because the noise logger failed.

Table 2.3: Ambient (2012) noise levels in rural area to north of Project area (W-ML3); RBL (Median LA90)

	Day	Evening	Night
Sat 23 Jun	23.6	24.8	23.7
Mon 25 Jun	21.0	24.1	21.3
Tue 26 Jun	22.2	21.3	20.8
Fri 29 Jun	22.9	29.9	21.7
Sun 8 Jul	22.1	19.3	ND
Mon 9 Jul	22.5	19.2	19.7
Tue 17 Jul	ND	ND	ND
Sun 15 Jul	ND	ND	ND
Sat 30 Jun	24.5	28.6	21.0
Mon 2 Jul	26.3	22.3	22.6
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**23**	**23**	**21**

Table 2.4: Ambient (2012) noise levels at residential property, rural locale north of the Project area (W-ML4); RBL (Median LA90)

	Day	Evening	Night
Sat 23 Jun	25.7	20.0	18.7
Mon 25 Jun	21.4	18.6	20.1
Tue 26 Jun	24.3	18.9	19.1
Fri 29 Jun	23.9	26.0	22.7
Sun 8 Jul	24.5	19.9	19.9
Mon 9 Jul	23.7	19.7	19.5
Tue 17 Jul	25.1	43.0	31.2
Sun 15 Jul	30.3	36.9	33.9
Sat 30 Jun	25.6	23.1	20.5
Mon 2 Jul	27.9	19.5	19.2
Time Period	7am to 6pm	6pm to 10pm	10pm to 7am
Rating Background Level (RBL)	**25**	**20**	**20**

2.6 Ambient Leq Noise Levels

The Leq sound levels calculated to the procedure under the Industrial Noise Policy are presented in the following tables. The levels were measured in continuous 15 minute intervals from 14th to 26th November 2012. Days affected by rain or high winds (average wind gusts over 5m/s) were excluded from assessment, where possible.

Table 2.5: Ambient LAeq noise levels at residence (ML1)

	Day	Evening	Daytime	Night
Wed 14 Nov	47.2	59.8	54.7	53.4
Thu 15 Nov	46.2	51.0	48.1	53.5
Fri 16 Nov	45.9	53.8	49.7	49.3
Sat 17 Nov	46.6	51.4	48.5	51.1
Sun 18 Nov	46.7	58.8	53.7	55.0
Mon 19 Nov	44.4	48.8	46.1	45.4
Tue 20 Nov	45.6	48.1	46.4	47.4
Wed 21 Nov	44.0	54.6	49.8	56.8
Thu 22 Nov	50.7	53.5	51.6	55.9
Fri 23 Nov	45.5	53.1	49.0	55.3
Sat 24 Nov	46.2	49.2	47.2	55.6
Sun 25 Nov	47.3	61.5	56.1	55.5
Mon 26 Nov	49.6	51.1	50.0	55.1
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**47**	**56**	**51**	**54**

Table 2.6: Ambient LAeq noise levels background location (ML2)

	Day	Evening	Daytime	Night
Wed 14 Nov	43	44	44	37
Thu 15 Nov	40	45	42	36
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**42**	**44**	**43**	**36**

Note: the measurements are truncated because the noise logger failed.

This location, ML2, is in the bush and affected by insects, birds and noise in vegetation.

Supplementary Data

The levels were measured in continuous 15 minute intervals from 20 June to 20 July 2012, whilst the gas powered generators at Wilga Park were not operational. Days affected by rain or high winds (average wind gusts over 5m/s) were excluded from assessment, where possible. The data is included as it provides an assessment for mid-year (June) weather conditions.

Table 2.7: Ambient LAeq 2012 noise levels at residential property, rural locale north of the Project area (W-ML3)

	Day	Evening	Daytime	Night
Sat 23 Jun	45	33	44	34
Mon 25 Jun	47	29	45	43
Tue 26 Jun	45	30	44	38
Fri 29 Jun	47	36	46	36
Sun 8 Jul	48	25	47	31
Mon 9 Jul	52	30	51	37
Tue 17 Jul	51	44	50	42
Sun 15 Jul	44	43	44	42
Sat 30 Jun	46	27	45	31
Mon 2 Jul	51	28	49	38
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**48**	**37**	**47**	**39**

Table 2.8: Ambient LAeq 2012 noise levels at rural property boundary north of the Project area (W-ML4)

	Day	Evening	Daytime	Night
Sat 23 Jun	43	32	42	32
Mon 25 Jun	42	29	41	33
Tue 26 Jun	43	29	42	32
Fri 29 Jun	43	36	42	36
Sun 8 Jul	ND	25	ND	ND
Mon 9 Jul	43	26	41	34
Tue 17 Jul	ND	ND	ND	ND
Sun 15 Jul	ND	ND	ND	ND
Sat 30 Jun	44	32	42	34
Mon 2 Jul	43	31	42	33
Time Period	7am to 6pm	6pm to 10pm	7am to 10pm	10pm to 7am
Existing Leq	**43**	**31**	**42**	**33**

3.0 Noise Assessment Criteria

3.1 Operational noise criteria

Under the provisions of the *Protection of the Environment Act*, any premises that has the capacity to produce more than 5 petrajoules of gas per annum must hold an environmental protection licence. The licence can include noise conditions. While it is not known (to NMS) if the trigger level is reached for this Project element it is 'best practice' to assume that noise conditions may be applied to this part of the Project. Potentially relevant legislation and guidelines include:

- Protection of the Environment Operations Act 1997 (POEO Act),
- Protection of the Environment Operations (General) Regulation 1998,
- Protection of the Environment Operations (Noise Control) Regulation 2000,
- NSW Industrial Noise Policy (INP), DEC January 2000,
- Interim Construction Noise Guideline, 2009
- Environmental Criteria for Road Traffic Noise (ECRTN), DEC, May 1999,
- NSW Environmental Noise Control Manual or ENCM (DEC Ref. 94/31),
- Environmental Noise Management, Noise Guide for Local Government (DEC Ref.2004/59).

Not all of the above need to be considered for this assessment. Noise generated within the Project area, including construction noise, noise from plant, truck movements, loading/unloading activities, mechanical services associated with site buildings, are assessed in accordance with the EPA's Industrial Noise Policy 2000 (INP) guidelines. Noise of the type that would be generated by the Project is classified under the INP as '*industrial noise*'. The INP assessment procedure for industrial noise sources has two components, which are:

- Controlling intrusive noise impacts in the short term for residences; and
- Protecting noise amenity for particular land uses and for residences.

3.2 Intrusive noise impacts

The INP states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15 minute period, does not exceed the background noise level (RBL), measured in the absence of the source, by more than 5 dB. This is termed the *Intrusiveness Criterion*. The RBL is the background noise level to be used for assessment purposes and is determined by the methods given in Section 3.1 of the INP. In accordance with the INP requirements, adjustments are to be applied to the level of noise produced if the noise at the receptor contains annoying characteristics such as tonality or impulsiveness.

3.3 Protecting noise amenity

To limit continuing increases in noise levels, the ambient noise level resulting from industrial type noise sources should not normally exceed the acceptable noise levels specified in *Table 2.1* of the INP. That is, the industrial noise level contribution should not exceed the level appropriate for the particular locality and land use. This is

termed the *Amenity Criterion*. Most applicable to this assessment are the amenity criteria for residential receptors in a '*Rural'* area and passive recreation areas. The recommended maximum values provide guidance on an upper limit to the level of noise from industry and industrial type facilities. In all cases, it is expected that all feasible and reasonable mitigation measures would be applied before the recommended upper limit noise levels are referenced.

3.4 Cumulative impact from Drilling and Operation of Pilot Wells

The site specific environmental noise criteria, which are derived based on existing ambient conditions, take into account the cumulative impact from the individual pilot wells within the area adjacent to the proposed Project area. This is achieved by calculating all 5 wells operating together. The predicted levels from the wells are below the RBL of 30 dB(A).

3.5 Sleep disturbance criteria

The INP discusses sleep disturbance and its objective assessment. To reduce the risk of sleep disturbance as a result of industrial type operations during the night-time period, Table 2.1 has a recommended amenity criterion of 40 dB(A) LAeq for night-time at a residence in a rural area. *(Note – in quiet rural areas and a low background level at night an activity level of 40 dB(A) at the outdoor façade will be audible indoors).* The INP application notes recommend that the $L_{A1(1\ minute)}$ noise level outside a bedroom window should not exceed the L_{A90} background noise level by more than 15 dB(A) during the night-time period (10.00 pm to 7.00 am).

3.6 Sound character

The character of the sound emissions from the site construction, drilling, and pilot well operation is different to that the existing environment. Low frequency sound (for example, generator sound), impulsiveness (for example, the clanging of drill pipes) and possible tonal noise (for example, from generators) are the most common sounds noticed at a distance under enhanced propagation conditions. The guidelines suggest a 'penalty' or 'adjustment' based on the degree that the sound may be noticed. A value of +5dB(A) is added to the modelled sound levels to represent "tonal components that are clearly audible and their presence can be detected by one-third octave analysis". If the sound is only just detectable by the observer and is determined by narrow-band analysis an adjustment of 2 to 3 dB is more appropriate.

3.7 Interim Construction Noise Guideline

The Project is considered a mining project for the purpose of this noise assessment. In accordance with the recommendations in the Interim Construction Noise Guidelines (ICNG), the construction activities for mining projects are to be assessed under the INP, therefore the operational noise criteria presented previously will also apply to construction works associated with the Project.

Drilling typically takes 3 - 7 days. In addition to this one to two weeks would be required for earthworks to establish the drill pad. Therefore the duration of works associated with a well site is in the order of weeks, with the greatest noise emissions (drilling) limited to approximately one week. In this context the drilling is akin to short-term construction noise and as such appropriate assessment guidelines are detailed in the *Interim Construction Noise Guideline* (ICNG, DECC 2009).

The Guideline presents noise management levels for use when undertaking a quantitative assessment, such as for major construction projects. The recommended standard hours are-

- Monday to Friday 7am to 6pm
- Saturdays 8am to 1pm
- No work on Sundays or public holidays

Construction Noise Criteria

The noise management level for works during the recommended standard hours is background + 10 dB(A). Above this noise level the proponent needs to implement all feasible and reasonable work practices, as defined in the Guideline, to minimise noise impacts.

For works outside the recommended standard hours, the noise management level is background + 5 dB(A).

The highly noise-affected level of LAeq 75 dB(A) represents the point above which there may be strong community reaction to noise and indicates a need to consider other feasible and reasonable ways to reduce noise, such as restricting the times of very noisy works to provide respite to affected residences.

4.0 Noise Calculations – Impact Assessment

4.1 Environmental noise prediction method

The method of prediction is ideally suited to a combination of both ISO 9613-2 and CONCAWE methods. The calculation programs available for this purpose are (a) SoundPLAN, which has both methods as separate modules, and (b) PEN3D, an environmental noise model developed by Noise Mapping Pty Ltd Queensland. The PEN3D environmental model is the program used in this Report. It is a faithful representation of the Environmental calculation method described in the book by Bies & Hansen *"Environmental Noise Control"*. The program has both propagation methods and is described in Appendix D.

The noise model is based on an assessed flat topography as the land effectively flat within the 5 km of the pilot wells to the nearest residences. Tonality is not allowed for in the models and is added into the calculation tables.

4.2 Meteorological conditions

Meteorological conditions such as the presence of a temperature inversion or light to moderate winds can have a significant effect on sound propagation. Temperature inversions (i.e. when the normal temperature profile of the atmosphere is reversed such that the air temperature increases with increasing height above ground) typically occur at night during winter periods and tend to assist the propagation of noise. Based upon information provided by Heggies (see Appendix C), the occurrence of F class or greater temperature inversions is 22% or less during the winter months. The INP suggests that the effects of temperature inversions on noise levels be assessed in locations where occurrence approaches or is in excess of 30%. An assessment under inversion conditions is not therefore part of this Report. Modelling with a 5m/s breeze from the south blowing towards the nearest residences was conducted as part of this assessment.

4.3 Operational activities

All operational equipment was assumed to be running 24 hours per day, 7 days a week, with similar capacity during the day, evening and night-time periods. All noise sources were modelled as point sources as the distance between source and receptor is large enough to warrant this assumption. Operational activities with the potential to create a noise impact within the Project area are described previously and for prediction purposes consist of:

- Site clearing — sound power level of 120 dB(Lin) or 118 dB(A), LAeq 1 hour
- Well drilling — sound power level of 120 dB(Lin) or 118 dB(A), LAeq 1 hour
- Pilot well operation — sound power level of 114 dB(Lin) or 97 dB(A), LAeq, 1 hour

All residential receptors were modelled at a height of 1.8 m above ground level. Noise predictions were carried out at the three nearest residential receptors to the Dewhurst wells. The distances of the three residential receptors to the Dewhurst locations are shown in the predictions' table, Table 4.3.1, for scenarios 1 to 6. Scenario 'F' is an assessment of the 5 pilot wells in operation at the same time and an inversion layer over the locale. The inversion is stability 'F' and calculated as a temperature gradient of 3.0 ℃/100m, 10℃ ambient, 50% relative humidity.

The noise criterion to be achieved is established as the Intrusive Noise Criterion under the Industrial Noise Policy. This is the Rating Background Level plus 5 dB(A) and is established as LAeq 35 dB.

As the exact location of the residences are not known (the locations have been estimated as closely as possible from Google Earth) the calculations are predicted in the free-field or nominally 5 metres from the assessed residence location. At the distances involved this assessment will not give rise to a significant variation in activity sound level. Table 4.3.1 gives the predicted free-field values and Table 4.3.2 gives the predicted façade-affected time-average LAeq sound levels at the residences.

Table 4.3.1: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated to 5 metres from the façade ('free-field')

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	24	34	<15	19	21	26	20
R2	3430	23	33	<15	19	21	26	20
R3	4070	20	30	<15	17	19	24	18
ML1-R4	5730	<15	15	<15	<15	<15	16	15
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

Table 4.3.2: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated at the residential façade

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	26	36	16	21	24	29	22
R2	3430	25	36	16	21	23	29	22
R3	4070	23	32	<15	19	21	27	21
ML1-R4	5730	16	17	<15	16	<15	18	17
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

The noise emissions from the operation of the 5 pilot wells together, under temperature inversion conditions, is calculated at approximately 18 dB(A) LAeq, at 5 km from the wells. The duration of noise from pilot well is taken as being '24/7' and is calculated on a 15-minute or 1-hour basis. This also applies to the operation of the drill rig. All other activities are taken as being 7am to 6pm daily.

The weather conditions in the Table relate to 'calm' conditions where there is no breeze blowing towards a residence; and 'enhanced' conditions when there is a 3 metres/sec breeze blowing towards a residence.

The 'worst case' assessments for noise from the drilling rig (or from similar noisy plant and machinery such as excavators) are given in Table 4.3.3.

Table 4.3.3: Predicted 'Worst Case' LAeq Sound Levels at Various Offset Distances for the drilling rig operation (or similar plant such as excavators) alone

Drill Rig and Operation	Weather Condition	Predicted LAeq Sound Level at Buffer Distances (metres)						
		50m	100m	500m	1000m	1500m	2000m	5000m
Open Hole Drilling	Calm	70	62	45	36	30	25	<10
	Enhanced	70	64	48	39	33	29	<10
Running casing	Calm	70	62	45	36	30	25	<10
	Enhanced	72	64	47	38	32	27	<10
Cementing Casing	Calm	70	62	45	36	30	25	<10
	Enhanced	77	69	51	41	35	30	13
Core Drilling	Calm	64	58	41	33	27	23	<10
	Enhanced	68	61	43	35	29	25	<10

Table 4.3.4 presents an assessment of the Industrial Noise Policy guideline values for Intrusive Noise with respect to the potential noise sources as they affect the residences. The criterion is 35 LAeq.

Table 4.3.4: Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	Pass	+1	Pass	Pass	Pass	Pass	Pass
R2	3430	Pass	+1	Pass	Pass	Pass	Pass	Pass
R3	4070	Pass	Pass	Pass	Pass	Pass	Pass	Pass
ML1-R4	5730	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

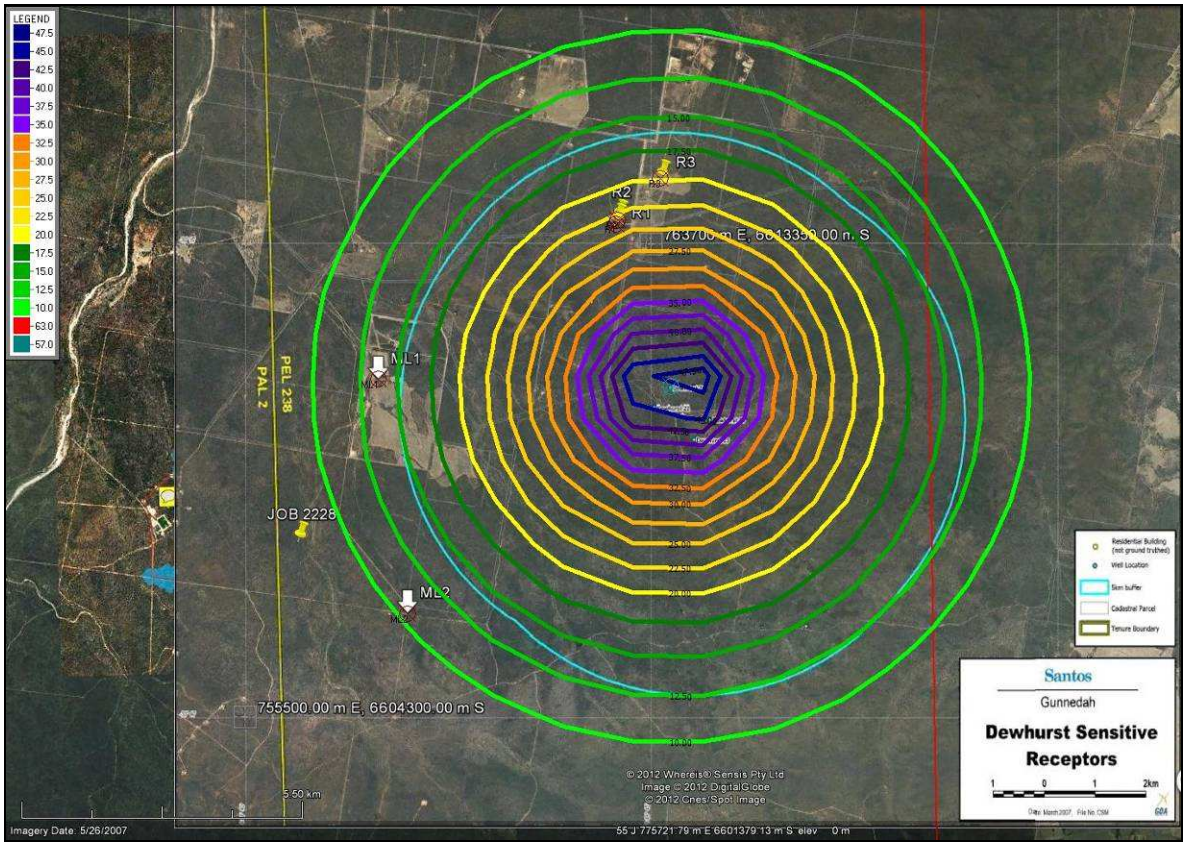
Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

Table 4.3.5 presents an assessment of the Industrial Noise Policy guideline values for Sleep Amenity (measured outdoors) with respect to the potential noise sources as they affect the residences. The criterion is 40 LAeq.

Table 4.3.5: Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	Pass	+1	Pass	Pass	Pass	Pass	Pass
R2	3430	Pass	+1	Pass	Pass	Pass	Pass	Pass
R3	4070	Pass	Pass	Pass	Pass	Pass	Pass	Pass
ML1-R4	5730	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

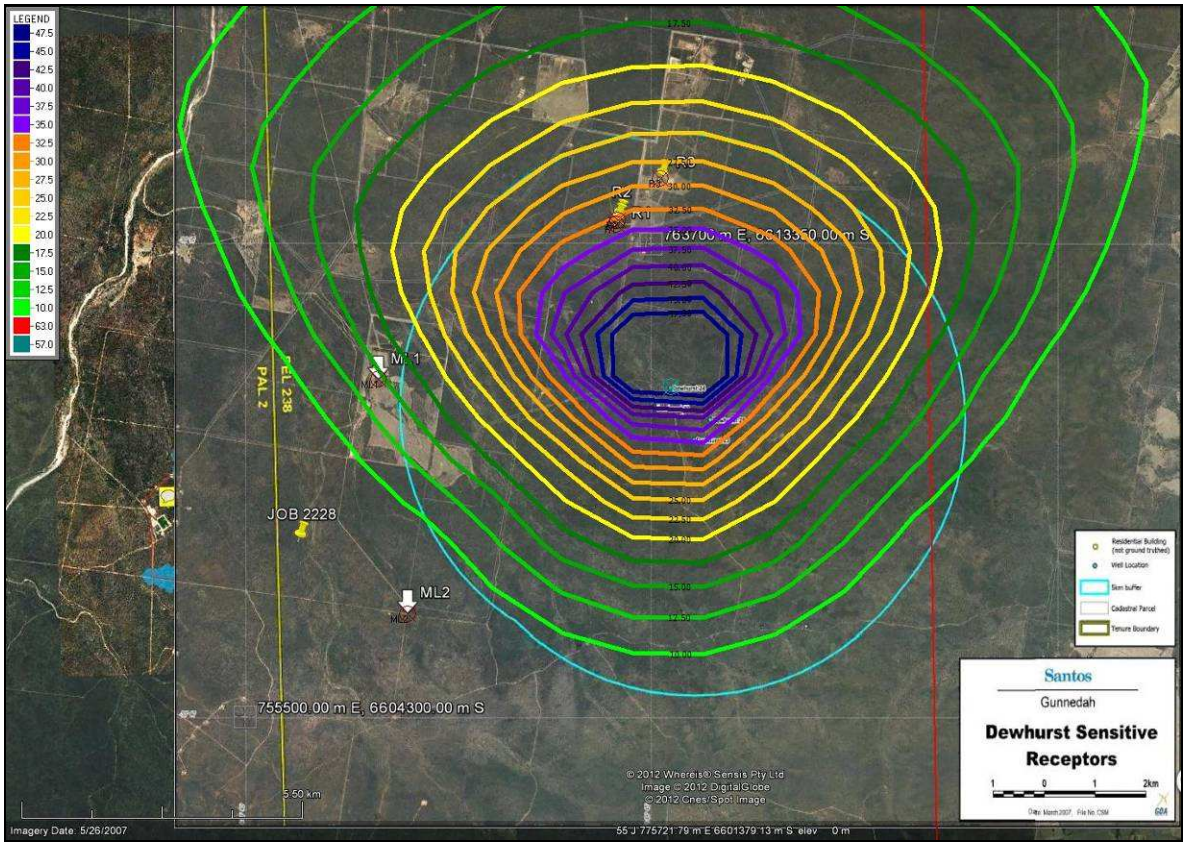
Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence



Scenario 1: site operations or single drilling rig, calm weather

Scenario 1: Point calculations for site operations or single drilling rig

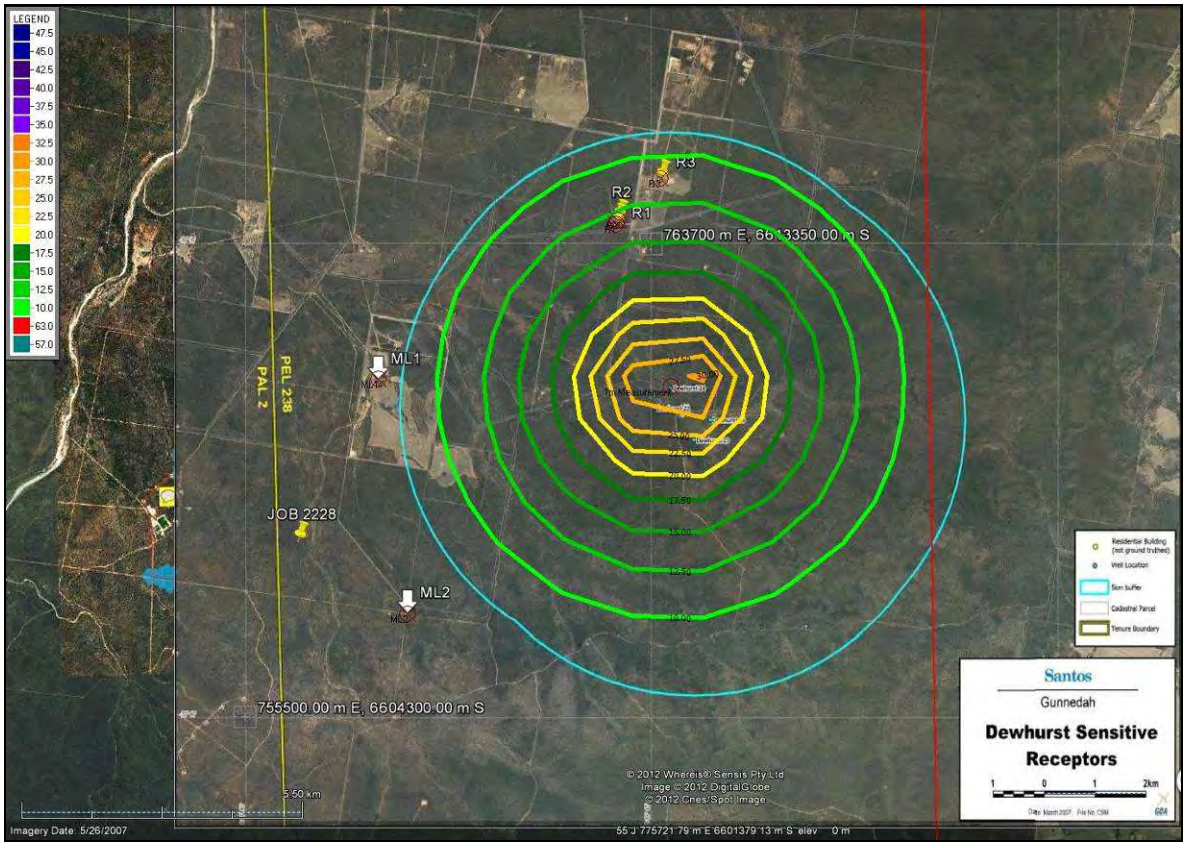
Plant Sound Power Level	dB(Lin)	dB(A)
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	13.6	
R2	23.8	
R3	23.4	
ML1 – R4	20.1	



Scenario 2: site operations or single drilling rig, wind 3 m/s from south

Scenario 2: Point calculations for site operations or single drilling rig

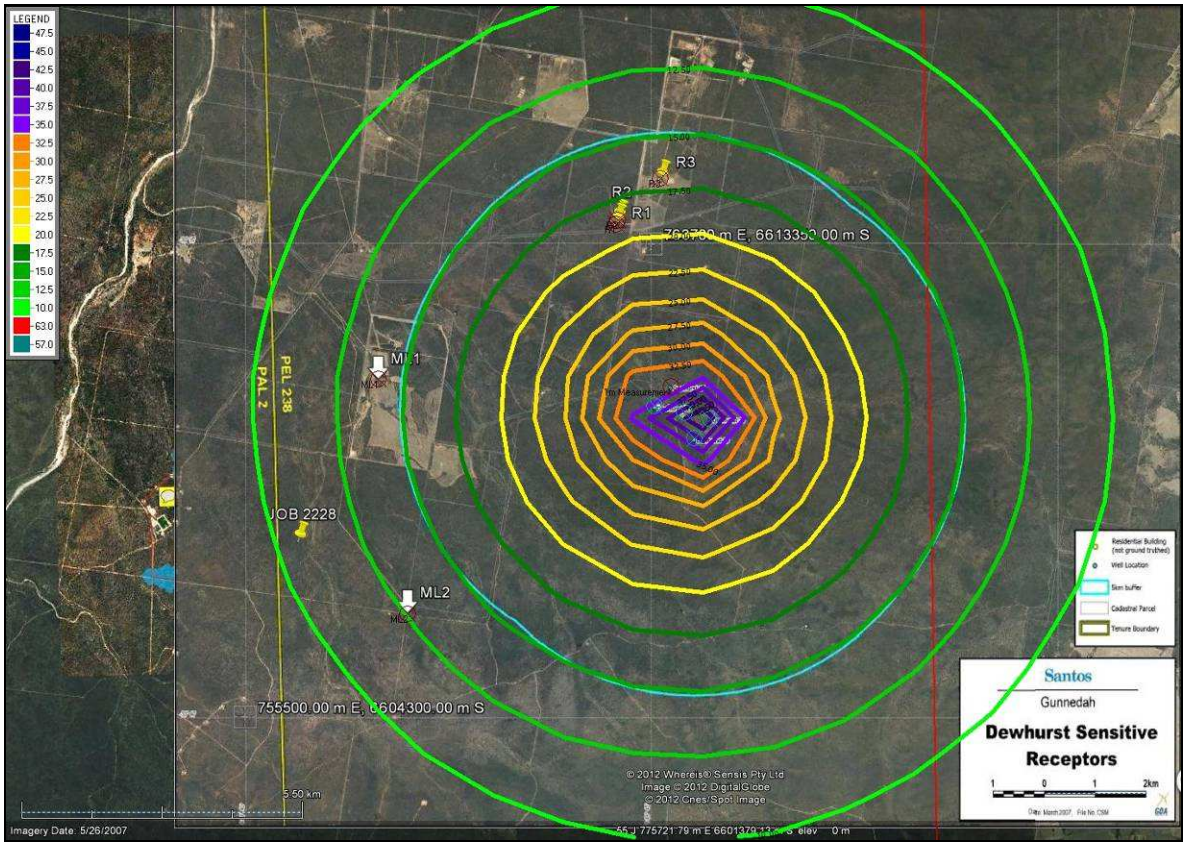
Plant Sound Power Level	dB(Lin)	dB(A)
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	15.1	
R2	33.7	
R3	33.3	
ML1 – R4	29.5	



Scenario 3: single pilot well, Dewhurst 24, calm weather

Scenario 3: Point calculations for single pilot well (Dewhurst 24)

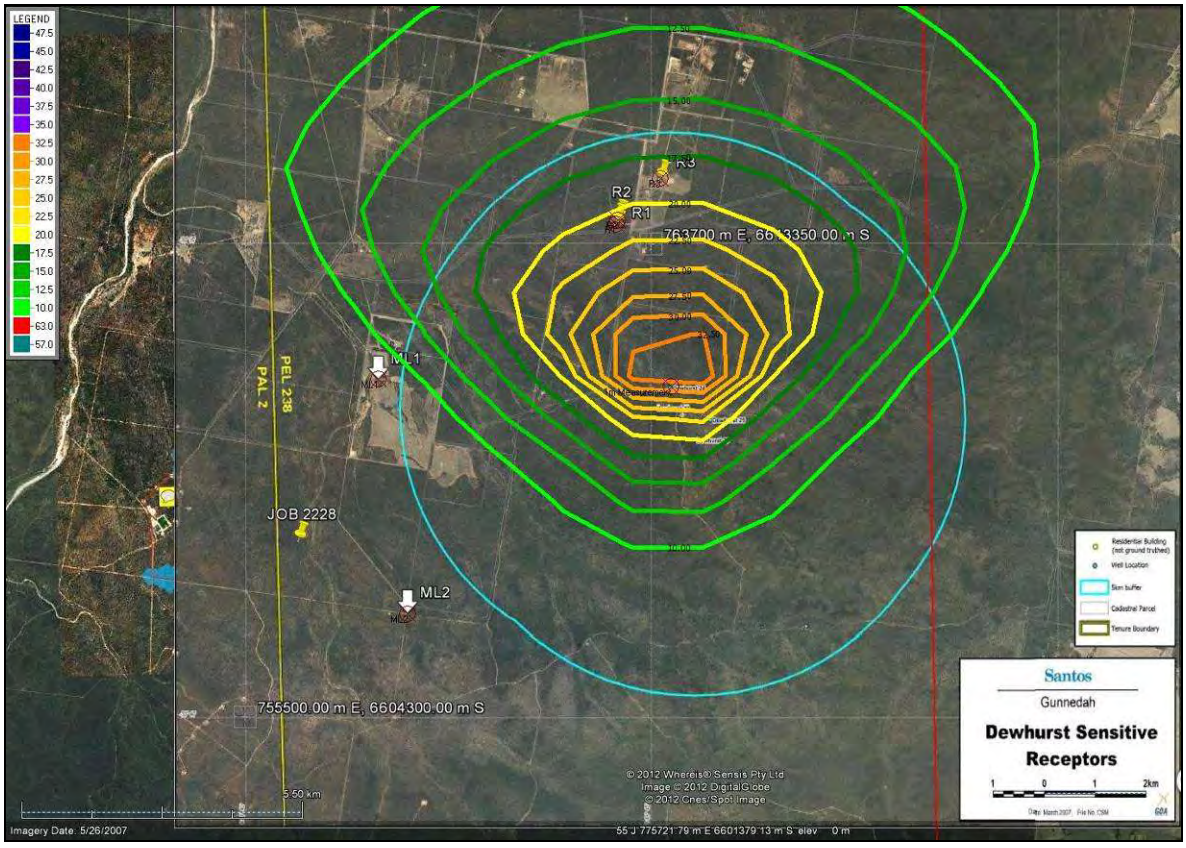
Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with Cummins generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	13.4	
R2	13.2	
R3	11.2	
ML1 – R4	7.4	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	



Scenario 4: All 5 wells at Dewhurst 6, 22-25 operating, calm weather

Scenario 4: Point calculations for all 5 pilot wells operating

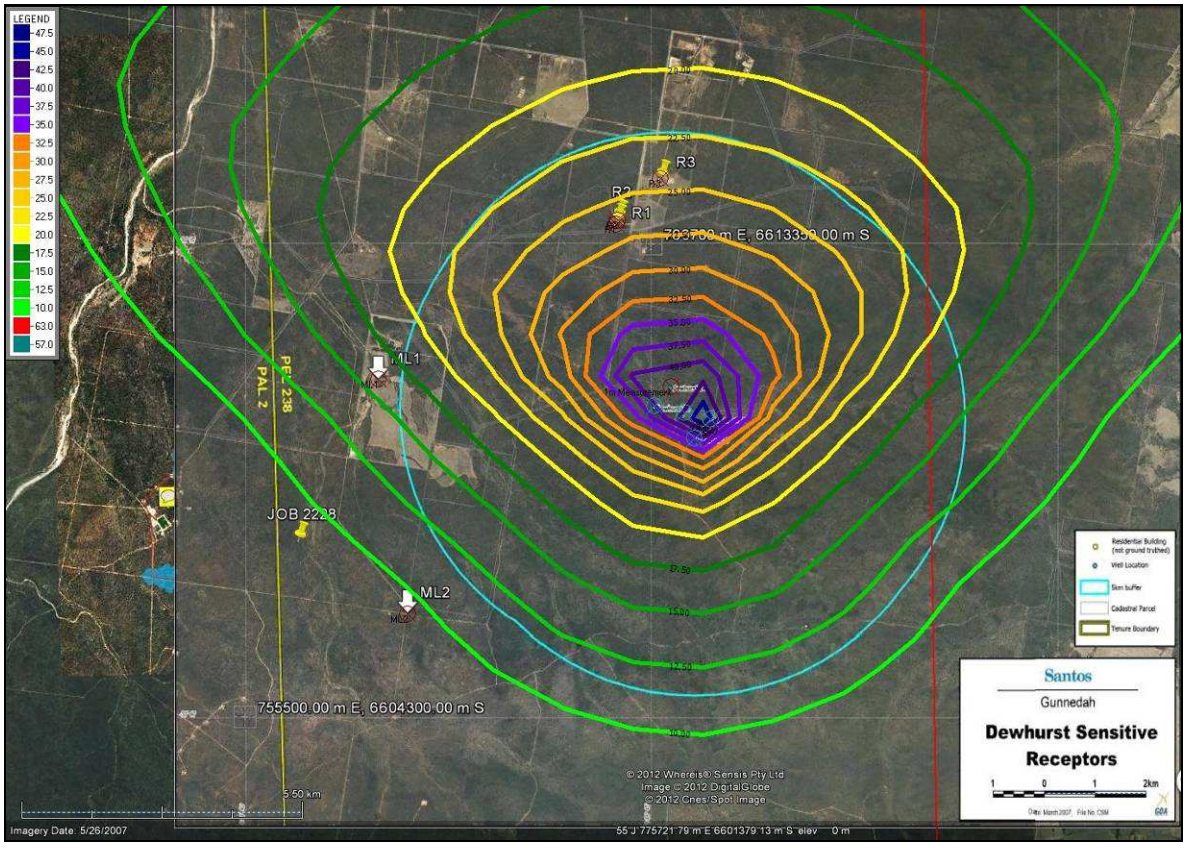
Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with Cummins generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	17.9	
R2	17.7	
R3	16.0	
ML1 – R4	13.0	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	



Scenario 5: single well, Dewhurst 24, wind at 3 m/s from the south

Scenario 5: Point calculations for single pilot well (Dewhurst 24)

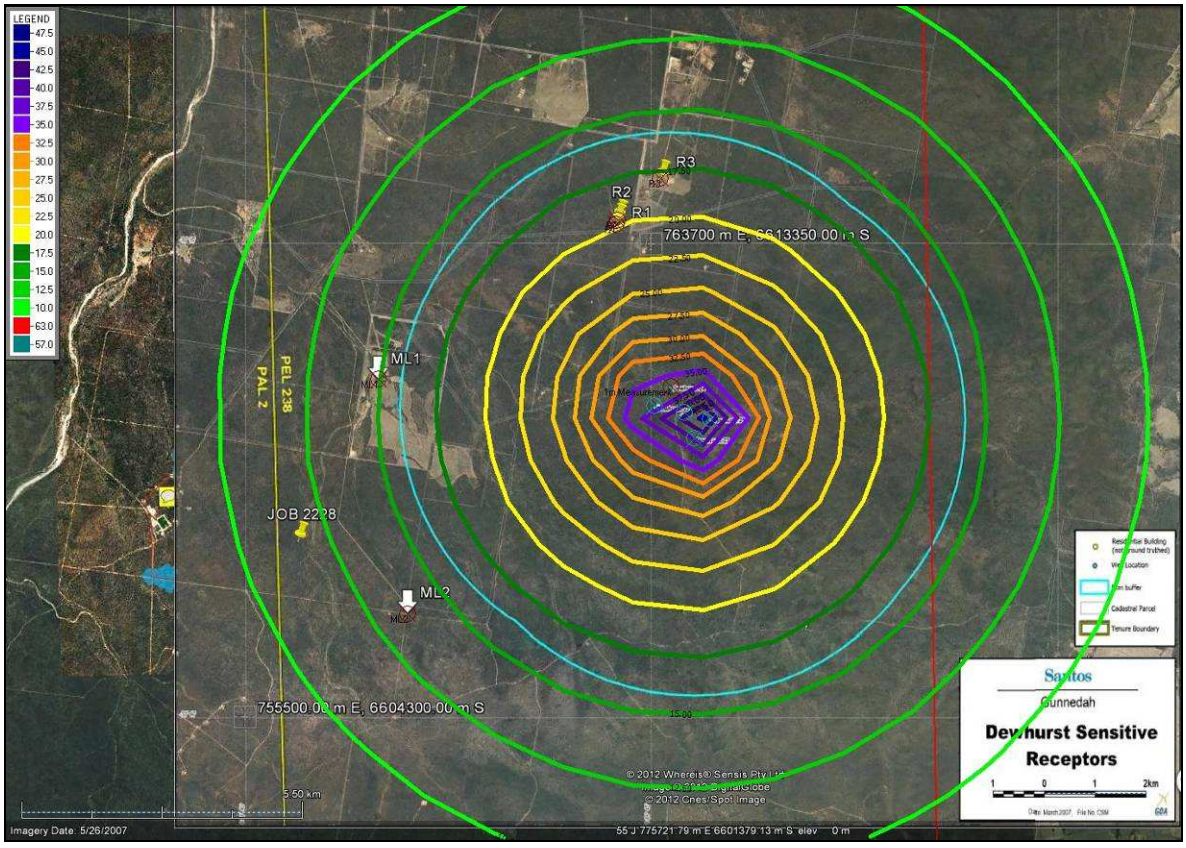
Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with Cummins generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	21.0	
R2	20.7	
R3	18.7	
ML1 – R4	8.2	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	



Scenario 6: All 5 wells at Dewhurst 6, 22-25 operating, wind at 3m/s from the south

Scenario 6: Point calculations for all 5 pilot wells operating

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with Cummins generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	25.5	
R2	25.3	
R3	23.5	
ML1 – R4	15.0	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	



Scenario 'F': All 5 wells at Dewhurst 6, 22-25 operating, Stability factor 'F' resulting in inversion

Scenario 'F': Point calculations for all 5 pilot wells operating

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with Cummins generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3℃/100m	
Temperature (modelled, ℃)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023	
Sound Levels at Residence	dB(A) LAeq, calculated at 5m from residence location	
R1	19.0	
R2	18.8	
R3	17.0	
ML1 – R4	14.0	
Tonality (just detectable)	Add 2 dB(A) to above sound levels	
Level at the residential facade	Add 2.5 dB(A) to above sound levels	

5.0 Conclusions

The noise criteria to be achieved are the Intrusive noise criterion and sleep disturbance criterion under the Industrial Noise Policy. The Rating Background Level plus 5 dB(A) and is established as LAeq 35 dB. The duration of works associated with a well site is in the order of weeks, with the greatest noise emissions (drilling) limited to approximately one week. In this context the drilling is similar to short-term construction noise and the appropriate assessment guidelines are detailed in the *Interim Construction Noise Guideline.*

Table 5.1: Noise 'Most Likely' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated at the residential façade

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	26	36	16	20	24	28	22
R2	3430	25	36	16	20	23	28	21
R3	4070	23	32	<15	19	21	26	20
ML1-R4	5730	16	17	<15	16	<15	18	17
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

The noise emissions from the operation of the 5 pilot wells together, under temperature inversion 'F' conditions, is calculated at approximately 18 dB(A) LAeq, at 5 km from the wells.

Table 5.2 presents an assessment of the Industrial Noise Policy guideline values for Intrusive Noise with respect to the potential noise sources as they affect the residences. The criterion is 35 LAeq.

Table 5.2: Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	Pass	+1	Pass	Pass	Pass	Pass	Pass
R2	3430	Pass	+1	Pass	Pass	Pass	Pass	Pass
R3	4070	Pass	Pass	Pass	Pass	Pass	Pass	Pass
ML1-R4	5730	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

Table 5.3 presents an assessment of the Industrial Noise Policy guideline values for Sleep Amenity (measured outdoors) with respect to the potential noise sources as they affect the residences. The criterion is 40 LAeq.

Table 5.3: Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 'F'
R1	3370	Pass	+1	Pass	Pass	Pass	Pass	Pass
R2	3430	Pass	+1	Pass	Pass	Pass	Pass	Pass
R3	4070	Pass	Pass	Pass	Pass	Pass	Pass	Pass
ML1-R4	5730	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Plant		Drilling	Drilling	1 x well	5 x wells	1 x well	5 x wells	5 x wells
Weather		calm	southerly	calm	calm	southerly	southerly	inversion

Note: 'Distance' is the distance in metres from Dewhurst 24 to the relevant residence

5.1 Summary of Conclusions

1. It is concluded that the drilling stages may be audible at night when the background levels drop to around 20 dB(A). The activity, however, is of short duration and noise mitigation to the mud-pump (the main source of noise) will reduce further any audible sound.

2. It is concluded that the operation of the pilot wells should not be audible at any of the residences identified in this assessment.

5.2 Noise Management Measures

The proposed activity will generate noise, particularly during drilling and cementing activities, which may occur up to 24 hours per day, seven days per week. The noise management approach will include:

- consultation with potentially affected receivers
- monitoring of noise impacts
- implementation of feasible and reasonable work practices
- complaint management and response.

Noise generated by the proposed development is unlikely to be audible at any residential receivers due to its remote location. Users of the Forest, such as bushwalkers, picnickers and Forests NSW staff, may be affected by noise and vibration during the works. Forests NSW will be notified of the proposed activity prior to commencing works. This will include details of the timing and duration of noise generating activities.

Santos will aim to maintain noise levels at the rating background level (RBL) plus 10 dB(A) during standard working hours (7am to 6pm Monday to Friday and 8am to 1pm Saturday) and the RBL plus 5 dB(A) outside of standard working hours. The RBL at the site has not been confirmed but is assumed to be no more than 30 dB(A). Noise monitoring will be conducted at the site to confirm the RBL prior to the proposed activity commencing.

Noise testing of the drilling rig will be carried out prior to its arrival on site to confirm predicted noise levels. Noise monitoring will be conducted at the commencement of drilling and cementing activities to confirm actual noise levels.

Where noise levels exceed the RBL plus 5 dB(A) during standard working hours, or the RBL plus 10 dB(A) outside of standard working hours, feasible and reasonable work practices will be implemented to reduce noise levels. Such practices may include:

- training contractors to operate plant and equipment in ways that minimise noise generation
- scheduling deliveries to occur during day time hours where practicable
- inspecting and maintaining equipment to ensure it is in good working order
- reducing throttle setting and turning off equipment when not in use.

In the event of a noise complaint, the source of the noise will be investigated. Where necessary, Santos will offer to conduct noise monitoring from the proposed activity at the affected receiver. If it is determined that noise levels are unacceptable, further feasible and reasonable work practices or mitigation measures will be implemented.

ANNEX A DRILLING RIG SOUND POWER LEVELS

Noise Measurement Services (NMS) has surveyed the potential for noise from a drilling rig referenced as 'Brigalow 1200-1'. This Annex covers different drilling modes and assesses the potential noise impacts at various distances from the rig. Noise measurements and predictions have been taken during four different operational modes:

- Open hole drilling;
- Running casing;
- Cementing; and
- Core drilling.

The sound levels from various items of plant such as the mud pump, lighting rigs, various generators, pumps and items of mobile plant have been included in the noise assessments.

The noise criterion reported as a reference point is the time-average level of 35 dB(A) for night-time operation. It is predicted that this level is achieved at a distance of 1100 metres (open hole drilling and running casing); 1250 metres (cement casing) and 800 metres (core drilling). These distances will vary, of course, if a different noise limit is applied. Cementing is completed relatively quickly (in around 30 minutes) from the time the cement vehicles arrive onsite and until the cementing process is complete. The other processes are of a longer time period lasting for a number of days.

Noise modeling has been made using SoundPLAN v7.0 and the prediction methodologies *ISO 9613-2 Acoustics-Attenuation of sound during propagation outdoors-Part 2: General method of calculation* (for 'neutral' conditions) and CONCAWE (for 'worst-case' conditions) with calculated sound power levels from field measurements taken in accordance with *AS1217.7-1985 Acoustics-Determination of sound power levels of noise sources* and ISO 3744:1994 *Acoustics-Determination of sound power levels of noise sources using sound pressure-Engineering method in an essentially free field over a reflecting plane* to derive sound power values for the activities. The calculations are made with an estimated uncertainty of ±3 dB(A) at 1000 metres. The sound levels calculated in this report are cross-checked with measured levels at 50 metres and with a variation of approximately 1 dB(A) this allows confidence in the prediction methodology and assumptions.

Sound, however, is not consistent in its propagation and is affected by wind and inversion conditions, especially under cold clear nights with little or no wind movement. Under these circumstances enhanced propagation can occur and the sound of the drilling rig can be heard further than under 'optimum' conditions. As a general rule an allowance of 5 dB(A) needs to be included to allow for these effects. The allowance includes the prediction uncertainty referred to previously. The criterion level then becomes the distance at which a time-average sound level of 30 dB(A) can be reasonably predicted.

The prediction model is referenced to ISO 9613-2 for the noise contours and to ISO 9613-2 and CONCAWE for offset distances, and to AS1217.7 for the sound power calculations used in the model. Broadly, the establishing the sound power levels of the operational plant involved taking measurements at 2 metre intervals around the equipment. The distance from the microphone(s) to the plant was set at 1.0 metres. Two measurement heights were employed at each measurement location; one at 1.35 metres above ground and one at 3.0 metres above ground. Six 10-second measurements of the A-weighted sound pressure levels were

taken at each measurement location. The sound levels were recorded in a variety of forms including A-weighted Slow response and the A-weighted time-average level, LAeq. The AS1217.7 standard refers to measurements as A-weighted Slow response. The standard, however, has been withdrawn and this Report references the time-average level, LAeq, as this is now the most common descriptor for sound power measurements and compliance assessments.

The measurements are then ascribed to the noisiest pieces of plant and the parallelepiped method employed to calculate the sound power levels. The plant noise was then cross-checked to the measurements locations in order to confirm the calculation process. A slight variation of ±1 dB(A) is expected in the calculation process as the different plant measurements are influenced by other plant, as noted in the measurement schedules. The overall level is then cross-checked to more distant measurement locations at 10 metres and 50 metres from the plant.

The following Table presents the calculated sound power levels.

Table A1: Summary sound power levels, LAeq, Brigalow 1200-1 Drilling Operation

Item of Plant	Sound Power Level LAeq SWL
Drilling Rig (truck, rig motor, drilling, mud pump) – Open hole drilling	115
Drilling Rig (truck, rig motor, drilling, mud pump) – Running casing	115
Drilling Rig (concrete truck and compressor) – Cement casing	118
Drilling Rig (truck, rig motor, drilling) – Core drilling	115
Drill engine	110
Truck engine	106
Mud Pump engine	113
Cement pump / compressor (on truck)	116
Cement pump truck	111
Lighting Generator	86
Power generator	77
Small dewatering pump	105

The predicted LAeq sound levels and distances due to the various drilling rig operations are presented in Table 2. Plates 1 and 2 provide the operational plant layout.

Table A2: Predicted LAeq Sound Levels at Various Offset Distances

Drill Rig and Operation	Weather Condition	Direction	Predicted LAeq Sound Level at Buffer Distances (metres)						
			50m	100m	500m	1000m	1500m	2000m	5000m
Open Hole Drilling	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	69	62	45	36	30	25	<10
Open Hole Drilling	Worst case	Front	72	64	47	38	32	27	<10
		Left	70	64	48	39	33	29	<10
		Back	69	63	47	38	33	28	<10
		Right	71	64	48	39	33	29	11
Running casing	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	69	62	45	36	30	25	<10
Running casing	Worst case	Front	72	64	47	38	32	27	<10
		Left	70	64	47	38	32	28	<10
		Back	69	63	47	38	32	28	<10
		Right	71	64	47	38	33	28	10
Cementing Casing	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	68	62	45	36	30	25	<10
Cement Casing	Worst case	Front	72	66	50	40	35	30	<10
		Left	77	69	51	41	35	30	13
		Back	76	69	50	41	35	30	13
		Right	71	66	50	40	35	30	<10
Core Drilling	Neutral	Front	60	54	39	31	26	22	<10
		Left	64	58	41	33	27	23	<10
		Back	64	58	41	33	27	23	<10
		Right	64	58	41	33	27	23	<10
Core Drilling	Worst case	Front	63	57	39	31	26	22	<10
		Left	68	61	43	35	29	25	<10
		Back	68	61	43	35	29	25	<10
		Right	68	61	43	35	29	25	<10

Notes:

'Front' refers to the direction located by the front of the truck holding the drill rig. That is, standing at the front of the truck and looking back to the drill rig is 'front-to-back'.

'Neutral' is the predictions to the ISO 9613-2 methodology, standard assumptions

'Worst Case' is to CONCAWE methodology with a 6m/s breeze blowing from front to back.

Plate 1: Plant Layout Drilling Operations, with measurement locations

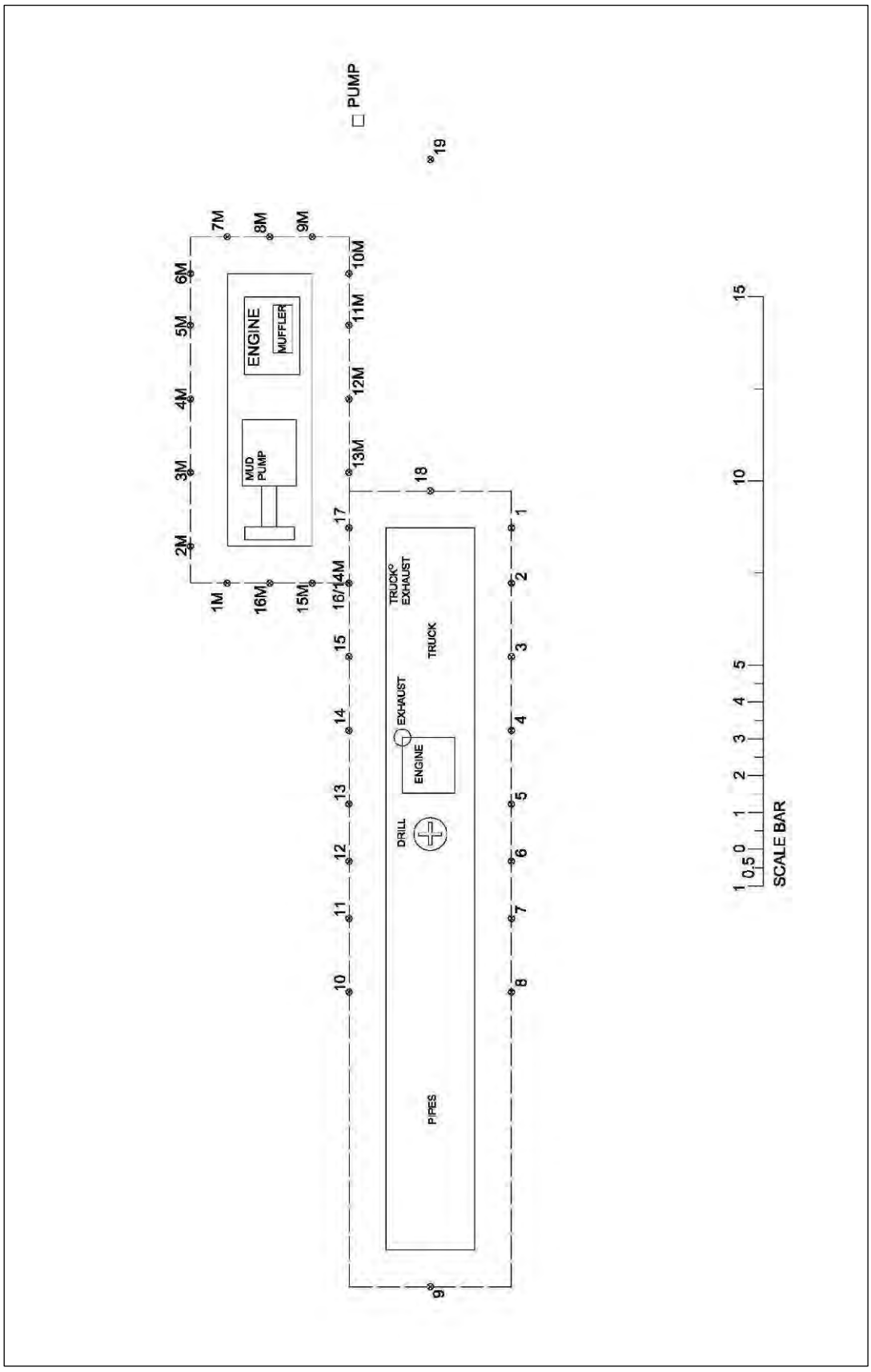
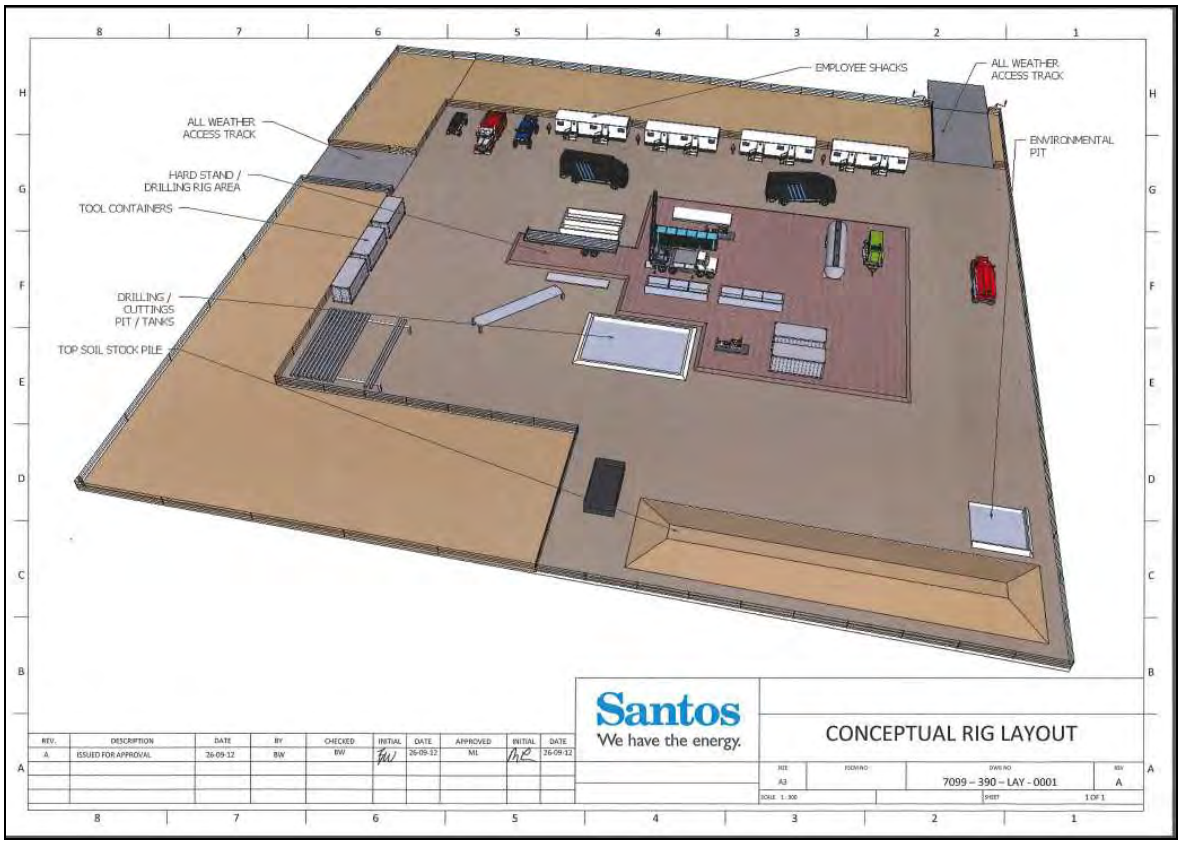


Plate 2: Plant Layout (Indicative)



ANNEX B EDA Rig 1 Source Noise Levels

A drilling rig that may be utilised within the Project is the Energy Australia Drilling Rig 1 (EDA Rig 1). The following information concerning the rig is drawn from the source noise report prepared by Wilkinson Murray: EDA Rig 1 Source Noise Level Measurements, Report No. 00574, Version A, October 2011. The Report was prepared on for the RPS Group on behalf of Santos Ltd.

Figure 2-1 Indicative EDA Rig 1 Layout

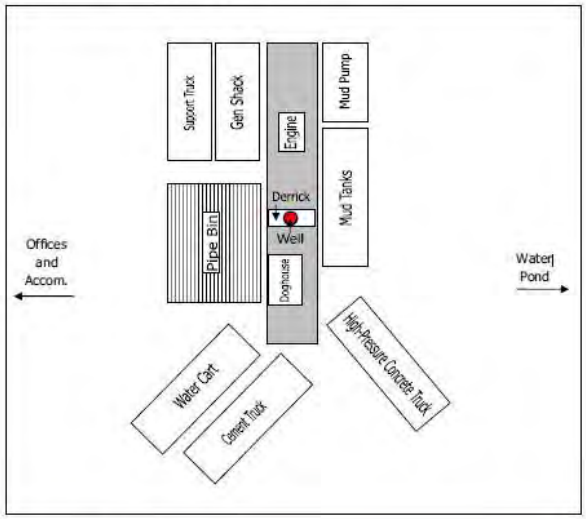


Figure 2-2 EDA Rig 1



Noise Measurement Results

Figure 3-1 presents a graphical level-history of the drilling cycle at one of the control locations. The figure shows the relative noise emissions from each activity. Drilling is reasonably consistent in noise level, with some elevation whilst drilling harder rock. Tripping produced much lower noise levels than drilling, though a worst-case 15 minute period during tripping was only approximately 5 dB below drilling noise levels. Running casing was 2-5 dB below drilling. Cementing casing was similarly 2-5 dB below drilling at the control location, though greater noise levels were measured at other locations with greater exposure to the high-pressure concrete truck.

Figure 3-1 Noise Level History at "Control" Location

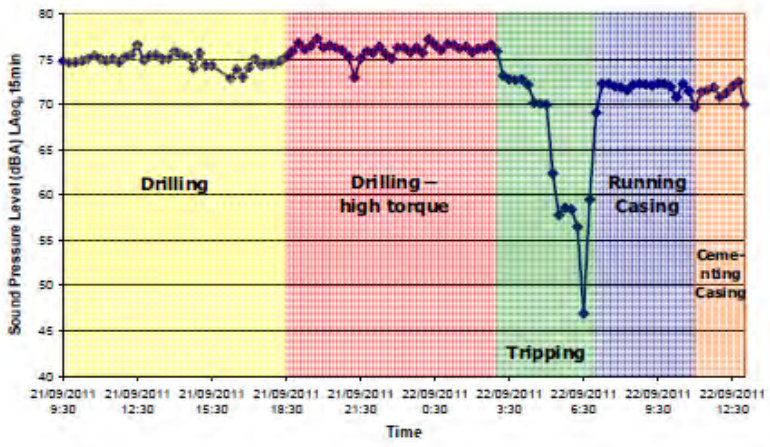


Table 3-1 presents the sound power levels for each plant item. Note that many of these sources radiate over significant areas and thus cannot be equated by point sources in the near field (less than 20m). Determination of the sound power levels has considered the radiated area of these sources. Near field measurements have been supplemented by more distant measurements (around the drill pad perimeter – approx. 50-70m from noise sources) in order to gain a greater understanding of the total noise emissions. We note that many of the sources are shielded in some directions. Furthermore, many of the sources are reflected by adjacent items. These sound power levels represent the on-axis (in this instance meaning the loudest direction in the horizontal plane surrounding the rig) equivalent sound power level including reflections (i.e. reflections are accounted for by the source level and need not be incorporated in any predictive calculations). Other noise sources were present, however the noise sources in Table 3-1 dominated the noise emissions from the site.

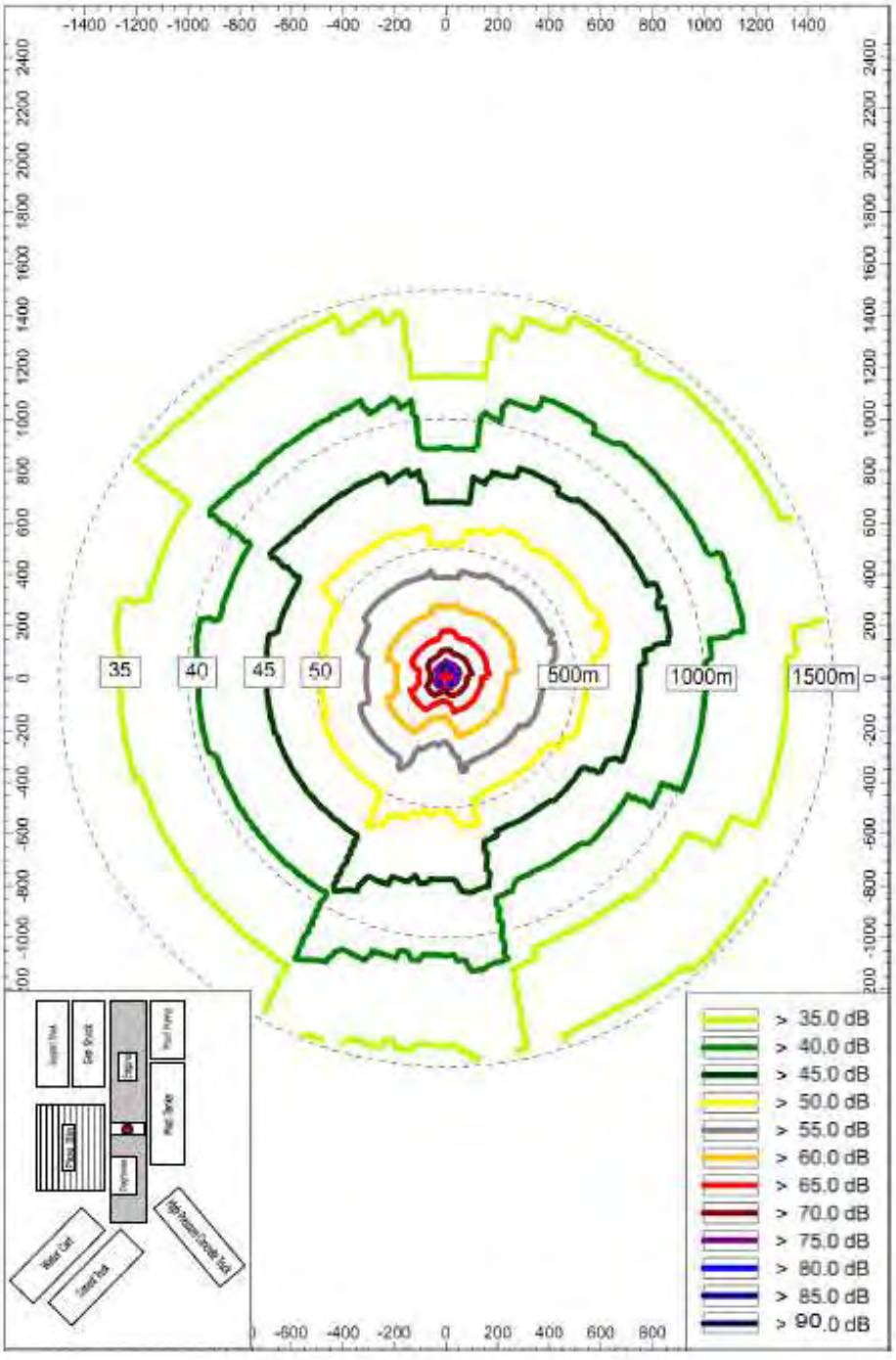
Table 3-1 Individual Source Sound Power Levels (SWL)

Plant Item	Operation	SWL dBA	Notes
Drill engine	Typical high load	120	Noise emanates from the engine casing (which is open at both ends for ventilation) and from the exhaust (which is fitted above the engine and discharges vertically).
	Typical low load/idle	116	
Mud pump	Typical high load	120	Noise emanates from the cooling fans at the rear of the pump engine, the engine casing and from the exhaust which is fitted above the engine and discharges vertically.
	Idle	112	
Drill pipe or derrick resonance	High torque drilling	117	We expect that this source could be reduced/avoided with damping and/or improved fitment of items to the derrick – primarily the aluminium cable tray that houses the hydraulic hoses.
High-pressure concrete truck	Cementing casing	122	Noise emanates from the engine, the exhausts and the radiators/fans at the front of the trailer.

Wilkinson Murray has undertaken detailed source noise level measurements of EDA Rig 1. From these measurements noise level predictions have been made for typical generic topographic and meteorological conditions. The noise level predictions show the variation in noise level and required offset distances due to site specific features, most notably those associated with topography, i.e. shielding and ground attenuation. The noise level contours suggest that for worst-case topographic conditions, i.e. a line of sight between source

and receiver and a valley or similar between the two, offset distances exceeding 1500m would be required to comply with the Interim Construction Noise Guideline noise affected level of 35 dBA. A representative noise emission contour is provided in Figure A-1, following.

Figure A-1 Scenario A – Drilling, Flat Ground, Still-isothermal – dBA



ANNEX C Narrabri Meteorological Data

The following meteorological data for the Narrabri area has been sourced from the report *Narrabri Coal Seam Gas Utilisation Project Part 1 – Air Quality Impact Assessment Report No. 585/06* Part 1 November 2007 prepared by Heggies Pty Ltd.

The 2005 annual wind rose from the Narrabri Weather Station is presented following as Figure C1 from the Heggies Report. The wind rose is representative of the meteorological input file used in the assessment, and displays occurrences of winds from all quadrants. The annual wind rose indicates that winds tend to be experienced from the southeast, west and north and are typically mild to moderate, having an average wind speed of between 1.5m/s and 8m/s.

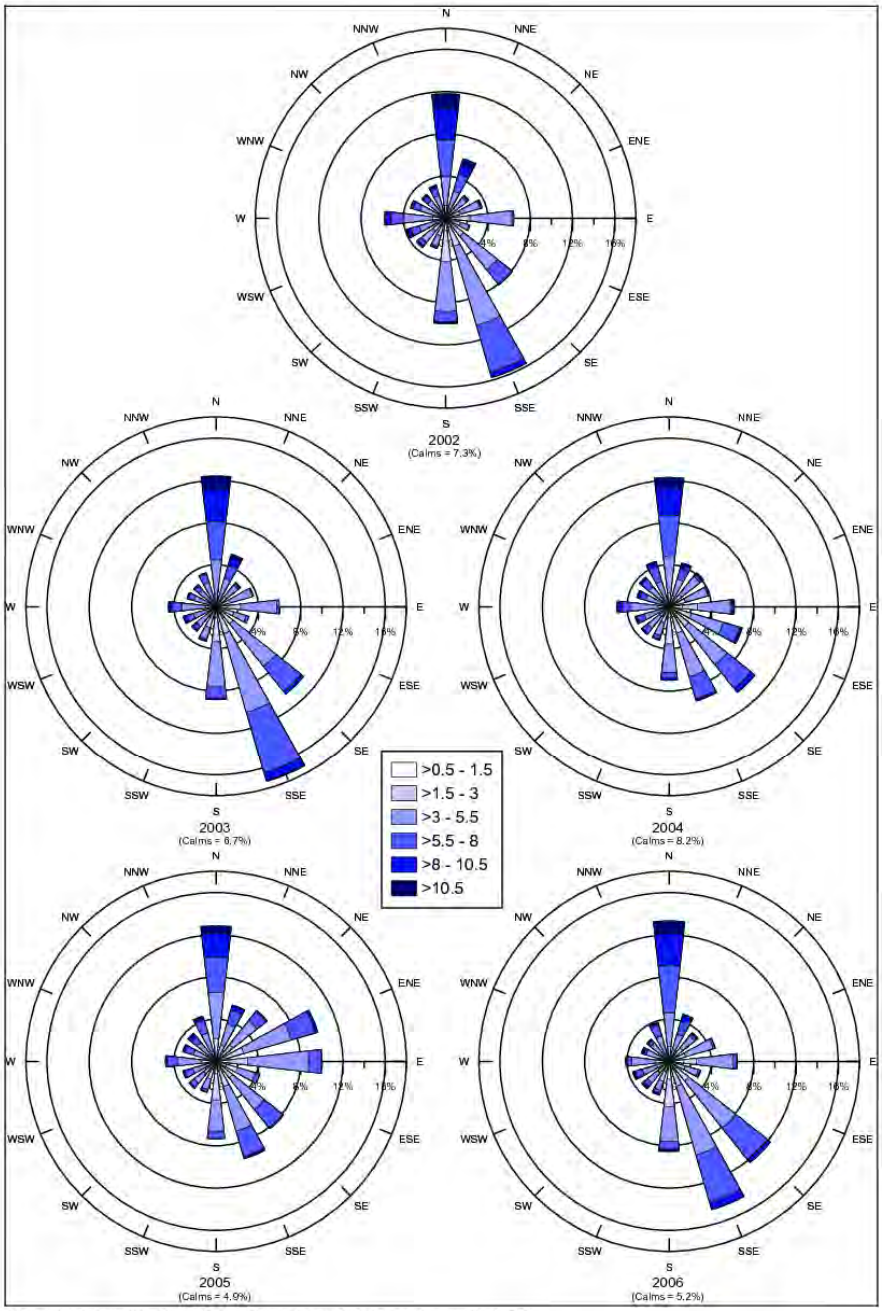
The seasonal variation in wind behaviour at the Narrabri Airport AWS is also presented following as Figure C2 from the Heggies Report. The seasonal wind roses indicate the following:

- In winter, mild to moderate south-southeast winds are experienced 13% of the time, and mild to fresh (1.5 m/s to 10.5 m/s) north winds occur 12% of the time.
- In spring, mild to moderate winds are present from the south-southeast to southeast approximately 13% of the time, while mild to fresh winds occur from the north approximately 17% of the time.
- In summer, moderate to fresh winds occur from the north approximately 15% of the time, while moderate east winds occur 13% of the time.
- In autumn, mild to moderate winds are prevalent from the east to northeast quadrant approximately 45% of the time.

The frequency of occurrence of stability class at the Narrabri AWS site for 2005 is presented in the third chart, following, from the Heggies Report. The results indicate a high frequency of conditions typical of Stability Class "D" throughout the year. Atmospheric stability refers to the tendency of the atmosphere to resist or enhance vertical motion. The Pasquill-Turner assignment scheme (see the EPA Industrial Noise Policy) identifies six Stability Classes, "A" to "F", to categorise the degree of atmospheric stability. These classes indicate the characteristics of the prevailing meteorological conditions.

- Stability Class "A" represents highly unstable conditions that are typically found during summer, and are categorised by strong winds and convective conditions.
- Conversely, stability class "F" relates to highly stable conditions, typically associated with clear skies, light winds and the presence of a temperature inversion.
- Classes "B" through to "E" represent conditions intermediate to these extremes.

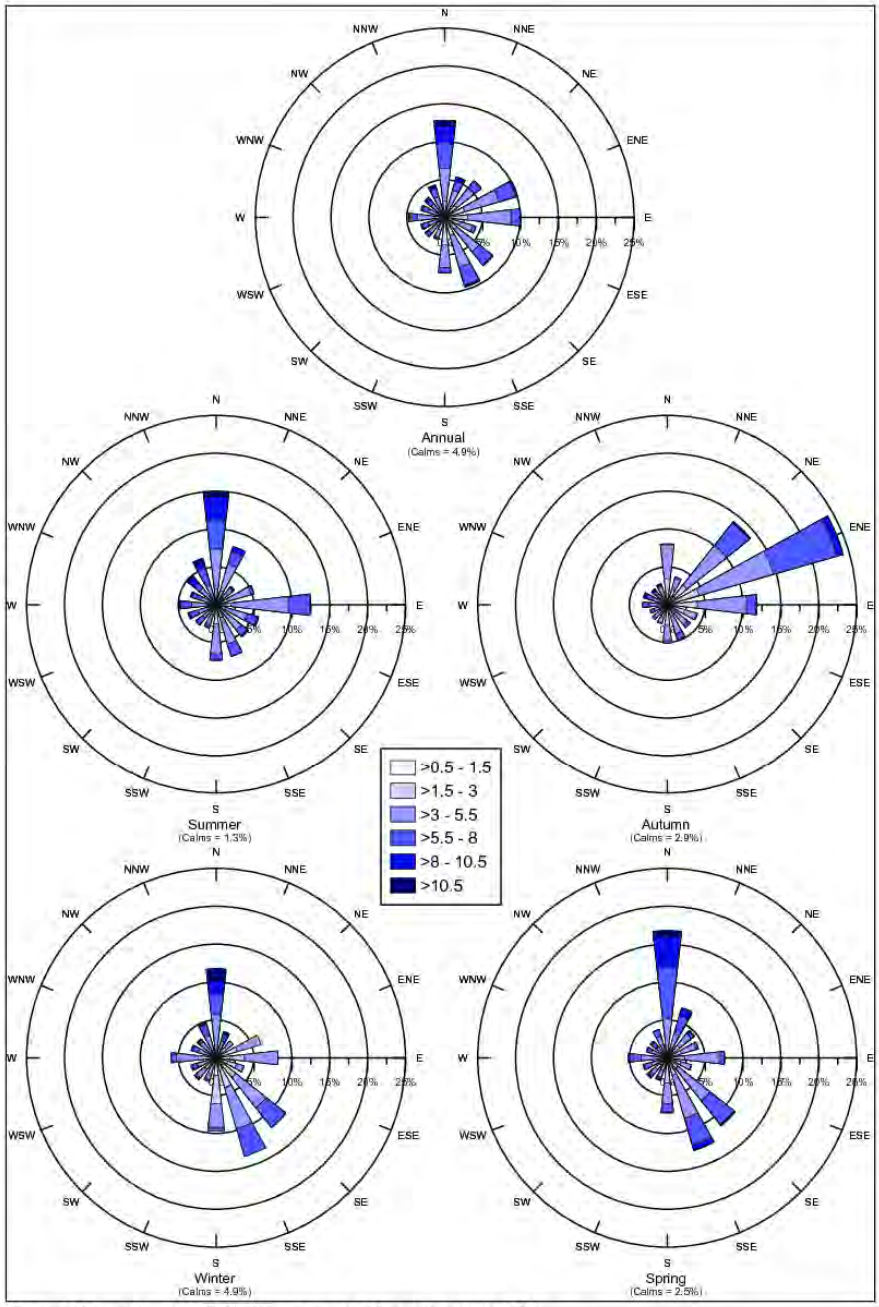
'Normal' or 'Neutral' conditions occur where the temperature slowly increases with height such as overcast conditions and / or when the wind is high enough to cause mixing of any atmospheric layers. These conditions can occur day or night; they will always prevail when it is fairly windy, overcast or at the beginning or end of the day. Category D should be used, regardless of wind speed, for overcast conditions during the day or night and for any sky condition during the hour preceding or following night. Class F conditions occur mainly at night when a layer of cold air is trapped close to the ground, under warmer air. Unusually high noise levels can be experienced.



Note: A Colour Version of this figure is available on the project CD

Figure C1 Annual Wind Roses for Narrabri Airport AWS, 2002-2006

Heggies Pty Ltd

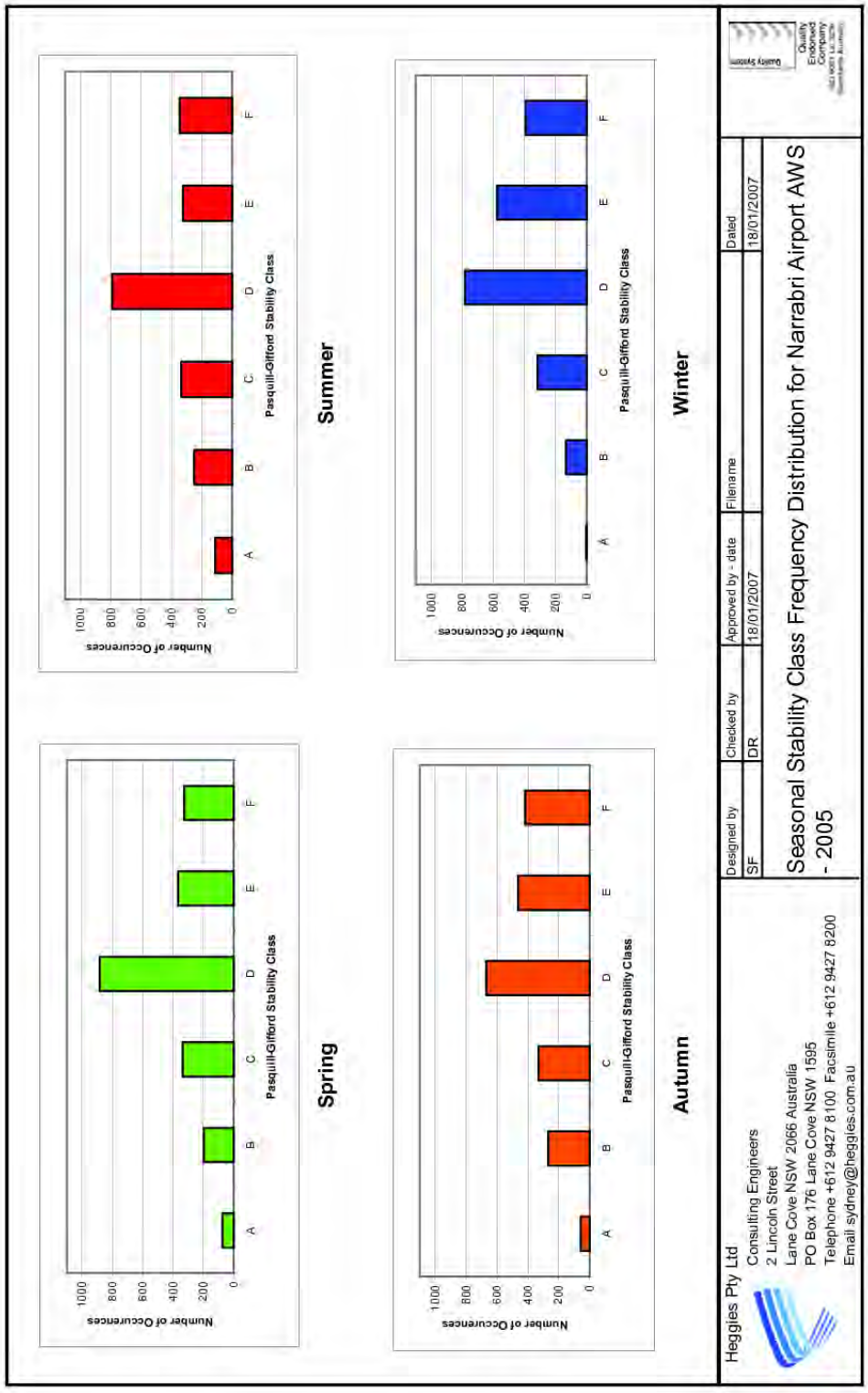


Note: A Colour Version of this figure is available on the project CD

Figure C2 Seasonal Wind Roses for Narrabri Airport AWS, 2005

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Narrabri Coal Seam Gas Utilisation Project *Part 1 – Air Quality Impact Assessment*
Report No. 585/06



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ANNEX D Noise Prediction Methods

Two different prediction methods are applied, ISO 9613-2 and CONCAWE.

ISO 9613-2

The calculations for the plant, equipment and haulage predictions are based on standard sound propagation theory described in ISO 9613-2 Acoustics – *Attenuation of sound during propagation outdoors – Part 2, General Method of Calculation.*

Equation of the Method

$Lp = Lw + Dc - A$

where

Lp is the sound pressure level at the receiver location

Lw is the sound power level of the source

Dc is the directivity correction of the source; and

A is the excess attenuation due to:

- A div geometric divergence
- A atm atmospheric absorption
- A gr ground cover
- A bar barrier effect
- A misc miscellaneous other effects

The calculation is in A-weighted equivalent continuous (LAeq) octave band values for the bands 63Hz to 8000Hz. The standard calculates the average downwind propagation with the wind blowing from source to receiver and a wind speed of 1 to 5 m/s.

The predictions are based on 'most-likely' placement of plant and equipment to give a representative assessment for different plant and activities operating in different locations and for varying times of day or night. Both single point and noise contour calculations are used to determine the noise level at noise sensitive premises. Noise contours show the range of noise levels in the locality due to the operation of the mine and plant. The single point calculations give the predicted noise at a specific location. Refinement may be made this model through collection of reliable sound power level data, modelling for variable source locations, topographic (barrier) effects and meteorological conditions. Night-time levels can be higher due to atmospheric conditions of temperature inversion, so detailed weather data would be of great assistance in modelling different weather based scenarios.

The general order of prediction uncertainty is ±3 dB at 100 - 1000 metres for an unverified model and less where measured data is used to refine the prediction scheme at distances up to 100 metres. The model is also limited to wind speeds of less than 5 m/s. Verification means that the model has been established with reference to measured sound levels at a receiver, known source levels and tightly defined propagation variables (wind speed and direction, for example). Alternatively a series of predictions with different programs but the same assumption variables can be used for verification purposes. Under light downwind

conditions or temperature inversion conditions, it is likely that the noise levels at the nearest residence will be slightly higher than the predicted level. Conversely, under upwind propagation conditions, lower noise levels would be expected to be encountered. Best practice means that the highest level in the uncertainty range is referenced for assessment of impact, rather than the predicted level.

CONCAWE

The CONCAWE method is based upon the CONCAWE research paper (1). Different implementations of the method have applied modifications e.g. in SoundPLAN, PEN3D. The CONCAWE noise propagation model deals specifically with the influence of wind and the stability of the atmosphere.

Equation of the Method

The sound pressure level at a receiver is calculated as:

$$L_p = L_w + D - \sum K$$

where L_w = sound power of the source
D = directivity of the source
$\sum K$ = correction factors K1...K7

The model takes account of the following attenuation mechanisms (K factors):

- Geometrical spreading (the attenuation of a source with distance);
- Atmospheric absorption (the attenuation due to the atmosphere, varying with temperature and humidity and affecting mainly the higher frequencies);
- Ground attenuation (the additional attenuation that occurs due to complex interference effects over acoustically absorptive (soft) ground);
- Meteorological correction (the correction that accounts for refraction of sound by wind and temperature gradients);
- Source / receptor height correction (validated at a receiver height of 1.2 metres)
- Barrier attenuation (Maekawa method)

The two principal variables are wind and vertical temperature gradient. (A positive gradient is called temperature inversion, zero gradient is neutral, and a negative gradient is termed lapse). The variable K_4 is the meteorological correction due to refractions by wind and temperature gradients based on the meteorological category of the atmosphere assessed in accordance with Pasquill stability factor (2), cloud cover and wind speeds. The meteorological category affects the prediction values, as discussed following.

Accuracy of the CONCAWE Noise Prediction Method

The CONCAWE method was originally developed to predict noise levels at long distances (validated at 100 metres to 2000 metres and for wind speeds up to 7 m/s) from petrochemical plants. With the exception of the geometrical spreading the method is primarily empirically based. The 95% confidence limits for the model were derived from independently measured data and vary with meteorological category. The predictions of the CONCAWE model are less accurate in upwind conditions, when measured noise levels would have been lower and the signal (i.e. the plant noise) to background noise (i.e. overall noise from all sources) ratio would have been lower as well. The 95% confidence limits were found to be:

- Met category 2: ± 6.8 dB(A) e.g. upwind, moderate wind speed vector and zero temperature gradient, or upwind, light wind vector with temperature lapse;
- Met category 3: ± 6.9 dB(A) e.g. upwind, light wind speed vector, zero temperature gradient, or calm

with temperature lapse;

- **Met category 4: ± 5.7 dB(A) calm and zero temperature gradient conditions);**
- Met category 5: ± 4.7 dB(A) e.g. light downwind with zero temperature gradient, or calm with temperature inversion;
- Met category 6: ± 4.5 dB(A) e.g. moderate downwind with zero temperature gradient, or light downwind with temperature inversion.

The 95% confidence limit is interpreted to mean that the "true" sound level at any location will be, with 95% certainty, the predicted level +/- the confidence limit (4.5 dB(A) - 6.8 dB(A)). In practice a mid-point value of ±6dB(A) is a reasonable approach.

1. CONCAWE, The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, Report 4/81.
2. NSW EPA 'Industrial Noise Policy' January 2000

IMPLEMENTATION

The method of prediction is ideally suited to a combination of both ISO 9613-2 and CONCAWE methods. The calculation programs available for this purpose are (a) SoundPLAN, which has both methods as separate modules, and (b) PEN3D, an environmental noise model developed by Noise Mapping Pty Ltd Queensland. The PEN3D environmental model is the program used in this Report. It is a faithful representation of the Environmental calculation method described in the book by Bies & Hansen *"Environmental Noise Control"*. The program has both propagation and stability analysis functions. The approach incorporates an incoherent reflection from the ground as recommended by Bies & Hansen as appropriate for calculating noise levels at distances more than 100 m from the source. NOTE: Source levels are entered as dB Lin sound power in the environmental model. Output is in dB Lin and dB(A).

Both single point and noise contour calculations are used to determine the noise level at noise sensitive premises. SoundPlan and PEN3D uses calculated sound power levels determined from measured sound pressure levels to calculate the noise level received at a specific location. Noise contours (isobars) show the range of noise levels in the locality due to the operation of the plant. The single point calculations give the predicted noise at a specific location. Best practice means that the uncertainty range of values is referenced for assessment of impact, rather than the (lower) single-number predicted level. Refinement may be made through collection of reliable sound power level data, modelling for variable source locations, topographic (barrier) effects and meteorological conditions. Night-time levels can be higher due to atmospheric conditions of temperature inversion, so detailed weather data is needed for modelling different "most-likely" scenarios. The tolerance in the Sound Power Levels quoted for various items of plant and equipment is typically ± 1 dB(A) under the refinement/verification process. The Primary sound power levels for the assessment are given in Table D1.

Table D1: Modelled sound power levels

Plant Item	SWL	Sum	63	125	250	500	1000	2000	4000	8000
Drilling Rig	Lin	120	114	108	107	111	114	113	105	95
	A	118	88	92	98	108	114	114	106	94
Wellhead	Lin	114	113	105	99	93	89	84	80	86
	A	97	87	89	90	89	89	85	81	84

ANNEX E Plant Sound Power Levels

Typical sound power levels for petroleum and gas activities

The sound power level of typical noise sources relevant to the activities are provided in Table 1. There are many different noise sources associated with petroleum and gas activities. The noise sources are described as having a continuous noise output over time (indicated by use of LAeq in Table 1) and may be *generically* described as being "tonal" with a similar shape of noise spectrum characteristic of a large diesel engine. Only the overall sound power levels differ. Noise sources which can be described as impulsive (indicated by the measure LAmax in Table 1) are more varied and managing these noise sources requires varied solutions such as changing operator behaviour (e.g. controlled braking of vehicles) or installation of specialised low noise equipment (e.g. broadband reverse beepers).

Table 1 – Typical sound power levels of petroleum and gas activity noise sources

Noise Source	Overall Sound Power Level (L_{WA})	Metric
Drill Rig (hydraulic pack)	95-100 dB(A)$_W$	L_{Aeq}
Drill Rig (air compressor)	95-100 dB(A) $_W$	L_{Aeq}
Drill Rig (mud pump)	100-105 dB(A) $_W$	L_{Aeq}
Field Compressor Station (screw drive engines)	110-115 dB(A) $_W$	L_{Aeq}
Central Compressor Station (reciprocating engines)	120-125 dB(A) $_W$	L_{Aeq}
Well Head Power Pack	95-105 dB(A) $_W$	L_{Aeq}
Generator (500kVA)	100-110 dB(A) $_W$	L_{Aeq}
Stimulation Activity (fraccing) (combined sources)	110-120 dB(A) $_W$	L_{Aeq}
Impacts of Drill Rods/Casings	100-110 dB(A) $_W$	L_{Amax}
Cavitation/Air Release	115-120 dB(A) $_W$	L_{Amax}
Engine Brakes	110-115 dB(A) $_W$	L_{Amax}
Reversing Beeper	100-105 dB(A) $_W$	L_{Amax}

Source: the Queensland Government Guideline *'Prescribing Noise Conditions for Environmental Authorities for Petroleum and Gas Activities'*, issued 2011 by the Department of Environment and Heritage Protection.

The process to install the gas flow line between the Dewhurst wells, and to the collection point, will involve firstly clearing an adequately wide corridor using a grader, digging a 350mm-400mm wide trench, laying out and joining the pipe segments, joining the pipe segments, filling the trench and rehabilitation the disturbed areas. The loudest noise sources during this process are the grader, excavator, diesel generators and other general diesel engined sources. The typical sound power level of a grader is 110-118 dB(A) and an excavator 118 dB(A). Generators and pipe-joining equipment may have a cumulative sound power level this high, although 102-105 dB(A) is more typical of generators. It is planned to have 76 KVA gas generators at Dewhurst 22-25 (inc. 24). The gas generator's model is 'Cummins 6BTAA CSM engine' and will be having

sound level limits of less than 85 dBA from a meter. The level of 85 dB(A) at 1 metre has been calculated as a sound power level of 114 dB(Lin) or 97 dB(A) including a directivity factor (half space) of +3dB.

For cross-reference purposes the sound power levels in Table 8.4 of the Sonus Report *"Surat Gas Project Noise and Vibration Impact Assessment",* Report S3257C17, November 2011 contains sound power levels and the quantity of each type of equipment proposed at each facility type. The octave band sound power levels for all of the equipment considered are provided in Table E.1, following, of the Report.

Table 8.4: Main noise sources during the construction of the production facilities.

Main Noise Source	Maximum Overall Sound Power Level (dB(A))
Truck	120
Front end loader	118
Excavator	118
Dozer	120
Grader	118
Scraper	116
Crane	115
Generator	119
Welding generator	113
Air compressor	107
Hand-held grinder	106

Table E.1: Sound power levels of the main noise sources at the production facilities.

Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)									Total (dB(A))
	31.5	63	125	250	500	1000	2000	4000	8000	
Long Term Noise Sources										
First Stage Gas Compression Unit										
Screw compressor	98	95	100	101	99	103	119	107	98	113
Electric motor - 2000hp	92	94	96	97	97	97	102	92	85	105
Cooler (2 fans, inlet plus outlet)	112	113	112	109	104	101	94	90	84	106
Further Stages Gas Compression Unit										
Reciprocating compressor	110	106	111	110	108	111	116	113	106	120
Electric motor - 5500hp	95	97	99	100	100	103	103	95	88	108
Cooler (3 fans, inlet plus outlet)	115	116	115	112	107	104	97	93	87	109
Power Generation Plant										
Power generator - 3.5 kW	74	74	77	79	82	82	81	76	68	87
Gas engine - exhaust with manufacturer installed silencer	77	84	88	72	69	73	78	79	68	84
Gas engine - air intake	88	95	101	99	94	93	92	94	95	101
Water Treatment Facility										
Centrifugal pump	74	74	77	79	82	82	81	76	68	87
Electric motor - 55 kW	74	74	77	79	82	82	81	76	68	87
Electric motor - 450 kW	82	84	86	88	90	90	90	86	81	95
Water Transfer Pump										
Centrifugal pump – 150 kW	75	75	88	93	94	95	89	83	75	98
Flare										
Normal operation – 0.02 TJ/d	78	78	79	80	82	83	85	90	85	93
Short Term Noise Sources										
Flare										
Maximum flow – 60TJ/d	102	105	110	105	95	90	95	105	100	107
Maximum flow – 150TJ/d	105	108	113	108	98	93	98	108	103	110

Table E.2: Sound power levels of the main noise sources at the production wells.

Noise Source	Maximum Sound Power Level (dB re 1 pW) by Octave Band Frequency (Hz)									Total (dB(A))
	31.5	63	125	250	500	1000	2000	4000	8000	
Reference Case										
5.7L –V8 gas engine, 60kW motor	111	102	99	98	83	82	73	69	76	86
Alternative Option										
60kW motor (electricity obtained from main power grid)	89	79	75	80	70	70	74	74	77	81

Appendix 6

Agricultural impact study
RPS

Dewhurst 22 – 25 Exploration Pilot Wells

Agricultural Impact Statement

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1.0 Summary

An agricultural impact statement (AIS) has been prepared for the proposed exploration pilot wells Dewhurst 22, 23, 24 and 25 (Dewhurst 22 – 25) and surrounding areas. The AIS determines if any agricultural resources or associated agricultural infrastructure would be impacted by the proposed drilling and ancillary activities at the site.

In the context of the total area of the site and the wider agricultural uses of the region, the temporary and minor loss of land is considered to have low risk on agricultural resources and industries. The proposed mitigation, management and monitoring systems in place suggest that the likelihood of impacts occurring would be unlikely or rare. The site will not impact on any biophysical Strategic Agricultural Land (BSAL) or Critical Industry Clusters (CIC). However, as the proposed activities includes pilot testing the, Strategic Regional Land Use Policy (SRLUP) considers the proposed activity moderate to high risk in nature.

There will be no pressure on agricultural support infrastructure including:

- Water services;
- Travelling stock routes;
- Railways; and
- Processing facilities.

The proposed activity will result in minor increases in traffic along Monument Road throughout the duration of the proposed activity. This level of traffic could easily be accommodated by the existing road network. Further, there will be no disruption to agricultural rail networks or travelling stock routes, as the site is not adjacent to any such infrastructure.

2.0 Introduction

The SRLUP (Department of Planning and Infrastructure (DoP&I, 2012a)) identifies and protects more than two million hectares of strategic agricultural land and valuable water resources, and provides greater certainty for companies wanting to invest in mining and coal seam gas projects in regional NSW.

As a result of this policy, all state significant mining and petroleum (including coal seam gas) projects as well as applications for associated state significant infrastructure, such as pipelines which have potential to affect agricultural resources or industries will be required to submit an agricultural impact statement (AIS) as part of the environmental impact statement (EIS).

Santos NSW (Eastern) Pty Ltd (a wholly owned subsidiary of Santos NSW (Eastern) Pty Limited) (Santos), as a coal seam gas (CSG) operator on behalf of the titleholders of Petroleum Exploration Licence 238 (PEL 238), proposes to drill four petroleum exploration pilot wells, known as Dewhurst 22, Dewhurst 23, Dewhurst 24 and Dewhurst 25 (Dewhurst 22 - 25), and carry out ancillary activities within the Pillaga East State Forest off Monument Road, to the south of Narrabri, New South Wales (the proposed activity). The purpose of the Dewhurst 22 - 25 pilot wells is to investigate the potential coal seam gas resource of the Gunnedah Basin within Petroleum Exploration Licence (PEL) 238. This activity is permissible without consent and is being assessed under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The Resources Minister is the determining authority for the activity.

RPS Australia East Pty Ltd (RPS) has prepared a Review of Environmental Factors (REF) to assess the potential environmental impacts of the proposed activity under Part 5 of the EP&A Act. RPS was also engaged to prepare this AIS to support the REF.

The purpose of the AIS is to assess the potential impacts of drilling and ancillary activities at Dewhurst 22 – 25 on agricultural resources and industries. The term 'agricultural resource' is used to describe the land on which agriculture is dependent and the associated water resources (quality and quantity) that are linked to that land. The AIS was prepared following the requirements of *'Guidelines for agricultural impacts statements at the exploration stage'* (DoP&I 2012b).

This document is an appendix of the REF and should be read in conjunction with the REF.

3.0 Project Description

3.1 Location

The site is located in the eastern section of PEL 238 (refer to **Figure 3.1**). PEL 238 covers an area of approximately 7,915 km^2 and extends across three local government areas (LGAs) including the Narrabri Shire, Warrumbungle Shire and Gunnedah Shire. The site is within the Narrabri Shire LGA.

The site is located approximately 30 km north-west of Boggabri and 30 km south of Narrabri. The site is within the Pilliga East State Forest. A number of State Conservation areas and National Parks are located in the vicinity of the site. These include:

- Pilliga East State Conservation area located approximately 13 km east of the study area;
- Willala Aboriginal Area located approximately 16 km south of the study area;
- Brigalow State Conservation area approximately 26 km and 29 km north-west of the study area; and
- Brigalow Park Nature Reserve approximately 27 km north-west of the study area.

3.2 Site Description

The study area is limited to the proposed leases and immediate surrounds, as well as proposed access tracks (**Figure 3.2**). The study area is well vegetated, dominated by heathy woodland communities. The nearest dwellings are located approximately 3.37 km and 3.43 km of the lease area.

3.3 Proposed Activities

The proposed activity will occur within the Pillaga East State Forest along Monument Road (the Forest), south of Narrabri, within PEL 238. Santos will conduct the activities for and on behalf of the titleholders of PEL 238 under a Permit to Occupy from the Forestry commission of New South Wales (trading as Forests NSW) and the State of NSW as they are located entirely on land managed by Forests NSW.

The scope of the proposed activity includes:

Site Establishment

- Constructing four access tracks from Monument Road to lease areas (including one creek crossing).
- Establishing four lease areas up to one hectare in size each.
- Installing surface infrastructure on the existing Dewhurst 6 lease (previously approved 3 April 2009) and Dewhurst 22-25 lease areas, including separators, metering skids, power generation equipment, telemetry units, motor control centres and drivers.
- Constructing a gas gathering system parallel to the access tracks (inclusive of Dewhurst 6), Monument Road and Yellow Springs Trail to a flare at Dewhurst 22.
- Constructing a water gathering system parallel to the gas gathering system with associated piping and pumps at Dewhurst 22. The gathering system extends from the riser located at the edge of the pilot well lease area to the transfer tank located at Dewhurst 22.

Drilling

- Drilling two vertical wells (Dewhurst 22 and 24) to a depth of approximately 1005 m.
- Drilling a tri-stacked horizontal well (Dewhurst 23) to intercept Dewhurst 22.
- Drilling a single horizontal well (Dewhurst 25) to intercept Dewhurst 24.

Operation

- Operating the Dewhurst 22-25 well sets (including Dewhurst 6) for the life of PEL 238 or until critical reservoir data is collected.
- Partial rehabilitation of Dewhurst 6, 23, 24 and 25 to well head and essential infrastructure.
- Installing a flare, water transfer tank (approximate capacity 40m^3) and pumps at the Dewhurst 22 lease area.
- Continued monitoring of pilot wells and gathering system.
- Maintenance and work over activities.

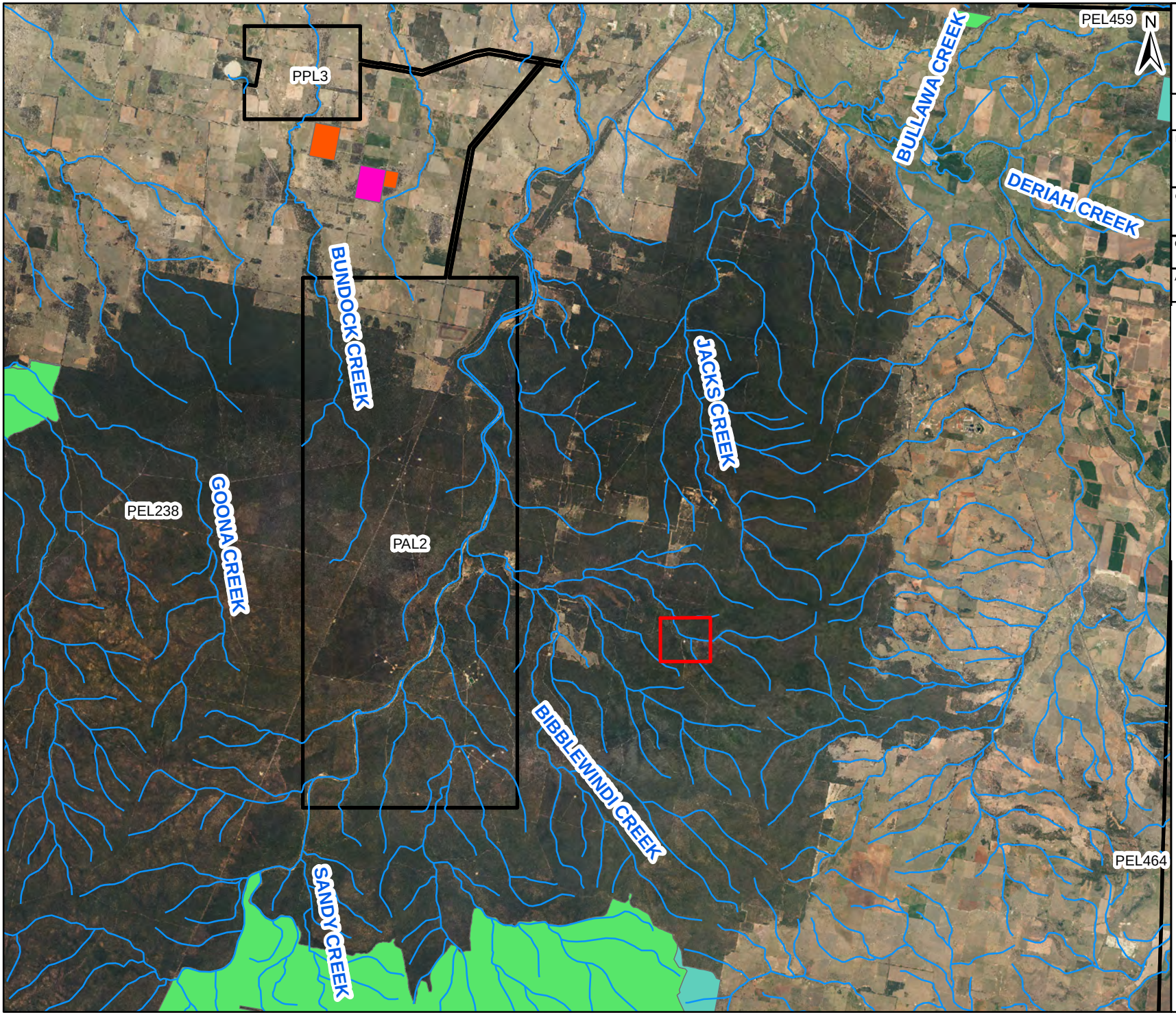
Each lease area will be approximately 100 m by 100 m pad and will be established using a combination, of the following methods:

- Slashing grass and vegetation and laying industrial matting over the area; or
- Constructing the lease area with cut and fill. If cut and fill is to be used, estimated volumes are 1,100 m^3 and 950 m^3 (Dewhurst 22), 1,050 m^3 and 850 m^3 (Dewhurst 23), 2,450 m^3 and 2,200 m^3 (Dewhurst 24), 700 m^3 and 750 m^3 (Dewhurst 25), respectively; and
- Apply industrial matting and / or gravel to areas to be trafficked.

Construction of the proposed activity will take approximately three months from site preparation until completion of the pilot wells. Partial rehabilitation of the lease area will occur within approximately six months of completion of the well where practical. Full rehabilitation will occur only once the well is no longer required for operation, which may be up to 30 years.

The duration of operation of the pilot wells at this stage is unknown, but the wells will need to be operated until critical reservoir data is obtained which could take a number of years. It is expected that they will continue to operate throughout the duration of the life of PEL 238.

The total area of potential disturbance assessed in this AIS is 6.29 ha. This includes the 4 ha required for the lease areas and 2.29 ha required for the construction of the four access tracks (one to each lease area) and the gathering system. References to ‘the study area’ here on include the four lease areas and associated access tracks and gathering system.



NSW Estates and Petroleum Titkes

Figure 3.1

Project:	Dewhurst Flowlines 22 - 25 AIS
Client:	Santos
Compiled by: JC	Date: 5/2/2013
Approved by: DF	Date: 5/2/2013

Legend

- Study Area
- Watercourses
- Petroleum Titles

NSW Estates

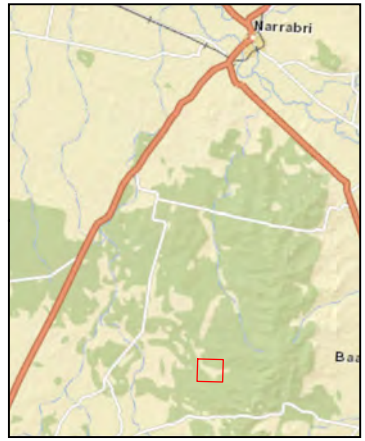
- ABORIGINAL AREA
- CCA ZONE 1 NATIONAL PARK
- CCA ZONE 2 ABORIGINAL AREA
- CCA ZONE 3 STATE CONSERVATION AREA
- NATIONAL PARK
- NATURE RESERVE
- STATE CONSERVATION AREA

Source: Imagery from Bing Maps 2012
Infrastructure located with Trimble GeoExplorer
Other data from OEH 2012

0 2.5 5 10 km

Datum: GDA94
Scale 1:250,000 @ A4

RPS





Site Layout

Figure 3.2

Project:	Dewhurst 22 - 25 AIS
Client:	Santos
Compiled by: JC	Date: 5/2/2013
Approved by: DF	Date: 5/2/2013

Legend

- Watercourses
- Access Track & Gathering System
- Well leases

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2012
Watercourses from OEH 2012

0 0.075 0.15 0.3 km

Datum: GDA94
Scale 1:8,500 @ A4

RPS



4.0 Project Design Review / Alternatives

4.1 Analysis of Alternatives

Alternatives to undertaking the work include:

- Do nothing;
- Reduced scale (less well sets); and
- Alternative location.

4.2 Do nothing option

There is limited previous targeted drilling in this area of the Gunnedah Basin that is sufficiently deep for petroleum exploration purposes. The proposed activity is essential to gain knowledge of the gas content, composition and detailed stratigraphic data. A do nothing option will not enable data to be collected.

4.3 Reduced Scale

Technical studies investigated opportunities to reduce the number of wells required. The provision of combined vertical and horizontal wells combined with a tri-stacked option reduced the well sets to a minimum of two sets (four wells) proximate to Dewhurst 6. There were no other lower impact alternatives to the proposed activity available that will adequately assess the potential gas resource.

4.4 Alternative location

The site selection process was influenced by:

- Minimum distances from Dewhurst 6 and between the vertical and directional wells;
- The need for a minimum of four wells;
- Underlying geology;
- Minimising the number of crossings of Spring Creek;
- Minimising the length of access tracks and the amount of vegetation to be cleared; and
- Minimising hollow bearing tree removal and impact on riparian vegetation.

The site was selected based on the principles of impact avoidance and harm minimisation. It was broadly identified by Santos' geologists and refined in consultation with Forests NSW and with the assistance of cultural heritage, ecological and environmental consultants. Access tracks were located to avoid hollow bearing trees, targeting areas of greatest disturbance. The presence of Pilliga Mouse habitat was also considered as the Dewhurst 25 lease area was initially located within the Heath community, however this was subsequently relocated to avoid Heath communities to minimise the impact on this species.

Dewhurst 22 was selected as the location of the flare and water transfer facility as it provided the most logical tie in to future infrastructure linking the wells to Bibblewindi ponds. The alternative vertical well, Dewhurst 24 was considered however was eliminated as it crossed Spring Creek.

5.0 Agricultural Enterprise and Resources

The following section identifies the agricultural enterprises that exist on the study area and within the surrounding catchment.

5.1 Agricultural Enterprise

In the Northern Plains, cropping is the most significant crop, while beef cattle and wheat production are the other main industries. Moree and Narrabri LGAs produce around 66% of NSW cotton from around 4% of the state's area. These same LGAs also produce 5% of the gross value of NSW beef cattle and the area known as the Golden Triangle (350,000 ha between Bellata, North Star and Yallaroi) produces consistently high yields of prime hard (high protein) wheat (DoP&I, 2012a).

There were an estimated 1,857 businesses registered in Narrabri Shire in June 2007. Agriculture, Forestry & Fishing is the largest industry, accounting for 49.8% of the total number of businesses (NSW 2007).

The dominant land use in the Namoi catchment is sheep and cattle grazing which accounts for 61% of land use by area (**Table 5.1** and **Figure 5.1**). Wheat, cotton and other broad acre crops are grown along the alluvial floodplains. Of the 1,120 km^2 irrigated in the year 2000, around 800 km^2 (over 70%) was used for cotton production in the Lower Namoi catchment (CSIRO 2007).

Extensive areas of land for conservation and forestry occur in the middle of the catchment to the south of Narrabri. Together with other native landscapes these land uses account for over 18% of the catchment. Much of this area comprises the Pilliga Scrub, a significant area of remnant dry sclerophyll forest.

The study area forms part of the Bohena sub-catchment. Cleared areas are mainly in the northern part of the sub-catchment and are predominantly used for sheep and cattle grazing of native and improved pastures. The study area is located in the Pilliga East State forest, with much of the surrounding area comprised of similar landscapes. Both the study area and its surrounds are not used for agricultural purposes.

Table 5.1: Land use statistics for the Namoi catchment (Green et al., 2011, sourced from 2001/02 Land use mapping of Australia, Bureau of Rural Sciences)

Land use	Extent (km2)	Proportion of Catchment (%)
Grazing	25,727	61.2
Dryland cropping and horticulture	6,810	16.2
Forestry	4,339	10.3
Native landscapes	2,136	5.1
Conservation	1,351	3.2
Irrigation	1,259	3
Residential	256	0.6
Lakes, river, dams	139	0.3
Wetland	12	<0.1
Mining	7	<0.1

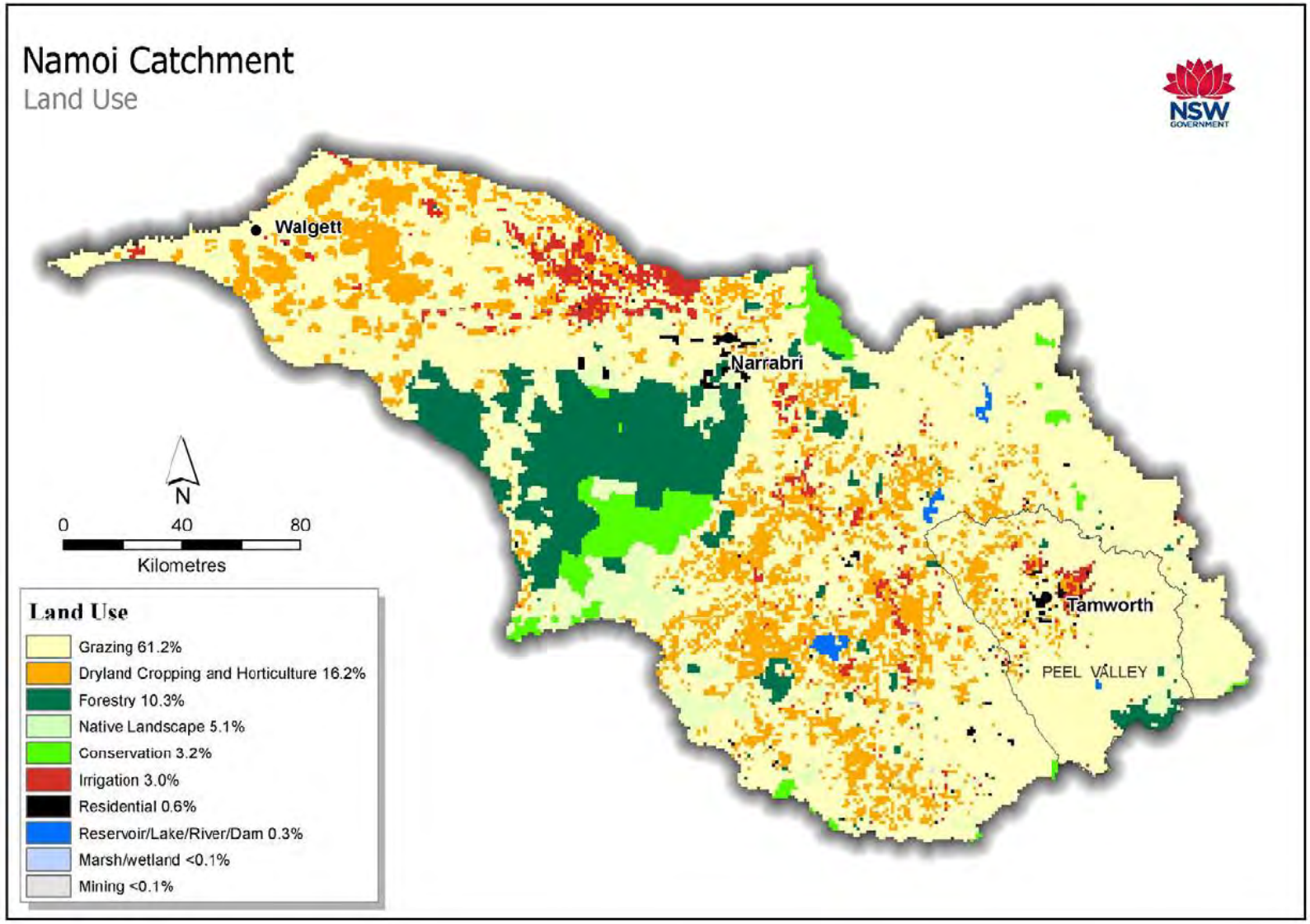


Figure 5.1: Land use in the Naomi Catchment (Green *et al.,* sourced from 2001/02 Land use mapping of Australia, Bureau of Rural Sciences).

5.1.1 Agricultural Production Value

Agriculture and agribusiness is worth $1.8 billion per annum to the New England - North West regional economy (ABS 2006 Census), which represents approximately 20% of the gross value of agriculture and agribusiness for the entire state. Sheep and cattle grazing, broad acre cereal crops, irrigated cotton, intensive livestock and plant agriculture and poultry production are the main contributors (DoP&I, 2012a).

In 2009 / 2010 the Narrabri Shire recorded a Gross Regional Product (GRP) of $730 million, with agriculture forestry and fishing contributing $115.30 million (15.8%) of total GRP (AEC, 2011), resulting in the sector being the second largest contributor to GRP in Narrabri Shire, behind the mining sector.

In 2006, the Narrabri LGA reported the gross value of crops in excess of $215 million, while the gross value of livestock slaughtering and livestock products were $41 million and $4 million, respectively (ABS 2006 Census). In 2007, the Agricultural, Forestry and Fishing sector reported a total industry turnover of $439.5 million, accounting for 50% of the total business by industry and turnover for the Narrabri shire.

5.1.2 Employment

The agriculture and agribusiness sector is currently the most significant employer in the New England - North West region, accounting for almost half of all businesses (ABS 2006 Census). Approximately 12,300 people or 16.8% of employment in the region is directly related to agriculture (2005-06 ABS). Taking into account flow-on, effects from this sector into other parts of the regional economy, more than 30,000 people are directly or indirectly employed as a result of agriculture in the New England - North West region. This accounts for 42% of the region's total employment (DoP&I 2012a).

Agricultural enterprises were the largest employers in the Narrabri Shire (2009 / 10), employing 25% of the workforce (or 1,527 people), which exceeds the average rate of employment for both the northern statistical district and the New South Wales State average (AEC, 2011). The largest agricultural enterprises in the region are cotton and grain, which employ approximately 47% of the agricultural workforce.

As the study area is located on a state forest it does not employ staff for agricultural purposes.

5.2 Agricultural Support Infrastructure

Due to the scale, diversity and productivity of agricultural enterprise within the Narrabri Shire, processing companies, research and development facilities, transport and warehousing and other service industries have established in the Narrabri Shire to support the agricultural industry (DoP&I, 2012a), including:

- Livestock selling centre;
- Farm management services;
- Grain and field bean merchant wholesalers; and
- Crop harvesting selling centres.

The Cargill Oilseeds plant in Narrabri processes approximately 250,000 tonnes of cottonseed each year. The Canzac Pulse Processors plant in Narrabri produces high quality pulse seeds for export. Other processing plants in the LGA include seed grading, mixing and packaging operations.

Research establishments are located in the Narrabri district; the I.A Watson Grains Research Centre (operated by the University of Sydney); and the big Australian Cotton Research Institute (ACRI). The Cotton Research and Development Corporation is also located in Narrabri, which is funded by the Federal Government and industry to select and fund suitable research projects.

Kimilaroi and Newell Highway run through Narrabri and provide access to the coast and inland NSW. The Newell Highway which is part of the National Land Transport Network and forms a major linkage between regional centres in North West NSW to Brisbane and Melbourne (DoP&I, 2012a). Approximately half of the traffic which utilises the Newell Highway consists of heavy vehicles carrying freight.

The Walgett railway line is a railway line in north-western New South Wales, Australia. Opening in 1908, it branches from the Main North line at Narrabri and passes through the towns of Wee Waa and Burren before ending in the town of Walgett. The line is used for wheat haulage, and runs adjacent to Culgoora Rd.

There is no agricultural rail infrastructure within the surrounds of the proposed activity. The railway line is located approximately 19 km east of the site. Further, the study area is not located on or in the vicinity of any travelling stock routes. The nearest stock route is located 15 km east of the study area.

5.3 Tourism

Tourism in the Narrabri shire is led by its natural attractions. The Pilliga State Forest and Mt Kaputar National Park are two of the largest tourism interests of the region. Farm holidays, historical museums, Yarrie Lake, artesian bore baths, art shows and visiting cultural production further add to the regions tourism attractions.

5.4 Agricultural Resources

5.4.1 Climate

The closest running weather station is located in Narrabri (station 54120). Climate in the Narrabri region is regarded as semi-arid, due to hot summers and mild winters (**Figure 5.2**). Average (1900 - 2012) monthly maximum temperatures range from 17.7°C (July) to 34.6°C (Jan) (**Table 5.2**). Maximum temperatures have historically exceeded 40°C. Frost can occur in all low lying parts of the region. Frost events generally occur between June and August though can begin as early as April. Narrabri has historically recorded frost events as late as October.

Average annual rainfall in Narrabri is 640.5 mm. Pan evaporation exceeds rainfall throughout the year, indicating the regions reliance on irrigation and soil water storage during fallow (**Figure 5.2**).

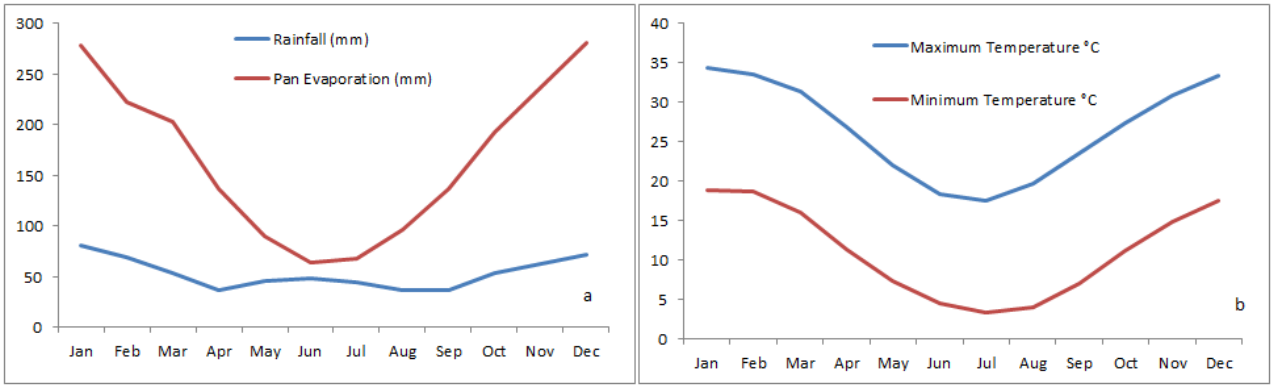


Figure 5.2: Mean maximum and minimum temperatures (°C) (a) and rainfall (mm) and Pan Evaporation (b) of Narrabri (1900 to 2012) (SILO 2012).

Table 5.2: Climate statistics of Narrabri for years 1900 to 2012, weather station 54120 (SILO 2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	79.7	64.1	48.4	35.8	42.9	42.9	42.1	34.1	34.2	48.6	57.9	60.4
Pan Evaporation (mm)	284	230	207	139	91.5	64.2	68.5	97.1	139	196	243	287
Maximum Temperature (°C)	34.6	33.7	31.4	27.1	22.3	18.5	17.7	19.9	23.8	27.7	31.1	33.7
Minimum Temperature (°C)	19.3	19.1	16.3	11.5	7.6	4.8	3.4	4.3	7.4	11.6	15.2	17.8

5.4.2 Landscape Units

Landscapes of New South Wales (NSW) are described by Mitchell (2002) at a 1:250,000 scale.

Mitchell (2002) indicated that the study area is characterised by two landscape units (Coghill Alluvial Plains and Cubbo Uplands) with the surrounding area consisting of similar formation. These landscape units can be viewed in **Figure 5.3** and are discussed below.

5.4.2.1 Geology and Topography

The topography of the study area is gentle, with no significant topographic features such as ridgelines occurring. A number of ephemeral waterways occur within the study area including Spring Creek. These creeks are headwaters of Bibblewindi Creek.

Coghill Alluvial Plains

Distal parts of the Quaternary alluvial fans largely derived from Jurassic quartz sandstone on streams draining from the Pilliga forests. Long gentle slopes broken by sandy abandoned stream channels. General elevation is 200 m to 280 m, local relief of 5 m to 9 m.

Cubbo Uplands

Pilliga horizontal Jurassic quartz sandstones, limited shales, Tertiary basalt caps and plugs plus the sediments derived from these rocks. Stepped sandstone ridges with low cliff faces and high proportion of rock outcrop. Long gentle outwash slopes intersected by sandy streambeds and prior stream channels. General elevation is 400 m to 550 m, with local relief of 50 m.

5.4.2.2 Soils

Coghill Alluvial Plains

Deep texture-contrast soils with harsh clay subsoils or grey clays with gilgai.

Cubbo Uplands

Along sandstone ridge tops thin discontinuous soils with stony, sandy profiles and low nutrients predominate. Down slopes areas consist of texture-contrast soils typically with harsh clay subsoils, while along valley floors sediments tend to be sorted into deep sands with yellow earthy profiles, harsh grey clays, or more texture-contrast soils with a greater concentration of soluble salts.

5.4.3 Soil Fertility

According to the Draft Inherent Soil Fertility mapping of the New England – North West region (OEH 2012a), the inherent soil fertility of the study area and immediate surrounds are moderately low to low (**Figure 5.4**).

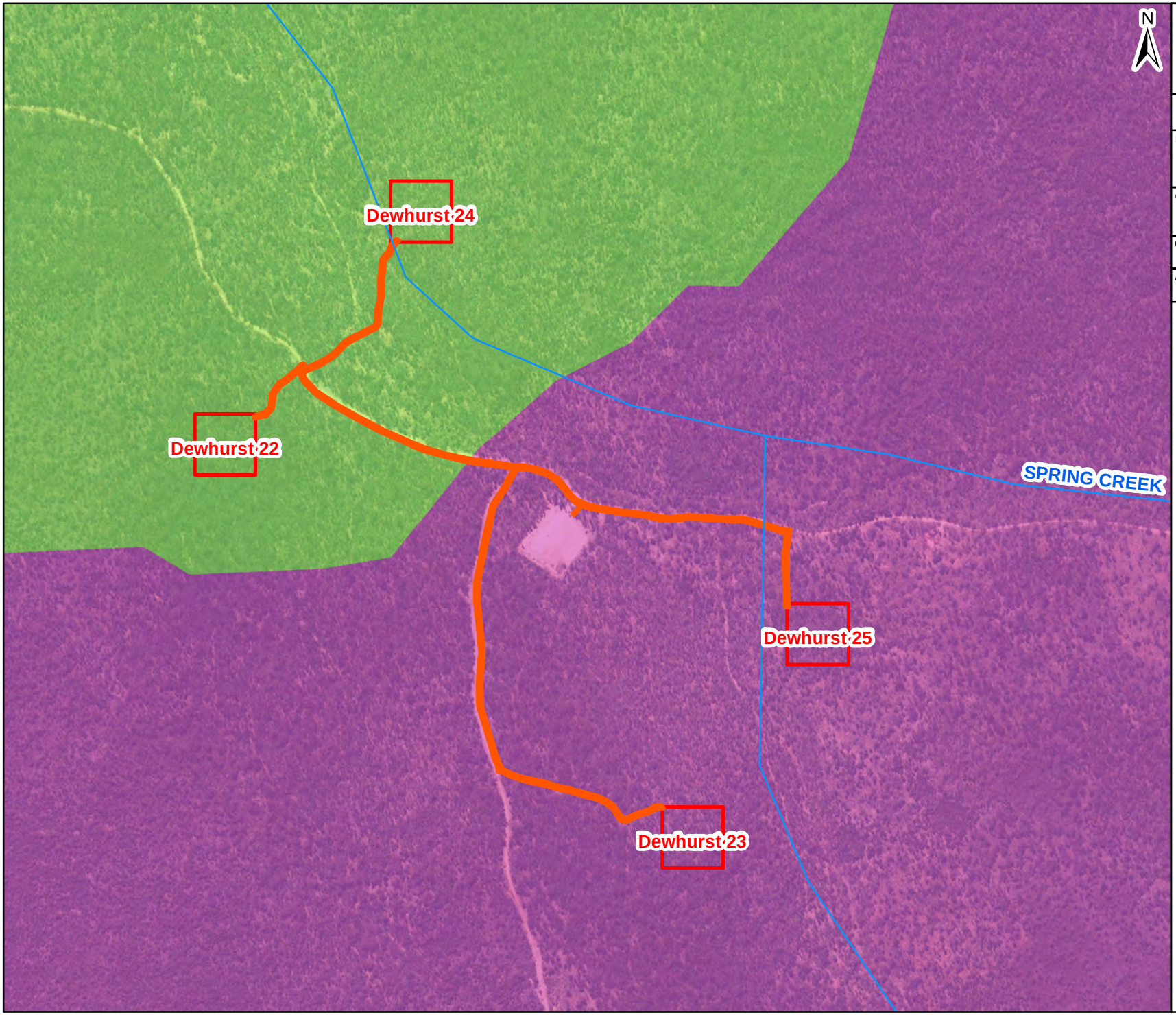
5.4.4 Soil limitations

Soil characteristics of the property indicate that the study area is considered to have moderate to severe limitations, as the features listed in **Table 5.3** limit agricultural productions.

Table 5.3: Soil limitations of the Dewhurst 22 – 25 project area

Soil landscape	Salinity	PAWC*	Stoniness	Soil Depth	Nutrients	Sodicity
Coghill Alluvial Plains	-	✓	✓	✓	✓	✓
Cubbo Uplands	✓	✓	✓	✓	✓	-
Bugaldie Uplands	-	✓	✓	✓	✓	✓

*PAWC – Plant available water capacity



Landscape Units

Figure 5.3

Project:	Dewhurst 22 - 25 AIS
Client:	Santos
Compiled by: JC	Date: 5/2/2013
Approved by: DF	Date: 5/2/2013

Legend

- Watercourses
- Access Track & Gathering System
- Well leases

Landscape Unit

- Coghill Alluvial plains
- Cubbo Uplands

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 0.075 0.15 0.3 km

Datum: GDA94
Scale 1:8,500 @ A4

RPS





Soil Fertility

Figure 5.4

Project:	Dewhurst 22 - 25 AIS
Client:	Santos
Compiled by: JC	Date: 5/2/2013
Approved by: DF	Date: 5/2/2013

Legend

- Watercourses
- Access Track & Gathering System
- Well leases
- Access Tracks
- High
- Moderately High
- Moderate
- Moderately Low
- Low

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 0.075 0.15 0.3 km

Datum: GDA94
Scale 1:8,500 @ A4

RPS



5.4.5 Agricultural Land Use Suitability

5.4.5.1 Strategic Agricultural Land Classification

Strategic Agricultural Land (SAL) is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DoP&I, 2012a). Based on this definition there are two (2) categories of SAL: Critical Industry Clusters (CIC) and biophysical SAL (BSAL).

A CIC is a localised concentration of interrelated productive industries based on an agricultural product that provides significant employment opportunities and contributes to the identity of the region (DoP&I, 2012a). No CIC's have been identified in the New England - North West Region.

According to the SAL mapping (DoP&I, 2012a), the study area and surrounds are not located on BSAL of the New England - North West region (**Figure 5.5**). The nearest BSAL polygon is located approximately 7.2 km south-east of the study area.

5.4.5.2 Land and Soil Capability

In NSW, land and soil capability classes (LSC Classes) have been mapped for the New England - North West region (OEH, 2012b). The mapping is based on an eight class system with values ranging between 1 and 8 which represent a decreasing capability of the land to sustain land use. Class 1 represents land capable of sustaining most land uses including those that have a high impact on the soil (e.g. regular cultivation), whilst class 8 represents land that can only sustain very low impact land uses (e.g. nature conservation).

The study area and surrounds have been mapped as LSC Class 4 and 5 (**Figure 5.6**). LSC Class 4 includes lands associated with moderate to severe limitation. These lands are generally not capable of sustaining high impact land uses (e.g. regular cultivation) unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses (e.g. grazing). LSC Class 5 includes lands associated with severe limitations. These lands are also not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices overcome limitations (e.g. high value crops). Lower impact land uses (e.g. grazing) can be managed by readily available practices.

5.4.6 Water Resources

5.4.6.1 Surface water

The study area is located within the Namoi River catchment which covers an area of approximately 42,000 km^2 stretching from Woolbrook in the east to Walgett in the west. The catchment is bounded by the Great Dividing Range in the east, the Liverpool Ranges and Warrumbungle Ranges in the south and the Nandewar Ranges and Mount Kaputar to the north.

The Namoi River flows in a westerly direction from its headwaters in the Great Dividing Range. Its main tributary, the Peel River, joins the Namoi near Gunnedah. The Peel River originates in the southeast of the catchment near its border with the Hunter Valley, and flows in a north-west direction towards the Namoi River (**Figure 5.7**). The Peel is regulated by Chaffey Dam which provides water for irrigation as well as supplementing the water supply for the city of Tamworth (in addition to Dungowan Dam on Dungowan Creek).

Other major tributaries of the Namoi River include the Manilla and McDonald Rivers upstream of Keepit Dam, Coxs Creek and the Mooki River, which join the Namoi upstream of Boggabri, and Pian, Narrabri, Baradine and Bohena Creeks joining below Boggabri. The Namoi River then flows westerly across the plains and joins the Barwon River near Walgett. The Pian Creek and Gunidgera Creek system is an anabranch of the Namoi River which flows from the northern side of the river near Wee Waa in a westerly direction and rejoins the Namoi upstream of Walgett.

The study area is located within the Bohena sub-catchment of the Namoi River catchment. The Bohena sub-catchment covers an area of approximately 830 km^2 south of Narrabri and is the northern extension of the Borah sub-catchment.

The main creek system with the study area is Spring Creek. A number of unnamed ephemeral waterways also intersect the study area, while Bibblewindi Creek is locating in the immediate vicinity. Spring Creek and Bibblewindi Creek are tributaries of Bohena Creek.

Surface water quality within the catchment is influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2012). The major water users of the Namoi River are generally irrigators with an annual entitlement of 254, 976 ML.

5.4.6.2 Ground water

Ground water is contained in the unconsolidated sediments along the Namoi River and its major tributaries. The alluvium of the Namoi River is by far the most important in the state in terms of ground water use, providing water for stock use, domestic supplies, irrigation, industry and town water supplies. There are a total of 700 license holders in the Namoi River catchment.

The high-yielding aquifers of the Namoi catchment are managed as two ground water resources – the Lower Namoi Ground water Source and the Upper Namoi Ground water Source, both of which are managed under a water sharing plan. The Namoi catchment is licensed to provide over 343,000 ML of ground water entitlement per year. In areas not covered by a water sharing plan, the main licensed use of ground water is for irrigation and stock, which represent 50% and 40%, respectively, of all ground water entitlement.

The Lower Namoi Ground water Source extends approximately 160 km west from Narrabri and covers an area of about 7,630 km^2. The alluvium is up to 120 m deep and some bores yield more than 200 L per second (WRC, 1984).

The Upper Namoi Ground water Sources extend about 175 km south from Narrabri and include the unconsolidated sediments associated with the Namoi River and its tributaries (including Mooki River and Coxs Creek) upstream of Narrabri. They cover an area of 3,800 km^2, and are divided into 12 separate ground water zones based on hydrogeological features.

The lower part of the catchment to the west of Narrabri is underlain by the aquifers of the Great Artesian Basin. This is one of the largest artesian basins in the world covering 1.7 million km^2 or 22% of Australia (Crabb, 1997) and containing an estimated 8,700 million ML of artesian water. The aquifers of the Great Artesian Basin have high levels of sodium which make them unsuitable for irrigation use (**Figure 5.8**).

The study area is defined as being within the Southern Recharge Groundwater source of the Great Artesian Basin. There are four licensed groundwater bores within 4.5 km of the proposed study area:

- GW059958 (maximum depth 66.0 m) – authorised purpose is domestic stock (water bearing zone located at a depth of 52.0 m to 65.0 m).
- GW038774 (maximum depth 76.2 m) – authorised purpose is domestic stock (water bearing zones located at depths 61.5 m to 66.6 m, 71.0 m to 71.3 m and 74.6 m to 76.1 m).
- GW969324 (maximum depth 71.0 m) – authorised purpose is domestic stock (water bearing zones located at a depth of 60.0 m to 71.0 m).
- GW003587 (maximum depth 72.5 m) – authorised purpose is domestic stock (water bearing zones located at a depth of 69.1 m)

These bores abstract water from the lower Namoi alluvium and the Pilliga Sandstone. The Pilliga Sandstone of the Surat Basin is considered the lowest (and most easterly) intake beds of the Great Artesian Basin (GAB). None of these layers will be impacted by the proposed activity (construction and operation).

Two high priority groundwater dependant ecosystems (GDEs) are identified in the vicinity of the project, Hardy's Spring and Ether Spring. These are hydrogeologically associated with the Pilliga sandstone. As there is no impact to the Pilliga sandstone, there is expected to be no impact on the GDE's.

5.4.6.3 Licensed Water Use

As Bohena Creek feeds into the Namoi River the following outlines the major features of water use in the Namoi River, including both surface and ground water systems.

Surface water

The Namoi catchment uses around 2.5% of the total surface water diverted for irrigation in the Murray-Darling Basin, and around 15% of the total groundwater resource that is extracted in the Basin (CSIRO 2007). The Namoi River and Peel River systems are operated separately from a water resource management perspective. The Namoi River system is regulated to meet the needs of water users and the environment from Split Rock Dam to its confluence with the Barwon-Darling River at Walgett. Split Rock Dam, Keepit Dam and the downstream re-regulating weirs are operated to meet water user needs with the tributary inflows from the Peel River, Mooki River, Coxs Creek and other tributaries utilised before dam releases are made.

The major water users in the Namoi River are general security irrigators with an annual entitlement of 254,976 ML (**Table 5.4**), of which 9,724 ML of entitlement is located on the Upper Namoi between Split Rock and Keepit Dams. Total share components issued for the regulated Namoi River is 379,000 ML. When flows in the river are above user requirements supplementary water access is declared so that irrigation users can divert water from the river without debit to their account. The valley operates under a total licensed supplementary cap of 110,000 ML per year. Water users situated on the various creeks and tributaries of the Namoi catchment may also extract water with an unregulated water licence. These licences are subject to a range of access conditions that protect the health of the water courses such as cease to pump flow rate triggers.

Table 5.4: Namoi regulated river share components as at 30 June 2010 (Green *et al*., 2011 sourced from NSW office of Water)

Access Licence Category	Allocation (ML/annum)	
	Upper Namoi	Lower Namoi
Domestic and stock	76	1,745
Domestic and stock (stock)	5	257
Domestic and Stock (domestic)	11	17
Local water utility	150	2,271
General security	9,724	245,222
High security	80	3,418
High security (research)	-	486
Supplementary water	-	115,469
Total	**10,046**	**368,885**

Groundwater

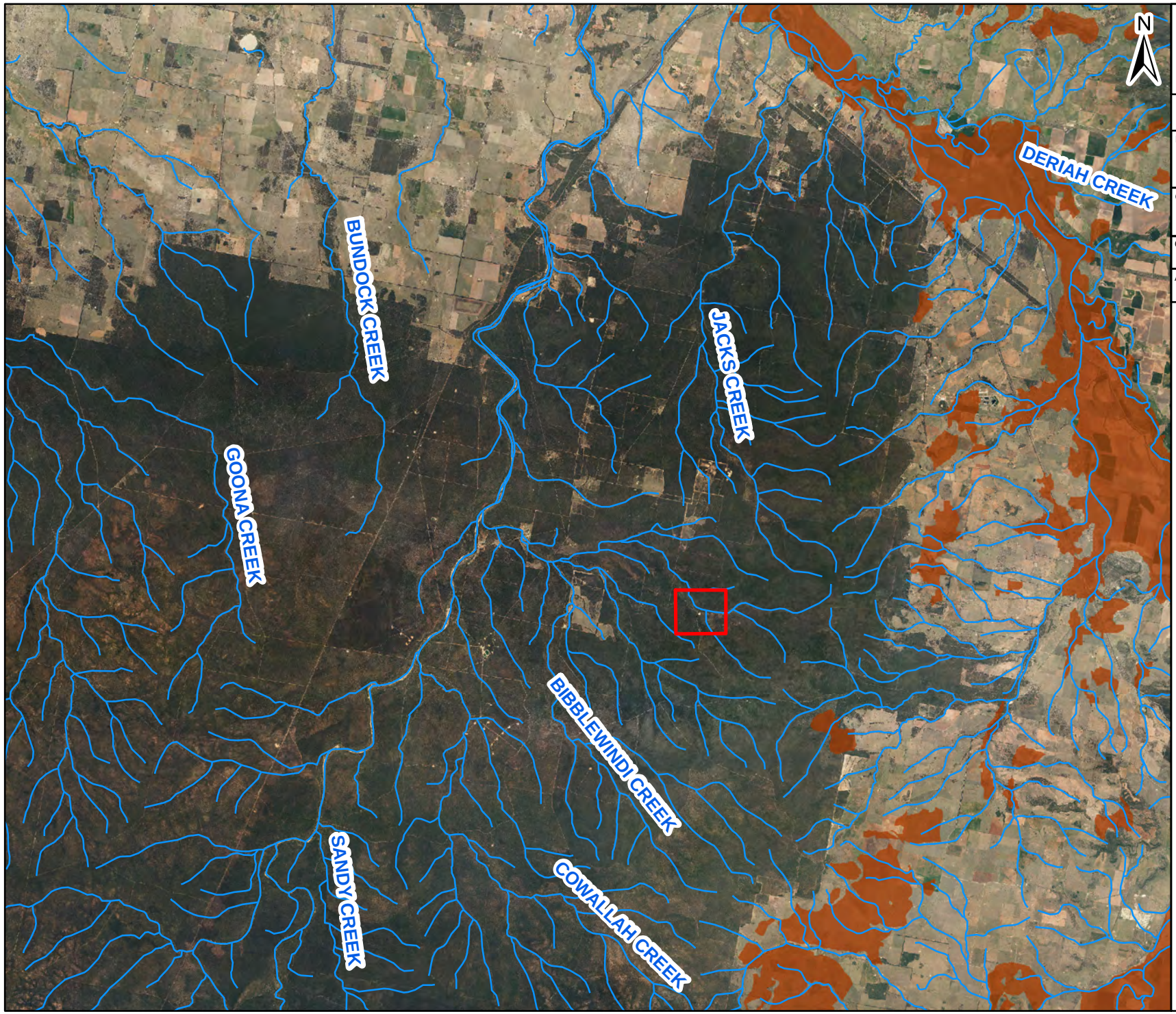
The Namoi catchment has the highest level of groundwater development in NSW, accounting for 15% of all groundwater use in the Murray-Darling Basin (CSIRO 2007). In 2004-05 a total of 255,000 ML of groundwater was extracted which represented approximately half of the total water used within the catchment that year (CSIRO 2007).

There are over 18,000 bores in the Namoi catchment which are licensed to provide over 343,000 ML of groundwater entitlement per year (**Table 5.5**). Of this entitlement 75% is associated with the Upper and Lower Namoi groundwater sources and is therefore subject to a water sharing plan.

Aquifer licences within the water sharing plan area cover a variety of purposes including irrigation, industrial, stock and domestic water. Town water supplies account for 11,752 ML of entitlement within the water sharing plan area. In areas of the catchment not covered by a water sharing plan, the main licensed use of groundwater is for irrigation and stock, which represent 50 per cent and 40 per cent respectively of all groundwater entitlements. Including both licensed and unlicensed ground water entitlements, a total of 247,480.66 ML was extracted in 2009 for agricultural purposes.

Table 5.5: Namoi catchment groundwater entitlements 2009 (Green *et al*., 2011 sourced from NSW office of Water)

License Category	Total Share Component (ML)
Upper and Lower Namoi groundwater sources	
Aquifer	188,609.5
Local water utility	11,752
Supplementary water	57,552
Total in Water Share Plan area	**257,913.5**
Outside water sharing plan areas	
Aquaculture / Pisciculture	44
Commercial	106
Dewatering / mining / industrial	3,691
Domestic	1,688.5
Farming	269
Feedlot / piggery	70
Irrigation	42,862
Recreation	392
Stock	34,507
Local water utility	2,066
Total outside the plan area	**85,695.5**
TOTAL	**343,609**



Strategic Agricultural Land

Figure 5.5

Project:	Dewhurst 22 - 25 AIS
Client:	Santos
Compiled by: JC	Date: 5/2/2013
Approved by: DF	Date: 5/2/2013

Legend

- Watercourses
- Study Area
- BSAL

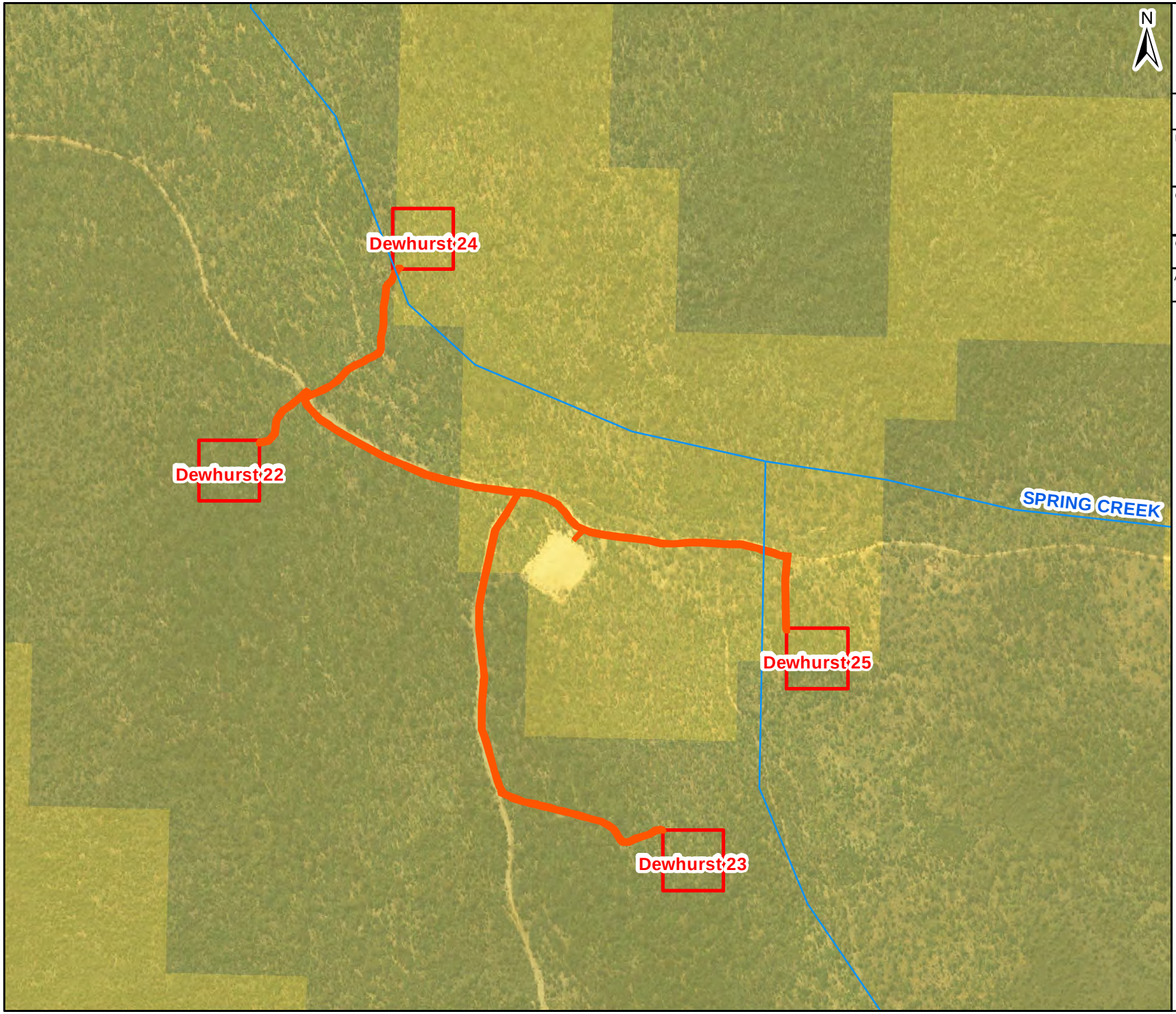
Source: Imagery from Bing Maps 2012
Infrastructure located with Trimble GeoExplorer
Other data from OEH 2012

0 2.5 5 10 km

Datum: GDA94
Scale 1:250,000 @ A4

RPS





Land and Soil Capability

Figure 5.6

Project:	Dewhurst 22 - 25 AIS
Client:	Santos
Compiled by: JC	Date: 5/2/2013
Approved by: DF	Date: 5/2/2013

Legend

- Watercourses
- Access Track & Gathering System
- Well leases

Land and Soil Capability (LSC) Classes

- LSC Class 1 *Very slight to negligible limitations*
- LSC Class 2 *Slight but significant limitations*
- LSC Class 3 *Moderate limitations*
- LSC Class 4 *Moderate to severe limitations*
- LSC Class 5 *Severe limitations*
- LSC Class 6 *Very severe limitations*
- LSC Class 7 *Extremely severe limitations*
- LSC Class 8 *Extreme limitations*

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2012
Other dats supplied from OEH 2012

0 0.075 0.15 0.3 km

Datum: GDA94
Scale 1:8,500 @ A4

RPS



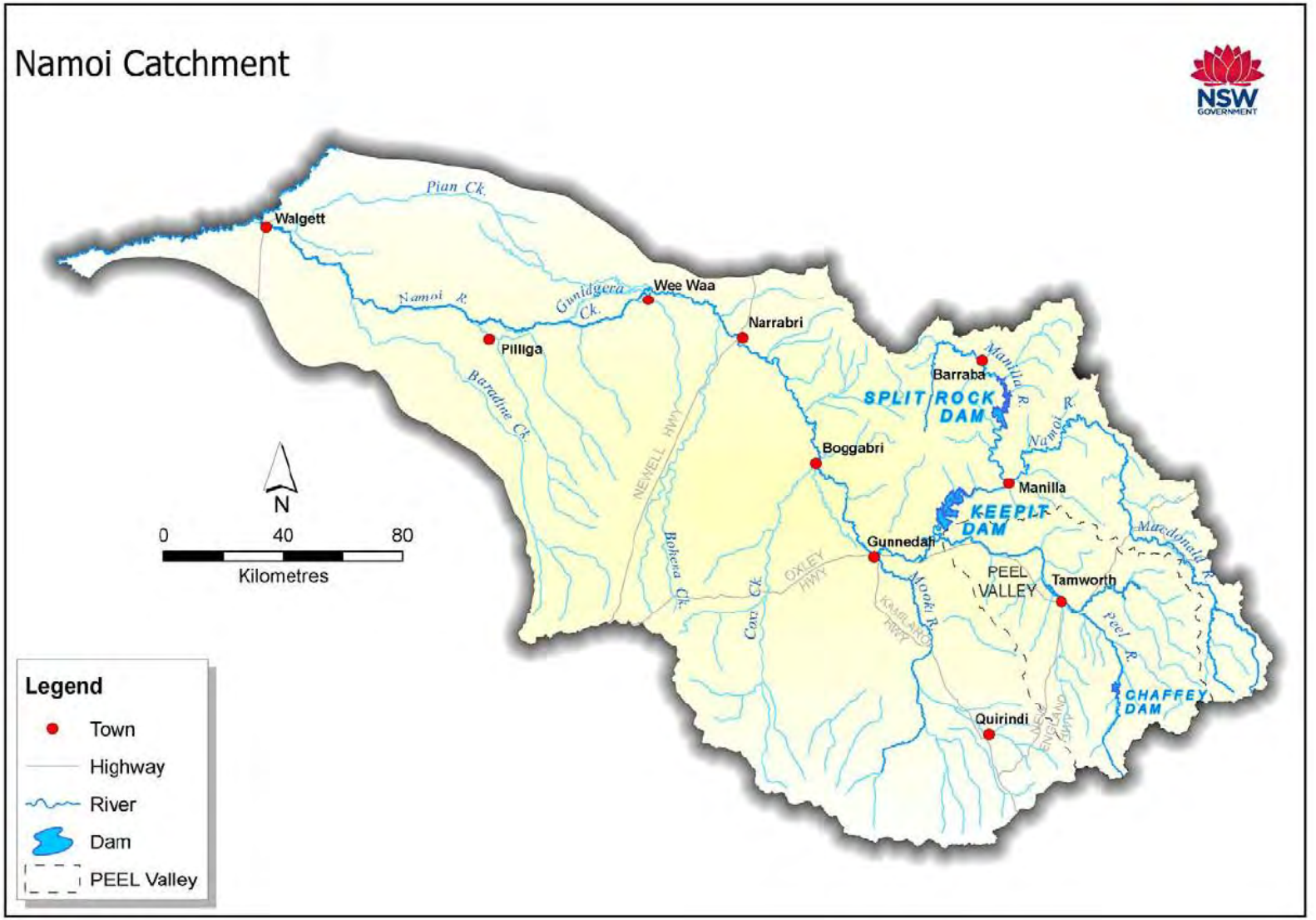


Figure 5.7: Surface waters in the Namoi catchment (Green et al., 2011)

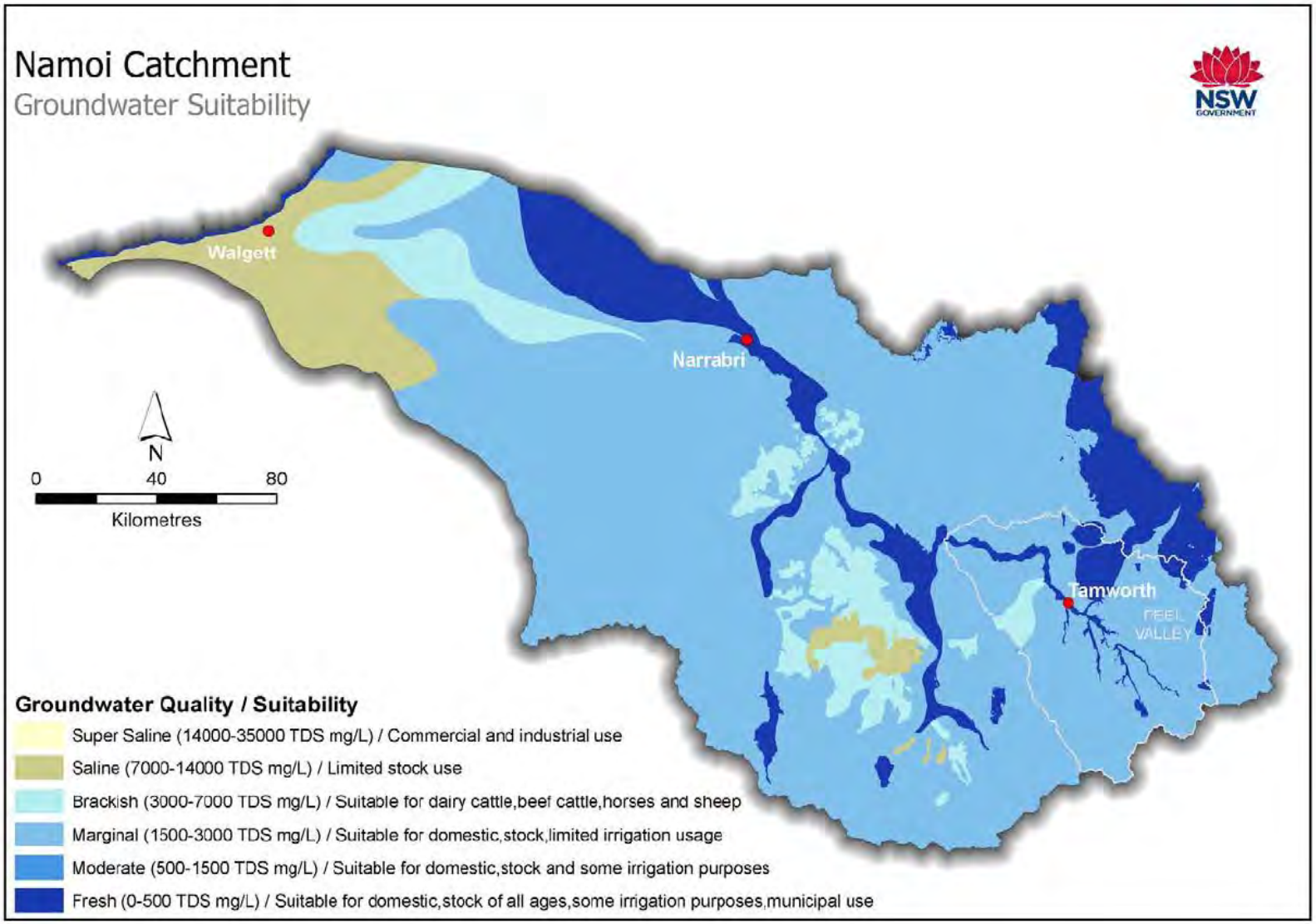


Figure 5.8: Ground water quality and suitability in the Namoi catchment (Green et al., 2011)

6.0 Agricultural Impact Risk and Potential Consequences

The SRLUP *"Guidelines for agricultural impact statement at the exploration stage"* has released an agricultural impact risk ranking system. This system is designed to identify the risk of proposed exploration activities on agricultural resources or industries (**Table 6.1**). The risk ranking system includes probability of the event occurring and the associated consequence of the event. Descriptions of probabilities are provided in **Table 6.2**, while descriptions of consequences are provided in **Table 6.3**.

Table 6.1 indicates that all red and orange areas in the Agricultural Risk Ranking Matrix are high or medium risk activities. In contrast, the DoP&I (2012b) later states in the *"guidelines for agricultural impact statements at the exploration stage"* that high or medium risk exploration activities are those defined as risk rankings A1 - A3, B1 - B2, C1 - C2 and D1. At this stage there is some uncertainty as to what is considered a high or moderate risk activity, though for the purpose of this report those risk rankings (A1 - A3, B1 - B2, C1 - C2 and D1) detailed by the DoP&I (2012b) as high or moderate risk activities have been utilised for such categorisation. Other high or moderate risk exploration activities identified by the DoP&I (2012b) include:

- Activities on or near BSAL or CIC;
- Significant concerns relating to the proposed activities in the agricultural community; and
- Exploration activities which include coal seam gas pilot testing.

Table 6.1: Agricultural Impact Risk Ranking (DoP&I 2012b). Yellow highlight indicates low risk, orange highlight indicates medium risk and red highlight indicates high risk.

CONSEQUENCE \ PROBABILITY	A Almost Certain	B Likely	C Possible	D Unlikely	E Rare
1. Severe and/or permanent damage. Irreversible impacts.	A1	B1	C1	D1	E1
2. Significant and /or long term damage. Long term management implications. Impacts difficult or impractical to reverse.	A2	B2	C2	D2	E2
3. Moderate damage and/or medium-term impact to agricultural resources or industries. Some ongoing management implications which may be expensive to implement. Minor damage or impacts over the long term.	A3	B3	C3	D3	E3
4. Minor damage and/or short-term impact to agricultural resources or industries. Can be managed as part of routine operations.	A4	B4	C4	D4	E4
5. Very minor damage and minor impact to agricultural resources or industries. Can be effectively managed as part of normal operations.	A5	B5	C5	D5	E5

Table 6.2: Agricultural Impact Risk Ranking – probability descriptors (DoP&I 2012b).

Level	Descriptor	Description
A	Almost certain	Common or repeating occurrence
B	Likely	Known to occur or it has happened
C	Possible	Could occur or I've heard of it happening
D	Unlikely	Could occur in some circumstances but not likely to occur
E	Rare	Practically impossible or I've never heard of it happening

Table 6.3: Agricultural Impact Risk Ranking – consequence descriptors (DoP&I 2012b).

Level: 1	Severe Consequences	Example of Implications
Description	• Severe and/or permanent damage to agricultural resources, or industries • Irreversible • Severe impact on the community	• Long term (eg 20 years) damage to soil or water resources • Long term impacts (eg 20 years) on a cluster of agricultural industries or Important agricultural lands
Level: 2	**Major Consequences**	**Example of Implications**
Description	• Significant and/or long-term impact to agricultural resources, or industries • Long-term management implications • Serious detrimental impact on the community	• Water or soil impacted, possibly in the long term (eg 20 years) • Long term (eg 20 years) displacement / serious impacts on agricultural industries
Level:3	**Moderate Consequences**	**Example of Implications**
Description	• Moderate and/or medium-term impact to agricultural resources, or industries • Some ongoing management implications • Minor damage or impacts but over the long term.	• Water or soil known to be affected, probably in the short – medium term (eg 1-5 years) • Management could include significant change of management needed to agricultural enterprises to continue.
Level: 4	**Minor Consequences**	**Example of Implications**
Description	• Minor damage and/or short-term impact to agricultural resources, or industries • Can be effectively managed as part of normal operations	• Theoretically could affect the agricultural resource or industry in short term, but no impacts demonstrated • Minor erosion, compaction or water quality impacts that can be mitigated. • For example, dust and noise impacts in a 12 month period on extensive grazing enterprises.
Level: 5	**Negligible Consequences**	**Example of Implications**
Description	• Very minor damage or impact to agricultural resources, or industries • Can be effectively managed as part of normal operations	• No measurable or identifiable impact on the agricultural resource or industry

Table 6.4 details the nature of risk, likelihood and consequence of potential impacts on agricultural resources and industries. Based on the Agricultural impact risk ranking system. The proposed activities are expected to have low risk to agricultural resources and industries due to the following:

- The proposed activity is located on land with low potential for commercial agricultural use;
- The proposed activity is not located on or near (<2 km radius) BSAL and CIC;
- No intensive agricultural activities are being undertaken on the study area or in the adjoining area;
- The exploration activity is constrained to a small area (approximately 6 ha) of the Pilliga East State Forest;
- All surface disturbances will be fully rehabilitated to the pre-existing land condition or better. Therefore, there will be no permanent land capability reduction of agricultural resources;
- The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries as described in **Section 7.0** and **8.0**.
- Although the proposed activity forms part of the larger Santos PEL 238 and PAL 2 exploration project, cumulative impacts to agricultural resources and industries are expected to be minimal due to the following:
  - » The area of land that will be quarantined for exploration activities within PEL 238 and Petroleum Assessment Lease (PAL) 2 is approximately 32.475 ha, a small amount considering the extent of the these petroleum leases (79,1478 ha),

- Approximately 447,751 ha of agricultural land use (both agricultural land and agricultural infrastructure) are mapped in PEL 238 and PAL 2. Approximately 7.225 ha or 0.002% of land will be quarantined from areas that are currently used for agriculture,
- As Dewhurst 22-25 will not quarantine any designated BSAL or CIC areas, the proposed activity will not have any cumulative impacts on such designations.
- Based on the nominated gross margins (GM) (**Table 6.5**) and potential agricultural land use (LSC classes identified by the DoP&I 2012a for the New England - North West region), the project area has the capacity to generate an estimated gross margin of approximately $16,264 per annum. However, when the amount is calculated for those well sites with a current agricultural enterprise, the amount reduces to approximately $4,389,
- The quarantined land will be rehabilitated to allow for future agricultural activities / production,
- The total volume of ground water anticipated to be lifted for Dewhurst 22-25 is 285 ML, this equates to approximately 0.12% of agricultural extracted ground water per annum. Approximately 1,091 ML of ground water will be extracted for the PEL 238 and PAL 2 exploration activities. This amount equates to approximately 0.44% of the total ground water extracted for agricultural purposes in the Namoi catchment. However, ground water quality investigations undertaken in the pilot testing seam indicate that these waters are not suitable for agricultural use. Total dissolved solids (TDS) are outside the general ranges for irrigation (650 – 5,200 mg/L) and livestock (2,000 – 10,000 mg/L) use and hence the proposed activity is not anticipated to have a cumulative impact on agricultural ground water resources.
- The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries.

- Although the broader agricultural community may be concerned about the potential agricultural impacts of the CSG industry, the proposed activity has been assessed as presenting a low risk to agricultural resources or industries.

However, as the Dewhurst 22 – 25 exploration project includes pilot testing the associated works are considered moderate to high risk in nature by the DoP&I (2012b).

Table 6.4: Agricultural Impact Risk Ranking of Dewhurst 22 – 25.

Potential Impact	Nature of Risk	Likelihood	Consequence level (1 to 5)	Impact Risk Ranking	Potential Consequence
Loss from Agricultural Use	▪ Direct surface removal from agricultural use	Rare (E)	5	E5	▪ Negligible consequence as the proposed works will not impact lands utilised for agricultural purposes.
Socio-Economic Impacts					
Agricultural Support Infrastructure	▪ Pressure on water supply services ▪ Pressure on agricultural railways ▪ Pressure on agricultural processing facilities	Rare (E)	5	E5	▪ Negligible consequence as the proposed works will not source or impact agricultural support infrastructure.
Employment and Economic Development	▪ Reduction of agricultural employment on the site ▪ Reduction of agricultural employment in the Narrabri LGA	Rare (E)	5	E5	▪ Negligible consequence to employment opportunities are anticipated as no intensive agricultural activities are being undertaken on or adjacent to the study area. Also, the site is located on land with low potential for commercial agricultural use.
Visual Amenity	▪ Disturbance of scenic quality and / or visual aesthetics	Certain (A)	5	A5	▪ Although the surface disturbance will detract from the scenic amenity of the study area, no consequence to agricultural visual amenity is anticipated, as the site is located in the Pilliga East State Forest.
Agricultural Resources					
Soil	▪ Soil erosion ▪ Contamination due to ground water discharge ▪ Chemical spill ▪ Soil profile inversion ▪ Soil compaction	Unlikely (D)	5	D5	▪ Very minor damage or impact to soils suitable for agricultural use as soils at the site are of low potential for commercial agricultural production.

Potential Impact	Nature of Risk	Likelihood	Consequence level (1 to 5)	Impact Risk Ranking	Potential Consequence
Water use	▪ Removal from agricultural supplies	Rare (E)	5	E5	▪ Approximately 285 ML of ground water will be extracted for the proposed activity. However, ground water quality is not suitable for agricultural use; therefore there will be no removal from agricultural supplies. ▪ Further the 22.94 ML required for the proposed activities will not be sourced from agricultural supplies.
Surface water	▪ Soil erosion ▪ Contamination due to ground water discharge ▪ Chemical spills	Unlikely (D)	4	D4	▪ Minor or short term impact to surface waters as potential impacts would be mitigated as outlined in Dewhurst 22 - 25 REF (RPS, 2012).
Ground water	▪ Cross contamination of aquifers ▪ Contamination by drilling fluids or mud ▪ Contamination due to spills, fuels or chemicals	Unlikely (D)	4	D4	▪ These potential impacts will be readily managed and mitigated through standard construction site environmental and engineering controls outlined in Dewhurst 22 - 25 REF (RPS, 2012).
Air and Noise	▪ Dust generation ▪ Exhaust emissions from, vehicle movements and plant and machinery operations ▪ Venting of methane (CH_4) and carbon dioxide (CO_2) during drilling ▪ Noise generation above agricultural background level of 30 dB(A)	Possible (C)	4	C4	▪ Minor or short term impact to air given the short duration of the construction works. Impacts would be mitigated by the measures outlined in Dewhurst 22 - 25 REF (RPS, 2012). ▪ Minor impact to agricultural enterprises as the study area is not located on or near other agricultural enterprises.

Potential Impact	Nature of Risk	Likelihood	Consequence level (1 to 5)	Impact Risk Ranking	Potential Consequence
Weeds	▪ Displace of native species by weeds ▪ Land degradation ▪ Reduced agricultural productivity	Possible (C)	5	C5	▪ Very minor damage or impact to agricultural resources or industries as potential impacts can be remediated in the short term. Impacts would be mitigated by the measures outlined in Dewhurst 22 - 25 REF (RPS, 2012).
Biosecurity	▪ Spread of *Phytophora*	Rare (E)	5	E5	▪ Very minor damage or impact to agricultural resources or industries as potential impacts can be remediated in the short term. Impacts would be mitigated by the measures outlined in Dewhurst 22 - 25 REF (RPS, 2012).

Table 6.5: Agricultural productivity of the Santos exploration project area

LSC Class	$/ha	Area Quarantined (ha)	GM based on the potential agricultural land use ($)	GM based on site with a current agricultural enterprise ($)
2 & 3	**Cropping land: Winter crop of short fallow cereal, canola and pulse rotation and summer crop of sorghum**			
2	860	1.025	882	882
3		3	2580	2580
4 & 5	**Grazing Land: best case scenario - sheep Merino ewes (18 micron) referred to as rams by DTIRIS.**			
4	450	16.313	7341	-
5		12.138	5462	927
	Total	**32.476**	**16,264**	**4389**

*Potential agricultural productivity was determined using the DTIRIS agricultural productivity data for agricultural enterprises suitable for each of the DoP&I (2012a) LSC Classes that will be impacted. The most profitable enterprises have been selected to provide best case scenarios under the current economic conditions for Dryland north-west region.

* The cropping enterprise selected would require average to above average rainfall and would generally be followed by a single crop in the following year

*The area quarantined in each LSC Class is based on knowledge and understanding at the time of writing (December 2012). The quarantined area does not include flowlines as they will be trenched and backfilled.

7.0 Potential Construction and Operational Phase Impacts

7.1 Agricultural Resources

The term 'agricultural resources' is defined in the SRLUP (DoP&I 2012a) as the land upon which agriculture is dependent and the associated water resources (quality and quantity) which are linked to that land.

7.2 Land Removed from Agricultural Use

The study area is located in the Pilliga East State forest, which has low agricultural production potential (LSC Classes 4 and 5). As the study area is located in the Pilliga East State Forest it will not quarantine any land currently used for agricultural purposes.

There will be no permanent land capability reduction. Once the works are completed, the study area will be partially rehabilitated. Partial rehabilitation will aim to be completed within six months of completion of the wells. Full rehabilitation will occur only once the well is no longer required for operation.

7.2.1.1 Mitigation Measures

- The disturbance area will be minimised to reduce unnecessary clearing and earthworks. Additionally, the disturbance area around the lease will be appropriately fenced to ensure machinery is limited to the designated disturbance area;
- Access tracks will be located along existing track routes, where practicable; and
- Where soil is disturbed or compacted, these areas will be partially rehabilitated in the short term with full rehabilitation occurring once the well is no longer required. Rehabilitation efforts are discussed in **Section 8.0**.

7.3 Socio-Economic Impacts

7.3.1 Agricultural Support Infrastructure

In the context of the non-agricultural land use of the site and the wider agricultural uses of the region, the temporary and minor loss of land is considered to be negligible. Further, there will be no pressure on agricultural support infrastructure including:

- Water supply services;
- Railways;
- Travelling stock routes; and
- Processing facilities.

The proposed activity will result in minor increases in traffic along the Newell Highway and Monument Road during well construction, though negligible increases are anticipated during the operational phase. This level of traffic could easily be accommodated by the existing road network. Further, there will be no disruption to rail networks, as the site is not adjacent to any rail lines.

7.3.1.1 Mitigation Measures

- No mitigation measures required.

7.3.2 Employment and Economic Development

Approximately 24 employees and contractors may be present on the site each day. No existing agricultural jobs will be lost as a direct result on the proposed activities. Further, the project area is not utilised for agricultural purposes and as such the study area will not prohibit agricultural activities. Therefore, the proposed activities will not result in a loss of agricultural employment opportunities at the site or in the Narrabri LGA.

As the study area is located in the Pilliga East State Forest no agricultural statistics exist. However, if the study area was to be cleared for agricultural purposes, the potential gross margin of this area is approximately $2,196 per annum.

This amount is based on the DTIRIS agricultural productivity data for agricultural enterprises suitable for each of the land classes that have been identified for the study area. For this assessment, the most productive agricultural enterprises have been selected to provide a best case scenario prediction for grazing lands with a Land and Soil Capability (LSC) Class of 4 and 5 (**Table 7.1**). Lands associated with LSC Classes 4 and 5 could support merino ewes (18 micron) and generate $450/ha per annum.

Table 7.1: Agricultural productivity of the study area

Land Capability Classes	Enterprise	Enterprise Assumptions	Gross Margin ($/ha/yr)	Disturbance Area (ha)	Gross Margin ($)
4 & 5	Merino ewes (18 micron) (referred to as rams by DTIRIS; however, is mainly stocking of ewes)	2.1 dry sheep equivalent (DSE)/ewe and fodder supplemented	450	4.88	2,196

*Values exclude the proposed gathering system along Monument Road and Yellow Spring Road, as it will be trenched and backfilled.

7.3.2.1 Mitigation Measures

- No mitigation measures required.

7.3.3 Tourism

The impact assessment has not identified any tourism infrastructure in the local area which agricultural enterprises are reliant. Therefore, it is not anticipated that the study area will not have any impact on local agriculture-related tourism (e.g. wineries, farm vacation locations).

7.3.3.1 Mitigation Measures

- No mitigation measures required.

7.3.4 Visual Amenity

The study area will be visible from Monument Road and Yellow Springs Trail. As the study area is located in the Pilliga East State Forest it will not be visible from agricultural properties. The nearest sensitive receiver to the study area is located a distance of 3.37 km and 3.43 km from the study area. The proposal may detract from the scenic qualities of the land temporarily during construction and drilling but will be partially rehabilitated following completion of these works, with full rehabilitation occurring once the well is no longer required. A negligible to low adverse impact is expected, as there will be no permanent impacts on scenic quality or visual amenity. Further, no agricultural enterprises are considered to be reliant on the landscape values of the area that would be affected by the addition of the proposed site.

7.3.4.1 Mitigation Measures

- Visual impacts will be mitigated through rehabilitation of the site.
- The site will be kept in a clean and tidy manner during site preparation, drilling activities and operation of the pilot well.

7.4 Agricultural Resource Impacts

7.4.1 Soils

The proposed activity will require vegetation clearing and earthworks for establishment of the lease area and access track, if required.

There is potential to impact agricultural resources (soil) at the site due to:

- Soil erosion;
- Groundwater discharging to the surface, which might cause flooding or impact on sediment characteristics;
- Chemical spills (e.g. drilling fluid additives, fuels or oil);
- Storage of drill cuttings on-site, prior to disposal;
- Soil profile inversion; and
- Soil compaction.

However, the risk of adverse impact to the agricultural resources is likely to be rare to low with the implementation of standard construction site environmental and engineering controls.

7.4.1.1 Mitigation Measures

- Mitigation measures are outlined in the Dewhurst 22 - 25 REF (RPS, 2012).

7.4.2 Water use

Drilling activities will require approximately 0.25 ML of water at Dewhurst 22, 24 and 25 respectively; while 0.27 ML will be required at Dewhurst 23. Alternatively, production water from other pilot wells will be used when available for the preparation of drilling mud. In addition, 0.02 ML per day of potable water will be required for facilities on the lease. This will be sourced from Narrabri's town water supply or local industrial licensed water bores and trucked to the site. Water licensing requirements are discussed in **Section 5.2.8** of the REF (RPS 2012). There will be no extraction from surface waters during both the construction and operational phases of the project.

In order to conduct the pilot, water will be extracted from the targeted seams from all four pilot well simultaneously. Water production will rise at a rate 0.25 ML/day for the first 30 days of inception of the pilot, whereupon it will be maintained at an average rate of approximately 0.263 ML/day for the duration of the trial. The trail is expected to last for 1096 days. The total volume of water anticipated to be lifted throughout the pilot inception and trials is 285 ML.

However, ground water quality investigations undertaken in the pilot testing seam indicate that these waters are not suitable for agricultural use. Total dissolved solids (TDS) levels identified in this seam are outside the general ranges for irrigation (650 – 5,200 mg/L) and livestock feed (2,000 – 10,000 mg/L) use. Therefore, waters extracted will not impact on agricultural supplies.

As water requirements for the project will be sourced either from Narrabri Shire Council or, alternatively, from treated production water from one of the pilot wells, there will be no impact on agricultural resources.

7.4.2.1 Mitigation measures

- No mitigation measures required.

7.4.3 Surface water

There is potential to impact agricultural resources (surface waters) at the site and in the local area due to:

- Soil erosion;
- Groundwater discharging to the surface, which might cause flooding or impact on surface water quality depending on the discharge and receiving water qualities; and
- Chemical spills (e.g. drilling fluid additives, drilling mud, fuels or oil).

However, the risk of adverse impact to the agricultural resources is considered low with the implementation of current best practice environmental and engineering controls for construction sites. Further, runoff from the study area is not anticipated to be significant given the flat nature of the site and moderate average rainfall of the area.

7.4.3.1 Mitigation Measures

- Erosion and sediment controls will be implemented during site preparation activities, including lease area construction and any upgrades to the existing access track, in accordance with best management practices (such as the Best Practice Erosion and Sediment Control Guidelines (IECA, 2008)). These controls will be maintained until disturbed areas of the site are stabilised.
- Further mitigation measures are outlined in the Dewhurst 22 - 25 REF (RPS 2012).

7.4.4 Ground water

The well will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity*. If the well is not constructed properly, potential impacts of drilling in mixed multi-aquifer systems include:

- Creating an artificial connection between water-bearing formations that bypasses aquitards or aquicludes resulting in cross contamination of aquifers;
- Contamination of the aquifers by drilling fluids or mud if these are lost in the formation; and
- Groundwater contamination due to spills of oil, fuels or chemicals if not cleaned up appropriately.

7.4.4.1 Mitigation Measures

- Mitigation measures are outlined in the Dewhurst 22 – 25 REF (RPS 2012).

7.4.5 Air and noise

There are few sensitive air and noise receptors surrounding the site. The nearest is located approximately 3.37 km away.

Regional air quality is likely influenced by mining activities, cropping, land clearing and soil preparation, sowing and harvesting of crops, vehicle and heavy machinery movements, bushfires and burn-offs.

The existing noise environment is likely to be influenced by birds, insects and other wildlife. Baseline noise monitoring has not been conducted at the site.

Potential air and noise emissions from the proposed activity will include:

- Dust generated during clearing, access track and well lease excavation and pilot well drilling;
- Exhaust emissions from vehicle movements to and from the site;
- Exhaust emissions from plant and machinery operations on site;
- Venting of methane (CH_4) and carbon dioxide (CO_2) during drilling; and
- Noise generated during site preparation, drilling and completion activities.

As the site is not located on or within the vicinity of any agricultural enterprises the potential air and noise emission impacts on agricultural enterprises or related industries are expected to be low.

7.4.5.1 Mitigation Measures

- Mitigation measures are outlined in the Dewhurst 22 – 25 REF (RPS, 2012).

7.4.6 Weeds

The proposed activity has the potential to introduce weeds to the study area or spread existing weeds on site throughout the site and surrounding area. Soil, seed or vegetation attached to plant, machinery, vehicles or personnel may transfer weeds to or from the site. Activities such as clearing and earthworks may create favourable conditions for weeds and encourage weed growth.

One listed noxious weed, Prickly Pear, was identified within the study area. Prickly pears (includes all *Opuncta* species other than *O. ficus-indica*) are a Class 4 weed under the *Noxious Weeds Act 1993*. As weeds can displace native species, contribute significantly to land degradation, and reduce agricultural productivity they have the potential to impact agricultural resources and must be controlled according to the measures specified in a management plan published by the local control authority. Further, the plant may not be sold, propagated or knowingly distributed.

7.4.6.1 Mitigation Measures

The following weed management procedures will be implemented to prevent the spread of weeds both on and off site:

- Weed monitoring will occur throughout the construction and operational phase, and weed removal will be carried out as necessary;
- Where plant and machinery are moving from the study area, wash down procedures must be implemented;
- All cleared weed species will be stockpiled separately, and removed off site. Weed material is not to be re-used as part of site rehabilitation;
- If practical, clearing will commence in areas of low weed infestation, and move towards areas of high weed infestation;
- Weed infestations identified within and adjacent to access tracks and well lease will be eradicated by hand, with non-residual herbicide, or mechanical removal. Appropriate weed removal techniques are outlined in **Table 7.2**;
- The plant may not be sold, propagated or knowingly distributed; and
- Further mitigation measures are outlined in the Dewhurst 22 – 25 REF (RPS 2012).

Table 7.2: Weed Removal Techniques

Weed Type	Removal Technique	Method
Woody Weeds	Cut and Paint	▪ Make a horizontal cut through the stem close to the ground using secateurs, loppers or a bush saw; and ▪ Immediately apply herbicide to the exposed flat stump surface.
	Stem Injection	▪ At the base of the tree drill holes at a 45 degree angle into the sapwood; ▪ Fill each hole with herbicide immediately; and ▪ Repeat the process at 5 cm intervals around the tree.
	Frilling or Chipping	▪ At the base of the tree make a cut into the sapwood with a chisel or axe; ▪ Fill each cut with herbicide immediately; and ▪ Repeat the process at 5 cm intervals around the tree.
Small Plants	Hand removal	▪ Remove any seeds or fruits and carefully place into a bag; ▪ Grasp stem at ground level, rock plant backwards and forwards to loosen roots and pull out; and ▪ Tap the roots to dislodge any soil, replace disturbed soil and pat down.
Vines and Scramblers	Hand removal	▪ Take hold of one runner and pull towards yourself; ▪ Check points of resistance where fibrous roots grow from the nodes; ▪ Cut roots with a knife or dig out with a trowel and continue to follow the runner; ▪ The major root systems need to be removed manually or scrape/cut and painted with herbicide; and ▪ Any reproductive parts need to be bagged.
	Stem Scraping	▪ Scrape 15 to 30 cm of the stem with a knife to reach the layer below the bark/outer layer; and ▪ Immediately apply herbicide along the length of the scrape.
Weeds with Underground Reproductive Structures	Hand removal	▪ Remove and bag seeds or fruits; ▪ Push a narrow trowel or knife into the ground beside the tap root, carefully loosen the soil and repeat this step around the taproot; ▪ Grasp the stem at ground level, rock plant backwards and forwards and gently pull removing the plant; and ▪ Tap the roots to dislodge soil, replace disturbed soil and pat down.
	Crowning	▪ Remove and bag stems with seed or fruit; ▪ Grasp the leaves or stems together so the base of the plant is visible; ▪ Insert the knife or lever at an angle close to the crown; ▪ Cut through all the roots around the crown; and ▪ Remove and bag the crown.
	Stem Swiping	▪ Remove any seed or fruit and bag; and ▪ Using an herbicide applicator, swipe the stems/leaves.

7.4.7 Biosecurity

Disease control is required due to the potential for particular plant / soil diseases to be spread, particularly *Phytopthora*. *Phytopthora* can be spread via unregulated exposure and movement of soils between areas of construction. Measures will therefore be implemented to avoid such disease facilitation and hence any potential impact to agricultural enterprises.

7.4.7.1 Mitigation Measures

A variety of mitigation measures will be adapted to minimise and control disease on and off the study area:

- Wash down procedures are to be implemented as per **Section 7.4.6.1**;
- Construction personnel will be trained adequately in pest management and hygiene procedures; and
- All machinery to be clean of foreign soil and propogative matter to avoid the importation of *Phytophthora*.

8.0 Post Operational Phase Impacts / Rehabilitation

The pilot wells are proposed to be shut in and suspended in accordance with relevant legislation. The lease facilities (telemetry system, separators, flaring system etc.) will be removed.

Downhole completions will remain in the wells and the area around each wellhead will be rehabilitated back to an area of approximately 5 by 5 m around each wellhead. The remaining areas immediately surrounding the wellheads are proposed to be maintained by the Operator as suspended petroleum well leases in accordance with legislative requirements. Isolation padlocks will be installed on wellhead valves to protect against vandalism and gas monitoring will be conducted at each suspended well on each site visit to check for leaks.

Once the pilot wells have reached the end of their functional lives, the wells will be plugged and abandoned and final rehabilitation will take place. This will include removing the well head, cap, surface infrastructure and fencing, revegetation and weed control

All rehabilitation works will be undertaken with maximum regard to environmental protection and rehabilitation, vegetation, subsoil and topsoil management, weed control, erosion and sedimentation management and revegetation in accordance with the relevant statutory requirements.

8.1 Land Removed from Agricultural Use

At the end of the project life the subject site will be decommissioned and rehabilitated to its pre-operational condition.

8.1.1.1 Mitigation Measures

- No mitigation measures are proposed.

8.2 Socio-Economic Impacts

8.2.1 Agricultural Enterprises and Support Services

Subsequent to on-site infrastructure being decommissioned, the site will be returned to its pre-operational condition, following removal of surface infrastructure and adequate rehabilitation of disturbed areas.

8.2.1.1 Mitigation Measures

- No mitigation measures required.

8.2.2 Employment and Economic Development

As stated in **Section 7.3.2**, the activities proposed on the site will not result in a loss of agricultural employment opportunities at the site or in the Narrabri LGA.

8.2.2.1 Mitigation Measures

- No mitigation measures required.

8.2.3 Visual Amenity

Following removal of surface infrastructure and adequate rehabilitation of disturbed areas, the presentation of the subject site will be consistent with the existing scenario.

8.2.3.1 Mitigation Measures

- No mitigation measures required.

8.3 Agricultural Resource Impacts

8.3.1 Soils

The subject site will be decommissioned and rehabilitated to its pre-operational condition. During the course of decommissioning works the potential for adverse impacts to the soil resource are as per **Section 7.4.1**.

8.3.1.1 Mitigation Measures

- Mitigation measures for potential soil resource impacts during the course of the decommissioning works are as per **Section 7.4.1.1**.

8.3.2 Surface water

During the course of decommissioning and rehabilitation the potential for adverse impacts on surface waters are as per **Section 7.4.3**.

8.3.2.1 Mitigation Measures

- Mitigation measures for potential surface water impacts during the course of the decommissioning / rehabilitation are as per **Section 7.4.3.1**.

8.3.3 Ground water

The pilot wells will be plugged and abandoned and final rehabilitation will take place. The pilot well will be plugged and abandoned with permanent casing installed across the shallowest formations in accordance with current regulatory requirements of the new Well Integrity Code of Practice and specific well design in accordance with that Code of Practice.

During the course of decommissioning and rehabilitation the potential for adverse impacts on ground waters are as per **Section 7.4.4**

8.3.3.1 Mitigation Measures

- Mitigation measures during the course of the decommissioning / rehabilitation are as per **Section 7.4.4.1**.

8.3.4 Air and Noise

During the course of decommissioning and rehabilitation the potential for adverse impacts on air and noise are as per **Section 7.4.5**.

8.3.4.1 Mitigation Measures

- Mitigation measures during the course of the decommissioning / rehabilitation are as per **Section 7.4.5.1**.

8.3.5 Weeds

Impacts associated with the spread of weeds during the course of decommissioning and rehabilitation are as per **Section 7.4.6**

8.3.5.1 Mitigation Measures

- Mitigation measures for during the course of the decommissioning / rehabilitation are as per

Section 7.4.6.1; and

- No weed species will be used to rehabilitate the lease area.

8.3.6 Biosecurity

During the course of decommissioning and rehabilitation the potential for adverse impacts to agricultural enterprises related to the spread of disease, such as *Phytophora* are as per **Section 7.4.7**.

8.3.6.1 Mitigation Measures

- Mitigation measures during the course of the decommissioning / rehabilitation are as per **Section 7.4.7.1**.

8.3.7 Buffers and Offsets

Due to the low impact nature of the proposed works, buffers and / or offsets are not required for the life of the project and therefore no further impact to agricultural enterprises or support infrastructure is predicted.

9.0 Monitoring, Auditing and Trigger Response Plan

The mitigation and monitoring strategy for the proposed activity is described in **Section 2.7** the Dewhurst 22 – 25 REF (RPS 2012).

The primary trigger response plans are highlighted in **Table 9.1**. Due the low impact nature and relative short duration of the proposed activity, no significant impact to agricultural resources or supporting infrastructure are anticipated. Further, any impacts to the site will be rehabilitated, as discussed in **Section 8.0**.

The pilot well and associated infrastructure will be established following best practice and the mitigation and monitoring program proposed will reduce the likelihood of potential impacts to agricultural resources and supporting infrastructure.

Table 9.1: Trigger Response Plans

Trigger	Response
Pressure testing to identify if aquifers have been isolated	Remedial action to ensure the seal is competent
Loss of excess drilling fluids into the formation	Application of Loss Circulation Material
Spill of chemicals or fuels to land	Immediate application of spill kit and disposal of any contaminated material

10.0 Consultation

Consultation for the proposed activity is described in **Section 2.3** of the Dewhurst 22 – 25 REF (RPS 2012).

11.0 Conclusion

- Santos NSW (Eastern) Pty Limited is proposing to construct four pilot wells at the 'Dewhurst 22 - 25' site, which is located off Monument Road in the Pilliga East State Forest, approximately 30 km south of Narrabri;
- The proposed area of disturbance is 6.29 ha, 4 ha for the lease areas and 2.29 ha of constructed access tracks and gathering system;
- The proposed activity was classified as low risk that will not have an adverse impact on the current or future agricultural production capacity or resources in the Narrabri LGA due to the following key points:
  - There are no intensive agricultural enterprises at the study area or adjoining lands. Therefore, the proposed development does not have an unreasonable impact on agricultural production at the subject site or within the Narrabri LGA.
  - The study area is characterised by two landscape units, which are more suited to low impact land uses such as grazing;
  - The study area is not located on or within 2 km of BSAL and/or a CIC;
  - The proposed activity will not extract ground or surface waters that are suitable for agricultural use;
  - The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries in the surrounding areas.
- The main adverse cumulative impacts of the proposed activity could include pressure on existing agricultural infrastructure and depletion of agricultural resources. However, the risk of these impacts are considered very low, provided that mitigation measures are followed and applied according to best known methods.

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Appendix 7

Ecological assessment
RPS

Ecological Assessment

Dewhurst 22 - 25 – PEL 238, Narrabri

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Terms and Abbreviations

Abbreviation	Meaning
API	Aerial Photograph Interpretation
AOS	Assessment of Significance
CMA	Catchment Management Area
CSG	Coal Seam Gas
EA	Ecological Assessment
EPBC	Environmental Protection and Biodiversity Act 1998
EEC	Endangered Ecological Community
LGA	Local Government Area
GIS	Geographic Information System
Ha	Hectare
MNES	Matters of National Environmental Significance
OEH	Office of Environment and Heritage
REF	Review of Environmental Factors
RPS	RPS Australia East Pty Ltd
RVC	Regional Vegetation Community
TEC	Threatened Ecological Community
TSC Act	Threatened Species and Conservation Act 1995
SEWPaC	Department of Sustainability, Environment, Water, Population and Community

1.0 Introduction

1.1 Background

RPS was engaged by Santos to undertake an ecological assessment for leases referred to as Dewhurst 22, 23, 24 and 25, associated access tracks, and gathering system (the survey area), located within the Pilliga East State Forest (**Figure 1.1**; **Figure 1.2**). The purpose of the ecological assessment was to identify ecological constraints, potential impacts, and recommended mitigation measures associated with the development of the leases.

1.2 Site Particulars

1.2.1 Regional Location

The survey area is located approximately 30km to the south and north-west of Boggabri respectively, in the Narrabri Local Government Area (LGA). The survey area is within the Brigalow Belt South IBRA Bioregion. The survey area is located within the Namoi Catchment Management Area (CMA), within the Pilliga (part A) sub-region.

The survey area occurs within the Pilliga East State Forest. The State Forest forms part of a large tract of bushland referred to as the Pilliga Scrub, which encompasses numerous protected estates.

1.2.2 Study Area

The survey area is limited to the proposed leases, access tracks and the gathering system (**Figure 1.2**). The survey area is well vegetated, co-dominated by heathy woodland and Eucalypt woodland communities. The topography of the survey area is gentle, with no significant topographic features such as ridgelines occurring.

Spring Creek runs between the four lease areas and crosses the Dewhurst 24 access track. An additional unnamped ephemeral waterway that is a headwater to Bibblewindi Creek also occurs within the survey area (**Figure 1.1**).

In addition, a broader area of consideration has been included in the assessment, encompassing an area of approximately 5ha. The area of consideration is also well vegetated. Several unnamed ephemeral waterways that are headwaters to Bibblewindi Creek occur within the area of consideration.

The Pilliga Forest has also been considered as part of this assessment.

1.2.3 Proposed Activity

Santos proposes to undertake drilling activities to assess the CSG potential within PEL 238. As part of the assessment program, Santos propose to drill and operate four petroleum exploration pilot wells at Dewhurst 22 to 25. A detailed project description is included in the Review of Environmental Factors (REF), prepared by RPS (2013). Refer to **Figure 1.2**.

Santos proposes to construct 100m by 100m lease areas, resulting in 1ha of disturbance at each pilot well location. Additional infrastructure, consisting of access tracks and a gathering system, will require disturbance in the form of a 10m wide corridor. A 35m by 35m flare is also proposed, located within the 1ha Dewhurst 22 lease area. The total project footprint will equal 6.29 ha.

Dewhurst 22 occurs to the south of Monument Road. The lease area will be accessed off Monument Road, and an access track of 120m will require construction.

Dewhurst 23 is located 320m south of Monument Road. The lease area will be accessed off Yellow Springs Trail, to the east of the lease area. An access track of approximately 300m will require construction.

Dewhurst 24 occurs to the north of Monument Road. Dewhurst 24 requires an access track of 290m from Monument Road, which will intersect an ephemeral waterway (Spring Creek). The watercourse spans approximately four metres from each top of bank.

Dewhurst 25 occurs to the south of Monument Road. An access track of 130m will require construction.

1.3 Scope of the Study

The objective of this assessment was to undertake an ecological assessment of the proposed lease areas and access tracks to identify ecological impacts of the proposed activities, and recommend appropriate mitigation measures to reduce and manage ecological impacts. The specific scope of the assessment was to:

- Conduct a background review of relevant environmental databases, maps and policies;
- Assess the extent, condition and composition of the vegetation communities present in survey area and area of consideration;
- Determine if any of the vegetation communities present constitute the definitions of regionally significant ecological communities such as Threatened Ecological Communities (TEC) under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Endangered Ecological Communities (EEC) under the *Threatened Species Conservation Act 1992* (TSC Act);
- Complete targeted searches for threatened flora species listed under the TSC Act and EPBC Act;
- Carry out a detailed trapping program (Elliott traps, cage traps, funnel traps, nocturnal searches, call-playback, Anabat etc), targeted searches and compilation of a fauna list, specifically targeting threatened fauna species listed under the TSC Act and EPBC Act;
- Assess the habitat types of the survey area and their value for supporting native flora and fauna, including significant species;
- Assess fauna movement corridors and pathways;
- Identify significant weed species occurring within the survey area;
- Identify constraints associated with the ecological features of the survey area in a legislative and planning context;
- Identify potential ecological impacts associated with the pilot well lease areas; and
- Recommend appropriate mitigation measures to minimise potential ecological impacts.

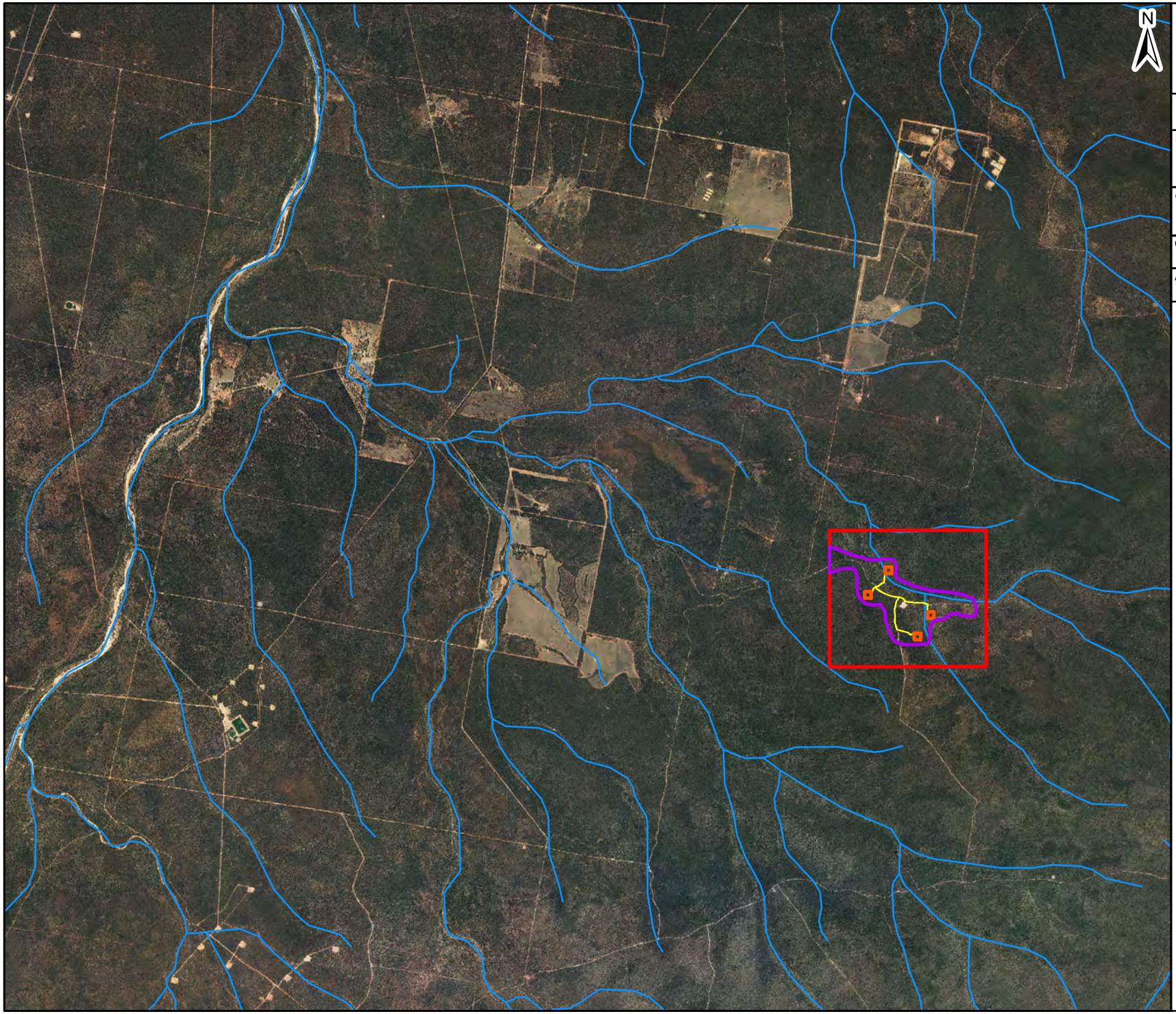
A desktop assessment of the survey area was conducted prior to conducting a preliminary ecological assessment on the 17th and 19th September 2012. A detailed ecological assessment, including fauna trapping program, was conducted between the 8th October and 12th October 2012. . An additional flora survey was conducted on the 24th January 2013.

This assessment details the findings of the background review, preliminary survey and detailed survey. Additionally, Commonwealth, state and local legislation relevant to the proposal have been addressed in this assessment.

1.4 Licensing and Certification

All field surveys were conducted under the following licenses and permits:

- NSW National Parks and Wildlife Service Scientific Investigation Licence S100536 (Valid 31 December 2012);
- Animal Research Authority (Trim File No: 01/1142) issued by NSW Agriculture (Valid 12 March 2013);
- Animal Care and Ethics Committee Certificate of Approval (Trim File No: 01/1142) issued by NSW Agriculture (Valid 12 March 2013); and
- Certificate of Accreditation of a Corporation as an Animal Research Establishment (Trim File No: 01/1522 & Ref No: AW2001/014) issued by NSW Agriculture (Valid 22 May 2014).



Regional Location

Figure 1.1

Project:	Dewhurst 22-25
Client:	Santos
Compiled by: CO	Date: 29/01/2013
Approved by: HR	Date: 29/01/2013

Legend

- Survey Area
- Area of Consideration
- Lease Area
- Collection System and Access Track (10m)
- Watercourses

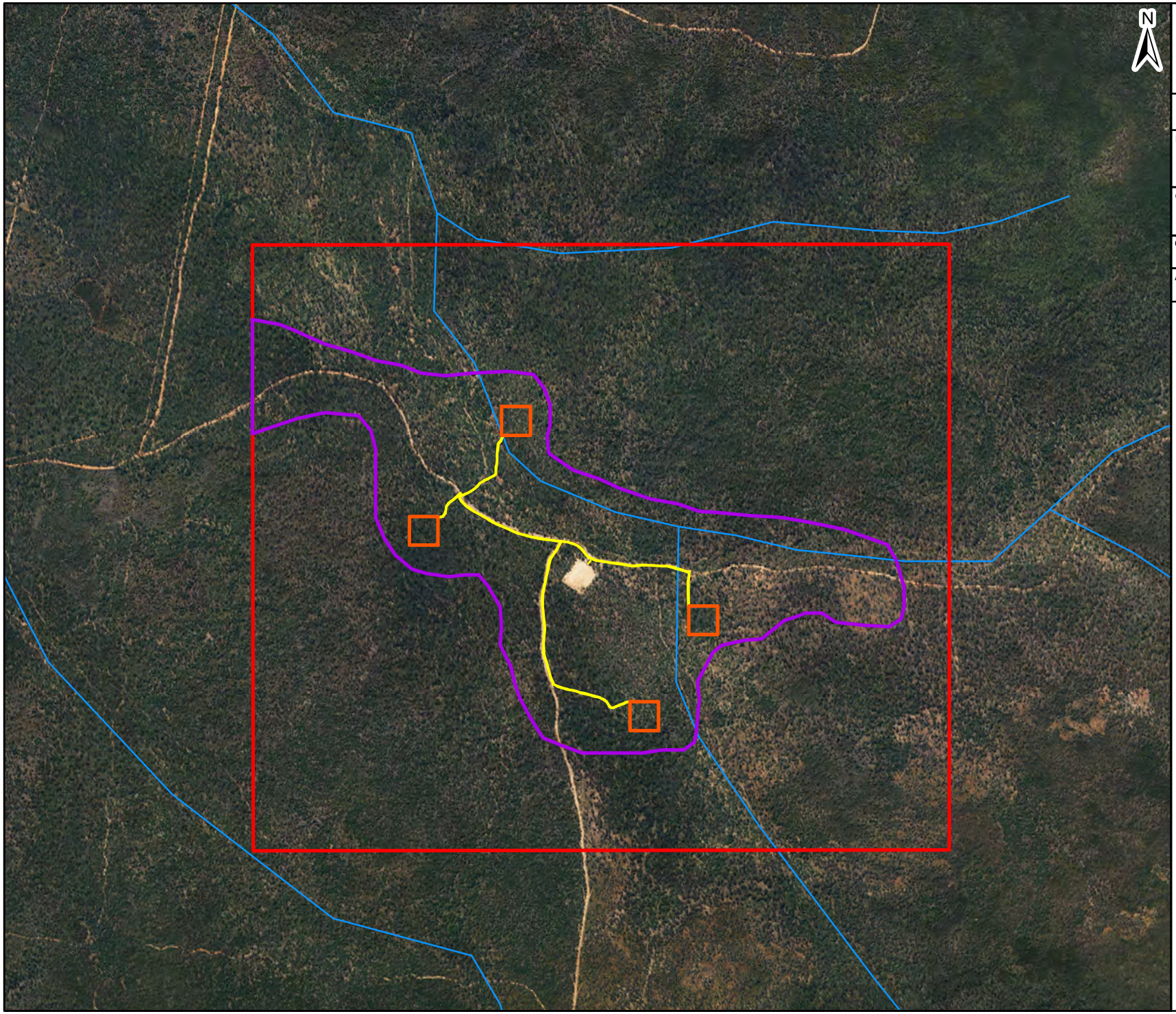
Source: Imagery from Bing Maps 2012
Infrastructure provided 2/5/2013
Watercourses from OEH 2012

0 0.5 1 2 km

Datum: GDA94
Scale 1:18,000 @ A4

RPS





Study Area

Figure 1.2

Project:
Dewhurst Flowlines / 22-25

Client:
Santos

Compiled by:	CO	Date:	29/01/2013
Approved by:	HR	Date:	29/01/2013

Legend

- Survey Area
- Area of Consideration
- Lease Area
- Collection System and Access Track (10m)
- Watercourses

Source: Imagery from Bing Maps 2012
Infrastructure provided 5/2/2013
Watercourses from OEH 2012

0 180 360 720 Meters

Datum: GDA94
Scale 1:18,000 @ A4

RPS



2.0 Legislative Context

2.1 NSW State Legislation

2.1.1 Environmental Planning and Assessment Act 1979

2.1.1.1 Overview

Development in NSW is assessed and approved under either Part 4 or Part 5 of the EP&A Act. Development is assessed under Part 5 if the relevant environmental planning instruments provide that the development does not require development consent and is not exempt development, and the development is either carried out by a determining authority or requires the approval of a determining authority.

The proposed activity falls within the Narrabri Shire LGA. The site is zoned as RU3 Forestry under the *Narrabri Local Environmental Plan 2012* (Narrabri LEP). The proposed activity is prohibited under the Narrabri LEP.

The Mining SEPP aims 'to provide for the proper management and development of mineral, petroleum and extractive material resources for the social and economic welfare of [NSW]'. Clause 6 of the Mining SEPP provides that development for the purposes of petroleum exploration may be carried out without development consent. Clause 6 applies despite the provisions of the LEP. This has the effect that the proposed activity is required to be assessed under Part 5 of the EP&A Act.

A determining authority, for the purposes of this activity, is defined in Part 5 to include a public authority or person whose approval is required before an activity may be carried out. The Resources Minister is the determining authority for the purposes of Part 5 of the EP&A Act.

2.1.1.2 Assessment under Part 5 of the EP&A Act

Under Part 5 of the EP&A Act, a determining authority is required to examine and take into account to the fullest extent possible all matters affecting or likely to affect the environment by reason of the proposed activity.

The determining authority must consider whether the proposed activity is likely to significantly affect the environment or threatened species, populations or ecological communities, or their habitats to determine whether an Environmental Impact Statement (EIS) or Species Impact Statement (SIS) is required. In deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities or their habitats, section 5A of the EP&A Act requires the following factors to be taken into account (the 'seven part' test of significance):

> *(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,*
>
> *(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction,*
>
> *(c) in the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:*

(i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

(d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly),

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan,

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

Narrabri Local Environmental Plan 2012

While the proposed activity does not require consent under Part 4 of the EP&A Act, consideration has been given to the relevant zone objectives under the Narrabri LEP. As stated above, the site is located within land zoned RU3 Forestry, the objectives of which are:

- To enable development for forestry purposes
- To enable other development that is compatible with forestry land uses.

2.1.2 Threatened Species Conservation Act 1995

The objectives the *Threatened Species Conservation Act 1995* (NSW) (TSC Act) include:

- To conserve biological diversity and promote ecologically sustainable development;
- Prevent the extinction and promote the recovery of threatened species, populations and ecological communities;
- To protect the critical habitat of those threatened species, populations and ecological communities that are endangered; and
- To ensure that the impact of any action affecting threatened species, populations and ecological preventing the extinction and promoting the recovery of threatened species, populations and ecological communities is properly assessed.

The TSC Act provides the procedure for the listing of threatened species, populations and ecological communities and key threatening processes in New South Wales and the preparation and implementation of recovery plans and threat abatement plans.

The TSC Act also provides the mechanism for applying for and obtaining licenses to take actions which will or are likely to result in harm to any animal that is a threatened species, population or

ecological community, the picking of any plant which is part of a threatened species, population or ecological community, damage to critical habitat or damage to habitat of a threatened species, population or ecological community where such actions require a license to be obtained.

A key threatening process is defined under the TSC Act as 'a process that threatens, or that may threaten, the survival or evolutionary development of a species, population or ecological community. Threatening processes that adversely affect threatened species, populations or ecological communities, or possibly cause others that are not currently threatened; to become threatened may be eligible for listing as a key threatening process (KTP).

2.1.3 National Parks and Wildlife Act 1974

Part 8A of the *National Parks and Wildlife Act 1974* (NPW Act) regulates the undertaking of activities which may impact on threatened species, populations and ecological communities listed under the TSC Act and their habitats. The NPW Act provides that a person must not harm any animal that is a threatened species, population or ecological community, pick any plant which is part of a threatened species, population or ecological community, damage any critical habitat or damage any habitat of a threatened species, population or ecological community without a licence being obtained under the NPW Act or TSC Act or unless another exception applies.

The NPW Act provides that these requirements do not apply if the action was essential for the carrying out of an activity in accordance with an approval of a determining authority under Part 5 of the EP&A Act where the determining authority has complied with Part 5.

2.2 Noxious Weeds Act

The *Noxious Weeds Act 1993* (NW Act) is a NSW government instrument outlining the definition, declaration, and control of noxious weeds throughout the State. Local government bodies have the responsibility to ensure that the Act is complied with within their boundaries.

For a plant to be declared a Noxious Weed it must be considered to pose a serious threat to humans, agriculture and/or the environment. There must also be consideration given to the feasibility of control and enforcement of those methods. Plants are declared noxious by order of the Minister for Agriculture.

Landowners or occupiers have obligations under the NW Act to control any declared weed on their property. Council is required to conduct inspections of private properties to check compliance with the NW Act and Noxious Weed Officers have the authority to issue control notices for any breach.

2.3 Native Vegetation Act

The *Native Vegetation Act 2003* (NV Act) sets a framework for:

- Encouragement of revegetation and rehabilitation of land with appropriate native vegetation;
- Providing incentives for landholders to undertake management of native vegetation on their properties; and
- An end to broad scale clearing, unless it improves or maintains the environment.

The NV Act provides three categories of native vegetation including regrowth, protected regrowth and remnant vegetation with clear definitions.

The NV Act provides greater flexibility and incentives for landholders to manage native vegetation sustainably. The Act gives effect to the Government's commitment to ending broad scale clearing unless it improves or maintains environmental outcomes.

Under section 25(g), the NV Act does not apply to any clearing that is part of an activity carried out by a determining authority within the meaning of Part 5 of the EP&A Act where the determining authority has complied with Part 5. Under section 25(m), the NV Act does not apply to any clearing authorised under the Petroleum (Onshore) Act 1991 (NSW).

3.0 Methods

3.1 Desktop Assessment

A desktop assessment was undertaken to identify potential development constraints as well as significant ecosystems and species that may potentially occur on the survey area. The following databases and maps were reviewed:

- EPBC Protected Matters Search Tool (Department of Sustainability, Environment, Water, Population and Community (SEWPaC), 2012), undertaken with a 10km radius (**Appendix 1**);
- Review of threatened fauna and flora records contained in the Office of Environment and Heritage (OEH) Atlas of NSW Wildlife (data within a 10km radius was reviewed);
- National Vegetation Information Systems mapping for the Namoi Catchment; and
- Aerial photography.

3.2 Field Assessment

A preliminary assessment was carried out on the 17th and 19th September 2012 to verify the results of the desktop assessment, and assess potential habitat for potentially occurring significant species as listed under the EPBC Act and TSC Act. Following the preliminary survey, a detailed assessment was conducted between the 8th October and 12th October, including detailed flora and fauna surveys. An additional flora survey was conducted on the 24th January 2013. The following sections details the methods utilised to assess the survey area.

3.2.1 Flora Survey

Flora surveys were conducted to verify and delineate vegetation communities occurring within the survey area. Aerial photograph interpretation (API) was utilised in conjunction with revision of the Namoi CMA vegetation mapping (Namoi CMA, 2010) to further delineate vegetation communities across the area of consideration. In addition, Namoi CMA vegetation mapping was utilised to calculate vegetation community areas for the Pilliga Forest.

A flora survey was conducted within each lease area (100m by 100m), to collect the following data:

- Vegetation structure, including number of strata, average height of each strata, and percent cover of each strata;
- Species composition, including dominant species within each strata;
- Diversity and abundance of weed species; and
- Presence of threatened species, and identification of suitable habitat for threatened species.

The data was collected by walking transects at 20m intervals throughout the lease area. Quadrates were utilised to assess ground cover, with one quadrate undertaken along each transect.

Additional data was collected along the access tracks and within the area of consideration to delineate vegetation community boundaries. Incidental flora observations were recorded within these areas.

All species recorded were identified as far as practicable to species and subspecies (where relevant) level. When a plant could not be identified accurately within the field, a voucher sample was collected, together with notes on habitat, form and height, labelled and identified according to nomenclature in Harden (1992–2002).

Opportunistic sightings of taxa were also collected if they were not found in any of the sampled sites. At a minimum, all dominant species were identified in all stratums to ensure that an informed delineation resulted.

3.2.2 Habitat Assessment

Assessments of the relative value of the habitat present within the survey area were undertaken to determine the potential value of the survey area for all native flora and fauna species. The survey area was assessed for specific habitat requirements for threatened species identified as likely to occur as part of the desktop assessment.

The habitat assessment for fauna species included determining the presence and abundance of:

- Hollow-bearing trees;
- Fallen woody debris, fallen logs, and hollow logs;
- Ground cover composition, including leaf litter, bare ground, grasses, shrubs, rocks, and herbs and forbs;
- Canopy and shrub cover density;
- Flowering canopy and shrub species; and
- Proximity to water.

Consideration was given to factors such as topography, soil, light and hydrology for threatened flora assemblages.

3.2.3 Landscape Assessment

An assessment of landscape scale attributes were evaluated and analysed utilising a Geographic Information System (GIS). Landscape attributes assessed included size of vegetation community, size of contiguous vegetation patch, and connectivity between patches.

GIS was also used to calculate areas of vegetation communities occuring across the Pilliga Forest.

3.2.4 Fauna Survey

The fauna survey methodology initially consisted of the production of an expected fauna species list and an assessment of the potential use of the survey area based on the desktop assessment and initial site assessment. A detailed fauna survey was then conducted, with methods outlined below.

Avifauna

The presence of avifauna within the survey area was assessed via opportunistic observations throughout all field work. Birds were identified by direct observation or by recognition of calls or distinctive features such as nests, feathers and owl regurgitation pellets etc.

Daily diurnal bird surveys were conducted at two locations each morning, for 30 minutes per location. Birds were identified in the same fashion as listed above.

Nocturnal surveys, during spotlighting, attempted to identify roosting diurnal birds in a similar fashion to methods employed during diurnal surveys.

Spotlighting was undertaken as described below and targeted nocturnal avifauna species such as owls.

Spotlighting

Spotlight searches for nocturnally active mammals, as well as birds and herpetofauna including dedicated listening periods for fauna vocalisations, were carried out over four nights throughout the survey area using 55 watt spotlights. Species were identified by observation under spotlight or by call identification.

Each survey involved a series of transects conducted on foot at approximately 1 km/hr in and around each survey area. Spotlighting was also undertaken along walking and vehicle tracks (**Figure 3.1**) and in adjacent woodland areas.

Surveys commenced 1.5 hours after dusk and targeted areas with hollow bearing trees to detect arboreal mammals, forest owls and bats emerging from diurnal roosts to forage. Aquatic habitats were also targeted to detect amphibians. Amphibians, mammals and nocturnal birds were identified by observation under spotlight or by vocalisations heard whilst spotlighting.

Active Searches

An active search for ground-dwelling mammals was focused around key habitat features, such as extensive grassy ground cover and fallen woody debris, hollow logs and burrows that offer potential suitable shelter for other ground dwelling mammals (bandicoots, native rats etc.). Evidence of mammal diggings was also noted as indicators of habitat use.

Reptile surveys involved active searches of the survey area to identify potential breeding and foraging habitat for reptile species, including in particular the Pale-headed Snake (*Hoplocephalus bitorquatus*), which may potentially occur in the survey area, as well as all fossorial species, including skinks, blind snakes, and other snakes.

Survey techniques employed included:

- Diurnal searches for sheltering or basking reptiles;
- Rock, log and debris rolling; and
- Spotlight surveys for nocturnally active species.

Anabat Detection

Two Anabat SD2 detection units were placed in suitable flyways within or adjacent to each of the survey areas. Positioning was focused on natural flyways below the canopy which typically provide an abundance of microbat foraging resources (insects). The Anabats were set before dusk and retrieved each morning after sunrise. Anabat survey locations are shown on **Figure 3.1**.

Greg Ford of Balance Environmental undertook Anabat analysis of all bat calls and provided an analysis summary report. Due to the high level of variability and overlap in call characteristics, a conservative approach was taken when analysing calls. Species names used in the Anabat analysis summary follow Churchill (2008), (Ford, 2012).

Call identification was based on published call descriptions for New South Wales (Pennay *et al* 2004) and on reference calls collected from southern Queensland and northern New South Wales (Ford, 2012). Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and Van Dyck & Strahan (2008), (Ford, 2012).

The format and content of the analysis summary report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon, 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/ (Ford, 2012).

Terrestrial Trapping

Terrestrial trapping was undertaken using 96 Elliott A traps, 10 Elliott B traps, 12 Elliott E traps, five cage traps, five camera traps, 58 hair funnels and four 20m long pitfall traps set over four trapping transect for three or four nights. In addition, four reptile funnel traps were set up along each pitfall line (Total = 16 funnel traps). The compositions of traps per site were:

- **Site 23** (Dewhurst 23 lease area): 24 Elliott A traps (4 nights), 1 cage trap (4 nights), 14 hair funnels (4 nights /3 days), 1 camera trap (3 nights / 2 days), 1 pitfall trap (3 nights /2 days) and 4 reptile funnel traps (3nights /2 days).
- **Site 24** (Dewhurst 24 lease area): 24 Elliott A traps (4 nights), 5 Elliott B traps (4 nights), 1 cage trap (4 nights), 14 hair funnels, 1 camera trap (3 nights / 2 days), 1 pitfall trap (3 nights /2 days) and 4 reptile funnel traps (3 nights / 2 days).
- **Site 25A** (Dewhurst 25 lease area): 24 Elliott A traps (4 nights), 5 Elliott B traps (4 nights), 6 Elliott E traps, 2 cage trap (4 nights), 14 hair funnels, 1 camera trap (3 nights / 2 days), 1 pitfall trap (3 nights /3 days) and 4 reptile funnel traps (3 nights / 3 days).
- **Site 25B** (north of Dewhurst 25 lease area): 24 Elliott A traps (4 nights), 6 Elliott E traps, 1 cage trap (4 nights), 14 hair funnels, 1 camera trap (3 nights / 2 days), 1 pitfall trap (3 nights /3 days) and 4 reptile funnel traps (3 nights / 3 days).

Elliott traps were baited with a mixture of rolled oats and peanut butter. Cage traps were baited with raw chicken or fruit and rolled oats and peanut butter balls. Traps were checked early each morning, with any captures identified and released at point of capture. Traps were re-baited where necessary. The location of each trap line is shown in **Figure 3.1**.

Elliott traps targeted small terrestrial mammals such as Dasyurids (e.g. antechinus and dunnarts) and rodents (e.g. rats and mice), while pitfalls targeted small mammals as well as reptiles and amphibians. Camera traps, hair funnels and cage traps targeted larger mammals (e.g. quolls and bettongs). In total there were 384 Elliott A trap nights, 40 Elliott B trap nights, 48 Elliott trap nights, 20 cage trap nights, 232 hair funnel trap nights, 15 camera traps nights, 12 pitfall trap nights and 60 reptile funnel traps within the survey area.

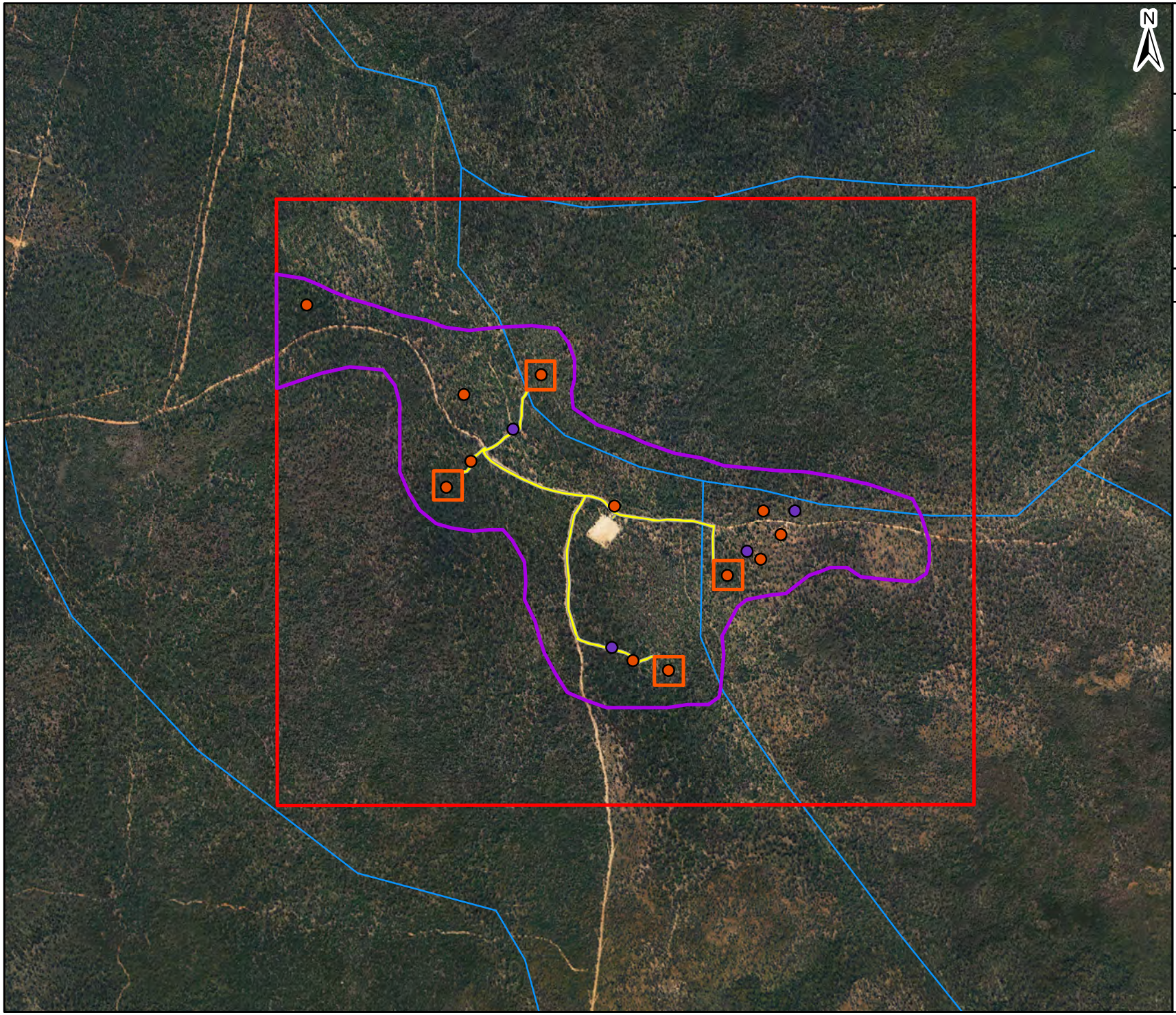
3.3 Survey Limitations

It should be noted that the detectability of plants and the ability to accurately identify plants to species level may vary greatly with the time of year, prevailing climatic conditions and the presence of reproductive material (e.g. flowers, fruit, and seed capsules). Specifically, native grass species and heath species can be difficult to identify due to seasonality. Consequently, the survey conducted for the survey area should not be regarded as conclusive evidence that certain protected plants do not occur within the survey area; however every effort has been made to detect these species in habitats that were considered suitable.

All fauna surveys are subject to inherent limitations in the detection success of targeted species. These limitations often result in a degree of false-absence records (i.e. a species is present, but not detected). It is important, therefore, that the limitations to fauna surveys are identified and the fauna survey results are viewed with these constraints in mind. The limitations to the fauna surveys conducted in the survey area included:

- The survey period not coinciding with the period that some migratory or nomadic species occur in the locality;
- Species with large home ranges (e.g. owls and raptors) not present in this part of their home range during the survey period;
- The difficulty in detecting certain species during the survey period (e.g. cryptic species, species present in the survey area at very low densities, and trap-shy species);
- Biological factors such as sex, age-class, and breeding biology, which may influence species' habitat use and detectability during different times of the year;
- The lack of suitable climatic conditions necessary for the presence and/or detectability of certain species (e.g. amphibians following heavy rainfall); and
- Despite the apparent deficiencies, suitable coverage of the survey area was accomplished, in particular the likely occurrence of species was assumed, based on habitat assessments, previous local records, seasonality, predicted faunal movements of locally occurring threatened species in combination with the local knowledge and experience of the authors.

In response to the abovementioned limitations the precautionary approach has been adopted; as such 'assumed presence' of known and expected threatened species, populations and ecological communities has been made where relevant to ensure a holistic assessment.



Survey Sites

Figure 3.1

Project:	Dewhurst 22-25
Client:	Santos
Compiled by: CO	Date: 29/01/2013
Approved by: BD	Date: 29/01/2013

Legend

- Survey Area
- Area of Consideration
- Lease Area
- Collection System and Access Track (10m)
- Watercourses

Survey Sites

- Fauna Trapping
- Flora Site

Source: Imagery from Bing Maps 2012
Infrastructure provided 5/02/2013
Watercourses from OEH 2012

0 0.15 0.3 0.6 km

Datum: GDA94
Scale 1:18,000 @ A4

RPS



4.0 Flora

4.1 Existing Condition

Three vegetation communities occur within the survey area, namely:

- Narrow-leaved Shrubby Ironbark Woodland;
- Heath; and
- Riparian Woodland.

A description of these communities is provided below, while the location and extent is outlined in **Figure 4.1**. A detailed flora species list for the survey area is included in **Appendix 2**.

4.1.1 Narrow-leaved Ironbark Shrubby Woodland

Description

This vegetation community occurs within the Dewhurst 22, Dewhurst 23, Dewhurst 24, and along the associated access tracks and collection systems. This community is the dominant vegetation community within the survey area (**Figure 4.1**).

The canopy of this community is dominated by Narrow-leaved Ironbark (*Eucalyptus crebra*) with Dirty Gum (*Eucalyptus chloroclada*) and White Cypress (*Callitris glaucophylla*) commonly occurring. Height ranges from 16m to 23m, with an average of 19m. Cover is approximately 25%. A secondary canopy layer occurs, and is dominated by White Cypress, with Dirty Gum and Bulloak (*Allocasuarina luehmannii*) commonly occurring. Height ranges from 10m to 12m, and cover is approximately 40%.

The understorey is comprised of two shrub layers. The primary shrub layer ranges in height from 3m to 7m, with cover averaging 40%. Common species include Bulloak, Mudgee Wattle (*Acacia spectabilis*), and Carol's Wattle (*Acacia caroleae*). The secondary shrub layer ranges in height from 0.5m to 2m, with an average cover of 30%. Species include Common Aotus (*Aotus ericoides*), Cough-bush (*Cassinia laevis*), Urn-heath (*Melichrus urceolatus*), Sandstone Boronia (*Boronia glabra*), Seven Dwarfs Grevillia (*Grevillia floribunda*), Honey Myrtle (*Homoranthus flavescens*), Common Fringe-myrtle (*Calytrix tetragona*), *Dodonaea falcata*, Rough Mint-bush (*Prostanthera denticulata*), and *Pimelea stricta*.

Ground-cover is sparse, with grasses, herbs and forbs totalling approximately 35%. Grasses are sparse, with few species observed. Grasses include Hairy Panic (*Panicum decompositum*), Barbed-wire Grass (*Cymbopogon refractus*), *Eragrostis* sp., *Aristida* sp., and Reed Grass (*Arundinella nepalensis*). Numerous herbs and forbs occur, including Woolly Mat-rush (*Lomandra leucocephala*), Many-flowered Mat-rush (*Lomandra multiflora*), Rough Saw-sedge (*Gahnia aspera*), Forest Goodenia (*Goodenia hederacea*), Serrated Goodenia (*Goodenia cycloptera*), Pomax (*Pomax umbellata*), Slender Wire Lily (*Laxmannia gracilis*), and False Sarsaparilla (*Hardenbergia violaceae*).

Condition

This community is generally in good condition, and is considered to be remnant. Disturbances are limited to land management practices associated with the forestry, such as access tracks, and historical clearing. No weeds were identified on site.

Classification

This community is commensurate with the Ironbark Shrubby Woodland of the Pilliga Area, Brigalow Belt South (RVC 33), as mapped by the Namoi CMA (**Figure 4.2**).

This vegetation community does not constitute any community that is listed within the schedules of the EPBC Act or the TSC Act.

4.1.2 Rough-barked Apple Riparian Woodland

Description

This vegetation community occurs within Dewhurst 24 lease area, access track, and collection systems, as well as along Monument Road. This community commonly occurs throughout the survey area, associated with the ephemeral drainage lines (**Figure 4.1**).

The canopy of this community is dominated Rough Barked Apple (*Angophora floribunda*) with occasional Dirty Gum, Brown Bloodwood (*Corymbia trachyphloia*) and Blakely's Red Gum (*E. blakelyi*) occurring. The canopy cover is approximately 35%, and heights range from 12m to 16m.

A sparse secondary canopy occurs, with a cover of approximately 10%. The secondary canopy is dominated by White Cypress, with occasional Black Cypress (*Callitris endlicheri*), Bulloak, and Narrow-leaved Ironbark. Height ranges from 8m to 10m.

The primary shrub layer ranges in cover from 30% to 50%, with a height of 1.5m to 3m. Species commonly occurring include Cough Bush, Dean's Wattle (*Acacia deanii*), Seven Dwarfs Grevillia, Common Aotus, Persoonia (*Persoonia cuspidifera*), Mulga Wattle, Fan Wattle (*Acacia amblygona*), and Carol's Wattle. A low, sparse secondary shrub layer also occurs, with height ranging from 0.5m to 0.75m, and cover averaging 10%. Species include Prickly Beard-heath, Urn Heath, and Common Fringe Myrtle.

The ground cover comprised approximately 15% herbs and forbs, and 5% native grasses. Common herbs and forbs include Many-flowered Mat-rush, Woolly Mat-rush, Rough Saw-sedge, Pomax, Serrated Goodenia, Tufted Bluebell (*Whalenbergia communis*) and Forest Goodenia. Grasses observed include Dark Wiregrass (*Aristida calycina*), *Eragrostis* sp, and Kangaroo Grass (*Themeda triandra*). Several *Macrozamia polymorpha* occur within this community.

Condition

This community is associated with ephemeral waterway areas throughout the survey area. Condition is considered to be good, with disturbances limited to damage from pigs, and historical forestry activities. Vegetation is considered to be in a remnant condition.

Classification

This community is commensurate with the Rough-barked Apple – Blakely's Red Gum Riparian Grassy Woodlands, Brigalow Belt South and Nandewar (RVC 20), as mapped by the Namoi CMA (**Figure 4.2**).

As outlined in the RVC description, this community can be commensurate with the EPBC Act listed White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands (Box-Gum Grassy Woodlands and Derived Grasslands), and the TSC Act White Box Yellow Box Blakely's Red Gum Woodland (Box-Gum Woodland). As outlined in **Section 4.2**, an assessment against the listing criteria determined that this community is not an EPBC Act or TSC Act listed community.

4.1.3 Heath

Description

This vegetation community occurs immediately adjacent to Dewhurst 25 lease area, access track and associated collection system, as well as several other patches within the survey area.

An emergent layer is present, and is dominated by Dirty Gum, with occasional Dwyer's Red Gum (*Eucalyptus dwyeri*), Brown Bloodwood, Black Cypress, and Rough-barked Apple occurring. Height ranges from 9m to 12m, with a cover of <20%.

A sparse primary shrub layer occurs, with a cover of approximately 20%. Height ranges from 2m to 4m. The shrub layer is dominated by Cough Bush, with Dean's Wattle, Kerosene Bush (*Pultenaea villosa*), Persoonia, and Forest Sheoak (*Allocasuarina torulosa*) commonly occurring.

The secondary shrub layer of this community is comprised of dense heath vegetation. Cover is approximately 70%, with height ranging from 0.5m to 1.5m. Species commonly occurring include Common Fringe Myrtle, Spur-wing Wattle (*Acacia triptera*), Honey Myrtle, Seven Dwarfs Grevillia, Prickly Beard Heath, Common Aotus, Urn Heath, Hoary Guinea Flower (*Hibbertia obtusifolia*), *Dodonaea peduncularis*, Sandstone Boronia, *Dodonaea cuniata*, and *Westringia cheelii*.

Ground cover is sparse, comprising approximately 30% herbs and forbs. Common species include Many-flowered Mat-rush, Woolly Mat-rush, Rough Saw-sedge, Serrated Goodenia, and Bushy Dampiera (*Dampiera adpressa*).

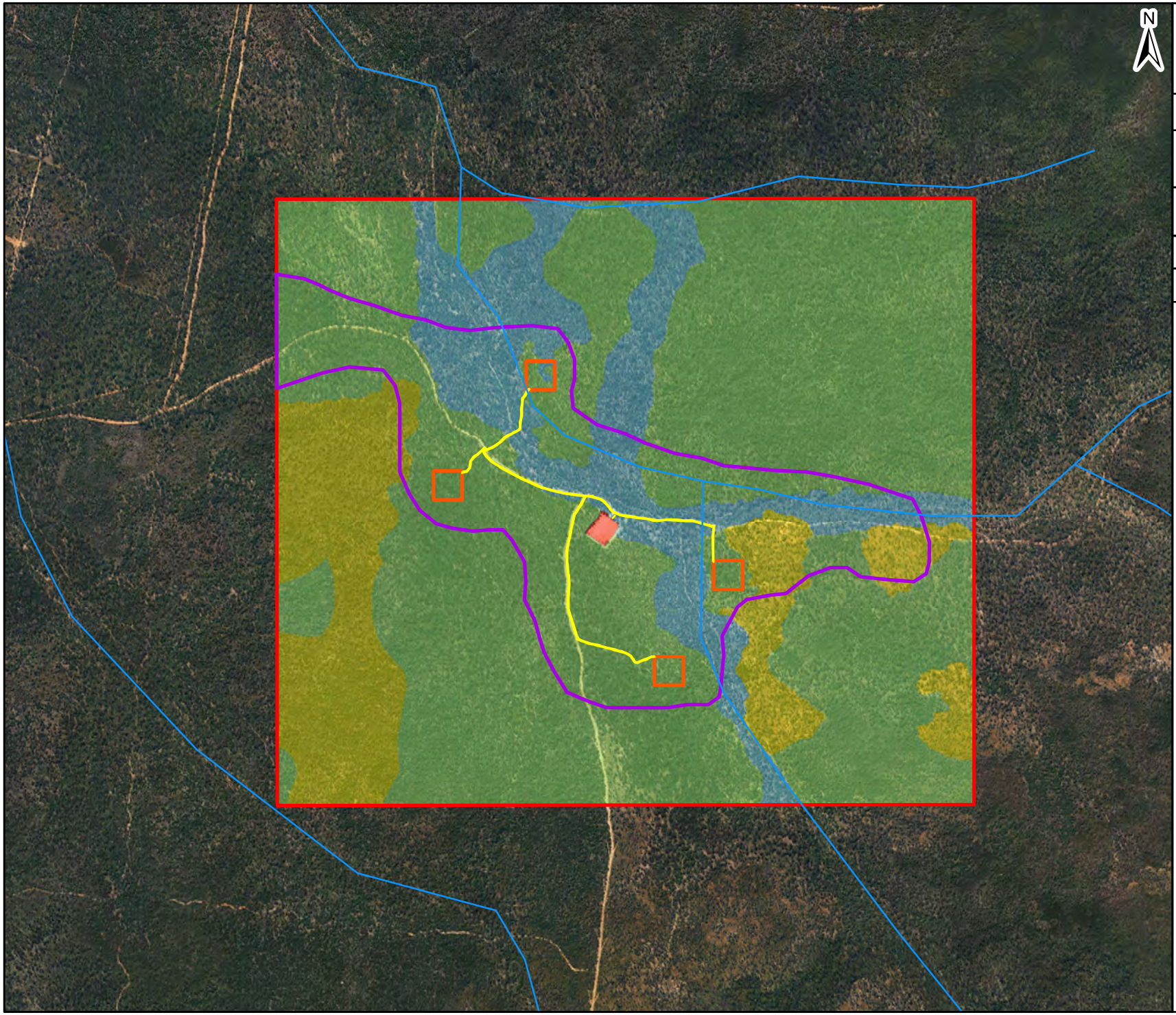
Condition

While a small portion of this community to the North-east of Dewhurst 25 access has been recently cleared, overall condition is considered to be good. Disturbances are limited to damage from pigs, and vegetation is considered to be in a remnant condition. Species diversity is high.

Classification

This community is similar in composition to RVC 56, namely Ironbark – Brown Bloodwood – Black Cypress Pine heathy woodlands mapped by the Namoi CMA (2010) (**Figure 3.2**).

This community is not considered to be a TEC under the EPBC Act or TSC Act.



Ground-truthed Vegetation Communities Occurring in the Study Area

Figure 4.1

Project:	Dewhurst 22-25
Client:	Santos
Compiled by: CO	Date: 29/01/2013
Approved by: BD	Date: 29/01/2013

Legend

- Survey Area
- Area of Consideration
- Collection System and Access Track (10m)
- Lease Area
- Watercourses

Vegetation Communities

- Cleared
- Heathland
- Ironbark Shrubby Woodland
- Riparian

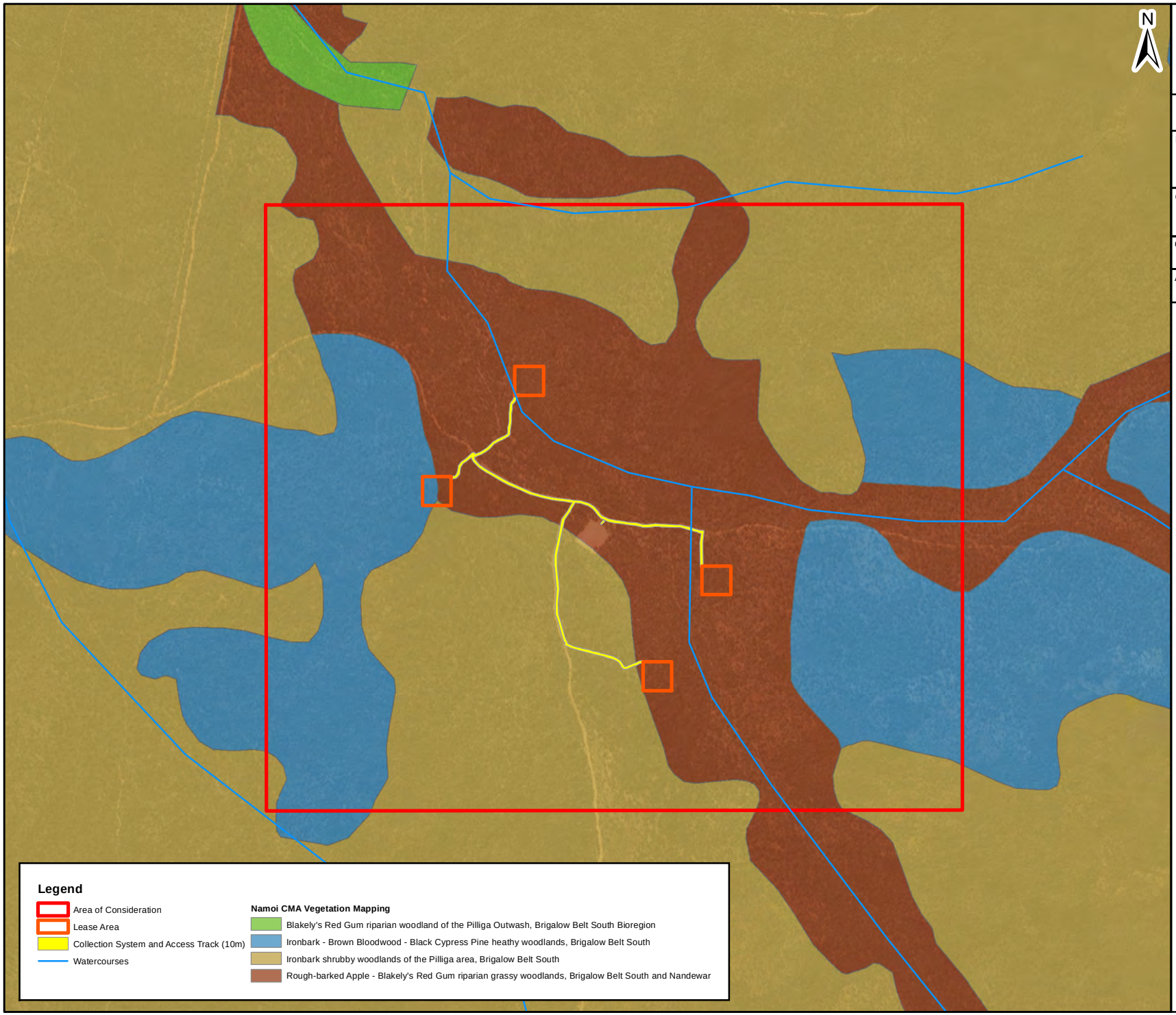
Source: Imagery from Bing Maps 2012
Infrastructure provided 5/2/2013
Watercourses from OEH 2012

0 0.15 0.3 0.6 km

Datum: GDA94
Scale 1:18,000 @ A4

RPS





Namoi CMA Vegetation Mapping

Figure 4.2

Project:	Dewhurst 22-25
Client:	Santos
Compiled by: CO	Date: 29/01/2013
Approved by: BD	Date: 29/01/2013

Source: Imagery from Bing Maps 2012
Infrastructure provided 5/2/2013
Watercourses from OEH 2012

0 0.15 0.3 0.6 km

Datum: GDA94
Scale 1:18,000 @ A4

RPS



4.2 Threatened Ecological Communities

4.2.1 EPBC Act

Five Threatened Ecological Communities (TEC) listed under the EPBC Act were identified as potentially occurring within the locality of the survey area as part of the EPBC Protected Matters Search Tool, including:

- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions
- Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia;
- Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland;'
- Weeping Myall Woodlands; and
- White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grasslands.

Additionally, two EEC listed under the TSC Act that are known or predicted to occur within the Namoi CMA have an equivalent TEC listed under the EPBC Act, including:

- EPBC Act - Brigalow (Acacia harpophylla dominant and co-dominant); and
- Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions.

An assessment of vegetation communities identified within the survey area was undertaken to identify potential TEC's, and is included in **Appendix 3**. As outlined in **Section 4.1.2** and **Appendix 3**, the Rough-barked Apple and Narrow-leaved Ironbark Riparian Woodland is commensurate with RVC 20, which can constitute the White Box – Yellow Box – Blakely's Red Gum Grassy Woodland TEC. Further assessment of this community is outlined below.

White Box – Yellow Box – Blakely's Red Gum Grassy Woodland Assessment

As outlined within the listing advice for this community (SEWPaC 2006), to be considered the Box-Gum Grassy Woodlands and Derived Grasslands, a community must be dominated or co-dominated by White Box (*Eucalyptus albens*), Yellow Box (*E. melliodora*), or Blakely's Red Gum. In addition, the listing advice outlines that a community with a continuous shrub layer of more than 30% is not considered to be a grassy woodland. The shrub layer in this community varies from 30% to 50%, indicating that it is not a grassy woodland.

As Blakely's Red Gum does not dominate or co-dominate this community, and a shrub layer with a cover of greater than 30% occurs, it is not considered to be a TEC under the EPBC Act.

4.2.2 TSC Act

Nine EEC listed under the TSC Act were identified as occurring within the survey area, based on known or predicted communities occurring within the Namoi CMA (NSW Atlas of Wildlife Search). These include:

- Brigalow within the Brigalow Belt South, Nandewar, and Darling Riverine Plains Bioregions;
- *Cadellia pentastylis* (Ooline) community in the Nandewar and Brigalow Belt South Bioregions;
- Coolibah-Black Box Woodland of the Darling Riverine Plains and the Brigalow Belt South bioregions;
- Fuzzy Box Woodland on alluvial Soils of the South Western Slopes, Darling Riverine Plains and

Brigalow Belt South Bioregions;

- Inland Grey Box Woodland in the Riverina; NSW South Western Slopes; Cobar Peneplain; Nandewar and Brigalow Belt South Bioregions
- Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions;
- Native Vegetation on Cracking Clay Soils of the Liverpool Plains;
- Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions; and
- White Box - Yellow Box - Blakely's Red Gum (Box – Gum) Woodland.

An assessment for likelihood of occurrence was conducted for each listed community, and is included in **Appendix 3**. As outlined in **Section 4.1.2** and **Appendix 3**, the Rough-barked Apple and Narrow-leaved Ironbark Riparian Woodland is commensurate with RVC 20, which can constitute the White Box - Yellow Box - Blakely's Red Gum (Box – Gum) Woodland EEC. Further assessment of this community is outlined below.

White Box – Yellow Box – Blakely's Red Gum Woodland Assessment

As outlined in the Box Gum Woodland fact sheet (NSW DECC 2007) Box-Gum Woodland is characterised by the presence (or prior occurrence) of White Box, Yellow Box, or Blakely's Red Gum, with a grassy understorey, and sparse scattered shrub layer. Given the presence of a dense shrub layer, and the low density of Red Gum in this community, this community is not considered to be an EEC under the TSC Act.

4.3 Threatened Flora Species

4.3.1 EPBC Act

The desktop assessment identified five threatened flora species listed under the EPBC Act that potentially occur in the locality. An assessment of likelihood of occurrence was completed for each species, and is included in **Appendix 4**. The assessment identified that the survey area provides suitable habitat for all species namely:

- *Bertya opponens* (Vulnerable);
- *Philotheca ericifolia* (Vulnerable);
- Cobar Greenhood Orchid (*Pterostylis cobarensis*)(Vulnerable);
- *Rulingia procumbens* (Vulnerable); and
- *Tylophora linearis* (Endangered).

Searches did not confirm the presence of any threatened flora species within the survey area. However two species, *Bertya opponens* and *Rulingia procumbens* have been previously recorded within 10km of the survey area (OEH 2012, Eco Logical 2011) and are therefore considered possible occurrences, despite not been recorded during the survey. Refer to **Section 7.1.6** and **Appendix 4** for potential for impact on the above species.

4.3.2 TSC Act

The desktop assessment identified five threatened flora species potentially occurring within the locality. As assessment of likelihood of occurrence was completed for each species, and is included in **Appendix 2**. The assessment identified that the survey area provides suitable habitat for the following species:

- *Bertya opponens* (Vulnerable);
- Native Milkwort (*Polygala linariafolia*) (Endangered);
- *Rulingia procumbens* (Vulnerable);
- Cobar Greenhood Orchid (*Pterostylis cobarensis*)(Vulnerable); and
- *Tylophora linearis* (Endangered).

Searches did not confirm the presence of any threatened flora species within the survey area. However three species, *Bertya opponens*, Native Milkwort and *Rulingia procumbens* have been previously recorded within 10km of the survey area and are therefore considered possible occurrences, despite not been recorded during the survey. Refer to **Section 7.2** and **Appendix 4** for potential for impact on the above species.

4.4 Weeds

The EPBC Protected Matters Search Tool identified five weeds of national significance (WoNS) as potentially occurring in the survey area, namely:

- African Boxthorn (*Lycium ferocissimum*);
- Radiata Pine (*Pinus radiata*);
- Blackberry (*Rubus fruticosus aggregate*);
- Willows (*Salix spp.*); and
- Athel Pine (*Tamarix aphylla*).

No WoNS were observed within the survey area.

One weed listed under the *Noxious Weeds Act 1993* was observed on site, namely Prickly Pear (*Opuntia stricta*). Weed cover within the survey area is low, with only Prickly Pear observed. No additional listed noxious weeds or environmental weeds were identified within the survey area.

5.0 Fauna

5.1 Fauna Results

The five day/ four night fauna survey revealed the presence of 50 bird species, 19 mammal species (including ten microbat species) and 11 reptile species. A detailed fauna species list is included in **Appendix 5**.

One threatened species listed under the EPBC Act, and six threatened species listed under the TSC Act were recorded in the survey area.

5.1.1 Birds

During this survey, 50 bird species were recorded within the survey area (**Appendix 5**). Of the 50 bird species recorded, four are listed as vulnerable under the TSC Act, namely,

- Grey-crowned Babbler (*Pomatostomus temporalis*);
- Turquoise Parrot (*Neophema pulchella*);
- Speckled Warbler (*Pyrrholaemus sagittatus*); and
- Hooded Robin (*Melanodryas cucullata*).

These species are discussed further in **Section 5.3**.

5.1.2 Mammals

In total, 20 mammals species (four of which were introduced) were recorded during this survey (**Appendix 5**).

The Pilliga Mouse (*Pseudomys pilligaensis*), listed as Vulnerable under the EPBC Act and TSC Act, was recorded within the survey area during the survey. The Pilliga Mouse was recorded through pitfall and Elliott trapping within Heath/Riparian vegetation adjacent to Dewhurst 25. This species is discussed in **Section 5.3.**

As discussed below, the Yellow-bellied Sheathtail-Bat (*Saccolaimus flaviventris*) was recorded in the survey area. This species is listed as Vulnerable under the TSC Act.

No other threatened mammals listed under the TSC Act and/or EPBC Act were recorded in the survey area.

Microbats

An analysis of Anabat data was undertaken, which identified up to 11 species of microbat occurring in the survey area. Refer to **Table 5.1** for results. Numbers in columns represent number of calls attributed to each species or species group (Ford, 2012). Of these species, one is listed as Vulnerable under the TSC Act, namely the Yellow-bellied Sheathtail-bat.

Table 5.1: Anabat Analysis Data

Species	8/10/2012	9/10/2012	10/10/2012	11/10/2012
Calls/species positively identified				
Chalinolobus gouldi	✓	✓	✓	✓
Chalinolobus morio	×	✓	✓	×
Nyctophilus sp.	✓	✓	✓	✓
Mormopterus species 3	✓	✓	✓	×
Mormopterus species 4	✓	✓	✓	×
Saccolaimus flaviventris	×	✓	✓	×
Scotorepens balstoni	×	✓	✓	×
Scotorepens greyii	✓	✓	✓	×
Tadarida australis	✓	✓	✓	×
Vespadelus vulturnus	✓	✓	✓	✓
Calls/species NOT positively identified *				
Miniopterus schreibersii oceanensis	✓	✓	✓	✓
Total calls NOT positively identified	**205**	**513**	**320**	**108**
Total calls recorded	**254**	**680**	**493**	**196**

*Species listed in this section and not above should be considered as possibly present in the survey area. See notes below regarding species identity for calls with poor resolution.

Notes – species / calls not reliably identified

Numerous fragmented and/or brief calls could not be reliably identified; and many good quality calls had intermediate features that may have been attributable to one of several species. Such calls are attributed to a species group depending on frequency range and pulse shape characteristics. Species groupings used in this analysis include (Ford 2012):

- *Chalinolobus gouldii* and *Mormopterus* species (Fc=26-32 kHz);
- *Nyctophilus* species (Fc=35-45 kHz); and
- *Vespadelus vulturnus* and *Miniopterus schreibersii oceanensis* (Fc=44-46 kHz).

Where a call is attributed to a species group, all species within the group are listed as “possible” in the results. In some cases, however, one or more of the group members are also identified positively in other calls, in which case, they are shown as ‘positive’ in the table. Issues of call identification reliability and probability of group members occurring in the survey area are discussed below (Ford 2012).

Chalinolobus gouldii and Mormopterus species

Chalinolobus gouldii calls (26-33 kHz) generally have steep, broad-band pulses that alternate in frequency, compared with flat to gently-curved, narrow-band pulses in *Mormopterus* species. *Mormopterus* sp 3 calls are usually at higher frequency (29-32 kHz) than those of *Mormopterus* sp 4 (25-28 kHz).

These characteristics were used to reliably identify many of the calls observed in this data set; however, numerous calls around 27-29 kHz contained pulses of intermediate shape that could have been from any of the three species (Ford 2012).

Nyctophilus species

These species' calls are generally easily distinguished from those of other bats; however, the species within the genus *Nyctophilus* cannot be reliably differentiated. Up to three *Nyctophilus* species potentially occur in the survey area, including*: N. corbeni, N. geoffroyi* and *N. gouldi*. The only reliable way to determine the identity of *Nyctophilus* species in the survey area would be to conduct a comprehensive trapping study. Such a trapping study is a mandatory requirement for assessing the likely presence of the EPBC-listed *N. corbeni* (Ford 2012).

Vespadelus vulturnus and Miniopterus schreibersii oceanensis

These species' frequency ranges overlap significantly; however, the two can usually be separated on distinctive pulse shapes. *Miniopterus* calls generally have relatively short initial frequency sweep (i.e. narrow band-width) and flattish pulse body of relatively long duration; compared with steep initial sweep (broad-band), shorter duration and curved or hooked pulse body in *V. vulturnus*. The majority of calls in this frequency range were clearly attributable to V. vulturnus, based on these characteristics. A few calls, however, particularly from Anabat 2, had slightly longer duration pulses with intermediate body shapes and could have represented either *M. s. oceanensis* or *V. vulturnus*.

5.1.3 Reptiles

Eleven reptile species were recorded in the survey area including one gecko species, four skink species, one snake species, one lizard species, three dragon species and one monitor species, as listed in **Appendix 5**.

No threatened reptile species such as the Pale-headed Snake were recorded during this survey.

5.1.4 Amphibians

No amphibians were recorded within the survey area during this survey. The dry conditions experienced throughout the survey are likely to have contributed to this result.

5.1.5 Pests

The EPBC Protected Matters Search Tool identified six feral animal species as potentially occur within the survey area, namely:

- Cane Toad (*Bufo marinus*);
- Goat (*Capra hircus*);
- Cat (*Felis catus*);
- Rabbit (*Oryctolagus cuniculus*);
- Pig (*Sus scrofa*); and
- Red Fox (*Vulpes vulpes*).

During this survey, four feral animals were recorded in the survey area, namely Goat, Red Fox, Rabbit and Hare (*Lepus europaeus*). Signs of Pig presence (e.g. diggings and rooting) were also recorded in surrounding areas. It is also considered likely that Cat do occur within the survey area.

Cane Toad has not previously been recorded based on OEH records, and was not recorded in the survey area.

5.2 Habitat Values of the Study Area

The survey area contains a diversity of habitats including heath, woodland and riparian ecosystems fulfilling habitat requirements for a range of species. These habitats consist of, and provide, various quality (condition) habitats and resources (e.g. foraging and breeding niches) for native flora and fauna, including:

- Small, medium and large tree hollows;
- Flowering Eucalypts;
- Fallen / felled timber, including hollow-bearing logs;
- Ephemeral waterways including semi-permanent waterholes;
- A ground layer comprising under-storey vegetation and coarse leaf litter;
- Dense shrub layer comprised of flowering heath species;
- Mistletoe within the canopy layer; and
- Roost trees.

Three distinct habitat types were identified in the survey area. In addition to the floristic composition of these habitat types and the food resources which they may provide to native fauna species (e.g. fruiting and/or flowering trees, water), both of these broad habitat types may also contain elements which fulfil a range of requirements for various native fauna species. For example, elements such as fallen woody debris/ logs, hollow bearing trees, flowering plants and waterholes fulfil important foraging, sheltering and nesting requirements for amphibians, birds, reptiles and mammals. The following sections outline the key habitat value and characteristics of each habitat type within the survey area and area of consideration.

5.2.1 Habitat Descriptions and Distribution

The habitat types identified during the ecological assessment are described below. For the purpose of this assessment, the study focused primarily on the survey area, as shown on **Figure 5.1**. The survey locations are shown on **Figure 3.1**.

Woodland

The woodland vegetation of the survey area consists of woodland with a moderately sparse canopy, and a varying shrub layer (**Figure 5.1**). This habitat type is generally in good condition, with disturbances limited to the understorey due to the presence of pigs. Edge effects resulting from the access tracks are minimal, and weed cover is extremely low. This vegetation has been historically disturbed due to harvesting of timber for foresty activities, resulting in denser areas of White Cypress in patches.

Hollow bearing Eucalypts are common throughout most of the woodland vegetation, with hollow-bearing trees present at a density of approximately 22 per hectare. These hollows generally range from small to medium in size, but ocassional large hollows occur. These hollows provide breeding habitat for numerous native birds, mammals and reptiles, including several threatened species, such as Squirrel Glider (*Petaurus norfolcensis*), Eastern Pygmy Possum (*Cercartetus nanus*), Greater Long-eared Bat (*Nyctophilus timoriensis*), Barking Owl (*Ninox connivens*) and Little Lorikeet (*Glossopsitta pusilla*) that have been recorded within 10km of the survey area. Several small and

medium sized bird nests were also observed throughout the woodland vegetation. Grey-crowned Babbler nests were reguarly observed.

While this community is dominated by a Eucalypt canopy, these species do not include primary food trees for Koalas. Three species of secondary food trees are present in low densities across the survey area,. Eucalypt canopy species also provide foraging resources for nectar reliant bird species, such as honeyeaters, parrots, and wattlebirds. The moderate to sparse understorey provides foraging, sheltering and breeding opportunities for a variety of native birds, such as Eastern Yellow Robins (*Eopsaltria australis*), Willie Wagtail (*Rhipidura leucophrys*), Rufous Fantail (*Rhipidura rufifrons)*, Fairy-wrens (*Malurus* spp.) and Thornbills (*Acanthiza* spp.). Threatened species that were observed in this habitat nclude Hooded Robin, Grey-crowned Babbler, and Speckled Warbler. Pilliga Mouse was also captured in riparian woodland with a heath understorey.

Ground cover is generally sparse, however, fallen timber and low shrubs provide additional habitat resources for small to medium sized mammals and reptiles. Fallen timber provides shelter and breeding habitat for many native reptiles and mammals.

The woodland habitat is the dominant habitat in the area of consideration (**Figure 5.1**), and within the Pilliga Forest. This habitat type occupies approximately 4.96 ha of land that is to be potentially impacted by the proposed activities. Within the Pilliga Forest, this community comprises approximately 198 200ha.

Riparian Woodland

Riparian vegetation occurs throughout the survey area, associated with the ephemeral creeks. Riparian Woodland is similar in structure to the Woodland habitat, with a moderately sparse canopy, and a varying shrub layer (**Figure 5.1**). As with the woodland habitat, the riparian habitat is generally in good condition, with disturbances limited to the understorey vegetation. Edge effects resulting from the access tracks are minimal, and weed cover is extremely low.

Hollow-bearing trees are common, at a similar density to the Woodland habitat. These hollows provide breeding habitat for numerous native birds and mammals. Numerous fauna species are likely to utilise the Riparin Woodland for foraging. In addition, Grey-crowned Babbler nests were regularly observed.

The riparian habitat is likely to provide habitat for a range of reptiles and amphibians that utilise the understorey vegetation in close proximity to the creek banks. The banks of the waterways are considered to provide breeding habitat for species such as Rainbow Bee-eater (*Merops ornatus)*.

In addition, these ephemeral waterways are also likely to provide habitat for the Pilliga Mouse (*Pseudomys pilliganensis*), particularly where a low heath layer occurs.

Riparian habitat occupies approximately 66 763 ha of the Pilliga Forest (**Figure 4.1**). Of this, 1.02 ha of riparian woodland may be impacted by the proposed activities.

Heath

The heath habitat of the survey area consists of a sparse canopy, and a dense shrub layer (**Figure 5.1**). As with the woodland community, this habitat type is generally in good condition, with disturbances limited to the understorey due to the presence of pigs. Edge effects resulting from the access tracks are minimal, and weed cover is extremely low.

Due to a sparse canopy, numbers of hollow-bearing trees are lower than within woodland habitat, with hollow-bearing trees present at a density of approximately 14 per hectare. These hollows range from small to medium in size and as discussed previously, provide breeding habitat for numerous native birds, mammals and reptiles, including several threatened species.

The dense shrub layer is generally dominated by *Calytrix tetragona, Acacia* species and *Dodonaea* species which also provide similar foraging resources for nectar reliant bird species, such as honeyeaters, babblers, wattlebirds, and parrots (including the TSC Act listed Turquoise Parrot). This dense shrub layer also provides increased foraging, sheltering and breeding opportunities for a variety of native birds and mammals (e.g. Pilliga Mouse and Yellow-footed Antechinus).

Ground cover varies greatly within this habitat, ranging from 20-80% cover. Areas with higher ground-cover are considered more suitable for native mammal species such as those mentioned previously. Although some areas have a lower density of ground-cover, this is generally due to species such as *Calytrix tetragona* and *Acacia caroleae* forming a dense shrub layer. The relative high abundance of fallen timber and low shrubs within all heath provide habitat resources for small to medium sized mammals and reptiles. In particular, fallen timber provides shelter and breeding habitat for many native reptiles and mammals, including Pilliga Mouse.

The heath habitat occupies approximately 17 763 ha of the Pilliga Forest. This habitat type occurs directly adjacent to disturbance areas, therefore no clearing is required. Several indirect impacts may however occur within this habitat.

5.3 Threatened Species

5.3.1 EPBC Act

Thirteen threatened fauna species listed under the EPBC Act were identified as potentially occurring in the survey area (10km buffer) during the desktop assessment, including three Endangered species and ten Vulnerable species. An assessment of likelihood of occurrence was completed for each species, based on habitat preference and known species distribution, and is included in **Appendix 4**. The following definitions were used to assess likelihood of occurrence:

- Known: Species recorded during the survey;
- Likely: Species previously recorded within 10 kilometres of survey area (OEH 2012) and suitable habitat for the species recorded within the survey area;
- Possible: Species previously recorded within 10 kilometres of survey area (OEH 2012) but no suitable habitat of the species recorded within the survey area. Or: species not previously recorded within 10 kilometres of survey area (OEH 2012) but suitable habitat of the species recorded within the survey area; and
- Unlikely: Species not previously recorded within 10 kilometres of survey area (OEH 2012) and no suitable habitat for the species recorded within the survey area.

Of these species, only **Pilliga Mouse** was recorded on the border of Heath and Riparian woodland. No additional species listed under the EPBC Act were recorded. Potential for impact on the above species is discussed in **Section 7.1.6, Section 7.2** and **Appendix 7 & 8.**

The following species are considered likely to occur in the survey area based on available habitat and known distribution:

- Regent Honeyeater (*Anthochaera phrygia*) – Endangered;
- South-eastern Long-eared Bat (*Nyctophilus corbeni*) – Vulnerable; and
- Koala (*Phascolarctos cinereus*) - Vulnerable.

The following species possibly occur in the survey area:

- Swift Parrot (*Lathamus discolor*) - Endangered;
- Malleefowl (*Leipoa ocellata)* - Vulnerable*;*
- Large-eared Pied Bat, Large Pied Bat (*Chalinolobus dwyeri*) - Vulnerable; and
- Spotted-tailed Quoll (*Dasyurus maculatus*) – Endangered.

5.3.2 TSC Act

Thirty threatened species were identified as potentially occurring within the survey area as part of the desktop assessment, including one Critically Endangered species, five Endangered species, and twenty-four Vulnerable species. An assessment of likelihood of occurrence was completed for each species based on habitat preference and known species distribution, and is included in **Appendix 4**. The following definitions were used to assess likelihood of occurrence:

- Known: Species recorded during the survey;
- Likely: Species previously recorded within 10 kilometres of survey area (OEH 2012) and suitable habitat for the species recorded within the survey area;
- Possible: Species previously recorded within 10 kilometres of survey area (OEH 2012) but no suitable habitat of the species recorded within the survey area. Or: species not previously recorded within 10 kilometres of survey area (OEH 2012) but suitable habitat of the species recorded within the survey area; and
- Unlikely: Species not previously recorded within 10 kilometres of survey area (OEH 2012) and no suitable habitat of the species recorded within the survey area.

Several TSC Act listed species were recorded in the survey area, namely, **Pilliga Mouse**, **Turquoise Parrot**, **Grey-crowned Babbler**, **Speckled Warbler**, **Hooded Robin**, and **Yellow-bellied Sheathtail-bat**. Potential for impact on the above species is discussed in **Section 7.2** and **Appendix 8**.

The following species are considered likely to occur in the survey area based on available habitat and known distribution:

- Regent Honeyeater (*Anthochaera phrygia*) – Critically Endangered;
- Brown Treecreeper (*Climacteris picumnus victoriae*) - Vulnerable;
- Varied Sittella (*Daphoenositta chrysoptera*) - Vulnerable;
- Little Lorikeet (*Glossopsitta pusilla*) - Vulnerable;
- Barking Owl (*Ninox connivens*) - Vulnerable;
- Masked Owl (*Tyto novaehollandiae*) - Vulnerable;
- Eastern Pygmy-possum (*Cercartetus nanus*); - Vulnerable;

- Little Pied Bat (*Chalinolobus picatus*) - Vulnerable;
- Black-striped Wallaby (*Macropus dorsalis*) - Endangered;
- South-eastern Long-eared Bat (*Nyctophilus corbeni*) - Vulnerable;
- Koala (*Phascolarctos cinereus*) – Vulnerable; and
- Pale-headed Snake (*Hoplocephalus botorquatus*) - Vulnerable.

The following species possibly occur in the survey area:

- Glossy Black Cockatoo (*Calyptorhynchis lathami*) - Vulnerable;
- Swift Parrot (*Lathamus discolor*) - Endangered;
- Malleefowl (*Leipoa ocellata)* - Endangered*;*
- Diamond Firetail (*Stagonopleura guttata*) - Vulnerable;
- Large-eared Pied Bat, Large Pied Bat (*Chalinolobus dwyeri*) - Vulnerable;
- Spotted-tailed Quoll (*Dasyurus maculatus*) - Vulnerable; and
- Squirrel Glider (*Petaurus norfolcensis*) – Vulnerable.

5.4 Migratory Species

The EPBC Protected Matters Search Tool identified 12 migratory species as potentially occurring in the survey area (**Appendix 6**). An assessment of likelihood of occurrence was completed for each species, based on habitat preference and known species distribution, and is included in **Appendix 6**. The assessment confirmed that three species are likely to occur on site, namely:

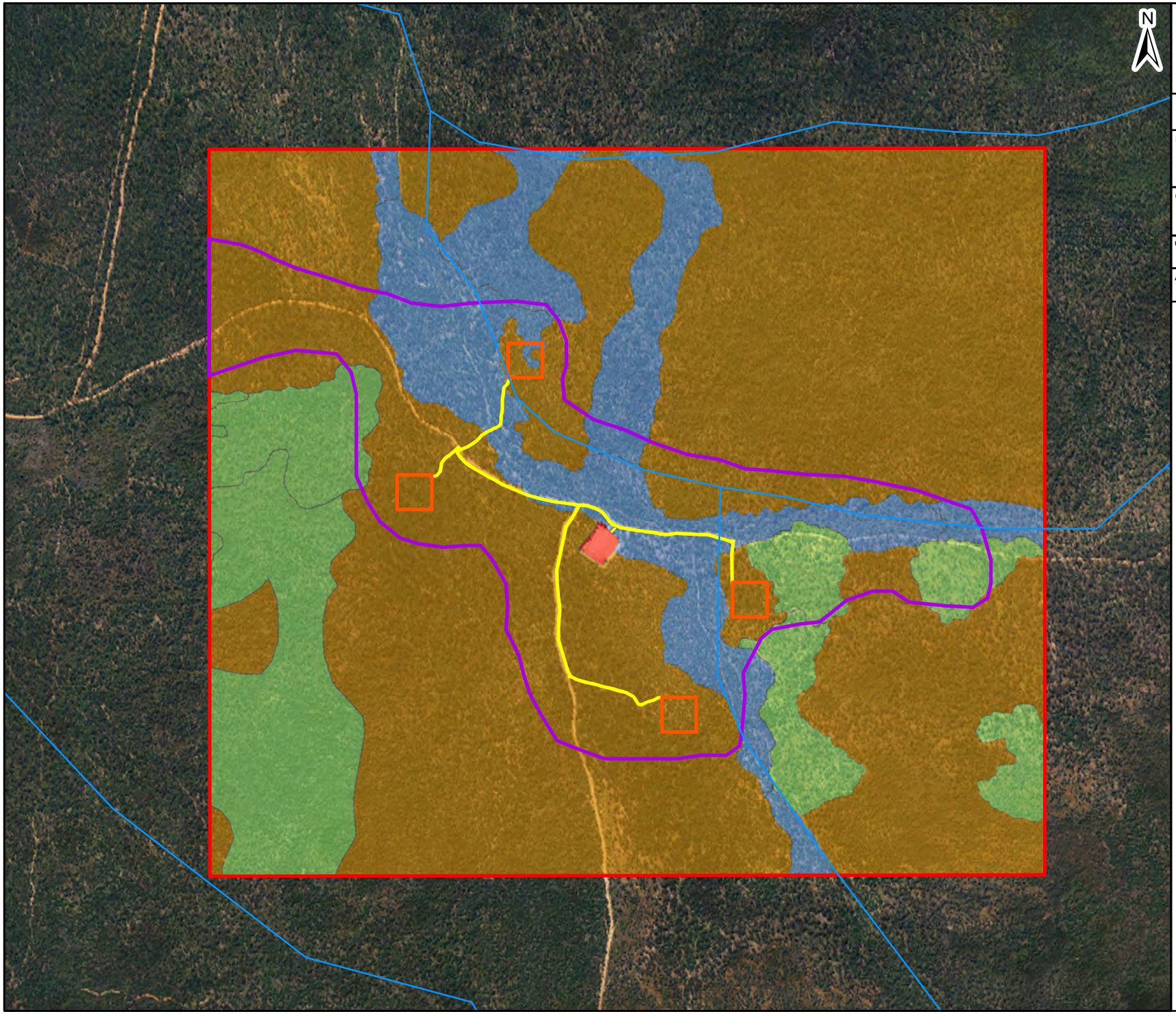
- Rainbow Bee-eater (*Merops ornatus*):
- White-throated Needletail (*Hirundapus caudacutus)*: and
- Regent Honeyeater (*Anthochaera phyrgia*).

No migratory species were observed during this survey. Potential for impact on the above species is discussed in **Section 7.1.7** and **Appendix 6**.

5.5 Regional Context

The survey area occurs within the Pilliga East State Forest, which forms part of the largest contiguous patch of remnant vegetation in NSW, much of which forms state forests and conservation area. The Pilliga Scrub supports a diverse array of habitats, and provides easy movement and dispersal opportunities.

At a local scale, the survey area is somewhat fragmented by access tracks, with some disturbances associated with forestry and existing CSG activities. However, these are not considered to be serious barriers for fauna movement.



Habitat Types

Figure 5.1

Project: Dewhurst 22-25

Client: Santos

Compiled by:	CO	Date:	29/01/2013
Approved by:	BD	Date:	29/01/2013

Legend

- Survey Area
- Area of Consideration
- Lease Area
- Collection System and Access Track (10m)
- Watercourses

Habitat Types

- Cleared
- Heath
- Eucalypt Woodland
- Riparian Woodland

Source: Imagery from Bing Maps 2012
Infrastructure provided 5/2/2013
Watercourses from OEH 2012

0 0.15 0.3 0.6 km

Datum: GDA94
Scale 1:15,000 @ A4

RPS



6.0 Waterways

Several waterways occur within the area of consideration (**Figure 1.2**). The majority of these waterways are small, highly ephemeral drainage lines that are subject to infrequent or seasonal flow. Ground-truthing verified that the majority of these drainage lines are associated with small linear bands of riparian vegetation. In some instances, the waterways are not associated with riparian vegetation, due to the small size and low flow nature of the creeks.

While these waterways are small, they are an important component of ecological function, providing breeding and habitat resources for species such as frogs and reptiles. They also provide for fauna movement throughout the broader landscape.

Of note, Spring Creek will be intersected by the access track and gathering system for Dewhurst 24. While this creek is highly ephemeral, it is a larger creek in the survey area, and a tributary to Bibblewindi Creek. This creek does appear to support small, highly isolated semi-permanent pools of water following high rainfall, however no permanent aquatic plant species are present. This creek is associated with a larger band of riparian vegetation throughout the survey area. Spring Creek has a defined channel, spanning approximately 3 metres from top of banks. Bank erosion is present, particularly where banks are steeper.

7.0 Ecological Impact Assessment

7.1 Discussion of Impacts

The majority of potential impacts are associated with vegetation removal, as well as increased noise, dust, and light. Additionally, there is the potential for weed incursion due to machinery.

The assessment identified the following impacts occuring as a result of Dewhurst 22-25 and associated infrastructure:

- Vegetation clearing;
- Disturbance to vegetation communities and habitats, including edge effects to vegetation to be retained;
- Hollow bearing tree removal;
- Relocation of hollow logs;
- Disturbance or removal of fallen woody debris;
- Fauna displacement;
- Disruption of breeding cycle, roosting and sheltering behaviour;
- Impacts on migration and dispersal ability;
- Disruption of pollination cycle and seed dispersion;
- Introduction of weeds and feral pest species; and
- Noise, dust, and light.

Each of the above listed potential impacts are discussed in greater detail within the following relevant sections.

7.1.1 Vegetation Clearing and / or Disturbance to Habitats and Habitat Features

Construction activities will require the removal of approximately 5.98 ha of vegetation, with disturbance to a total area of 6.29 ha (**Table 7.1**). This will include the clearing of trees with small hollows, removal of old stockpiles of felled vegetation, and disturbances to understorey vegetation and ground cover such as leaf litter and fallen bark.

It is expected that hollow bearing trees may be removed as a result of the proposed activities. These trees provide viable nesting, roosting and/or breeding resources for native birds, arboreal mammals and some reptile species. Of note, hollow-bearing trees provide breeding habitat for a range of threatened species that are known, or potentially occur in the survey area, including Little Lorikeet, Masked Owl, South-eastern Long-eared Bat, and Turquoise Parrot.

In consideration of the Pilliga Forest and the area of consideration providing an abundance of hollow bearing trees that also contain viable nesting, roosting and/or breeding resources, the potential removal of hollow bearing trees is not considered to be significant as it is considered unlikely that hollow dependant fauna will be adversely impacted by the proposed activities and should be able to relocate successfully into hollow bearing resources that are present throughout the adjacent habitats. Mitigation measures to help ameliorate these impacts are prescribed in **Section 8**.

It is expected that a relatively small volume of hollow log and fallen woody debris habitats that are currently present in the survey area will be disrupted and relocated as a result of the proposed activities. This is likely to temporarily disrupt the nesting, breeding and/or sheltering behaviour of some reptiles and ground dwelling mammals. However, this disruption is likely to be minimal in extent and is unlikely to be significant, as these habitat resources will be relocated into adjacent habitats within the survey area and retained over the long-term, and as a result will not be permanently lost from the survey area. Mitigation measures to help ameliorate these impacts are prescribed in **Section 8**.

Table 7.1 outlines vegetation clearing required, and assesses the clearing amount against remaining vegetation within the Pilliga Forest. A total disturbance area of 6.29ha will be required.

Table 7.1: Summary of Vegetation Removal

Vegetation Community	Clearing Required (ha)	Overall Community (ha)*	% of Community Removed**	Associated Threatened Species**
Narrow-leaved Ironbark Woodland	4.96	198 219	0.002	Grey-crowned Babbler Hooded Robin Turquoise Parrot Speckled Warbler
Riparian Woodland	1.02	66 763	0.001	Grey-crowned Babbler Hooded Robin Turquoise Parrot Speckled Warbler Pilliga Mouse
Heath	0	17 763	0	Pilliga Mouse Grey-crowned Babbler Hooded Robin Turquoise Parrot Speckled Warbler
Total vegetation clearing	5.98	264982	0.002	N/A

* Overall Community refers to the total area of each community within the Pilliga Forest, using analagous Namoi CMA RVC (refer to **Section 4**).
% of community removed refers to clearing undertaken in comparison to overall community within the Pilliga Forest, using analagous Namoi CMA RVC (refer to **Section 4).
**Only species recorded in the survey area are included in the above table

7.1.2 Fauna Displacement / Disruption of Fauna

The proposed activities are likely to result in the clearing of 5.98 ha of viable habitat from the survey area. This habitat provides foraging, breeding, roosting and sheltering resources that may currently be utilised by all the faunal groups identified in the survey area. This will result in the displacement of native fauna across the survey area. Displaced fauna will need to be relocated into adjacent habitats, which will place short-term pressure on the available habitat resources within these habitats.

The degree of displacement within the survey area and the intensity of pressure placed on adjacent habitats are minimal based on the percentage of habitats to be lost in comparison to what will be retained in the survey area.

The breeding cycle, roosting, sheltering and foraging behaviour for some species is likely to be impacted by the proposed activities. This impact is most likely to occur where the proposed activities

will result in the removal of hollow bearing trees and where hollow logs and fallen woody debris are to be removed from the impact areas and relocated into the area of consideration.

The impact on the migration and dispersal ability of native flora and fauna, like most of the other impacts, is species specific. Species, which are less mobile (e.g. reptiles and amphibians), residents (e.g. some birds) or species whereby the habitat to be removed forms an important component of the overall habitat area, are those that would be most likely impacted.

The proposed activities are unlikely to fragment or isolate areas of vegetation or impose a significant barrier to the migration and dispersal ability of native biota. Mobile species such as microbats, medium to large mammals and woodland birds would not be impacted by the proposed activities.

The less mobile smaller species are also unlikely to be significantly impacted, as the area/ extent of habitats to be cleared is 5.98 ha in comparison to the area of habitats to be retained acrossthe Pilliga Forest and area of consideration.

7.1.3 Disruption of Pollination Cycle and Seed Dispersion

Excessive dust from the proposed activities could potentially disrupt the pollination cycle and ability of native plants to regenerate (i.e. germination, revegetation and re-colonisation of existing plants). Mitigation measures to help ameliorate these impacts are prescribed in **Section 8**.

7.1.4 Introduction of Weeds and Feral Pest Species

The proposed activities have the potential to create favourable conditions for introduced weed species within the survey area, which could potentially lead to an increase of existing weed populations and introduction of additional weed species. This is most likely to occur where soil disturbance may occur, including along access roads, and where earthworks are required. Weed cover in the survey area is very low, with only one noxious weed (Prickly Pear) observed in very low densities. While spread of weeds off-site is considered unlikely, there is the risk of introducing weeds to the site from machinery and vehicles. Mitigation measures to help ameliorate these impacts are prescribed in **Section 8**.

7.1.5 Noise and Light

Noise and light pollution as a result of vehicles, machinery and drilling may deter native fauna from utilising the survey area and immediate surrounding areas as habitat. The proposed activities could affect the migration and dispersal ability of native fauna particularly in relation to vehicular movements. The proposed activities may result in increased noise and light pollution which has the potential to disrupt the breeding cycle and the foraging and roosting behaviour of some native fauna species.

7.2 Impact Assessment under the EPBC Act

7.2.1 World Heritage Areas

The proposed activities are not in a World Heritage area, and are not in close proximity to any such area.

7.2.2 National Heritage Places

The proposed activities are not in a National Heritage Place, and are not in close proximity to any such area.

7.2.3 Wetlands Protected by International Importance

The proposed activities are not upstream or in an area where there is any form of Ramsar Wetlands.

7.2.4 Great Barrier Reef Marine Park and Commonwealth Marine Areas

The proposed activities are not within the Great Barrier Reef Marine Park or Commonwealth Marine Area.

7.2.5 Listed Threatened Ecological Communities

As outlined in **Section 4**, seven TEC were identified as potentially occurring in the survey area throughout the desktop assessment. The field assessment determined that no TEC occur within the survey area.

While a key indicator species (Blakely's Red Gum) occurs within the riparian vegetation within the survey area, this community is not considered to be the White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands, as Blakely's Red Gum is not, and doesn't appear to previously have been, a common canopy species. Additionally, the understorey of this community comprises heath rather than the characteristic grasses of a grassy woodland.

7.2.6 Listed Threatened Species

While no listed flora species were recorded in the survey area, five species have the potential to occur based on habitat available. An assessment of significance was not considered necessary, as targeted searches for these flora species did not record these species within the survey area, and an initial assessment of potential for impact determined that significant impacts are considered unlikely. Refer to **Appendix 4**.

One Vulnerable fauna species, Pilliga Mouse was recorded in the survey area. While no additional threatened fauna species were recorded in the survey area, it is considered possible that a further four bird species and four mammal species occur. An assessment of significance for each of the fauna species whose occurrence is considered to be 'likely' has been undertaken in accordance with the EPBC Act and *EPBC Act Policy Statement 1.1 - Significant Impact Guidelines Matters of National Environmental Significance* (DEWHA, 2009), and is included in **Appendix 7**. The assessments concluded that no significant impact is anticipated for fauna species. **Table 7.2** provides a summary of the significant impact assessments.

Table 7.2: Summary of EPBC Act Impact Assessment for Threatened Fauna Species

Species	Common Name	EPBC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
Recorded in the Survey area				
Pseudomys pilligaensis	Pilliga Mouse	V	▪ Disturbances due to noise and light ▪ Disturbances to riparian habitat due to vegetation clearing	Significant impact unlikely, however EPBC Act referral is recommended
Considered to Likely Occur				
Anthochaera phrygia	Regent Honeyeater	E	▪ Loss of woodland habitat and flowering Eucalypts ▪ Disturbances due to noise and light	Significant impact unlikely
Phascolarctos cinereus	Koala	V	▪ Loss of secondary food trees ▪ Vehicle strike ▪ Disturbances due to noise and light	Significant impact unlikely
Nyctophilus corbeni	South-eastern Long-eared Bat, Corben's Long-eared Bat	V	▪ Loss of woodland habitat and hollow-bearing trees ▪ Disturbances due to noise and light	Significant impact unlikely

7.2.7 Listed Migratory Species

Three migratory species are considered likely to utilise the survey area, namely the Rainbow Bee-eater, White-throated Needletail and Regent Honeyeater. An assessment of significance has been conducted for Regent Honeyeater, which is also a listed threatened species, as outlined above.

An assessment of significance was not considered necessary for the Rainbow Bee-eater or White-throated Needletail, as an initial assessment of potential for impact determined that significant impacts are considered unlikely (**Appendix 4**).

7.3 Impact Assessment under the TSC Act

Section 5A of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of proposed activities on 'threatened species, populations or ecological communities (or their habitats)' listed under the TSC Act. The Assessment of Significance (7-part test) is used to determine whether there is likely to be a significant affect on threatened species, populations or ecological communities, or their habitats and thus whether a Species Impact Statement (SIS) is required.

On this basis an assessment of significance was completed for the threatened species populations and ecological communities that are known to occur, or considered likely to occur within the survey area. A total of 18 AOS were undertaken for ten birds, seven mammals, and one reptile. (**Appendix 8**).

The application of the 7-part test concluded that there is not likely to be a significant effect on any threatened species, populations, or their habitats arising from the proposed activities. **Table 7.3** provides a summary of assessment of significance of potential impacts.

Table 7.3: Summary of Assessment of Significance for TSC Act listed species

Species	Common Name	TSC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
Fauna Species Recorded in the survey area				
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	▪ Loss of habitat ▪ Modification to ground habitat	Significant impact unlikely
Neophema pulchella	Turquoise Parrot	V	▪ Loss of habitat, particularly hollow bearing trees and ground covers ▪ Potential for increased predation	Significant impact unlikely
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	▪ Loss of woodland habitat ▪ Disturbance to movement patterns as they are unable to cross open areas ▪ Disturbance or removal of nests	Significant impact unlikely
Pseudomys pilligaensis	Pilliga Mouse	V	▪ Disturbances due to noise and light ▪ Disturbances to riparian habitat due to clearing	Significant impact unlikely
Pyrrholaemus sagittatus	Speckled Warbler	V	▪ Loss of woodland	Significant impact unlikely

Species	Common Name	TSC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
			habitat, particularly understorey vegetation ▪ Disturbances to nests, often located on the ground ▪ Potential for increased predation of nest sites	
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	▪ Loss of woodland habitat ▪ Loss of roosting sites	Significant impact unlikely
Fauna Species Considered Likely to Occur				
Anthochaera phrygia	Regent Honeyeater	CE	▪ Loss of woodland habitat and flowering Eucalypts ▪ Disturbances due to noise and light	Significant impact unlikely
Cercartetus nanus	Eastern Pygmy-possum	V	▪ Loss of habitat ▪ Loss of hollow-bearing trees ▪ Disturbances due to noise and light	Significant impact unlikely
Chalinolobus picatus	Little Pied Bat	V	▪ Loss of woodland habitat ▪ Loss of roosting sites	Significant impact unlikely
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	▪ Loss of woodland habitat ▪ Disturbances to fallen timber ▪ Loss of hollow-bearing trees required for nesting	Significant impact unlikely
Daphoenositta chrysoptera	Varied Sittella	V	▪ Loss of habitat ▪ Disturbances to nests	Significant impact unlikely
Glossopsitta pusilla	Little Lorikeet	V	▪ Loss of habitat, particularly riparian habitat ▪ Loss of hollow-bearing trees ▪ Loss of flowering	Significant impact unlikely

Species	Common Name	TSC Act Status	Potential Impact	Assessment of Significance of Potential Impacts
			Eucalypts	
Macropus dorsalis	Black-striped Wallaby	E	▪ Loss of dense woody or shrubby habitat ▪ Vehicle strike	Significant impact unlikely
Ninox connivens	Barking Owl	V	▪ Loss of habitat ▪ Loss of nesting sites (hollow-bearing trees)	Significant impact unlikely
Nyctophilus corbeni	South-eastern Long-eared Bat, Corben's Long-eared Bat	V	▪ Loss of woodland habitat and hollow-bearing trees ▪ Disturbances due to noise and light	Significant impact unlikely
Phascolarctos cinereus	Koala	E	▪ Loss of secondary food trees ▪ Vehicle strike ▪ Disturbances due to noise and light	Significant impact unlikely
Tyto novaehollandiae	Masked Owl	E	▪ Loss of habitat ▪ Loss of nesting sites (hollow-bearing trees) ▪ Vehicle strikes	Significant impact unlikely
Hoplocephalus bitorquatus	Pale-headed Snake	V	▪ Loss of habitat, particularly riparian vegetation ▪ Removal of loose-barked trees ▪ Vehicle strike	Significant impact unlikely

7.4 Key Threatening Processes Relevant to Proposed Activities

The EPBC Act and TSC Act provide for the identification and listing of key threatening processes (KTP). KTP are defined as a threatening process 'if it threatens or may threaten the survival, abundance, or evolutionary development of a native species or ecological community' (SEWPaC, 2012).

KTP under the EPBC Act and TSC Act that are relevant to the proposed activities are discussed in **Table 7.4**.

Table 7.4: Key Threatening Process Summary

Key Threatening Process	Relevance to Proposed Activities
EPBC Act / TSC Act	
Competition and land degradation by feral European Rabbits	While Rabbits were observed within the survey area, it is not anticipated that the proposed activities will increase opportunities for increase to the Rabbit population.
Competition and land degradation by unmanaged goats	While goats were observed within the survey area, it is not anticipated that the proposed activities will result in an increase to the Goat population. Mitigation measures may be required at the completion of the project to ensure rehabilitation activities are not disturbed by unmanaged goats
Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*)	There exists the potential for the importation of this pathogen on unclean vehicles and plant machinery.
Land clearance / removal of native vegetation	Vegetation clearing will be required. Approximately 5.98 of vegetation will be removed to facilitate the construction of four wells and associated infrastructure.
Predation by European Red Fox	Red Fox was observed in the survey area. It is considered unlikely that the proposed activities will result in increased predation by European Red Fox, given the relatively limited amount of clearing proposed, in comparison to habitat available in the surrounding areas.
Predation by feral cats	Feral Cats were not observed in the survey area, but are considered likely to occur. If waste is not managed on site, there is the potential for an increase in the Feral Cat population.
Predation, habitat degradation, competition and disease transmission by feral Pigs	Evidence of feral pigs was observed in the survey area. It is considered unlikely that the proposed activities will result in increased predation, habitat degradation, competition or disease transmission.

Key Threatening Process	Relevance to Proposed Activities
TSC Act	
High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition	The proposed activity will not result in high frequency fires. Fire prevention strategies will be outlined in the REF.
Removal of dead wood and dead trees	Some dead wood in the form of hollow logs and fallen woody debris will be disturbed by the proposed activities, but these habitat resources will be relocated elsewhere in the survey area.
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	Some disturbance is proposed to a creek located to the south of Dewhurst 24. To ensure no alteration to natural flow regimes, works will be undertaken to prevent erosion of banks, and timed to correspond with the dry season. Refer to the REF.
Predation and hybridisation by feral dogs, (*Canis lupus familiaris*)	Feral dogs were not observed in the survey area, but are considered likely to occur. It is considered unlikely that the proposed activities will result in increased predation from feral dogs.
Loss of hollow-bearing trees	Hollow-bearing trees will be removed to facilitate construction (**Figure 5.1**). Where hollow-bearing trees occur adjacent to leases, they will be retained. The hollow bearing trees to be removed will be placed into adjacent habitats as hollow logs and woody debris.
Invasion of native plant communities by exotic perennial grasses	There exists the potential for the invasion of native woodland and grassland communities by exotic perennial grass species, transferred via vehicles and site machinery.

8.0 Impact Mitigation and Management

8.1 Introduction

In order to minimise potential ecological impacts resulting from the proposed activity, the location and design of the proposed pilot well lease areas and associated infrastructure, and identification of appropriate mitigation measures has been undertaken in accordance with the 'avoid – minimise – mitigate – offset' hierarchy:

- **Avoiding** the impact altogether by relocating the proposed activity, or parts of an activity;
- **Minimising** impacts by restricting the magnitude of the proposed activity and its implementation;
- **Mitigating** the impact of the activity by appropriately managing the proposed activity, and rehabilitating, or restoring the affected environment; and
- **Offsetting** the impacts.

Avoid

Clearing of habitat trees will be avoided where possible. Where hollow-bearing trees occur along lease boundaries, lease areas will be reduced to minimise the removal of these trees.

Existing roads have been utilised for connection between well leases. New access tracks have been located to avoid the removal of hollow-bearing trees, and distances minimised where possible.

Access tracks have been located to avoid hollow-bearing trees and large Eucalypt species. Areas of greater disturbance have been selected for access tracks.

Given the presence of Pilliga Mouse, infrastructure has been located to avoid Heath communities to minimise the impact upon this species.

Minimise

The disturbance area will be minimised to reduce unnecessary clearing and earthworks by ensuring leases are kept to the minimum size requirement of 1ha. Additionally, the disturbance areas will be appropriately demarcated to ensure machinery and personell are limited to the designated disturbance area. Vehicle speeds along the access track will be limited to minimise dust generation.

The gathering system has been placed adjacent to existing roads and proposed access tracks to minimise the disturbance width required.

While clearing or disturbances to vegetation occurs, a fauna spotter-catcher will be on site to supervise works to minimise impacts upon fauna populations.

To minimise impacts on nearby waterway, all liquids (fuel, oil, cleaning agents, drilling liquids etc) will be stored appropriately and disposed of at suitably licensed facilities.

Mitigate

A range of mitigation measures will be implemented to minimise impacts upon flora and fauna in the survey area.

Introduction and prolifercation of weeds may be encouraged due to disturbance of soil, or transport of seeds via dirty vehicles and machinery. Weed managment measures will be implemented, including the need for washdowns when travelling from areas of known weed infestations to the site. Monitoring will occur to ensure any weed growth is controlled via mechanical or chemical methods, and will be undertaken within and adjacent to disturbance areas.

Clearing of vegetation cannot be avoided, and may result in disturbances to fauna species. As such, a Flora and Fauna Management Plan is recommended to ensure appropriate mitigation measures are implemented.

When disturbances to vegetation occur, a fauna spotter-catcher must be present to oversee works. The fauna spotter-catcher is responsible for removing fauna from habitat prior to clearing, and inspecting fallen timber following clearing.

Hollow logs are to be removed from the disturbance areas and relocated in habitats adjacent to the lease areas under supervision from the fauna spotter-catcher. Fauna sensitive clearing techniques will be implemented, including vibrating the bucket on large trees (particuarly hollow-bearing trees) prior to clearing, and dismantling large trees is recommended.

Should injury to fauna occur, the fauna spotter-catcher must immediately transport injured fauna to a vet. Works cannot recommence until the fauna spotter-catcher returns to site. Should injury occur whilst the fauna spotter-catcher isn't present (e.g. – vehicle strike), fauna must be transported to the vet by contractors.

In addition to sensitive clearing techniques, fencing must be installed around lease areas prior to vegetation clearing commencing to clearly demarcate work areas and prevent over-clearing. Access tracks must also be clearly pegged or flagged to ensure vegetation clearing is minimised. Where hollow bearing trees occur on the edge of lease areas, they are to be protected where possible, and clearly marked.

Access to the sites is to be limited to only the designated access tracksto prevent additional disturbances to vegetation. All equipment and machinery is to be stored within the lease areas, and not outside of the fenced areas. Parking is not to occur within adjacent areas.

Dogs are not permitted on site to prevent further risk to native fauna.

Following construction of the lease areas, and operation of the pilot wells, partial rehabilitation will commence, incorporating the reduction of the lease area footprint. A Rehabilitation Management Plan will be implemented. Topsoil is to be stockpiled within the lease area, and is to be respread as part of partial rehabilitation. Where large trees are cleared, timber is to be stockpiled within the lease area for re-spreading as part of partial rehabilitation. Natural regeneration is the preferred approach, with assisted regeneration occuring if natural regeneration is unsuccessful.

Offset

Due to the proposed activities being minimal in extent, as well as the recommended mitigation measures to rehabilitate the activity site being implemented, offsets are not required.

9.0 Conclusion

Santos is proposing to drill and operate four petroleum exploration pilot wells at Dewhurst 22 to 25. The survey area occurs within the Pilliga East State Forest which forms part of a large tract of bushland referred to as the Pilliga Scrub. The survey area is well vegetated and mostly occurs on undulating low rises. Spring Creek and several ephemeral drainage lines occur within the vicinity of the area of consideration. These waterways drain into Bibblewindi Creek.

The proposed activity will require the construction of four 100m by 100m lease areas, resulting in 1ha of disturbance at each pilot well location. Additional infrastructure, consisting of access tracks and a gathering system, will require disturbance in the form of a 10m wide corridor. A 35m by 35m flare is also proposed, located within the 1ha Dewhurst 22 lease area.

The total disturbance arising from the well leases, tracks and flare is 6.29 ha, including existing roads. A total of approximately 5.98 ha of vegetation will require removal.

RPS have undertaken an ecological assessment of the proposed lease areas, access tracks and gathering system corridor to identify potential ecological impacts and recommend appropriate mitigation measures to reduce and manage ecological impacts. A preliminary assessment was carried out on the 17th and 19th September 2012 to identify ecological constraints and assess habitat for potentially occurring significant species as listed under the EPBC Act and TSC Act. A detailed assessment was subsequently conducted between the 8th October and 12th October which included detailed flora and fauna surveys, with an additional flora survey conducted on the 24th January 2013.

Three vegetation communities and habitats occur within the survey area. Narrow-leaved Shrubby Ironbark Woodland is the dominant community within the survey area with Heath and Riparian Woodland also occurring. None of these communities are commensurate with any of the seven TECs or nine EECs that were identified during the desktop assessment.

Although suitable habitat was identified for five EPBC Act and five TSC Act listed flora species, no threatened flora species were recorded in the survey area during flora surveys. Three threatened flora species (*Bertya opponens*, Native Milkwort and *Rulingia procumbens*) were considered to possibly occur, despite not being recorded, owing to the fact that they have been previously identified within 10km of the site (OEH 2012, Eco Logical 2011).

Fauna habitat in the survey area is characterised by woodland and heath communities that provide distinctly unique resources and niches for native fauna. Both habitats are generally in good condition with disturbances limited to logging for forestry, clearing of roads and minor impacts associated with introduced fauna and weeds.

Woodland habitats generally consist of moderately sparse canopy and variable understorey.Hollow bearing Eucalypts are common throughout most of the woodland vegetation and generally range from small to medium in size, but occasional large hollows also occur. Ground cover is generally sparse, however, fallen timber and low shrubs provide additional habitat resources for terrestrial species.

Riparian woodland is similar in stucture to the Woodland habitat, and is associated with the ephemeral waterways occuring throughout the survey area.

The heath habitat consists of a sparse canopy, and a dense shrub layer, with some patches having mutliple shrub layers. Hollow-bearing trees occur but in much lower densities than woodland habitat. A dense and floristically diverse shrub layer provide abundant habitat resources for native fauna including foraging resources for nectar reliant bird species as well as increased foraging, sheltering and breeding opportunities for ground-dwelling fauna. Groundcover is highly variable with areas with higher cover considered more suitable for native mammal species. A high abundance of fallen timber provides shelter and breeding habitat for many native reptiles and mammals.

Fauna surveys identified 50 bird species, 19 mammal species and 11 reptile species within the survey area. One threatened species listed under the EPBC Act, and six threatened species listed under the TSC Act were recorded in the survey area.

Two Pilliga Mouse (*Pseudomys pilligaensis*), listed as Vulnerable under the EPBC Act and TSC Act, were captured along the ecotone between Heath and Riparian woodland habitats, to the north-east of Dewhurst 25.

The remaining five TSC Act listed species recorded during the surveys were Turquoise Parrot, Grey-crowned Babbler, Speckled Warbler, Hooded Robin and Yellow-bellied Sheathtail-bat which are all listed as Vulnerable. A further 20 threatened fauna species are considered likely or possible to occur in the area based on the habitat and proximity of previous records.

Although no migratory species were observed during the survey, it is expected that the Rainbow Bee-eater (*Merops ornatus*), White-throated Needletail (*Hirundapus caudacutus*) and Regent Honeyeater (*Anthochaera phyrgia*) are likely to occur on site.

One MNES was confirmed as occurring in the survey area during this assessment. The Pilliga Mouse was recorded along an ephemeral drainage line with a dense understorey consisting of flora species typical of the adjacent heath community. This species is known to prefer habitats consisting of high plant species richness, a moderate to high low shrub cover, and a moist groundcover of plants, litter and fungi, especially areas dominated by Broombrush and areas containing an understorey of *Acacia burrowii* with a *Corymbia trachyphloia* canopy (SEWPaC, 2012a).

A total of 155.5 ha of Pilliga Mouse habitat was recorded in the survey area, comprising Heath and Riparian Woodland. To minimise impacts upon the Pilliga Mouse, clearing within core habitat has been minimised where possible. All Heath has been avoided, and only 1.02 ha of Riparian Woodland is to be removed, much of which is lacking the high species richness preferred by this species.

Impacts from Dewhurst 22 to 25 have been minimised through location of the four wells access tracks and gathering systems to avoid and minimise sensitive areas where possible. In particular, the location of wells has been designed to avoid disturbance to Spring Creek and clearing of associated riparian habitat and impacts on Pilliga Mouse have been reduced by avoiding suitable heath habitat.

The majority of potential impacts from the project are associated with vegetation removal, as well as increased noise, dust, and light. Additionally, there is the potential for weed incursion due to introduction from vehicles and machinery. In particular the following ecological impacts are likely to occur as a result of Dewhurst 22-25 and associated infrastructure:

- Loss of 5.98 ha of vegetation;
- Loss of hollow bearing trees;
- Disturbance and/or loss of habitat associated with fallen woody debris and particularly hollow logs;
- Fauna displacement;
- Disruption of breeding cycle, roosting and sheltering behaviour;

- Impacts on migration and dispersal ability;
- Disruption of pollination cycle and seed dispersion;
- Introduction of weeds and feral pest species; and
- Increased noise, dust and light, particularly during construction and drilling.

To minimise the impacts on the local population of the Pilliga Mouse and other native fauna species, a number of key mitigation measures are proposed and recommended:

- Where possible retain hollow bearing trees occur on the edge of lease areas and access tracks;
- Weed management including washdowns of all vehicles and machinery;
- Fauna spotter-catchers engaged to oversee vegetation clearing;
- Hollow logs are relocated in adjacent vegetation to the lease areas;
- Installation of fencing around lease areas prior to vegetation clearing commencing to clearly demarcate work areas and prevent over-clearing;
- Access tracks must also be clearly pegged or flagged to ensure vegetation clearing is minimised;
- Dogs are not permitted on site to prevent further risk to native fauna;
- Following construction of the lease areas partial rehabilitation will commence to reduce the lease area footprint. Natural regeneration is the preferred approach, with assisted regeneration occurring if natural regeneration is unsuccessful;
- Topsoil is to be stockpiled within the lease area, and is to be respread as part of partial rehabilitation;
- Where large trees are cleared, timber is to be stockpiled within the lease area for re-spreading as part of partial rehabilitation; and
- Full rehabilitation of the well lease is to occur upon decommissioning of the pilot wells and access tracks.

The assessment under the significant impact guidelines concludes that the proposed activities will not have a significant impact on MNES or threatened species and communities listed under the TSC act provided that the recommended controls and mitigation measures are implemented.

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Appendix 1

EPBC Protected Matters Search

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

EPBC Act Protected Matters Report

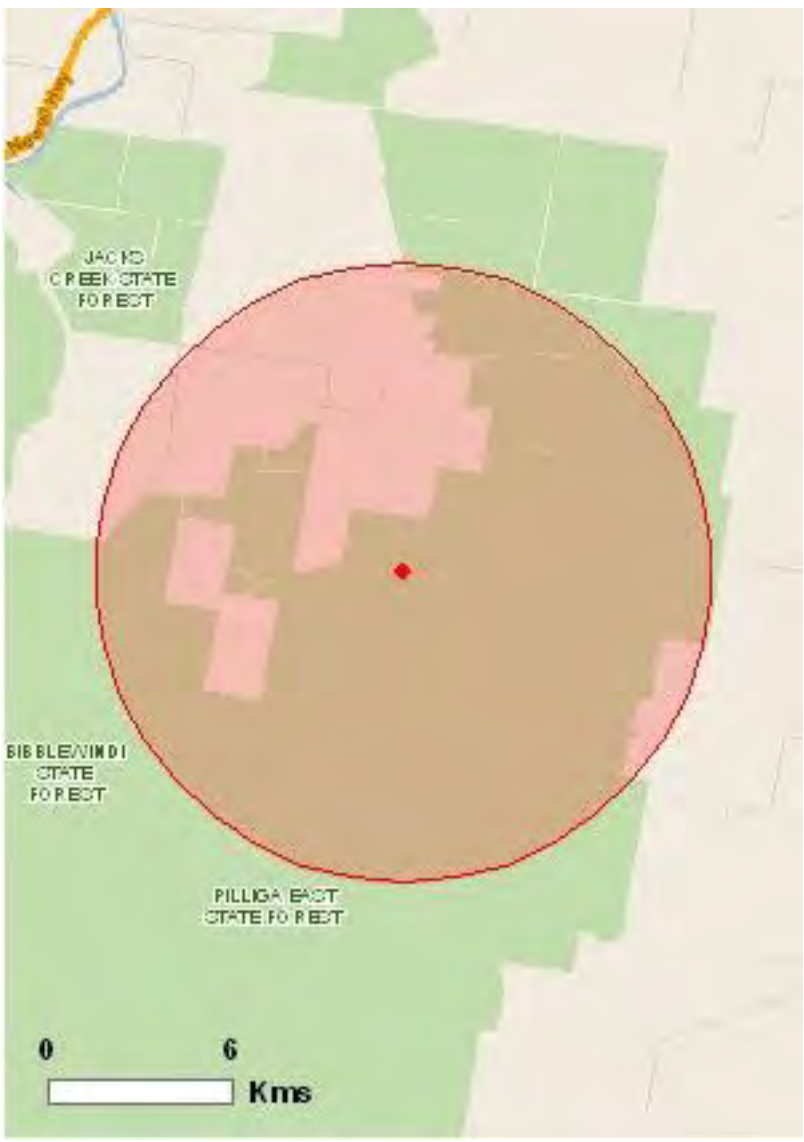
This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 19/09/12 10:40:20

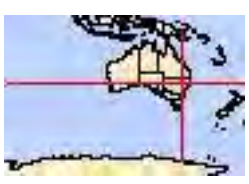
Summary
Details
Matters of NES
Other Matters Protected by the EPBC Act
Extra Information
Caveat
Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates

Buffer: 10.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	18
Listed Migratory Species:	12

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate.

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	9
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	11
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Community may occur within area
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Critically Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community may occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anthochaera phrygia		
Regent Honeyeater [82338]	Endangered	Species or species habitat may occur within area
Geophaps scripta scripta		
Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat may occur within area
Lathamus discolor		
Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Leipoa ocellata		
Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Polytelis swainsonii		
Superb Parrot [738]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
[Rostratula australis](#)		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
Fish		
[Maccullochella peelii](#)		
Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area
Mammals		
[Chalinolobus dwyeri](#)		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
[Nyctophilus corbeni](#)		
South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
[Petrogale penicillata](#)		
Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat may occur within area
[Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)](#)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
[Pseudomys pilligaensis](#)		
Pilliga Mouse [99]	Vulnerable	Species or species habitat likely to occur within area
Plants		
[Bertya opponens](#)		
[13792]	Vulnerable	Species or species habitat likely to occur within area
[Philotheca ericifolia](#)		
[64942]	Vulnerable	Species or species habitat likely to occur within area
[Pterostylis cobarensis](#)		
Cobar Greenhood Orchid [12993]	Vulnerable	Species or species habitat likely to occur within area
[Rulingia procumbens](#)		
[12903]	Vulnerable	Species or species habitat likely to occur within area
[Tylophora linearis](#)		
[55231]	Endangered	Species or species habitat may occur within area
Reptiles		
[Uvidicolus sphyrurus](#)		
Border Thick-tailed Gecko, Granite Belt Thick-tailed Gecko [84578]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
[Apus pacificus](#)		
Fork-tailed Swift [678]		Species or species habitat may occur within area
[Ardea alba](#)		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
[Ardea ibis](#)		
Cattle Egret [59542]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Xanthomyza phrygia Regent Honeyeater [430]	Endangered*	Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species

Name	Threatened	Type of Presence
		habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Endangered	Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Vulnerable*	Species or species habitat may occur within area

Extra Information

Invasive Species	[Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur within area
Mammals		
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area

Name	Status	Type of Presence
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Tamarix aphylla		
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area

Coordinates

-30.61194 149.75861

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix 2

Survey Area Species List

Scientific Name	Common Name
Acacia amblygona	Fan Wattle
Acacia caroleae	Carol's Wattle
Acacia dealbata	Silver Wattle
Acacia deanei	Green Wattle
Acacia pilligaensis	Pilliga Wattle
Acacia spectabilis	Mudgee Wattle
Acacia triptera	Spur-wing Wattle
Allocasuarina luehmanni	Bull oak
Angophora floribunda	Rough-barked Apple
Aotus ericoides	Common Aotus
Aristida calycina	Dark Wiregrass
Arundinella nepalensis	Reed Grass
Boronia glabra	Sandstone Boronia
Callitris endlicheri	Black Cypress
Callitris glaucophylla	White Cypress
Calytrix tetragona	Common Fringe-myrtle
Cassinia laevis	Cough Bush
Cheilanthes sieberi	
Corymbia trachyphloia	White Bloodwood
Damperia appressa	Bushy Dampiera
Damperia lanceolata	Grooved Dampiera
Daviesia acicularis	Sandplain Bitter-pea
Dodoneae viscosa	
Eragrostis sp.	
Eucalyptus blakelyi	Blakely's Red Gum
Eucalyptus chloroclada	Dirty Gum
Eucalyptus crebra	Narrow-leaved Ironbark
Eucalyptus dwyeri	Dwyer's Red Gum
Fimbristylis dichotoma	
Gahnia aspera	Rough Saw-sedge
Goodenia cycloptera	Serrated Goodenia
Goodenia hederacea	Forest Goodenia
Grevillea floribunda	Seven Dwarfs Grevillea
Hardenbergia violaceae	Purple Coral Pea
Hibbertia obtusifolia	Hoary Guinea Flower
Homoranthus flavescens	
Laxmannia gracilis	Wire lily
Leucopogon juniperous	Prickly Beard-heath
Leucopogon biflorus	Twin-flower Beard-heath
Lomandra leucocephala	Woolly Mat-rush

Scientific Name	Common Name
Lomandra multiflora	Many-flowered Mat-rush
Macrozamia polymorpha	
Melaleuca uncinata	Broom bush
Melichrus erubescens	Ruby Urn Heath
Melichrus urceolatus	Urn-heath
Micromyrtus ciliata	Fringed Heath Myrtle
Pomax umbellata	Pomax
Persoonia cuspidifera	
Pimelea stricta	Cough Bush
Wahlenbergia gracilis	Australian Bluebells
Wahlenbergia communis	Tufted Bluebells
Xanthorrhoea johnsonii	Grass tree
Jacksonia scoparia	Native Cherry
Alphitonia excelsa	Red Ash
Pultanea villosa	Kerosene Bush
Xanthorrhoea acaulis	

Appendix 3

Threatened Ecological Communities – Likelihood of Occurrence and Potential for Impact

Threatened ecological communities (listed under the TSC Act and the EPBC Act) that have been gazetted / recorded from within the locality have been considered in this ecological assessment. Each community is considered for its potential to occur within the survey area and the likely level of impact as a result of the proposed activities. This ecological assessment deals with each community separately and identifies the ecological parameters of significance associated with the proposed activities.

'TEC'– Lists each threatened ecological community known from the vicinity of the site. The status of each community under the *TSC Act* and *EPBC Act* is also provided.

'Habitat' – Provides a brief account of community and the preferred habitat attributes required for the existence / survival of each community.

'Likelihood of Occurrence'– Assesses the likelihood of each community to occur within the site in terms of the aforementioned habitat description and taking into account local habitat preferences, results of recent field investigations, data gained from various sources and previously gained knowledge via fieldwork undertaken within other ecological assessments in the locality.

'Potential for Impact' – Through consideration of the likely level / significance of impacts to each community that would result from the proposed activities, taking into account both short and long-term impacts, a decision has been made whether further assessment is required. This assessment is largely based on the chance of occurrence of each community. It also considers the scope of the proposed activities.

Community	TSC Act	EPBC Act	Description	Likelihood of Occurrence	Potential for Impact
TSC Act - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions EPBC Act - Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	EEC	E	Distribution is limited to the Darling Riverine Plains and the Brigalow Belt South Bioregions. This ecological community represents occurrences of one type of eucalypt woodland where (Coolibah, Coolabah (Eucalyptus coolabah subsp. coolabah) and/or Black Box (Eucalyptus largiflorens) are the dominant canopy species and where the understorey tends to be grassy. This community is found on the grey, self-mulching clays of periodically waterlogged floodplains, swamp margins, ephemeral wetlands, and stream levees. The main tree species in the canopy of the woodland are Coolibah (*Eucalyptus coolabah* subsp. *coolabah*) and/or Black Box (*Eucalyptus largiflorens*). Other trees that may be present include: *Acacia salicina* (Cooba), *Acacia stenophylla* (River Cooba), *Casuarina cristata* (Belah), *Eremophila bignoniiflora* (Eurah), *Eucalyptus camaldulensis* (River Red Gum) and *Eucalyptus populnea* (Bimble Box, Poplar Box).	This ecological community was not identified in the survey area.	Considered unlikely to be adversely affected by the proposed activities, as this ecological community is not known to occur in the survey area, therefore AoS for this species is not required.
TSC Act - Inland Grey Box Woodland in the Riverina; NSW South Western Slopes; Cobar Peneplain; Nandewar and Brigalow Belt South Bioregions EPBC Act - Grey Box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of south-eastern Australia	EEC	E	Inland Grey Box Woodland includes those woodlands in which the most characteristic tree species, *Eucalyptus microcarpa* (Inland Grey Box), is often found in association with *E. populnea* subsp. bimbil (Bimble or Poplar Box), *Callitris glaucophylla* (White Cypress Pine), *Brachychiton populneus* (Kurrajong), *Allocasuarina luehmannii* (Bulloak) or *E. melliodora* (Yellow Box), and sometimes with *E. albens* (White Box). The community generally occurs as an open woodland 15–25 m tall but in some locations the overstorey may be absent as a result of past clearing or thinning, leaving only an understorey. Inland Grey Box Woodland occurs predominately within the Riverina and South West Slopes regions of NSW down to the Victorian border. This community also extends across the slopes and plains in Central and Northern NSW up to the Queensland Border.	The main indicator canopy species (Grey Box) was not was recorded within the survey area, therefore this community does not occur.	Considered unlikely to be adversely affected by the proposed activities, as this ecological community is not known to occur in the survey area, therefore AoS for this species is not required.
TSC Act - Native Vegetation on Cracking Clay Soils of the Liverpool Plains EPBC Act – Natural Grasslands on Basalt and Fine-textured	EEC	CE	Native Vegetation on Cracking Clay Soils of the Liverpool Plains is mainly a native grassland community which includes a range of small forb and herb species. The main grass species include Plains Grass (*Austrostipa aristiglumis*), Queensland Bluegrass (*Dichanthium sericeum*) and Coolibah Grass (*Panicum queenslandicum*). It also contains scattered and patchy shrubs and trees, including Boree (*Acacia pendula*), Rough-barked Apple (*Angophora floribunda*), Fuzzy Box (*Eucalyptus conica*), Bimble Box (*E. populnea*) and Yellow Box	No grasslands were observed within the survey area. This community does not occur.	Considered unlikely to be adversely affected by the proposed activities, as this ecological community is not known to occur in the survey area, therefore AoS for this species is not required.

Community	TSC Act	EPBC Act	Description	Likelihood of Occurrence	Potential for Impact
Alluvial Plains of Northern New South Wales and Southern Queensland			(*E. melliodora*). In wetter locations rushes and sedges are common. This community is located around Coonabarabran, Gunnedah, Murrurundi, Narrabri, Tamworth and Quirindi, on the North West Slopes and Plains of NSW. Most surviving remnants of the community are on Travelling Stock Routes.		
EPBC Act - Weeping Myall Woodlands TSC Act - Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions	EEC	E	This ecological community is scattered across the eastern parts of the alluvial plains of the Murray-Darling river system. Typically, it occurs on red-brown earths and heavy textured grey and brown alluvial soils within a climatic belt receiving between 375 and 500 mm mean annual rainfall. The structure of the community varies from low woodland and low open woodland to low sparse woodland or open shrubland, depending on site quality and disturbance history. The tree layer grows up to a height of about 10 metres and invariably includes Weeping Myall (Acacia pendula) as one of the dominant species or the only tree species present. This EEC is known from parts of the Local Government Areas of Berrigan, Bland, Bogan, Carrathool, Conargo, Coolamon, Coonamble, Corowa, Forbes, Gilgandra, Griffith, Gwydir, Inverell, Jerilderee, Lachlan, Leeton, Lockhart, Moree Plains, Murray, Murrumbidgee, Narrabri, Narranderra, Narromine, Parkes, Urana, Wagga Wagga and Warren, and but may occur elsewhere in these bioregions.	This ecological community was not identified in the survey area.	Considered unlikely to be adversely affected by the proposed activities, as this ecological community is not known to occur in the survey area, therefore AoS for this species is not required.
TSC Act - White Box Yellow Box Blakely's Red Gum Woodland EPBC Act - White Box-Yellow Box-Blakely's Red Gum grassy woodland and derived native grassland	EEC	E	White Box Yellow Box Blakely's Red Gum Woodland (commonly referred to as Box-Gum Woodland) is an open woodland community (sometimes occurring as a forest formation) , in which the most obvious species are one or more of the following: White Box Eucalyptus albens, Yellow Box E. melliodora and Blakely's Red Gum E. blakelyi. Intact sites contain a high diversity of plant species, including the main tree species, additional tree species, some shrub species, several climbing plant species, many grasses and a very high diversity of herbs.	Blakely's Red Gum was observed within the survey area, and is considered to be a key indicator species for this TEC. However, as Blakely's Red Gum is not a dominant species, and a dense shrub layer is present (ranging from 30% to 50% cover), the Riparian Woodland that contains Blakely's Red Gum is not considered to be a TEC.	Considered unlikely to be adversely affected by the proposed activities, as this ecological community is not known to occur in the survey area, therefore AoS for this species is not required.
TSC Act - Brigalow	EEC	E	The listed ecological community is characterised by the presence of	This community was not	Unlikely to be impacted by

Community	TSC Act	EPBC Act	Description	Likelihood of Occurrence	Potential for Impact
within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions EPBC Act - Brigalow (*Acacia harpophylla* dominant and co-dominant).			Brigalow (*Acacia harpophylla*) as one of the three most abundant tree species. Brigalow is usually either dominant in the tree layer or co-dominant with other species such as *Casuarina cristata* (Belah), other species of *Acacia*, or species of *Eucalyptus*. Occasionally Belah, or species or *Acacia* or *Eucalyptus* may be more common than Brigalow within the broad matrix of Brigalow vegetation. The structure of the vegetation ranges from open forest to open woodland. The height of the tree layer varies from about 9 m in low rainfall areas (averaging around 500 mm per annum) to around 25 m in higher rainfall areas (averaging around 750 mm per annum) (Butler 2007). A prominent shrub layer is usually present.	observed within the survey area, and is considered unlikely to occur.	the proposed activity.
TSC Act - *Cadellia pentastylis* (Ooline) community in the Nandewar and Brigalow Belt South Bioregions	EEC	-	The Ooline community is an unusual and distinctive forest community with the canopy dominated by the tree Ooline (*Cadellia pentastylis*). Other canopy species include White Box (*Eucalyptus albens*), Ironbarks (*E. beyeriana* and *E. melanophloia*), Dirty Gum (*E. chloroclada*), Narrow-leaved Grey Box (*E. pilligaensis*), Green Mallee (*E. viridis*) and White Cypress Pine (*Callitris glaucophylla*). The understorey is made up of a range of shrubs such as Wattles and grasses.	This community was not observed within the survey area, and is considered unlikely to occur.	Unlikely to be impacted by the proposed activity.
Fuzzy Box Woodland on alluvial soils of the south western slopes, Darling Riverine Plains and Brigalow Belt South bioregions	EEC	-	Woodland or open forest usually dominated by Fuzzy Box *Eucalyptus conica,* which often grows with Inland Grey Box *Eucalyptus microcarpa*, Yellow Box *Eucalyptus melliodora* or Kurrajong *Brachychiton populneus*. Bulloak *Allocasuarina luehmannii* is common in places. Shrubs are generally sparse and include *Acacia deanei*, *Dodonaea viscosa, Geijera parvifolia, Acacia implexa, Senna artemisioides* sens. lat., *Myoporum montanum* and *Cassinia aculeata*. Small shrubs include *Maireana microphylla* and *Sclerolaena muricata*. The ground cover may be dense after rain but is usually moderately dense. It comprises native forbs, including *Calotis cuneifolia, Sida corrugata, Einadia hastata, Dianella revoluta* and *Bracteantha viscosa*, prostrate shrubs such as *Eremophila debilis, Maireana enchylaenoides,* and native grasses including *Austrostipa scabra, Chloris truncata, Elymus scaber, Themeda australis* and *Austrodanthonia setacea.*	This community was not observed within the survey area, and is considered unlikely to occur.	Unlikely to be impacted by the proposed activity.

Community	TSC Act	EPBC Act	Description	Likelihood of Occurrence	Potential for Impact
Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions	EEC	E	A form of dry rainforest which in New South Wales is found in the Brigalow Belt South and Nandewar Bioregions. The Community is made up of vines, deciduous (and/or facultatively deciduous) tree species that have affinities with species from subtropical rainforest. Characteristic canopy dominants are *Cassine australis var. angustifolia, Geijera parvifolia* and *Notelaea microcarpa var. microcarpa*, but with emergents typical of the surrounding woodlands (*Eucalyptus albens, Eucalyptus melanophloia and Callitris glaucophylla*).	This community was not observed within the survey area, and is considered unlikely to occur.	Unlikely to be impacted by the proposed activity.

Appendix 4

Threatened Flora and Fauna - Likelihood of Occurrence and Potential for Impact

Those threatened flora and fauna species (listed under the *TSC Act* and the *EPBC Act*) that have been gazetted / recorded from within the locality have been considered in this ecological assessment. EEC's and Endangered Populations known from the broader area have also been addressed. Each species / community / population is considered for its potential to occur within the survey area and the likely level of impact as a result of the proposed activities. This ecological assessment deals with each species / community / population separately and identifies the ecological parameters of significance associated with the proposed activities.

Those species / communities that have been identified as potentially being impacted have been assessed as set out in **Appendix 4** and **Appendix 5**.

'Species' or **'EEC / Population'** – Lists each threatened species / EEC / population known from the vicinity of the site. The status of each threatened species under the *TSC Act* and *EPBC Act* is also provided.

'Habitat' – Provides a brief account of the species / community / population and the preferred habitat attributes required for the existence / survival of each species / community / population.

'Likelihood of Occurrence'– Assesses the likelihood of each species / community / population to occur within the site in terms of the aforementioned habitat description and taking into account local habitat preferences, results of recent field investigations, data gained from various sources and previously gained knowledge via fieldwork undertaken within other ecological assessments in the locality.

Likelihood of occurence were divided into four categories (Known, Likely, Possible and Unlikely), with classifcation differing slightly between flora and fauna species:

Fauna

- **Known:** Species recorded during the survey; and
- **Likely:** Species previously recorded within 10km of survey area (OEH 2012) and suitable habitat of the species recorded within the survey area; and
- **Possible:** Species previously recorded within 10km of survey area (OEH 2012) but no suitable habitat of the species recorded within the survey area. Or: species not previously recorded within 10km of survey area (OEH 2012) but suitable habitat of the species recorded within the survey area; and
- **Unlikely:** Species not previously recorded within 10km of survey area (OEH 2012) and no suitable of the species recorded within the survey area.

Flora

- **Known:** Species recorded during the survey; and
- **Possible:** Species previously recorded within 10km of survey area (OEH 2012) and suitable habitat occurs in the survey area; and
- **Unlikely:** Species not previously recorded within 10km of survey area (OEH 2012) and no suitable of the species recorded within the survey area.

'Potential for Impact' – Through consideration of the likely level / significance of impacts to each species / community / population that would result from the proposed activities, taking into account both short and long-term impacts, a decision has been made whether further assessment is required. This assessment is largely based on the chance of occurrence of each species / community with due recognition to other parameters such as home range, habitat use, connectivity etc. It also considers the scope of the proposed activities.

Threatened species included in the table below have been identified as potentially occurring based on:

- Results from an EPBC Act Protected Matters Search using a central coordinate buffered by 10km, and
- Records extracted from data provided by OEH (Ban Baa map sheet) within a 10km radius of the well leases.

Table 10.1 Threatened Flora and Fauna Likelihood of Occurrence and Potential for Impact

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
Flora						
Bertya opponens	Coolabah Bertya	V	V	Known populations within NSW occur in a number of different habitats, ranging from stony mallee ridges, heathy understoreys, and cypress pine forests of the inland, to cliff edges in the high rainfall eastern fall areas of the Great Dividing Range (DSEWPaC, 2012a).	Possible. Vegetation within the survey area comprises suitable habitat for this species, particularly within heathy areas. While not observed in the survey area, this species is known to occur within 10km of the survey area	While suitable habitat to support this species occurs within the survey area, clearing is considered to be minimal compared to surrounding available habitat. Given that it is unlikely that this species will be removed as part of the proposed activity, the potential for impact is considered to be low. Therefore, an AOS has not been undertaken for this species.
Philotheca ericifolia	-	-	V	Occurs in drainage areas in dry sclerophyll open forest or woodland on sandstone and in heath on damp sandy flats and gullies. Specific microclimates include damp sandy flats, alluvial deposits of coarse gravel in dry creek beds and along a spur receiving soakage from high ground. Associated species include *Eucalyptus crebra*, *Beyeria viscosa* and *Philotheca australis* (DSEWPaC, 2012a).	Possible. Suitable habitat occurs throughout the survey area. Vegetation surveys did not identify this species occurring within the survey area, and it has not previously been identified within 10km of the survey area.	The potential for significant impact is considered to be low. Targeted searches for this species were conducted, and it was not observed.
Polygala linariifolia	Native Milkwort	E	-	Occurs in sandy soils in dry eucalypt forest and woodland with a sparse understorey. The species has been recorded from the Inverell and Torrington districts growing in dark sandy loam on granite in shrubby forest of *Eucalyptus caleyi, Eucalyptus dealbata* and *Callitris*, and in yellow podsolic soil on granite in layered open forest. In the Pilliga area, this species has been recorded in Fuzzy Box woodland, White Cypress Pine-Bulloak - Ironbark woodland, Rough-barked Apple riparian forb-grass open forest, and Ironbark - Brown Bloodwood shrubby woodland. Other associated species include	Possible. Suitable habitat occurs in the survey area. While not observed in the survey area, this species is known to occur within 10km of the survey area.	While suitable habitat to support this species occurs within the survey area, clearing is considered to be minimal compared to surrounding available habitat. Given that it is unlikely that this species will be removed as part of the proposed activity, the potential for impact is considered to be low. Therefore, an AOS has not been undertaken for this species.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				Eucalyptus trachyphloia, Eucalyptus sphaerocarpa, Angophora floribunda, Angophora leiocarpa, Tristania suaveolens, Allocasuarina torulosa and *Wahlenbergia* species in the understorey (OEH, 2012a).		
Pterostylis cobarensis	Greenhood Orchid	V	V	This species inhabits Eucalypt woodland, open mallee, or *Callitris* shrubland on low stony ridges and slopes with skeletal sandy-loam soils. The known distribution of this species overlaps with the Semi-Evergreen Vine Thickets of the Brigalow Belt and Nandewar Bioregions, the Brigalow ecological communities and the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland communities and the Buloke Woodlands of Riverina and Murray-Darling Depression Bioregions (DSEWPaC, 2008a).	Possible. Suitable habitat occurs within the survey area, given the presence of Eucalypt Woodland. Vegetation surveys did not identify this species occurring within the survey area, and it is not known to occur within 10km of the survey area.	The potential for significant impact is considered to be low. This species was not observed within the survey area. Therefore, an AOS has not been undertaken for this species.
Rulingia procumbens	-	V	V	Occurs in sandy soils, often in disturbed habitats such as road verges, quarry boundaries, gravel stockpiles, and power line easements It is often found in communities of *Eucalyptus dealbata–E. sideroxylon* woodland, *Melaleuca uncinata* shrubland, and mallee eucalypt with *Calytrix tetragona* understorey. Associated species include *Acacia triptera, Callitris endlicheri, Eucalyptus melliodora, Allocasuarina diminuta, Philotheca salsolifolia, Xanthorrhoea* spp., *Exocarpos cupressiformis, Leptospermum parvifolium*, and *Kunzea parvifolia*. The distribution of this species overlaps with the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland EPBC Act-listed threatened ecological community (TSSC, 2008c).	Possible. Suitable habitat occurs in the survey area, particularly within heathland, and Narrow-leaved Ironbark Shrubby Woodland, as well as adjacent to the existing access tracks within sandy soils. Vegetation surveys did not identify this species occurring within the survey area, however, it is known to occur within 10km of the survey area (Eco Logical 2011)	While suitable habitat to support this species occurs within the survey area, clearing is considered to be minimal compared to surrounding available habitat. Given that it is unlikely that this species will be removed as part of the proposed activity, the potential for impact is considered to be low. Therefore, an AOS has not been undertaken for this species.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
Tylophora linearis	-	V	E	Grows in dry scrub, open forest and woodlands associated with *Melaleuca uncinata*, *Eucalyptus fibrosa, E. sideroxylon, E. albens, Callitris endlicheri, C. glaucophylla, Allocasuarina luehmannii, Acacia hakeoides, A. lineata, Myoporum* spp., and *Casuarina* spp. The distribution of this species overlaps with the Brigalow (*Acacia harpophylla* dominant and co-dominant), and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland threatened ecological communities (DSEWPaC, 2008b).	Possible. Suitable habitat occurs in the survey area, particularly within Heath and Narrow-leaved Ironbark Shrubby Woodland. Vegetation surveys did not identify this species occurring within the survey area, and it is not known to occur within 10km of the survey area.	The potential for significant impact is considered to be low. This species was not observed within the survey area. Therefore, an AOS has not been undertaken for this species.
Birds						
Anthochaera phrygia	Regent Honeyeater	CE	E	Mostly occur in dry Box-Ironbark eucalypt woodland and dry sclerophyll forest associations in areas of low to moderate relief, wherein they prefer moister, more fertile sites available, for example along creek flats, or in broad river valleys and foothills. In NSW, riparian forests containing River Oak (*Casuarina cunninghamiana*), and with Needle-leaf Mistletoe (*Amyema cambagei*), are also important for feeding and breeding. At times of food shortage (e.g. when flowering fails in preferred habitats), Regent Honeyeaters also use other woodland types and wet lowland coastal forest dominated by Swamp Mahogany (*Eucalyptus robusta*) or Spotted Gum (*Corymbia maculata*). They are typically associated with plant species that reliably produce copious amounts of nectar, such as Mugga Ironbark (*Eucalyptus sideroxylon*), Yellow Box (*E. melliodora*), White Box and Yellow Gum (*E. leucoxylon*), but also are in association	Likely. Suitable habitat present within areas of Narrow-leaved Ironbark Woodland, and Riparian woodland. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records. Birdlife Australia has historically recorded this species within the Pilliga Forests however.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 7** and **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				with woodland species such as Grey Box (*E. microcarpa*), Red Box (*E. polyanthemos*), Blakely's Red Gum (*E. blakelyi*), River Red Gum (*E. camaldulensis*), Silver-leaved Ironbark (*E. melanophloia*), Narrow-leaved Ironbark (*E. crebra*), Caley's Ironbark (*E. caleyi*) and Rough-barked Apple (*Angophora floribunda*) (DSEWPaC, 2012a).		
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	-	Occurs mainly in eucalypt forests and woodlands in which there is a sub canopy or understory of *Allocasuarina* or *Casuarina*, however Brigalow is also used in south-eastern Queensland (DSEWPaC, 2012b).	Possible. Suitable habitat occurs within the Narrow-leaved Ironbark Woodland, as some food trees are present. Suitable hollow-bearing trees also occur within the Riparian woodland, however the understorey does not comprise food trees. This species was not recorded within the survey area, but has been recorded within 10km of the site, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated given the minimal food trees and hollow-bearing trees to be removed. Therefore, an AOS has not been undertaken for this species.
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	-	Occupies eucalypt woodlands, particularly open woodland lacking a dense understorey, nesting in tree hollows (OEH, 2011a).	Likely. Suitable habitat occurs within Narrow-leaved Ironbark Woodland and Riparian Woodland, particularly within areas with a sparser understorey. This species was not recorded within the survey area, but has been recorded within 10km of the site, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
Daphoenositta chrysoptera	Varied Sittella	V	-	The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands, with a nearly continuous distribution in NSW from the coast to the far west. It inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland (OEH, 2011b).	Likely. Suitable habitat occurs within Narrow-leaved Ironbark Woodland and Riparian Woodland. This species was not recorded within the survey area, but has been recorded within 10km of the site, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.
Geophaps scripta scripta	Squatter Pigeon	E	V	Range from tropical, open dry sclerophyll woodlands and savannahs of north-eastern Australia. Prefer grassy understorey of eucalypt woodland close to permanent water bodies (Garnett, 1992).	Unlikely. The survey area is at the far southern extent of this species habitat. While Eucalypt woodland is a preferred habitat type, given the lack of permanent water bodies, and lack of grassy understorey that provides breeding habitat, this species is considered unlikely to occur. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records.	Unlikely to be significantly impacted by the proposed action. Therefore, an AOS has not been undertaken for this species.
Glossopsitta pusilla	Little Lorikeet	V	-	Mostly occur in dry, open eucalypt forests and woodlands. They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes. They feed primarily on nectar and pollen in the tree canopy, particularly on profusely-flowering eucalypts and also on melaleucas and mistletoes. On the western slopes and tablelands, White Box (*Eucalyptus albens*) and Yellow *Box* (*E. meliodora*) are particularly important food sources for pollen and nectar respectively	Likely. Suitable habitat occurs within Narrow-leaved Ironbark Woodland and Riparian Woodland. This species was not recorded within the survey area, and has been recorded within 10km of the survey area, based on OEH records, and is therefore considered likely to occur.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				(OEH, 2011c).		
Lathamus discolor	Swift Parrot	E	E	This species is semi-nomadic during winter, foraging in dry woodlands mainly in Victoria and New South Wales. Smaller but significant numbers have been recorded regularly in south-eastern Queensland and occasionally in the Australian Capital Territory and south-eastern South Australia. In New South Wales, Swift Parrots forage in forests and woodlands throughout the coastal and western slopes regions each year. Coastal regions tend to support larger numbers of birds when inland habitats are subjected to drought. The breeding range closely mirrors the distribution of Blue Gum *Eucalyptus 76lobules* in Tasmania (Birds Australia, 2011).	Possible. Suitable habitat present within survey area, particularly within Narrow-leaved Ironbark Woodland, however this species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat. However, a significant impact is unlikely given the minimal disturbances proposed. Further assessment is not considered necessary.
Leipoa ocellata	Malleefowl	E	Migratory Vulnerable	Occurs in semi-arid and arid zones of temperate Australia, where it occupies shrublands and low woodlands that are dominated by mallee vegetation. It also occurs in other habitat types including eucalypt or native pine Callitris woodlands, acacia shrublands, Broombush *Melaleuca uncinata* vegetation or coastal heathlands.	Possible. Potential habitat is present within survey area, particularly within heathland communities. However, none of these areas are dominated by Mallee vegetation. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records. No recent records exist within the Pilliga Forest.	Proposed action has potential to remove and disturb suitable habitat. However, a significant impact is unlikely given the minimal disturbances proposed. Further assessment is not considered necessary.
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	-	Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses. Often perches on low dead stumps and	Known. This species was recorded during fauna surveys, within areas of Narrow-leaved Ironbark Woodland and Heath.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated, particularly given that this species is locally common. Refer to **Appendix 8**for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				fallen timber or on low-hanging branches, using a perch-and-pounce method of hunting insect prey (OEH, 2012b).		
Neophema pulchella	Turquoise Parrot	V	-	Habitat includes the steep, rocky ridges and gullies, rolling hills, valleys and river-flats and the nearby plains of the Great Dividing Range. The species occurs in eucalyptus woodlands and open forests, with a ground cover of grasses and low understorey of shrubs. These forests/woodlands usually have mixed assemblages of native pine Callitris and a variety of Eucalyptus species, especially White Box *E. albens*, Yellow Box *E. melliodora*, Blakely's Red Gum *E. blakelyi*, Red Box *E.polyanthemos* , Red Stringybark *E.macrorhyncha*, Bimble Box *E. populnea* or Mulga Ironbark *E. sideroxylon.* The species has also been recorded in a variety of other habitats, including savannah and riparian woodlands and farmland, preferring edges of forest and pasture or other grassland (NPWS, 1999b).	Known. This species was recorded during fauna surveys, within areas of Narrow-leaved Ironbark Woodland and Heath.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated, particularly given that this species is locally common. Refer to **Appendix 8**for AOS.
Ninox connivens	Barking Owl	V	-	Habitat typically dominated by eucalypts, often red gum species and, in the tropics, paperbarks *Melaleuca* species. It usually roosts in or under dense foliage in large trees including rainforest species of streamside gallery forests, River She-oak *Casuarina cunninghamiana*, other *Casuarina* and *Allocasuarina* species, eucalypts, *Angophora* or *Acacia* species. Roost sites are often near watercourses or wetlands. It typically breeds in hollows of large eucalypts or paperbarks, usually near watercourses or wetlands. Barking Owls have been recorded in remnants of forest and woodland and in clumps of trees at farms, towns and golf courses	Likely. Suitable habitat occurs within the survey area, particularly within and adjacent to Riparian Woodland habitat. This species was not recorded within the survey area, but has been recorded within 10km of the site, based on OEH records. The Pilliga Scrub is known to support a significant population. Given the large home ranges of these species, it is therefore considered likely that this species utilises the	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				(NPWS, 2003).	survey area.	

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
Polytelis swainsonii	Superb Parrot	V	V	Mainly inhabits forests and woodlands dominated by eucalypts, especially River Red Gums (*Eucalyptus camaldulensis*) and box eucalypts such as Yellow Box (*Eucalyptus melliodora*) or Grey Box (*E. 79acrocarpa*). The species also seasonally occurs in box-pine (Callitris) and Boree (*Acacia pendula*) woodlands (DSEWPaC, 2012a).	Unlikely Suitable foraging habitat for this species does not occur in the survey area. While limited preferred nesting trees occur, given that there is generally a positive correlation between nesting sites and adequate foraging habitat, this species is considered unlikely to occur. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat. However, a significant impact is unlikely given the minimal disturbances proposed. Further assessment is not considered necessary.
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	-	In NSW, the Grey-crowned Babbler occurs on the western slopes and plains but was less common at the higher altitudes of the tablelands. Isolated populations are known from coastal woodlands on the North Coast, in the Hunter Valley and from the South Coast near Nowra. The species occupy open woodlands dominated by mature eucalypts, with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (NSWSC, 2011).	Known. This species was recorded during fauna surveys, within areas of Narrow-leaved Ironbark Woodland and Heath.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated, given that this species is locally common. Refer to **Appendix 8** for AOS.
Pyrrholaemus sagittatus	Speckled Warbler	V	-	Occurs in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (NSWSC, 2012).	Known. This species was recorded during fauna surveys, within areas of Narrow-leaved Ironbark Woodland and Heath.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated given that this species is locally common. Refer to **Appendix 8** for AOS.
Rostratula australis	Australian Painted Snipe	E	V	Inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (DSEWPaC, 2012a).	Unlikely Suitable habitat is not present in survey area.	Unlikely to be significantly impacted by the proposed action. Therefore an AOS has not been undertaken.
Stagonopleura	Diamond Firetail	V	-	Species mainly inhabit grassy woodlands or wooded farmlands containing River Red	Possible.	Proposed action has potential to remove and disturb suitable habitat,

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
guttata				Gum *Eucalyptus camaldulensis*, Yellow Gum *Eucalyptus leucoxylon*, Murray Pine *Callitris gracilis* or Bulloak *Allocoasuarina luehmannii* near permanent water (SWIFFT, 2008).	No suitable habitat occurs within the survey area with no grassy understorey communities or permanent water occurring. This species was not recorded within the survey area, but has been recorded within 10km of the site, based on OEH records.	however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.
Tyto novaehollandiae	Masked Owl	V	-	The Masked Owl inhabits a diverse range of forests and woodlands including agricultural and forest mosaics. Forests with relatively open understoreys, particularly when these habitats adjoin areas of open or cleared land, are particularly favoured (DSEWPaC, 2012a).	Likely. Suitable habitat occurs within the survey area, particularly within and adjacent to Riparian Woodland habitat. This species was not recorded within the survey area, but has been recorded within 10km of the site, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.
Fish						
Maccullochella peelii	Murray Cod	-	V	Occur in diverse range of habitats, including clear rocky streams to slow flowing, turbid rivers and billabongs. Usually found near complex structural cover such as large rocks, snags, overhanging vegetation and other woody structures (National Murray Cod Recovery Team, 2009).	Unlikely. No suitable habitat occurs in the survey area. This species has not been recorded within 10km of the survey area, based on OEH records.	Unlikely to be significantly impacted by the proposed action.
Mammals						
Cercartetus nanus	Eastern Pygmy-possum	V	-	Found in temperate rainforest, dry and wet sclerophyll forest, banksia woodland, and coastal heath. The species shelters in a spherical nest of bark and leaves in tree hollows or other crannies (Dickman, Lunney & Menkhorst, 2008).	Likely. Large areas of suitable habitat present within survey area, with numerous hollow-bearing trees observed. This species was not recorded within the survey area, but has been recorded within 10km of the	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
					site, based on OEH records.	
Chalinolobus dwyeri	Large-eared Pied Bat, Large Pied Bat	V	V	Known populations in Queensland are from sandstone escarpments in the Carnarvon, Expedition Ranges and Blackdown Tablelands and Isla Gorge National Parks. Prefer sandstone cliffs and fertile woodland valley habitat as well as rainforest and moist eucalypt forest habitats on other geological substrates (DSEWPaC, 2012c).	Possible. Suitable foraging habitat is present within the survey area, particularly within Narrow-leaved Ironbark Woodland, but the likelihood of the species occurring is reduced due to the lack of sandstone ridges. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records.	Unlikely to be significantly impacted by the proposed action, as suitable breeding and roosting habitat will not be disturbed by the proposed action. Therefore, an AOS has not been undertaken for this species. .
Chalinolobus picatus	Little Pied Bat	V	-	Occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress pine forest and mallee and Bimbil box woodlands. Roosts in caves, rocky outcrops, mine shafts, tunnels, tree hollows and buildings (REF).	Likely. Large areas of suitable habitat present within survey area. This species has been recorded within 10km of the site, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat. however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.
Dasyurus maculatus	Spotted-tailed Quoll	V	E	The Spotted-tailed Quoll utilises a variety of habitats including sclerophyll forest and woodlands, coastal heathlands and rainforests. Occasional sightings have been made in open country, grazing lands, rocky outcrops and other treeless areas. This species' habitat requirements include suitable den sites (such as hollow logs, tree hollows, rocky outcrops or caves) and an abundance of food (such as birds and small mammals) (NSWPW).	Possible. Habitat present within survey area provides suitable foraging habitat, however the survey area does not include adequate habitat for den sites to support breeding. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records.	Unlikely to be significantly impacted by the proposed action, as suitable breeding and roosting habitat will not be disturbed by the proposed action. Therefore, an AOS has not been undertaken for this species. .
Macropus dorsalis	Black-striped Wallaby	E	-	Eucalypt and acacia forests with a dense understorey, often in areas infested with lantana. Common throughout coastal and inland range from Chillagoe, Qld, to northern NSW (QM, 2007).	Likely. Suitable habitat occurs within Narrow-leaved Ironbark Woodland and Heath. While this species was not observed	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
					throughout the site assessment, it is known to occur within 10km of the site, based on OEH records.	
Nyctophilus corbeni	South-eastern Long-eared Bat, Corben's Long-eared Bat	V	V	Occurs in a range of inland woodland vegetation types, including box, ironbark and cypress pine woodlands. The species also occurs in Buloke woodland, Brigalow woodland, Belah woodland, Smooth-barked Apple, *Angophora leiocarpa*, woodland; River Red Gum, *Eucalyptus camaldulensis*, forests lining watercourses and lakes, Black Box, *Eucalyptus largiflorens*, woodland, dry sclerophyll forest. Throughout inland Queensland, the species habitat is dominated by various eucalypt and bloodwood species, and various types of tree mallee with it being most abundant in vegetation with a distinct canopy and a dense cluttered shrub layer. In the Hunter Valley, NSW, the species is found in areas such as the Monobalai Nature Reserve and Goulburn River and Wollemi National Parks. It has primarily been recorded in moister woodland of various eucalypt species with a distinct shrub layer frequently adjacent to watercourses. There are a small number of records from closed forest adjacent to dry sclerophyll woodlands; in Araucarian notophyll vine forest in the Bunya Mountains and in semi evergreen vine thickets on the banks of the Dawson River and in the Brigalow Belt Bioregion (DSEWPaC, 2012a).	Likely. Large areas of suitable habitat present within survey area, namely, Narrow-leaved Ironbark Woodland.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 7** and **Appendix8** for AOS.
Petaurus norfolcensis	Squirrel Glider	V	-	The Squirrel Glider requires hollow-bearing, floriferous eucalypt open forests and woodlands with a *Banksia* or *Acacia* shrub layer, that provide den sites in tree	Possible. Suitable habitat is present within survey area, particularly within Narrow-leaved Ironbark	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				cavities and a good winter supply of nectar. Large trees with abundant hollows are critical elements (NSW Scientific Committee 2008).	woodlands. This species was not recorded on site, and has not been recorded within 10km of the survey area, based on OEH records.	AOS.
Phascolarctos cinereus	Koala (combined populations of Qld, NSW and the ACT)	V	V	Common throughout the broad band of forests and woodlands dominated by *Eucalyptus* spp. extending from north Queensland to the south-eastern corner of mainland South Australia (Maxwell *et al.,* 1996). Occupy forests and woodlands where there are acceptable food trees (*Eucalyptus* spp., *Corymbia* spp., etc.). Distribution is affected by altitude, temperature and leaf moisture (DSEWPaC, 2012a).	Likely. Suitable habitat is present within the survey area, particularly within Narrow-leaved Ironbark woodlands, Although no primary food trees occur within the survey area, scattered secondary tree species occur, namely Blakely's Red Gum, Dirty Gum, and Dwyer's Red Gum. While this species was not recorded in the survey area, it has previously been recorded within 10km of the site, based on OEH records.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 7** and **Appendix 8** for AOS.
Pseudomys pilligaensis	Pilliga Mouse	V	V	No specific habitat type has been identified for the Pilliga Mouse as specimens have been captured in different vegetation types within the Pilliga Scrub (Fox & Briscoe 1980). These included mixed Eucalyptus, Acacia and Callitris open forest. However, the Pilliga Mouse is found in greatest abundance in recently burnt moist gullies, areas dominated by Broombush (*Melaleuca uncinata*) and areas containing an understorey of *Acacia burrowii* with a *Corymbia trachyphloia* overstorey. Habitat features include a relatively high plant species richness; a moderate to high low-shrub cover; site moisture retention; and groundcover of plants, litter and fungi. Areas with high rates of capture have extensive low grasses and sedges, with	Known. This species was recorded twice in heath / riparian habitat.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated given the minimal clearing proposed. Refer to **Appendix 7** and **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
				little shrub cover and large areas of ash-covered ground (Fox & Briscoe 1980; NSW DECC 2005ad; Tokushima et al. 2008).		
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	The Yellow-bellied Sheath-tailed bat is found in a wide variety of habitats, including eucalypt forests and open habitats. It roosts in tree hollows. In the arid and semi-arid parts of its range, it is most frequent in mangrove or riparian habitat (McKenzie & Pennay, 2008).	Known. The species was recorded on two nights at two different locations.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.
Vespadelus troughtoni	Eastern Cave Bat	V	-	The Eastern Cave Bat is found in a broad band on both sides of the Great Dividing Range from Cape York to Kempsey, with records from the New England Tablelands and the upper north coast of NSW. The western limit appears to be the Warrumbungle Range, and there is a single record from southern NSW, east of the ACT. The species is cave-roosting, usually found in dry open forest and woodland, near cliffs or rocky overhangs. The species has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals. They are occasionally found along cliff-lines in wet eucalypt forest and rainforest (OEH, 2012c).	Unlikely The area of consideration does not provide suitable caves and overhangs.	Unlikely to be significantly impacted by the proposed action. Therefore, an AOS has not been prepared for this species.
Reptiles						
Hoplocephalus bitorquatus	Pale-headed Snake	V	-	Lives in wet and dry eucalypt forests and woodlands, and cypress woodlands. Favours areas surrounding watercourses (QM, 2007).	Likely. Some suitable habitat present within survey area, namely within areas of Woodland riparian habitat. This species was not recorded in the survey area, but has been recorded	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated. Refer to **Appendix 8** for AOS.

Scientific Name	Common Name	TSC Act	EPBC Act	Habitat Description	Likelihood of Occurrence	Potential for Impact
					within 10km of the site based on OEH records.	
Uvidicolus sphyrurus	Border Thick-tailed Gecko	V	V	Occurs in dry sclerophyll open forest and woodland associated with outcrops of granite, basalt, sandstone and metamorphic rocks. Geckos show a preference for canopy cover between 45 and 60 %, low vegetation cover (average 34 %), medium rock cover (average 37 %) and high litter cover (average 25 %). Shelter sites include rocks, decaying logs, bark, and litter in rocky rubble. Shelter sites are usually laying on a litter substrate and shaded by nearby vegetation (DSEWPaC (2012a).	Unlikely Species distribution does not include the Pilliga Forest. Suitable habitat does not occur in the area of consideration.	Unlikely to be significantly impacted by the proposed action, given the species range and previous species records. Therefore, an AOS has not been prepared for this species.

Appendix 5

Survey Area Fauna Species List

Non-listed Species

Species	Common Name
Reptiles	
Amphibolurus burnsi	Burn's Dragon
Amphibolurus muricatus	Jacqui Lizard
Amphibolurus nobbi	Nobbi Dragon
Carlia foliorum	-
Ctenotus robustus	Striped Skink
Demansia psammophis	Yellow-faced Whip Snake
Egernia striolata	Tree Skink
Morethia boulengeri	Boulenger's Skink
Pogona barbata	Eastern Bearded Dragon
Strophurus williamsi	Eastern Spiny-tailed Gecko
Varanus gouldii	Sand Goanna
Mammals	
Antechinus flavipes	Yellow-footed Antechinus
Capra hircus	Feral Goat
Chalinolobus gouldii	Gould's Wattle Bat
Chalinolobus morio	Chocolate Wattle Bat
Lepus europaeus	Hare
Macropus giganteus	Eastern Grey Kangaroo
Mormopterus sp. (3)	-
Mormopterus sp. (4)	-
Nyctophilus sp.	-
Oryctolagus cuniculus	European Rabbit
Scotorepens balstoni	Inland Broad-nosed Bat
Scotorepens greyii	Little Broad-nosed Bat
Tachyglossus aculeatus	Echidna
Tadarida australis	White-striped Freetail Bat
Vespadelus vulturnus	Little Forest Bat
Vulpes vulpes	Red Fox
Wallabia bicolor	Swamp Wallaby
Birds	
Acanthiza apicalis	Inland Thornbill
Acanthiza lineata	Striated Thornbill
Acanthiza reguloides	Buff-rumped Thornbill
Aegotheles cristatus	Owlet Nightjar
Anthochaera carunculata	Red Wattlebird
Aprosmictus erythropterus	Red-winged Parrot
Aquila audax	Wedge-tailed Eagle
Artamus superciliosus	White-browed Woodswallow
Artamus personatus	Masked Woodswallow
Barnardius zonarius	Australian Ringneck Parrot
Cacatua galerita	Sulphur-crested Cockatoo
Chenonetta jubata	Australian Wood Duck
Colluricincla harmonica	Grey Shrike Thrush
Corcorax melanorhamphos	White-winged Chough
Cracticus torquatus	Grey Butcherbird

Dacelo novaeguineae	Laughing Kookaburra
Dromaius novaehollandiae	Emu
Elanus axillaris	Black-shouldered Kite
Entomyzon cyanotis	Blue-faced Honeyeater
Eolophus roseicapilla	Galah
Eopsaltria australis	Eastern Yellow Robin
Gerygone fusca	Western Gerygone
Gerygone olivacea	White-throated Gerygone
Grallina cyanoleuca	Magpie Lark
Gymnorhina tibicen	Australian Magpie
Haliastur sphenurus	Whistling Kite
Lichenostomus chrysops	Yellow-faced Honeyeater
Lichenostomus leucotis	White-eared Honeyeater
Lichmera indistincta	Brown Honeyeater
Macropus rufogriseus	Red-necked Wallaby
Malurus cyaneus	Superb Fairywren
Manorina melanocephala	Noisy Miner
Milvus migrans	Black Kite
Myiagra inquieta	Restless Flycatcher
Oryctolagus cuniculus	Rabbit
Pachycephala rufiventris	Rufous Whistler
Pardalotus striatus	Striated Pardalote
Phaps chalcoptera	Common Bronzewing
Philemon corniculatus	Noisy Friarbird
Platycercus eximius	Eastern Rosella
Plectorhyncha lanceolata	Striped Honeyeater
Pomatostomus temporalis	Grey-crowned Babbler
Rhipidura albiscapa	Grey Fantail
Rhipidura leucophrys	Willy Wagtail
Smicrornis brevirostris	Weebill
Strepera graculina	Pied Currawong

Listed Species

Species	Common Name
Melanodryas cucullata	Hooded Robin
Neophema pulchella	Turquoise Parrot
Pomatostomus temporalis	Grey-crowned Babbler
Pseudemys pilligaensis	Pilliga Mouse
Pyrrholaemus sagittatus	Speckled Warbler
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat

Appendix 6

Migratory Species – Likelihood of Occurrence and Potential for Impact

Migratory species (listed under the *EPBC Act*) that have been gazetted / recorded from within the locality have been considered in this ecological assessment. Each species is considered for its potential to occur within the survey area and the likely level of impact as a result of the proposed activities. This ecological assessment deals with each species and identifies the ecological parameters of significance associated with the proposed activities.

Those species / communities that have been identified as potentially being impacted have been assessed as set out in **Appendix 4** and **Appendix 5**.

'Species' – Lists each threatened species known from the vicinity of the site. The status of each threatened species under the *EPBC Act* is also provided.

'Habitat' – Provides a brief account of the species and the preferred habitat attributes required for the existence / survival of each species.

'Likelihood of Occurrence'– Assesses the likelihood of each species to occur within the site in terms of the aforementioned habitat description and taking into account local habitat preferences, results of recent field investigations, data gained from various sources and previously gained knowledge via fieldwork undertaken within other ecological assessments in the locality.

Likelihood of occurence were divided into four categories (Known, Likely, Possible and Unlikely):

- **Known:** Species recorded during the survey; and
- **Likely:** Species previously recorded within either Pilliga East State Forest or Bibblewindi State Forest (OEH 2012) and suitable habitat of the species recorded within the survey area; and
- **Possible:** Species previously recorded within either Pilliga East State Forest or Bibblewindi State Forest (OEH 2012) but no suitable habitat of the species recorded within the survey area or species not previously recorded within either Pilliga East State Forest or Bibblewindi State Forest (OEH 2012) but suitable habitat of the species recorded within the survey area; and
- **Unlikely:** Species not previously recorded within either Pilliga East State Forest or Bibblewindi State Forest (OEH 2012) and no suitable of the species recorded within the survey area.

'Potential for Impact' – Through consideration of the likely level / significance of impacts to each species / community / population that would result from the proposed activities, taking into account both short and long-term impacts, a decision has been made whether further assessment is required. This assessment is largely based on the chance of occurrence of each species / community with due recognition to other parameters such as home range, habitat use, connectivity etc. It also considers the scope of the proposed activities.

Threatened species included in the table below have been identified as potentially occurring based on:

- Results from an EPBC Act Protected Matters Search using a central coordinate buffered by 10km, and
- Records extracted from data provided by OEH (BioNet Atlas) within either Pilliga East State Forest or Bibblewindi State Forest 10km radius of the well leases.

Scientific Name	Common Name	Status		Habitat Description[1]	Likelihood of Occurrence	Potential for Impact
		TSC Act	EBPC Act			
Birds						
Anthochaera phrygia	Regent Honeyeater	CE	Migratory Endangered	Refer to Threatened Species table	Refer to Threatened Species table	Refer to Threatened Species table
Apus pacificus	Fork-tailed Swift	-	Marine Migratory	Exclusively aerial, this species occurs over inland plains, cliffs and beaches, mostly over dry or open habitat including riparian woodland and tea-tree swamp. Sometimes occurs above foothills or in coastal areas.	Possible. Some suitable habitat present within survey area though would only be observed flying over site.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated.
Ardea alba / Egretta alba	Great Egret	-	Marine	Occurs in a diversity of wetland habitats. Its distribution is widely spread around Australia.	Unlikely due lack of suitable habitat present within survey area.	Unlikely to be significantly impacted by the proposed action.
Ardea ibis	Cattle Egret	-	Marine Migratory	Occurs in tropical and temperate grasslands, woodlands and terrestrial wetlands. Its distribution is widely spread around Australia.	Unlikely due lack of suitable habitat present within survey area.	Unlikely to be significantly impacted by the proposed action.
Gallinago hardwickii	Latham's Snipe	-	Marine Migratory	Occurs in permanent and ephemeral wetlands up to 2,000 m above sea-level but can also be found in saline and brackish water, modified or artificial habitat, saltmarsh, mangrove creeks, around bays and beaches. Migrates to Australia in summer. Its distribution is widely spread around the eastern side of Australia.	Unlikely due lack of suitable habitat present within survey area.	Unlikely to be significantly impacted by the proposed action.
Haliaeetus leucogaster	White-bellied Sea-Eagle	-	Marine Migratory	Found in coastal habitats (especially those close to the sea-shore) and around terrestrial wetlands in tropical and temperate regions of mainland Australia and its offshore islands. Habitats include the presence of large areas of open water (larger rivers, swamps, lakes, the sea).	Unlikely due lack of suitable habitat present within survey area.	Unlikely to be significantly impacted by the proposed action.

Scientific Name	Common Name	Status		Habitat Description[1]	Likelihood of	Potential for
Hirundapus caudacutus	White-throated Needletail	-	Marine Migratory	Exclusively aerial. Its distribution is widespread in eastern and south-eastern Australia, flying above a wide variety of habitats ranging from heavily treed forests to open habitats, such as farmland, heathland or mudflats.	Likely. Some suitable habitat present within survey area and has previously been recorded within Bibblewindi or Pilliga East SF.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated.
Lathamus discolour	Swift Parrot	V	Marine Endangered	Refer to Threatened Species table	Refer to Threatened Species table	Refer to Threatened Species table
Leipoa ocellata	Malleefowl	E	Migratory Vulnerable	Refer to Threatened Species table	Refer to Threatened Species table	Refer to Threatened Species table
Merops ornatus	Rainbow Bee-eater	-	Marine Migratory terrestrial	The Rainbow Bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands. The species occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. Open woodlands and shrublands, including mallee, and in open forests that are usually dominated by eucalypts provide suitable habitat. It also occurs in grasslands, especially in arid or semi-arid areas, in riparian, floodplain or wetland vegetation assemblages.	Likely. Suitable habitat is present within the survey area and has previously been recorded within Bibblewindi or Pilliga East SF. Particularly along riparian woodland habitats.	Proposed action has potential to remove and disturb suitable habitat, however a significant impact is not anticipated.
Myiagra cyanoleuca	Satin Flycatcher	-	Marine Migratory	In NSW, the Satin Flycatcher is widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains. They inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests. Satin Flycatchers are mainly recorded in eucalypt forests, especially wet sclerophyll forest, often dominated by eucalypts such as Brown Barrel, *Eucalypt fastigata,* Mountain Gum, *E. dalrympleana*, Mountain Grey Gum, Narrow-leaved Peppermint,	Unlikely due lack of suitable habitat present within survey area.	Unlikely to be significantly impacted by the proposed action.

Scientific Name	Common Name	Status		Habitat Description[1]	Likelihood of	Potential for
				Messmate or Manna Gum, or occasionally Mountain Ash, *E. regnans*. Such forests usually have a tall shrubby understorey of tall acacias, for example Blackwood, *Acacia melanoxylon*.		
Rostratula australis	Australian Painted Snipe	E	Marine Migratory Vulnerable	The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (Melaleuca). The Australian Painted Snipe sometimes utilises areas that are lined with trees, or that have some scattered fallen or washed-up timber.	Unlikely due lack of suitable habitat present within survey area.	Unlikely to be significantly impacted by the proposed action.

Appendix 7

EPBC Act Significant Impact Assessment

Pilliga Mouse (*Pseudomys pilligaensis*)

Significant Impact Criteria	Preliminary Assessment
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** The species was recorded adjacent to the proposed disturbance area at Dewhurst 25 during fauna surveys. If activities are confined to the proposed disturbance area the proposed works will result in the clearing of minimal habitat for this species, as small areas of riparian woodland may be removed. Given the small area of clearing proposed, it is unlikely that this will lead to the long-term decrease of a population. Due to the close proximity of suitable habitat to the disturbance area the species may be exposed to indirect impacts including increased noise, dust and vibrations. These indirect impacts are not expected to lead to a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	**Unlikely.** If activities are confined to the proposed disturbance area the proposed works will result in the clearing of 1.02ha of core Riparian Woodland that may potentially be utilised by this species, with an additional 1ha of sub-optimal habitat to be removed (Ironbark Shrubby Woodland where a dense shrubby understorey occurs). This is considered a minor disturbance, and it is therefore unlikely that clearing will reduce their area of occupancy.
Fragment an existing important population into two or more populations	**Unlikely.** Clearing of 1.02ha of core riparian woodland is required, with additional areas of sub-optimal habitat to be removed. This is not likely to fragment an existing population, given that access tracks have already fragmented habitat in the survey area.
Adversely affect habitat critical to the survival of a species	**Unlikely.** While 1.02 ha of core riparian vegetation is to be removed, with an additional 1 ha of sub-optimal habitat to be removed, all heath vegetation within the survey area has been retained. The removal of 2.02 ha of optimal and sub-optimal habitat is not considered likely to adversely affect this species.
Disrupt the breeding cycle of an important population	**Possibly.** The peak breeding season for the species is between October and April (SEWPaC 2012). If works are to occur during this period increased noise, dust and vibrations may interfere with breeding. If works were to occur outside this period it is expected that there would be little to no impact on the breeding cycle of the species.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** While 1.02 ha of core riparian vegetation is to be removed, and 1 ha of sub-optimal habitat is to be disturbed, all heath vegetation within the survey area has been retained. The removal of 1.02ha of core habitat and 1 ha of sub-optimal habitat is not considered likely to adversely affect this species, particularly given that large tracts of vegetation suitable for this species occur throughout the survey area.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely.** If appropriate mitigation measures are put in place it is expected that the proposed works will not result in an increase in invasive species.
Introduce disease that may cause the species to decline, or	**Unlikely.** The proposed works is unlikely result in the introduction of any diseases that may cause a decline in the species.
Interfere substantially with the recovery of the species.	**Unlikely.** The main identified threats to the species include loss or degradation of habitat through inappropriate fire regimes, forestry operations and broombrush harvesting; predation by feral cats and foxes; and competition from the common house mouse (SEWPaC 2012). If the prescribed mitigation measures are followed it is expected that the proposed works will not interfere substantially with the recovery of the species.

Koala (*Phascolarctos cinereus)*

Significant Impact Criteria	Preliminary Assessment
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** Although the species has been previously recorded within 10km of the survey area (OEH 2012), the species was not recorded during the survey. The survey area does not contain any primary food trees under Schedule 2 of State Environmental Planning Policy 44 (SEPP 44) (Environmental Planning and Assessment Act 1979), and is therefore not considered to be potential or core Koala habitat under the policy. The potential habitat within the survey area does contain three secondary food tree species and therefore there is potential for the species to occur within the disturbance area, however it is unlikely to support an important population. The proposed works will only disturb 3.02 ha of potential habitat (Ironbark Shrubby Woodland and Riparian Woodland). Of this, 1.02 ha is comprised of Riparian vegetation, and only 2 ha of Ironbark Shrubby woodland are considered to comprise areas of core habitat for this species, where dense stands of White Cypress occur. In comparison to equivalent habitat available within the Pilliga Forest, this equates to a reduction of 0.002%. Given that a minor amount of clearing of sub-optimal habitat is proposed, it is not expected that the works will lead to a long-term decrease in the population.
Reduce the area of occupancy of an important population	**No.** The proposed work will result in a minor loss of habitat for the species, however only secondary food trees will be removed. The loss of habitat is considered to be minimal in the context of equivalent habitat within the Pilliga Forest. Habitat to be removed is unlikely to support an important population. It is therefore unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	**Unlikely.** The survey area is a smaller component of the overall habitat used by this species as they often have large home ranges and are known to traverse open landscapes. This species would primarily utilise the survey area as a foraging resource, as the like habitats within the Pilliga Forest are more extensive and are of greater foraging and breeding importance to this species. Koala food trees are generally concentrated on alluvial soils associated with waterways and drainage lines in the survey area. These areas are likely to be more critical for dispersal and impacts on these areas have been minimised.
Adversely affect habitat critical to the survival of a species	**Unlikely.** The proposed activities involve the clearing of 1.02 ha of riparian woodland, 2 ha of areas of dense White Cypress, though no primary food trees will be removed. Therefore, it is unlikely to constitute habitat critical for the survival of the species due to an expanse of native vegetation in adjacent lands that has similar habitat values.
Disrupt the breeding cycle of an important population	**Possibly.** The breeding season for the species is between September and March (SEWPaC 2012). If works are to occur during this period increased noise, dust and vibrations may interfere with breeding. If works were to occur outside this period it is expected that there would be little to no impact on the breeding cycle of the species despite the direct impact of clearing habitat.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** The proposed works will remove, destroy and degrade potential habitat of the species but due to the small area in which the works is to occur it is expected that this will not be at an extent that is likely to cause a decline in the species.

Significant Impact Criteria	Preliminary Assessment
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely.** If appropriate mitigation measures are put in place it is expected that the proposed works will not result in an increase in invasive species.
Introduce disease that may cause the species to decline, or	**Unlikely.** The proposed works is unlikely result in the introduction of any diseases that may cause a decline in the species.
Interfere substantially with the recovery of the species.	**Unlikely.** The main identified threats to the species include habitat loss, degradation or fragmentation, encounter mortality from dogs and cars; disease, climate change and drought, habitat degradation due to overbrowsing, and low genetic variability (SEWPaC 2012). The proposed works primarily relates to the threat of habitat loss, degradation or fragmentation, however, as the proposed works will only impact a small area of potential habitat (3.02 ha) it is unlikely that this will substantially interfere with the recovery of the species.

South-eastern Long-eared Bat (South-eastern Form) / Corben's Long-eared Bat (*Nyctophilus corbeni)*

Significant Impact Criteria	Preliminary Assessment
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** The species has been previously recorded within 10km of the survey area (OEH 2012), though was not recorded during the survey. Large areas of potential habitat were recorded within the area of consideration, including many hollow bearing / loss barked tress. It is therefore likely that the species does occur within survey area and maybe potentially impacted by the proposed activities. The proposed works will only disturb a small area of the potential habitat within the survey area (5.98ha). This is considered to be approximately 0.002% of equivalent habitats available within the Pilliga Forest. Given the minimal clearing proposed, and the ability of the species to easily relocate when disturbed, it is not expected that the works will lead to a long-term decrease in the population. This population was assessed as an important population as it has potential to be necessary for maintaining genetic diversity, particularly within the Narrabri / Pilliga Area.
Reduce the area of occupancy of an important population	**No.** The proposed work will disturb areas identified as suitable habitat for the species, therefore reducing the area of available habitat for this species. However, the removal of 5.98ha of potential roosting and foraging habitat is considered to be minimal in the context of habitat within the Pilliga Forest, equalling approximately 0.002%. Additionally, an important population is not known to occur within the Pilliga Forest.
Fragment an existing important population into two or more populations	**Unlikely.** The survey area is a small component of the overall habitat used by this species as they often have large home ranges and are known to exploit large areas. This species would primarily utilise the survey area as a foraging resource. The proposed activities are likely to disturb a relatively small amount (5.98 ha) of existing potential habitat for the species; however the amount to be removed is minimal in comparison to the amount to be retained in the Pilliga Forest, and area of consideration. As the species would be easily able to move around these cleared areas it is unlikely that the proposed works will fragment the population.
Adversely affect habitat critical to the survival of a species	**Unlikely.** The proposed activities involve the clearing of 5.98 ha of woodland habitat; in which no individuals were recorded during the survey. In addition, this area to be removed is considered minimal (0.002%) in comparison to the amount of similar habitat to be retained within the Pilliga Forest Therefore, the disturbance area is unlikely to constitute habitat critical for the survival of the species due to an expanse of native vegetation in adjacent lands that has similar habitat values.
Disrupt the breeding cycle of an important population	**Possibly.** Little information is known about the breeding cycle of this species and therefore it is difficult to plan works around peak breeding times (SEWPaC 2012). If works do occur during this period, increased noise, dust and vibrations may interfere with breeding. If works were to occur outside this period it is expected that there would be little to no impact on the breeding cycle of the species despite the direct impact of clearing habitat.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** The proposed works will remove, destroy and degrade potential habitat of the species but due to the small area in which the works is to occur it is expected that this will not be at an extent that is likely to cause a decline in the species.
Result in invasive species that are	**Unlikely.** If appropriate mitigation measures are put in place it is expected that the proposed works will not result in an increase in

Significant Impact Criteria	Preliminary Assessment
harmful to a vulnerable species becoming established in the vulnerable species' habitat	invasive species.
Introduce disease that may cause the species to decline, or	**Unlikely.** The proposed works is unlikely result in the introduction of any diseases that may cause a decline in the species.
Interfere substantially with the recovery of the species.	**Unlikely.** The main identified threats to the species include habitat loss, habitat fragmentation, fire, forestry activities, overgrazing, predation by feral species, tree hollow competition, exposure to agrichemicals and climate change (SEWPaC 2012). The proposed works primarily relates to the threats of habitat loss and tree hollow competition, however, as the proposed works will only impact a small area of potential habitat (5.98 ha) and minimal hollow bearing trees it is unlikely that this will substantially interfere with the recovery of the species.

Regent Honeyeater (*Anthochaera phrygia*)

Significant Impact Criteria	Preliminary Assessment
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** The species has been previously recorded within the Pilliga and Bibblewindi State Forests, of which the survey area is located (OEH 2012), though was not recorded during the survey. Large areas of potential habitat were recorded within the area of consideration and therefore it is likely the species does occur periodically within the survey area due to its migratory nature and may be potentially impacted by the proposed activities. The proposed works will only disturb a small area of the potential habitat within the survey area (5.98ha). This is considered to be approximately 0.002% of equivalent habitats available within the Pilliga Forest. Given the minimal clearing proposed, and the ability of the species to easily relocate when disturbed, it is not expected that the works will lead to a long-term decrease in the population. The population was assessed as an important population due to small population size of the species (800-2000 individuals) and therefore a population occurring in such a large area (Pilliga Scrub) of suitable habitat may contribute largely to maintaining genetic diversity.
Reduce the area of occupancy of an important population	**No.** The proposed work will disturb areas identified as suitable habitat for the species, however an important population is not known to occur within the Pilliga Forest.
Fragment an existing important population into two or more populations	**Unlikely.** The survey area is a smaller component of the overall habitat used by this species as they often have large home ranges and are known to exploit large areas. This species would primarily utilise the survey area as a foraging resource, although the like habitats within the Pilliga Forest are of equal or greater foraging and breeding importance to this species. The proposed activities are likely to disturb a relatively small amount (5.98 ha) of existing potential habitat for the species; however the amount to be removed is minimal in comparison to the amount to be retained in the survey area. As the species would be easily able to move around these cleared areas it is unlikely that the proposed works will fragment the population.
Adversely affect habitat critical to the survival of a species	**Unlikely.** The proposed activities involve the clearing of 5.98 ha of woodland habitat; in which no individuals were recorded during the survey. In addition, this area to be removed is considered minimal in comparison to the amount of similar habitat to be retained within the Pilliga Forest and area of consideration. Therefore, the disturbance area is unlikely to constitute habitat critical for the survival of the species due to an expanse of native vegetation in adjacent lands that has similar habitat values.
Disrupt the breeding cycle of an important population	**Possible.** The breeding season for the species is between May and March (SEWPaC 2012). If works are to occur during this period increased noise, dust and vibrations may interfere with breeding. If works were to occur outside this period it is expected that there would be little to no impact on the breeding cycle of the species despite the direct impact of clearing habitat.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** The proposed works will remove, destroy and degrade potential habitat of the species but due to the small area in which the works is to occur and the migratory nature of the species, it is expected that this will not be at an extent that is likely to cause a decline in the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Unlikely.** If appropriate mitigation measures are put in place it is expected that the proposed works will not result in an increase in invasive species.

Significant Impact Criteria	Preliminary Assessment
Introduce disease that may cause the species to decline, or	**Unlikely.** The proposed works is unlikely result in the introduction of any diseases that may cause a decline in the species.
Interfere substantially with the recovery of the species.	**Unlikely.** The main identified threats to the species include loss, fragmentation and degradation of the species' habitat (SEWPaC 2012). The proposed works primarily relates to the threats of habitat loss, however, as the proposed works will only impact a small area of potential habitat (5.98 ha) it is unlikely that this will substantially interfere with the recovery of the species.

Appendix 8

TSC Act Assessment of Significance

A1.1 Approach

Section 5A of the EP&A Act lists seven factors that must be taken into account in the determination of the significance of potential impacts of proposed activities on 'threatened species, populations or ecological communities or their habitats' (threatened biota) listed under the TSC Act. The so-called '7-part test' is used to determine whether there is likely to significantly effect a threatened species, populations or ecological communities, or their habitats and thus whether a Species Impact Statement (SIS) is required to be produced.

The significance of the impacts on those threatened species, which have been recorded in the survey area or are likely to occur, and are likely to utilise habitat to be potentially impacted by the proposed activities have been assessed. The following species have been considered:

Fauna

- Pilliga Mouse (*Pseudomys pilligaensis*);
- Eastern Pygmy-possum (*Cercartetus nanus*);
- Black-striped Wallaby (*Macropus dorsalis*);
- Koala (*Phascolarctos cinereus*); and
- Pale-headed Snake (*Hoplocephalus bitorquatus*).

Those threatened fauna species that possess similar habitat requirements or are from the same faunal group have been grouped together into a table format for ease of presentation and include the following:

Woodland / Forest Owls

- Barking Owl (*Ninox connivens*); and
- Masked Owl (*Tyto novaehollandiae*).

Woodland Dependent Birds

- Little Lorikeet (*Glossopsitta pusilla*);
- Brown Treecreeper (*Climacteris picumnus*);
- Grey-crowned Babbler (*Pomatostomus temporalis temporalis*);
- Hooded Robin (*Melanodryas cucullata cucullata*);
- Turquoise Parrot (*Neophema pulchella*);
- Varied Sittella (*Daphoenositta chrysoptera*); and
- Speckled Warbler (*Pyrrholaemus sagittatus*).

Woodland Dependent Microbats

- Little Pied Bat (*Chalinolobus picatus*);
- South-eastern Long-eared Bat (*Nyctophilus corbeni*); and
- Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*).

A1.1.1 Threatened Fauna

Pilliga Mouse (*Pseudomys pilligaensis*)

This species is found in the Pilliga region of New South Wales. The Pilliga Mouse is terrestrial and lives in burrows. Studies in 2005 indicated the Pilliga Mouse occurs in greatest abundance in recently burnt moist gullies, areas dominated by Broombrush and areas containing an understorey of *Acacia burrowii* with a *Corymbia trachyphloia* overstorey. Consistent features of the latter two habitats are relatively high plant species richness, a moderate to high low shrub cover, and a moist groundcover of plants, litter and fungi. They live in burrows that can be up to 30cm under the ground. There is a designated nest chamber complete with leaves for comfort. In general this species will use the same burrow for up to six months (DSEWPaC, 2012a).

7-Part Test Criteria

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

If activities are confined to the proposed disturbance area, the proposed works will not result in clearing of any Heath habitat. A total of 1.02 ha of core riparian habitat may be removed, in addition to approximately 1 ha of sub-optimal habitat located within areas of Ironbark Shrubby Woodland that contain a dense shrubby understorey. This is not considered likely to have an adverse effect on the like cycle of this species, given that suitable habitat is being retained across the area of consideration and within the Pilliga Forest. Due to the close proximity of suitable habitat to the disturbance area the species may be exposed to indirect impacts including increased noise, dust and vibrations. These indirect impacts are not expected to lead to a long-term decrease in the size of an important population. Furthermore, these impacts will be minimised through the use of the prescribed mitigation measures in **Section 8.0**.

Surveys only recorded two individuals which suggests that the survey area does not support a significantly large population of the species. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Pilliga Mouse such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

There is no endangered population for these species currently listed on the TSC Act within the survey area.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

This factor does not apply to threatened species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

A total of 1.02ha of core riparian habitat that provides suitable resources for this species will be removed, however all Heath habitat has been avoided. The extent of vegetation clearing is not considered significant when compared to suitable habitat that is to be retained. Within the Pilliga Forest, clearing of 1.02ha is the equivalent of the removal of 0.002 ha of riparian habitat. In addition, 1 ha of sub-optimal habitat will be removed, comprising areas of Ironbark Shrubby Woodland with a dense shrubby understorey.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

A total of 1.02 ha of core riparian habitat that provides suitable resources for this species will be removed, in addition to approximately 1 ha of sub-optimal habitat. This habitat is already fragmented by forestry roads. Additional clearing is unlikely to significantly impact upon this species.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

If activities are confined to the proposed disturbance area the proposed works will result in clearing 1.02 ha of core Pilliga Mouse riparian habitat, and approximately 1 ha of sub-optimal habitat . All heath habitat has been retained throughout the survey area. The importance of the habitat to be removed is considered moderate, as many areas are lacking critical habitat features. Areas of higher value (heath) have been retained.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat listed for these species on the register of critical habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no recovery plan for this species however there are 6 priority actions listed for this species within the priority action statement. The proposed activities do not relate to any of the 6 priority actions for the species and as no suitable habitat is to be cleared it is considered that the proposed activities will not impact the long-term recovery of the species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts.

Clearing of native vegetation - The proposed activities will clear approximately 1.44 ha of optimal habitat, which is considered insignificant compared to vegetation to be retained. For this reason it is unlikely the proposed activities will result in the decline of this species in the locality.

Conclusion

Based on the consideration of the above factors, the proposed activities are not likely to significantly impact the listed threatened species Pilliga Mouse or its habitats.

Eastern Pygmy-possum (*Cercartetus nanus*)

The Eastern Pygmy-possum (*Cercartetus nanus*) is a small arboreal marsupial that is distributed in the south-eastern corner of mainland Australia and in Tasmania. In New South Wales the species is found in coastal areas and at higher elevation in the south, but north of Newcastle at higher elevation only. Pygmy-Possums are agile climbers that feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (NSWDEH 2012). Found in temperate rainforest, dry and wet sclerophyll forest, banksia woodland, and coastal heath. The species shelters in a spherical nest of bark and leaves in tree hollows or other crannies (Dickman, Lunney & Menkhorst, 2008).

7-Part Test Criteria

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

No Eastern Pygmy-possums were recorded during the survey but potential habitat occurs in the survey area. The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that potentially provides breeding and foraging resource for the species, due to the presence of large hollow bearing Eucalypts. However the relatively small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Eastern Pygmy-possum, due to the survey areas connectivity with similar habitats.

The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Eastern Pygmy-possum is a mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Eastern Pygmy -possum such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

There is no endangered population for these species currently listed on the TSC Act within the survey area.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

> ***(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or***
>
> ***(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.***

This factor does not apply to threatened species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Habitat within the survey area has been identified as a breeding and foraging resource for the Eastern Pygmy-possum. Adjacent and relatively extensive woodland habitats surrounding the survey area provide similar breeding and foraging resources, of which the species may currently inhabit. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or the Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat listed for these species on the register of critical habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no recovery plan for this species however there are 7 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any the 7 priority actions and the small area affected, it is considered that there would be no negative impact on the long-term persistence and recovery of this species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts.

Clearing of native vegetation - The proposed activities will clear approximately 5.98 ha of this species habitat, which results in the removal of 0.002% of equivalent habitats within the Pilliga Forest. The loss of this relatively small amount of habitat is unavoidable in light of the objective of the proposed activities and is unlikely to result in the decline of this species habitat in the locality.

Conclusion

Based on the consideration of the above factors, the proposed activities are not likely to significantly impact the listed threatened species Eastern Pygmy-possum or its habitats.

Black-striped Wallaby (*Macropus dorsalis*)

Black-striped Wallaby populations are associated with open forest with thick regrowth Brigalow (*Acacia harpophylla*) or other shrub understory woodland, closed forest margins and dense wet sclerophyll forests with a viney understorey. Colonies use dense vegetation for shelter during the day and open forest and grassland edges at night for feeding. The Black-striped Wallaby establishes well-used paths to connect the two habitats. Individuals rarely venture far from dense cover.

7-Part Test Criteria

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

No Black-striped Wallabies were recorded during the survey but potential habitat occurs in the survey area. The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that provides potential breeding and shelter resource for the species. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Black-striped Wallaby, due to the survey area's connectivity with similar habitats.

The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted. The Black-striped Wallaby is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Black-striped Wallaby such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

There is no endangered population for these species currently listed on the TSC Act within the survey area.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

This factor does not apply to threatened species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Habitat within the survey area has been identified as a breeding and shelter resource for the Black-striped Wallaby. Adjacent and relatively extensive woodland habitats surrounding the survey area provide similar habitat resources. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Due to the presence of alternative breeding and shelter habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or the Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat listed for these species on the register of critical habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no recovery plan for this species however there are 14 priority actions listed for this species within the priority action statement. However, the proposed activities do not relate to any of these priorities. Due to this and the small area to be impacted it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts.

Clearing of native vegetation - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objective of the proposed activities and is unlikely to result in the decline of this species habitat in the locality.

Conclusion

Based on the consideration of the above factors, the proposed activities are not likely to significantly impact the listed threatened species Black-striped Wallaby or its habitats.

Koala (*Phascolarctos cinereus*)

The Koala is the largest of Australia's arboreal mammals. Its home range size varies with quality of habitat, ranging from less than two hectares to several hundred hectares in size. Koalas typically inhabit eucalypt

woodlands and forests where they feed on the foliage of more than 70 eucalypt species and 30 non-eucalypt species, but in any one area would select preferred browse species.

They are generally inactive for most of the day, feeding and moving mostly at night. Koalas spend most of their time in trees, but would descend and traverse open ground to move between trees. This species is generally solitary, but has complex social hierarchies based on a dominant male with a territory overlapping several females and subordinate males on the periphery. Females breed at two years of age and produce one young per year (DECC, 2008).

7-Part Test Criteria

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

No Koalas were recorded during the survey, however secondary food trees occur in the survey area. Under SEPP 44, the survey area is not considered to be potential or core habitat, as the canopy does not comprise at least 15% primary food tree species. The proposed activities involve the clearing of only 5.98 ha of woodland habitat; though no primary food trees will be removed. Therefore, it is unlikely to constitute habitat critical for the maintenance of a local population of the Koala due to an expanse of native vegetation in adjacent lands that has similar habitat values.

The survey area is a smaller component of the overall habitat used by this species as they often have large home ranges and are known to traverse open landscapes. This species would primarily utilise the survey area for dispersal and as an occasional foraging resource, although the like habitats within the area of consideration and Pilliga Forest are more extensive and are of greater importance to this species.

The proposed activities are likely to disturb a relatively small amount (5.98 ha) of existing foraging habitat for a local Koala; however the amount to be removed is insignificant in comparison to the amount to be retained in the area of consideration and the Pilliga Forest. The proposed activities are unlikely to significantly affect breeding and foraging success, or dispersal of local Koalas.

It is therefore unlikely that the proposed activities would have an adverse effect on the life cycle of the Koala such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

There is no endangered population for these species currently listed on the TSC Act within the survey area.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

This factor does not apply to threatened species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

The vegetation to be cleared comprises structurally modified woodland habitat due to past and ongoing agricultural land use. There are three species of SEPP 44 listed secondary Koala feed trees located within the survey area along with other less significant habitat trees, the Koala may utilise these trees opportunistically as a foraging resource. However, this impact is minimal in comparison to the relatively high number of Koala feed trees that are to be retained in the area of consideration and the Pilliga Forest.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

The effectiveness of the survey area as a movement corridor and habitat resource for a local Koala population would not be negatively affected, as connectivity with like woodland habitat surrounding the disturbance area will be. Therefore, the proposed activities would not impose a barrier to movement for the Koala into adjacent lands.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Due to the relatively minor loss of marginal habitat and the large amount of alternative breeding and feeding habitat within surrounding areas, the area to be affected by the proposed activities are not considered an important resource for the Koala and the proposed vegetation clearing would not have a significant impact on the long-term survival of the species or the local population of Koalas.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat listed for these species on the register of critical habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is a recovery plan for the Koala (DECC 2008), which outlines specific objectives to help conserve the Koala and its habitat. Ten current threats to Koalas are identified. Habitat loss and fragmentation are the most important threats to this species in NSW. Although the proposed activities are not consistent with the objectives of the recovery plan it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.

The similar woodland habitats within Bibblewindi and Pilliga East State Forest, strengthens the vegetation connectivity of the survey area and provides habitat linkages in the survey area.

The vegetation to be cleared is small in comparison to woodland vegetation associated with adjacent lands and would not be significantly fragment Koala populations or habitats within the area.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one to this proposed activities and the Koala is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts.

Clearing of native vegetation - The proposed activities will disturb approximately 5.98 ha of Koala habitat that contains three species of secondary Koala feed trees under Schedule 2 of SEPP 44. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.

Conclusion

Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Koala or its habitats.

Pale-headed Snake (*Hoplocephalus bitorquatus*)

The Pale-headed snake has a patchy distribution from north-east QLD to north-east NSW. IN NSW it occurs from the coast to the western side of the Great Dividing Range, as far as Tuggerah. Found mainly in dry eucalypt forests and woodlands, cypress woodland and occasionally in rainforest or moist eucalypt forest, favouring streamside areas in drier habitats. They shelter during the day between loose bark and tree-trunks, or in hollow trunks and limbs of dead trees. Their main food source is frogs but also feed on small lizards and mammals (DEH 2012).

7-Part Test Criteria

a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction.

No Pale-headed Snakes were recorded during the survey but potential habitat occurs in the survey area. The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, due to the presence of loose barked Eucalypts. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Pale-healed Snake, due to the survey area's connectivity with similar habitats.

The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted. The Pale-headed Snake is a mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Pale-headed Snake such that a viable local population of the species is likely to be placed at risk of extinction.

b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction.

There is no endangered population for these species currently listed on the TSC Act within the survey area.

c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed:

(i) Is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) Is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction.

This factor does not apply to threatened species.

d) In relation to the habitat of a threatened species, population or ecological community:

(i) The extent to which habitat is likely to be removed or modified as a result of the action proposed, and

Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities.

(ii) Whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

Habitat within the survey area has been identified as a breeding and foraging resource for the Pale-headed Snake. Adjacent and relatively extensive woodland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit.

(iii) The importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.

e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly)

There is no critical habitat listed for these species on the register of critical habitat.

f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.

There is no recovery plan for this species however there are 13 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any of the 13 priority actions and the small area affected, it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.

g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process

There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts.

Clearing of native vegetation - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objective of the proposed activities and is unlikely to result in the decline of this species habitat in the locality.

Conclusion

Based on the consideration of the above factors, the proposed activities are not likely to significantly impact the listed threatened species Pale-headed Snake or its habitats.

Table A8.1: Assessment of Significance of Woodland Dependent Owls

Barking Owl (*Ninox connivens*)	**Masked Owl (*Tyto novaehollandiae*)**
Background Information	
Barking Owl is found throughout Australia except for the central arid regions and Tasmania (DECC 2008). The species inhabits eucalypt woodland, open forest, swamp woodlands and, especially in inland areas, timber along watercourses (DECC 2008). Denser vegetation is used occasionally for roosting (DECC 2008). Territories range from 30 to 200 hectares and birds are present all year (DECC 2008). During the day they roost along creek lines, usually in tall understorey trees with dense foliage such as *Acacia* and *Casuarina* species, or the dense clumps of canopy leaves in large Eucalypts (DECC 2008). Breeding occurs during late winter and early spring, with eggs laid in nests in hollows of large, old eucalypts including River Red Gum (*Eucalyptus camaldulensis*), White Box (*Eucalyptus albens*), Red Box (*Eucalyptus polyanthemus*) and Blakely's Red Gum (*Eucalyptus blakelyi*) (DECC 2008).	The Masked Owl lives in eucalypt forests and woodlands from the coast, where it is most abundant, to the western plains. Inland records for this species are sparse but, overall, records fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in distribution. Potential habitat for the Masked Owl is mostly in conservation reserves and state forests, although this species is also found throughout large areas of forest or woodland on other public lands and on private land, including suburban bushland. The Masked Owl has been recorded in many national parks and state forests throughout its range in NSW (DECC 2006)
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;	
The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, due to the presence of large hollow bearing trees, in particular large eucalypt trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Barking Owl, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Barking Owl is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Barking Owl such that a viable local population of the species is likely to be placed at risk of extinction.	The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, due to the presence of large hollow bearing trees, in particular large eucalypt trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Masked Owl, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Masked Owl is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Masked Owl such that a viable local population of the species is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction;	
There is no endangered population of these species currently listed on the TSC Act within the survey area.	
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: ▪ ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ▪ ***is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of***	

Barking Owl (*Ninox connivens*)	Masked Owl (*Tyto novaehollandiae*)
extinction,	
This factor does not apply to threatened species.	
d) In relation to the habitat of a threatened species, population or ecological community: ▪ ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*** ▪ ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*** ▪ ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,***	
Approximately 5.98 ha of woodland habitat is to be cleared at the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Barking Owl. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Masked Owl. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);	
There is no critical habitat listed for these species on the register of critical habitat.	
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan;	
There is a recovery plan for the Barking Owl (NSW National Parks and Wildlife Service, 2003), which outlines specific objectives to help conserve the Barking Owl and its habitat. Five current threats to Barking Owls are identified. “Clearing of native vegetation” is the primary threat posed by the proposed activities. The retention of woodland remnants, especially those containing hollow bearing trees is one of the key strategies to recover the species. Although the proposed activities are inconsistent with these objectives due to the small area of habitat being cleared it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.	The Masked Owl is included in the Large Forest Owls recovery plan. As part of this recovery plan there are 7 recovery objectives. The objective that is most relevant to the proposed activities is objective 5, “Minimise further loss and fragmentation of habitat by protection and more informed management of significant owl habitat. In addition to this there are 26 priority actions of which the proposed actions are inconsistent with a few. Although the proposed activities are inconsistent with these objectives and actions, due to the small area of habitat being cleared it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	

Barking Owl (*Ninox connivens*)	**Masked Owl (*Tyto novaehollandiae*)**
There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.
Conclusion	
Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Barking Owl or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Masked Owl or its habitats.

Table A8.2: Assessment of Significance of Woodland Dependent Threatened Birds

Little Lorikeet (*Glossopsitta pusilla*)	Brown Treecreeper (*Climacteris picumnus*)	Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)
Background Information		
Forages primarily in the canopy of open Eucalypt forest and woodland. Riparian habitats are particularly used, due to higher soil fertility. Also found in isolated flowering trees in open country, e.g. paddocks and roadside remnants.	The Brown Treecreeper is endemic to eastern Australia. It is found in eucalypt woodlands (including Box-Gum Woodland) and dry open forest of the inland slopes and plains inland of the Great Dividing Range. It is typically not found in woodlands with a dense shrub layer. Fallen timber is an important habitat component for foraging. Hollows in standing dead or live trees and tree stumps are essential for nesting (DECCW, 2005).	In NSW, the Grey-crowned Babbler occurs on the western slopes of the Great Dividing Range, the woodlands in the Hunter Valley and in several locations on the north coast of NSW. This species prefers open Box-Gum Woodlands on the slopes, and Box-Cypress-pine and open Box Woodlands on alluvial plains. Grey-crowned Babblers feed on invertebrates, either by foraging on the trunks and branches of eucalypts and other woodland trees or on the ground, digging and probing amongst litter and tussock grasses. They build and maintain several conspicuous, dome-shaped stick nests about the size of a football. Nests are usually located in shrubs or sapling eucalypts, although they may be built in the outermost leaves of low branches of large eucalypts.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;		
The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Little Lorikeet, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Little Lorikeet is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Little Lorikeet such that a viable local population of the species is likely to be placed at risk of extinction.	The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Brown Treecreeper, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Brown Treecreeper is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Brown Treecreeper such that a viable local population of the species is likely to be placed at risk of extinction.	The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Grey-crowned Babbler, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Grey-crowned Babbler is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Grey-crowned Babbler such that a viable local population of the species is likely to be placed at risk

Little Lorikeet (*Glossopsitta pusilla*)	Brown Treecreeper (*Climacteris picumnus*)	Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)
		of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction;		
There is no endangered population of these species currently listed on the TSC Act within the survey area.		
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: ▪ ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ▪ ***is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,***		
This factor does not apply to threatened species.		
d) In relation to the habitat of a threatened species, population or ecological community: ▪ ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*** ▪ ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*** ▪ ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,***		
Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Little Lorikeet. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species currently inhabits. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Brown Treecreeper. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Grey-crowned Babbler. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in area of consideration or Pilliga Forest and as such would not have a

Little Lorikeet (*Glossopsitta pusilla*)	**Brown Treecreeper (*Climacteris picumnus*)**	**Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)**
		significant impact on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);		
There is no critical habitat listed for these species on the register of critical habitat.		
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan;		
There is no recovery plan or priority action statement for this species. However, there are some objectives relevant to the proposed activities to recover the species, these include: ▪ Retain large old trees, especially those that are hollow-bearing; ▪ Ensure recruitment of trees into the mature age class so that there is not a lag period of decades between the death of old trees and hollow formation in younger trees; ▪ Protect large flowering Eucalyptus trees throughout the habitats frequented by this species. Manage remnant woodlands and forest for recovery of old-growth characteristics; and ▪ Where natural tree recruitment is inadequate, replant local species to maintain foraging habitat and breeding sites. Although the proposed activities are inconsistent with these objectives due to the small area which will be affected it is assessed that there would be no negative impact on the long term persistence and recovery of this species.	There is no recovery plan for this species however there are 7 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any the 7 priority actions and the small area affected, it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.	There is no recovery plan for this species however there are 5 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any the 5 priority actions and the small area affected, it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.		
There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will	There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will	There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed

Little Lorikeet (*Glossopsitta pusilla*)	**Brown Treecreeper (*Climacteris picumnus*)**	**Grey-crowned Babbler (*Pomatostomus temporalis temporalis*)**
clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.
Conclusion		
Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Little Lorikeet or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Brown Treecreeper or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Grey-crowned Babbler or its habitats.

Table A8.3: Assessment of Significance of Woodland Dependent Threatened Birds

Regent Honeyeater (*Anthochaera phrygia* / *Anthochaera phrygia*)	**Hooded Robin (*Melanodryas cucullata cucullata*)**	**Turquoise Parrot (*Neophema pulchella*)**
Background Information		
Mostly occur in dry Box-Ironbark eucalypt woodland and dry sclerophyll forest associations in areas of low to moderate relief, wherein they prefer moister, more fertile sites available, for example along creek flats, or in broad river valleys and foothills. In NSW, riparian forests containing River Oak (*Casuarina cunninghamiana*), and with Needle-leaf Mistletoe (*Amyema cambagei*), are also important for feeding and breeding. At times of food shortage (e.g. when flowering fails in preferred habitats), Regent Honeyeaters also use other woodland types and wet lowland coastal forest dominated by Swamp Mahogany (*Eucalyptus robusta*) or Spotted Gum (*Corymbia maculata*). They are typically associated with plant species that reliably produce copious amounts of nectar, such as Mugga Ironbark (*Eucalyptus sideroxylon*), Yellow Box (*E. melliodora*), White Box and Yellow Gum (*E. leucoxylon*), but also are in association with woodland species such as Grey Box (*E. microcarpa*), Red Box (*E. polyanthemos*), Blakely's Red Gum (*E. blakelyi*), River Red Gum (*E. camaldulensis*), Silver-leaved Ironbark (*E. melanophloia*), Narrow-leaved Ironbark (*E. crebra*), Caley's Ironbark (*E. caleyi*) and Rough-barked Apple (*Angophora floribunda*) (DSEWPaC, 2012a).	Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas. Requires structurally diverse habitats featuring mature eucalypts, saplings, some small shrubs and a ground layer of moderately tall native grasses. Often perches on low dead stumps and fallen timber or on low-hanging branches, using a perch-and-pounce method of hunting insect prey (OEH, 2012b).	Habitat includes the steep, rocky ridges and gullies, rolling hills, valleys and river-flats and the nearby plains of the Great Dividing Range. The species occurs in eucalyptus woodlands and open forests, with a ground cover of grasses and low understorey of shrubs. These forests/woodlands usually have mixed assemblages of native pine Callitris and a variety of Eucalyptus species, especially White Box *E. albens*, Yellow Box *E. melliodora*, Blakely's Red Gum *E. blakelyi*, Red Box *E.polyanthemos* , Red Stringybark *E.macrorhyncha*, Bimble Box *E. populnea* or Mulga Ironbark *E. sideroxylon.* The species has also been recorded in a variety of other habitats, including savannah and riparian woodlands and farmland, preferring edges of forest and pasture or other grassland (NPWS, 1999b).
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;		
The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Regent Honeyeater, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Regent	The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include shrubby understorey. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Hooded Robin, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Hooded	The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Turquoise Parrot, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland

Regent Honeyeater (*Anthochaera phrygia* / *Anthochaera phrygia*)	**Hooded Robin (*Melanodryas cucullata cucullata*)**	**Turquoise Parrot (*Neophema pulchella*)**
Honeyeater is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Regent Honeyeater such that a viable local population of the species is likely to be placed at risk of extinction.	Robin is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Hooded Robin such that a viable local population of the species is likely to be placed at risk of extinction.	to be potentially impacted within the survey area. The Turquoise Parrot is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Turquoise Parrot such that a viable local population of the species is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction;		
There is no endangered population of these species currently listed on the TSC Act within the survey area.		
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: ▪ ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ▪ ***is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,***		
This factor does not apply to threatened species.		
d) In relation to the habitat of a threatened species, population or ecological community: ▪ ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*** ▪ ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*** ▪ ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality,***		
Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Regent Honeyeater. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species currently inhabits.	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Hooded Robin. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit.	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Turquoise Parrot. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area,

Regent Honeyeater (*Anthochaera phrygia* / *Anthochaera phrygia*)	**Hooded Robin (*Melanodryas cucullata cucullata*)**	**Turquoise Parrot (*Neophema pulchella*)**
Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);		
There is no critical habitat listed for these species on the register of critical habitat.		
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan;		
There is no recovery plan for this species however there are 41 priority actions listed for this species within the priority action statement. The main priority action that relates to the proposed activities is “Ensuring appropriate environmental impact assessment of proposals impacting on Regent Honeyeater habitat”. As the proposed activities are consistent with the recovery plan objectives and will only impact a small area of suitable habitat, it is assessed that there would be no negative impact on the long term persistence and recovery of this species.	There is no recovery plan for this species however there are 5 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any the 5 priority actions and the small area affected, it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.	There is no recovery plan for this species however there are 10 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any the 10 priority actions and the small area affected, it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.		
There are currently 36 key threatening processes (KTP’s) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	There are currently 36 key threatening processes (KTP’s) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	There are currently 36 key threatening processes (KTP’s) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.

Regent Honeyeater (*Anthochaera phrygia* / *Anthochaera phrygia*)	**Hooded Robin (*Melanodryas cucullata cucullata*)**	**Turquoise Parrot (*Neophema pulchella*)**
Conclusion		
Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Regent Honeyeater or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Hooded Robin or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Turquoise Parrot or its habitats.

Table A8.4: Assessment of Significance of Woodland Dependent Threatened Birds

Varied Sittella (*Daphoenositta chrysoptera*)	Speckled Warbler (*Chthonicola sagittata*)
Background Information	
The Varied Sittella inhabits most of mainland Australia except the treeless deserts and open grasslands, with a nearly continuous distribution in NSW from the coast to the far west. It inhabits eucalypt forests and woodlands, especially rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland (OEH, 2011b).	Occurs in a wide range of Eucalyptus dominated communities that have a grassy understorey, often on rocky ridges or in gullies. Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (NSWSC, 2012).
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;	
The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Varied Sittella, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Varied Sittella is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Varied Sittella such that a viable local population of the species is likely to be placed at risk of extinction.	The proposed activities may lead to the clearing of approximately 5.98 ha of woodland habitat that currently provides an important breeding and foraging resource for the species, which include hollow bearing trees. However the small amount of habitat to be removed is unlikely to constitute habitat critical for the maintenance of a local population of the Speckled Warbler, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values to the woodland to be potentially impacted within the survey area. The Speckled Warbler is a highly mobile species and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Speckled Warbler such that a viable local population of the species is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction;	
There is no endangered population of these species currently listed on the TSC Act within the survey area.	
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: ▪ ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or*** ▪ ***is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,***	
This factor does not apply to threatened species.	
d) In relation to the habitat of a threatened species, population or ecological community: ▪ ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*** ▪ ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and*** ▪ ***the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological***	

Varied Sittella (*Daphoenositta chrysoptera*)	Speckled Warbler (*Chthonicola sagittata*)
community in the locality,	
Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Varied Sittella. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species currently inhabits. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Speckled Warbler. Adjacent and relatively extensive woodland and Heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);	
There is no critical habitat listed for these species on the register of critical habitat.	
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan;	
There is no recovery plan or priority action statement for this species. For this reason and due to the small area of habitat which will be affected by the proposed activities it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.	There is no recovery plan for this species however there are 7 priority actions listed for this species within the priority action statement. However, as the proposed activities do not relate to any the 7 priority actions and the small area affected, it is assessed that there would be no negative impact on the long-term persistence and recovery of this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.	
There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.
Conclusion	

Varied Sittella (*Daphoenositta chrysoptera*)	**Speckled Warbler (*Chthonicola sagittata*)**
Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Varied Sittella or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Speckled Warbler or its habitats.

Table A8.5: Assessment of Significance of Woodland Dependent Threatened Bats

Little Pied Bat (*Chalinolobus picatus*)	South-eastern Long-eared Bat / Corben's Long-eared Bat (*Nyctophilus corbeni*)	Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)
Background Information		
Occurs in dry open forest, open woodland, Mulga and riverine open forests, dry open forest, open woodland, chenopod shrublands, Callitris forest, Casuarina pauper woodlands and mallee and forage predominantly on Moths. The Little Pied Bat roosts in hollow bearing trees, caves, abandoned mines and buildings. They often roost alone and favour large mature trees with dead limbs and dead trees that have fallen over leaving a hollowed stump. They will move roost location most days, although remaining in the same general area (all roosts within 200 m) (Churchill, 2008).	Occurs in a range of inland woodland vegetation types, including box, ironbark and cypress pine woodlands. The species also occurs in Buloke woodland, Brigalow woodland, Belah woodland, Smooth-barked Apple, *Angophora leiocarpa*, woodland; River Red Gum, *Eucalyptus camaldulensis*, forests lining watercourses and lakes, Black Box, *Eucalyptus largiflorens*, woodland, dry sclerophyll forest. Throughout inland Queensland, the species habitat is dominated by various eucalypt and bloodwood species, and various types of tree mallee with it being most abundant in vegetation with a distinct canopy and a dense cluttered shrub layer. In the Hunter Valley, NSW, the species is found in areas such as the Monobalai Nature Reserve and Goulburn River and Wollemi National Parks. It has primarily been recorded in moister woodland of various eucalypt species with a distinct shrub layer frequently adjacent to watercourses. There are a small number of records from closed forest adjacent to dry sclerophyll woodlands; in Araucarian notophyll vine forest in the Bunya Mountains and in semi evergreen vine thickets on the banks of the Dawson River and in the Brigalow Belt Bioregion (DSEWPaC, 2012a).	*Saccolaimus flaviventris* (Yellow-bellied Sheathtail-bat) is widespread across Australia and its apparent rarity is probably due to its flying so high and fast that it is seldom collected. It has been reported from a wide variety of habitats. Hunting height appears to vary depending on the height of the dominant vegetation in Eucalypt forests it feeds above the canopy, but in mallee or open country it comes lower to the ground. Prey species include beetles, long-horned grasshoppers, shield bugs and flying ants. Usually solitary, but occasionally occurring in colonies of less than ten individuals, the *S. flaviventris* roosts in tree hollows, animal burrows, dry clay cracks, under rock slabs, abandoned *Petaurus breviceps* (Sugar Glider) nests, and has been found resting on the walls of buildings in broad daylight, and one such individual, caught at Queanbeyan, NSW, appeared to be so exhausted that it made no effort to escape. Similar reports suggest that it is migratory in southern Australia and that individuals found resting in the open are in the course of a winter migration from the cooler to warmer areas. They have been reported from southern Australia only between January and June.
a) In the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction;		
The proposed activities may lead to the clearing of 5.98 ha of woodland habitat that provides important foraging, roosting and breeding resources for the species. However the small amount of primarily breeding habitat to be potentially removed is unlikely to constitute habitat critical for the maintenance of a local population of the species, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values than the woodland to be potentially impacted within the survey area.	The proposed activities may lead to the clearing of 5.98 ha of woodland habitat that provides important foraging, roosting and breeding resources for the species. However the small amount of primarily breeding habitat to be potentially removed is unlikely to constitute habitat critical for the maintenance of a local population of the species, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values than the woodland to be potentially impacted within the survey area. The South-	The proposed activities may lead to the clearing of 5.98 ha of woodland habitat that provides important foraging, roosting and breeding resources for the species. However the small amount of primarily breeding habitat to be potentially removed is unlikely to constitute habitat critical for the maintenance of a local population of the species, due to the survey area's connectivity with similar habitats. The woodland habitat surrounding the survey area also provides similar habitat values than the woodland to be potentially impacted within the survey area. The Yellow-

Little Pied Bat (*Chalinolobus picatus*)	**South-eastern Long-eared Bat / Corben's Long-eared Bat (*Nyctophilus corbeni*)**	**Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)**
Even though the Little Pied Bat generally has a small home range based around regular roosts sites, it is known to travel up to 17 km to forage and is a highly mobile species that would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Little Pied Bat such that a viable local population of the species is likely to be placed at risk of extinction.	eastern Long-eared Bat is a mobile species with large home ranges and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the South-eastern Long-eared Bat such that a viable local population of the species is likely to be placed at risk of extinction.	bellied Sheathtail Bat is a highly mobile species with large home ranges and would be able to relocate into these surrounding habitats. It is therefore unlikely that the proposed activities would have an adverse affect on the life cycle of the Yellow-bellied Sheathtail Bat such that a viable local population of the species is likely to be placed at risk of extinction.
b) In the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction;		
There is no endangered population currently listed on the TSC Act within the survey area.		
c) In the case of an endangered ecological community or critically endangered ecological community, whether the action proposed: ***is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or***		
d) In relation to the habitat of a threatened species, population or ecological community: ▪ ***the extent to which habitat is likely to be removed or modified as a result of the action proposed, and*** ***whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and***		
This factor does not apply to threatened species.		
Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Little Pied Bat. Adjacent and relatively extensive woodland and heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for South-eastern Long-eared Bat. Adjacent and relatively extensive woodland and heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species may currently inhabit. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the	Approximately 5.98 ha of woodland habitat is to be cleared from the survey area, as a result of the proposed activities. The clearing of a small proportion of this species habitat is unlikely to fragment the remainder, as good connectivity already exists. Therefore it is unlikely to isolate or fragment the remaining habitat from similar adjacent habitats as a result of the proposed activities. This habitat has been identified as a breeding and foraging resource for the Yellow-bellied Sheathtail Bat. Adjacent and relatively extensive woodland and heathland habitats surrounding the survey area provide similar breeding and foraging resources as the survey area, of which the species currently inhabits. Due to the presence of alternative breeding and foraging habitat adjacent to the survey area, the minimal amount of habitat to be affected by the proposed activities are not isolating the species from similar viable habitats in

Little Pied Bat (*Chalinolobus picatus*)	**South-eastern Long-eared Bat / Corben's Long-eared Bat (*Nyctophilus corbeni*)**	**Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)**
proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	proposed activities are not isolating the species from similar viable habitats in the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.	the area of consideration or Pilliga Forest and as such would not have a significant impact on the long-term survival of the species.
e) Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly);		
There is no critical habitat listed for this species on the register of critical habitat.		
f) Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan;		
There is no recovery plan for this species however there are 24 priority actions listed for this species within the priority action statement. Two high priority actions include ensuring the largest hollow bearing trees and standing dead trees are given highest priority for retention and identify areas of private land that contain high densities of trees with hollows and dead standing trees as areas of high conservation value for planning and land management instruments. Although the proposed activities are not consistent with some of the objectives of the 24 priority actions it is assessed that due to the small area the proposed activities will impact there would be no negative impact on the long-term persistence and recovery of this species.	There is no recovery plan for this species however there are 23 priority actions listed for this species within the priority action statement. Two high priority actions include ensuring the largest hollow bearing trees and standing dead trees are given highest priority for retention and encouraging the protection and enhancement of understorey vegetation. Although the proposed activities are not consistent with some of the objectives of the 23 priority actions it is assessed that due to the small area the proposed activities will impact there would be no negative impact on the long-term persistence and recovery of this species.	There is no recovery plan for this species however there are 21 priority actions listed for this species within the priority action statement. High priority actions include encouraging the retention of the largest hollow bearing trees. Although the proposed activities are not consistent with some of the objectives of the 21 priority actions it is assessed that due to the small area the proposed activities will impact there would be no negative impact on the long-term persistence and recovery of this species.
g) Whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.		

Little Pied Bat (*Chalinolobus picatus*)	**South-eastern Long-eared Bat / Corben's Long-eared Bat (*Nyctophilus corbeni*)**	**Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)**
There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.	There are currently 36 key threatening processes (KTP's) listed under the TSC Act. The most relevant one is the clearing of native vegetation which is listed as a KTP under TSC and EPBC Acts. *Clearing of native vegetation* - The proposed activities will clear approximately 5.98 ha of this species habitat. The loss of this relatively small amount of habitat is unavoidable in light of the objectives of the proposed activities and is unlikely to result in the decline of this species in the locality.
Conclusion		
Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Little Pied Bat or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species South-eastern Long-eared Bat or its habitats.	Based on the consideration of the above factors, the proposed activities are not likely to significantly affect the listed threatened species Yellow-bellied Sheathtail Bat or its habitats.

Appendix 8

Aboriginal and European cultural heritage due diligence report
RPS

Aboriginal and Historic Heritage Due Diligence Report

Dewhurst 22-25 Pilot Wells
PEL 238, Gunnedah Basin, NSW

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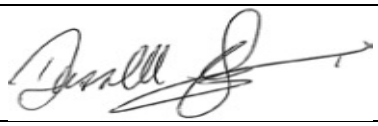
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Executive Summary

RPS has been engaged by Santos NSW (Eastern) Pty Ltd (a wholly owned subsidiary of Santos Limited) (Santos) to prepare an Aboriginal and Historic Heritage Due Diligence Assessment for the following proposed activities:

- The installation of four pilot wells in the centre of four 100 x 100 metre lease areas (herein referred to as the 'Dewhurst 22-25 Project Areas');
- the construction of access tracks of various lengths for the proposed Dewhurst 22-25 Project Areas; and
- the installation of a gathering system that will connect Dewhurst 6, 22, 23 and 25 with Dewhurst 24. This gathering system will run parallel to existing access roads (Monument Road and Yellow Springs Trail) as well as along the proposed access tracks for Dewhurst 22-25.

This assessment has been undertaken in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects* (DECCW 2010) which requires reasonable and practicable steps be taken to: identify whether or not Aboriginal objects are, or are likely to be, present in an area; determine whether or not their activities are likely to harm Aboriginal objects (if present); and determine if an Aboriginal Heritage Impact Assessment is required (DECCW 2010:2).

The assessment contained in this report goes beyond the requirements of the Due Diligence Code to consider any potential impact on identified historic heritage items within the Project Areas and determine if a Statement of Heritage Impact for historic heritage is required.

Investigations under the code have considered:

- a search of the Aboriginal Heritage Information Management System (AHIMS) database, which identified that there were no Aboriginal objects or Aboriginal places in the Project Areas;
- a search of the relevant heritage registers and databases, which identified that there were no historic heritage objects or sites within the Project Areas;
- a consideration of archaeologically sensitive landscape features and whether or not the proposed activity will occur: within 200 metres of water; within dune systems; on ridge tops and headlands; immediately above or below cliff faces and/or rockshelters/caves. Although a number of creek lines run within close proximity to the Dewhurst 22-23 and 25 Project Areas, these are located outside of these Project Areas. The creek identified in the Dewhurst 24 Project Area (intersecting the proposed access track), although considered to be a sensitive landscape feature, did not contain any evidence of Aboriginal objects or sites. No other sensitive landforms were identified;
- a desktop assessment including a review of previous archaeological and heritage studies in the vicinity of the Project Areas; and
- a visual inspection of the Dewhurst 22-25 Project Areas was undertaken and no Aboriginal objects or historic heritage items were identified.

CONCLUSIONS AND RECOMMENDATIONS

This report has considered the available environmental and archaeological information for the Project Areas, the land condition, as well as, the nature of the proposed activities.

The results of the AHIMS search suggest that no registered Aboriginal sites or places are present in or within one kilometre of the Project Areas, and no Aboriginal sites or objects were identified during the visual inspection of the Project Areas. The potential for the proposed activities to impact upon or harm Aboriginal sites or objects is therefore assessed as low, and an AHIP is not required for the proposed activities.

Similarly, there are no known (i.e. reported, recorded or identified) historic heritage items within or near to the Project Areas, and no historic heritage items were identified during the visual inspection of the Project Areas. The potential for the proposed activities to impact upon or harm historic sites or objects is therefore assessed as low, and further historic heritage assessments, including a Statement of Heritage Impact, are not required for the proposed activities.

General mitigations have been provided for undertaking the proposed activity/works as they set out contingency procedures should unexpected Aboriginal objects, skeletal remains or suspected additional historic cultural heritage material be identified during the proposed works. The following recommendations must be followed for undertaking the proposed works.

The proposed works can proceed within the Project Areas as planned.

Recommendation 1

All relevant Santos staff and contractors should be made aware of their statutory obligations for heritage under NSW *National Parks and Wildlife Act 1974* and the NSW *Heritage Act 1977,* which may be implemented as a heritage induction.

Recommendation 2

This due diligence report must be kept by Santos so that it can be presented, if needed, as a defence from prosecution.

Recommendation 3

If Aboriginal object/s are identified in the Project Areas during works, then all works in the immediate area must cease and the area cordoned off. The Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 so that the site can be adequately assessed and managed.

Recommendation 4

In the event that skeletal remains are uncovered, work must cease immediately in that area and the area cordoned off. Santos must contact the NSW Police with no further action taken until written advice is provided by the Police. If the remains are determined to be of Aboriginal origin, the Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 and a management plan prior to works re-commencing must developed in consultation with the relevant Aboriginal stakeholders.

Recommendation 5

If, during the course of development works, suspected historic cultural heritage material is uncovered, work should cease in that area immediately. The Heritage Branch, Office of Environment and Heritage (Enviroline 131 555) should be notified and works only recommence when an approved management strategy developed and the relevant permits are in place.

1.0 Introduction

RPS has been engaged by Santos NSW (Eastern) Pty Ltd (the proponent) to prepare an Aboriginal and Historic Heritage Due Diligence Report. The purpose of a due diligence report is to demonstrate that reasonable and practicable measures were taken to prevent harm to an Aboriginal object or place and has been undertaken in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (2010) ("Due Diligence Code").

The assessment contained in this report goes beyond the requirements of the Due Diligence Code to consider any potential impact on identified historic heritage items within the Project Areas and determine if a Statement of Heritage Impact for historic heritage is required.

This report has considered the relevant environmental and archaeological information, landscape features, disturbances and the nature of the proposed activities in addition to formulating appropriate recommendations.

1.1 The Project Areas

This due diligence report has been prepared for the areas subject to the proposed activity, herein referred to as the "Project Areas." For the purposes of this Due Diligence assessment, each "Project Area" comprises both the proposed pilot well lease area, as well as any associated access tracks. All of the Dewhurst 22-25 Project Areas are located within the Narrabri Local Government Area (LGA), approximately 32 kilometres south of Narrabri and 30 kilometres northwest of Boggabri in the Pilliga East State Forest, and are located within one kilometre of each other.

The proposed pilots wells will be contained within 100 metre x 100 metre lease areas, and will be accessible from Monument Road, an unsealed access road which leads east from the Newell Highway (Figure 1). The proposed pilot wells are located in the centre of each lease area at:

- Dewhurst 22: GDA, Zone 55: Eastings 763704 Northings 6610149
- Dewhurst 23: GDA, Zone 55: Eastings 764471 Northings 6609505
- Dewhurst 24: GDA, Zone 55: Eastings 764025 Northings 6610531
- Dewhurst 25: GDA, Zone 55: Eastings 764677 Northings 6609837

This Due Diligence Assessment also encompasses a gathering system connecting Dewhurst 6, 22, 23 and 25 with Dewhurst 24 that will be installed parallel to existing access roads (Monument Road and Yellow Springs Trail) and along the proposed Dewhurst 22-25 access tracks (Figure 1). As the sections of Monument Road and Yellow Springs Trail that will be impacted by the installation of the gathering system have been the subject of a previous cultural heritage assessment (RPS 2012b), they were not inspected again as part of this Due Diligence Assessment.

1.2 The Proposed Activity

The proposed activity is to install pilot wells in the centre of each of the Dewhurst 22-25 lease areas for the purposes of coal seam gas exploration and extraction. This will necessitate the construction of a 100 metre x 100 metre lease area for each of the pilot well locations, resulting in 1 hectare of disturbance at each site. Access tracks of varying lengths are also required for access to each of the lease areas.

As part of these proposed works, a gathering system connecting Dewhurst 6, 22, 23 and 25 with Dewhurst 24 will also be installed parallel to existing access roads (Monument Road and Yellow Springs Trail) and the

proposed access tracks for the Dewhurst 22-25 Project Areas. This will have a total impact area approximately 10 metres wide.

Works associated with the proposed activity will involve sub-surface excavation and drilling, as well as ground surface disturbance due to the frequent and sustained movement of heavy machinery, ancillary equipment and vehicles within the Project Areas. A due diligence assessment is therefore required under S1 and S2a of the Due Diligence Code (DECCW 2010:11). This due diligence assessment was extended to include historic heritage, to determine if this would be impacted by the proposed development works.

1.3 Authorship and Acknowledgements

This report was prepared by RPS Archaeologist Karyn Virgin with contributions from RPS Senior Spatial Analyst Thomas Wilson. Assistance with report production was provided by Audrey Churm, RPS Business Support Manager.

The report was reviewed by RPS Regional Cultural Heritage Technical Director, Darrell Rigby.

Fieldwork for the Dewhurst 22-24 Project Areas was undertaken from 18 to 19 September 2012 by RPS Senior Archaeologist Sarah Ward in conjunction with RPS Ecologist Hannah Rowan and in the presence of Wayne Bartesko (Senior Landholder Advisor) and Warwick Moppett (Land Access Advisor) of Santos.

Fieldwork for the Dewhurst 25 Project Area was undertaken on 24 January 2013 by RPS Archaeologist Karyn Virgin in conjunction with RPS Ecologist Hannah Rowan and in the presence of Warwick Moppett (Land Access Advisor) of Santos.

2.0 Legislative Context

The following overview of the legal framework is provided solely for information purposes for the client, it should not be interpreted as legal advice. RPS will not be liable for any actions taken by any person, body or group as a result of this general overview, and recommend that specific legal advice be obtained from a qualified legal practitioner prior to any action being taken as a result of the summary below.

Although there are a number Acts protecting and managing cultural heritage in New South Wales (see Appendix 1) the primary ones which apply to this report include:

- *National Parks & Wildlife Act 1974*;
- *National Parks & Wildlife Regulation 2009; and*
- *Heritage Act 1977.*

In brief, the *National Parks & Wildlife Act 1974* protects Aboriginal cultural heritage (places and objects) within NSW; the *National Parks and Wildlife Regulation 2009* provides a framework for undertaking activities and exercising due diligence; whilst the *Heritage Act 1977* protects historic heritage.

2.1 *National Parks & Wildlife Act 1974*

The *National Parks & Wildlife Act 1974* (NPW Act) protects Aboriginal cultural heritage within NSW. Protection of Aboriginal cultural heritage is outlined in s86 of the Act, as follows:

- "A person must not harm or desecrate an object that the person knows is an Aboriginal object" s86(1);
- "A person must not harm an Aboriginal object" s86(2); and
- "A person must not harm or desecrate an Aboriginal place" s86(4).

Penalties apply for harming an Aboriginal object or place. The penalty for knowingly harming an Aboriginal object (s86[1]) and/or an Aboriginal place (s86[4]) is up to $550,000 for an individual and/or imprisonment for 2 years; and in the case of a corporation the penalty is up to $1.1 million. The penalty for a strict liability offence (s86[2]) is up to $110,000 for an individual and $220,000 for a corporation.

Harm

Under the NPW Act, harm is defined as any act that: destroys, defaces or damages the object; moves the object from the land on which it has been situated; and/or causes or permits the object to be harmed. However, it is a defence from prosecution if the proponent can demonstrate: 1) that harm was authorised under an Aboriginal Heritage Impact Permit (AHIP) (and the permit was properly followed); or 2) that the proponent exercised due diligence in respect to Aboriginal cultural heritage. The **'due diligence' defence** (s87(2)), states that if a person or company has exercised due diligence to ascertain that no Aboriginal object was likely to be harmed as a result of the activities proposed for the Project Area (subject area of the proposed activity); then liability from prosecution under the NPW Act will be removed or mitigated if it later transpires that an Aboriginal object was harmed.

Notification of Aboriginal Objects

Under section 89A of the NPW Act, Aboriginal objects (and sites) must be reported to the Director-General (now Chief Executive) of OEH within a reasonable time (unless it has previously been recorded and submitted to AHIMS). Penalties of $11,000 for an individual and $22,000 for a corporation may apply for each object not reported.

2.2 *National Parks and Wildlife Regulation 2009*

The *National Parks and Wildlife Regulation 2009* ("NPW Regulation") provides a framework for undertaking activities and exercising due diligence in respect to Aboriginal cultural heritage. The NPW Regulation outlines the recognised due diligence codes of practice which are relevant to this report, but it also outlines procedures for Aboriginal Heritage Impact Permit (AHIP) applications and Aboriginal Cultural Heritage Consultation Requirements (ACHCRs); amongst other regulatory processes.

2.3 Due Diligence and Codes of Practice

The **advantage of a Due Diligence** assessment is that:

- it assists in avoiding unintended harm to Aboriginal objects;
- provides certainty to land managers and developers about appropriate measures for them to take;
- encourages a precautionary approach;
- provides a defence against prosecution if the process is followed; and
- results in more effective conservation outcomes for Aboriginal cultural heritage.

One of the benefits of the due diligence provisions is that they provide a simplified process of investigating the Aboriginal archaeological context of an area to determine if an Aboriginal Heritage Impact Permit (AHIP) is required.

Under the s80A *National Parks & Wildlife Regulation* 2009 ("NPW Regulation") the following due diligence codes are recognised:

(a) the Due Diligence Code published by the Department of Environment, Climate Change and Water and dated 13 September 2010;

(b) the Plantations and Reafforestation Code (being the Appendix to the *Plantations & Reafforestation (Code) Regulation 2001*) as in force on 15 June 2010;

(c) the *Private Native Forestry Code of Practice for Northern New South Wales* approved by the Minister for Climate Change, Environment and Water and published in the Gazette on 8 February 2008;

(d) the *NSW Minerals Industry Due Diligence Code of Practice for the Protection of Aboriginal Objects* published by NSW Minerals Council Ltd and dated 13 September 2010;

(e) the *Aboriginal Objects Due Diligence Code for Plantation Officers Administering the Plantations and Reafforestation (Code) Regulation 2001* published by the Department of Industry and Investment and dated 13 September 2010; and

(f) the *Operational Guidelines for Aboriginal Cultural Heritage Management* published by Forests NSW and dated 13 September 2010.

This report has been written to meet the Due Diligence Code (DECCW 2010).

2.3.1 *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010)

This publication sets out a minimum benchmark for acceptable due diligence investigations to be followed. The purpose of the code is to set out reasonable and practical steps in order to:

(1) identify whether or not Aboriginal objects (and places) are, or are likely to be, present in an area;

(2) determine whether or not their activities are likely to harm Aboriginal objects (if present); and

(3) determine whether an AHIP application is required. (DECCW 2010:2).

Investigations under the code include the following:

- a search of the Aboriginal Heritage Information Management System (AHIMS) database to identify if there are previously recorded Aboriginal objects or places in the Project area;
- identification of landscape features including land within 200 metres of water, dune systems, ridge tops, headlands, land immediately above or below cliff faces and/or rockshelters/caves;
- desktop assessment including a review of previous archaeological and heritage studies and any other relevant material;
- visual inspection of the Project Area to identify if there are Aboriginal objects present; and
- assessment as to whether an AHIP is required.

This report has complied with the requirements of the code listed above. Other requirements under the code are outlined below.

Aboriginal consultation is not required for an investigation under the Due Diligence Code (DECCW 2010:3). However, if the due diligence investigation shows that the activities proposed for the area are likely to harm objects or likely objects within the landscape, then an AHIP will be required with full consultation.

A record of the due diligence procedure followed must be kept to ensure it can be used as a defence from prosecution (DECCW 2010:15).

Following a due diligence assessment (where an AHIP application was not required), such as this, an activity must proceed with caution. If any Aboriginal objects are identified during the activity, then works should cease in that area and OEH notified (DECCW 2010:13). The due diligence defence does not authorise continuing harm.

2.3.2 *Aboriginal Community Consultation*

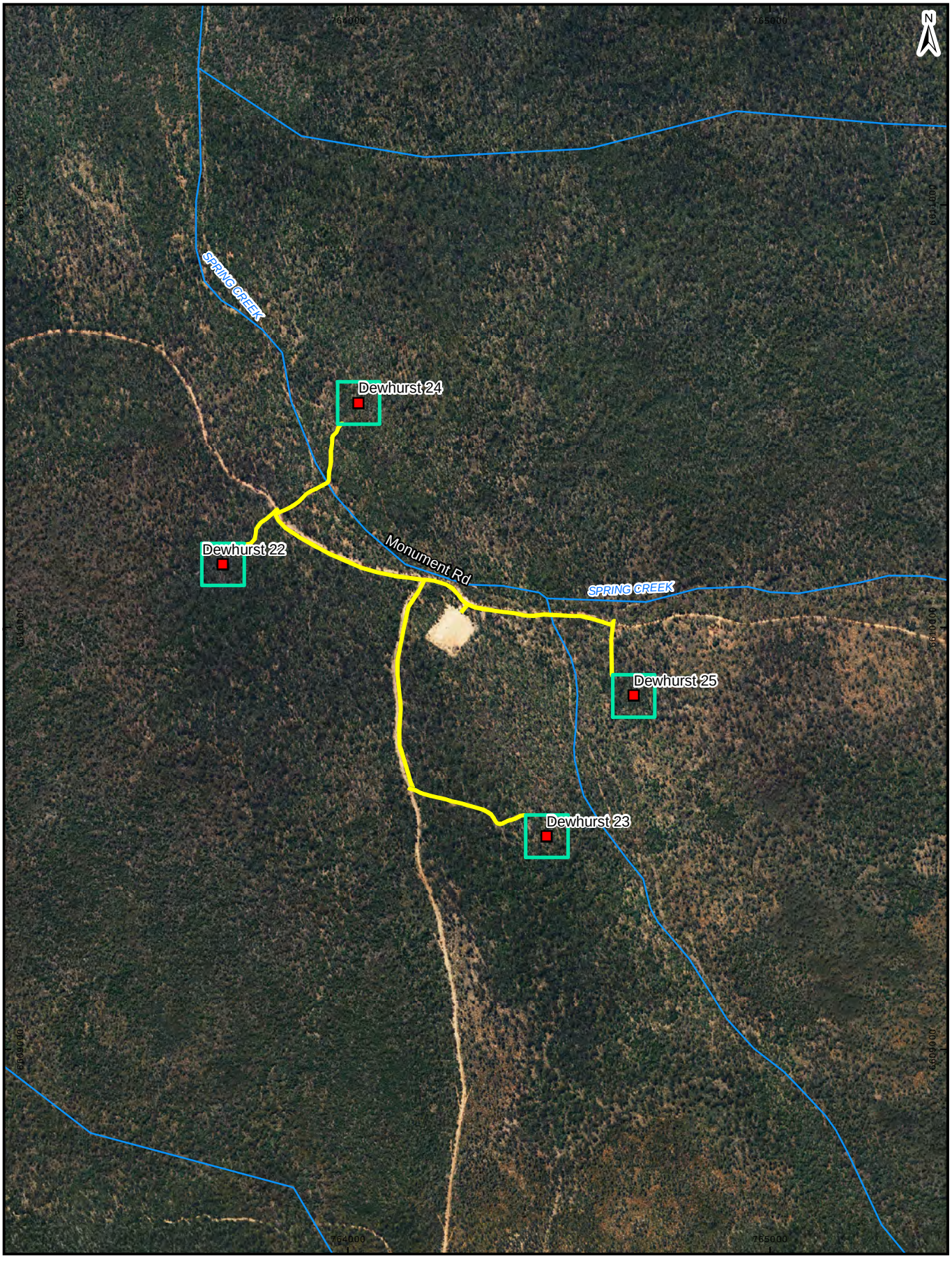
Aboriginal community consultation is not a formal requirement of the due diligence process (DECCW 2010:3); therefore the proponent is not obliged to undertake Aboriginal community consultation.

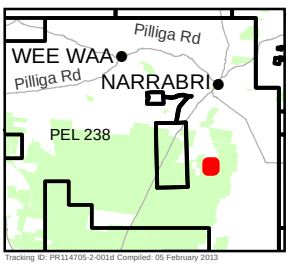
Aboriginal community consultation was not undertaken for this due diligence report.

2.4 Heritage Act 1977

This Act protects the natural and historic cultural history of NSW with emphasis on historic heritage (such as place, building, works, relic, moveable object, precinct, historic shipwreck, or archaeological site) of State or local significance, through protection provisions and the establishment of a Heritage Council and a State Heritage Register. Additionally, Government agencies have special obligations under the *Heritage Act 1977 (*NSW). Agencies are required to compile a register of heritage assets (known as a Section 170 Heritage and Conservation Register) and look after their assets on behalf of the community. Further information on historic heritage items associated with the proposed activity and Project Area is provided in Section 4.2 of this report.

Although Aboriginal objects and places of significance are primarily protected by the NPW Act, if an Aboriginal site, object or place is of State or local significance, it may be protected by a heritage order issued by the Minister subject to advice by the Heritage Council. Penalties of up to $1.1 million are in place for breeches of the Heritage Act and its Regulations.





Tracking ID: PR114705-2-001d Compiled: 05 February 2013

N

100 0 100 200

Metres

APPROX SCALE 12,500 @ A4

GDA 1994 MGA Zone 55

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

DATA SOURCES

Point features and proposed Lease area located by GPS

LEGEND

- Pilot Well
- Proposed Lease Area
- Collection System 10m Corridor
- Watercourse

RPS

FIGURE 1

Project Area

3.0 Environmental Context

Aboriginal cultural heritage due diligence requires that available knowledge and information is considered and forms part of the desktop assessment required under S4 of the Due Diligence Code (DECCW 2010:12-13). The purpose of reviewing the relevant environmental and heritage information is to assist in identifying whether Aboriginal objects or places are present within the Project Area.

3.1 Local Environment

An understanding of environmental context is important for the predictive modelling of Aboriginal sites and their interpretation. The local environment is understood to have provided natural resources for Aboriginal people, such as stone (for manufacturing stone tools), food and medicines, wood and bark (for implements such as shields, spears, canoes, bowls, shelters, amongst others), along with areas for camping and other activities. The nature of Aboriginal occupation and resource procurement is related to the local environment and it therefore needs to be considered as part of the cultural heritage assessment process. The Project Areas are in the Pilliga sub-region of the Brigalow Belt South Bioregion (NSW National Parks and Wildlife Service 2003: 137).

3.1.1 Geology and Soils

The Project Areas are predominantly located on the Jurassic Pilliga Sandstone landscape. Pilliga Sandstone is coarse textured and porous quartz sandstone with interbedded claystones, pebble beds and conglomerates (Ward 1999: 14). In areas, Pilliga Sandstone overlies the Walloon Coal Measures, which comprise claystone, shale, siltstone (Geoscience Australia 2012: Online).The landscape is characterised by stepped sandstone ridges with low cliff faces, and broad alluvial floodplains and valleys. There is a high proportion of rock outcrop and long gentle outwash slopes, which are intersected by sandy stream beds and prior stream channels, and interspersed with patches of heavy clay (Wallis 1971: 1).

Soils in the Project Areas are typically shallow black earths and red loams on basalts. Extensive harsh texture contrast duplex soils with linear patterns of deep yellow sands and stony red broth earths are typical, as are cracking clay sub-soils. These soils are typical of those derived from the Pilliga Sandstone and are described as highly siliceous. They are characterised by the dense growth of trees and shrubs and high species diversity (Norris 1996: 1).

The geology and soils of the Project Areas demonstrate that the landscape prior to European contact was capable of supporting Aboriginal resources suitable for habitation.

3.1.2 Topography and Hydrology

The Project Areas are located within the Pilliga East State Forest on slightly elevated land of around 300 metres Australian Height Datum (AHD) (Department of Lands 1973: Topoview Raster Viewer). Several water sources, predominantly ephemeral, are located in the vicinity of the Project Areas. At its closest, the ephemeral Bohena Creek is within 13 kilometres of the Project Areas. A tributary of this high order water course, Yellow Spring Creek, is located less than two kilometres away, while Pine Creek, also a tributary of Bohena Creek, runs within four kilometres of the Project Areas, to the southeast. Spring Creek and a number of its tributaries run within 200 metres of the Project Areas; these tributaries are ephemeral drainage lines, active only in periods of high water. These water courses would have provided ephemeral sources of water.

The topography and hydrology of the Project Areas demonstrate that the landscape would have been habitable for past populations; the area would have provided sufficient intermittent water resources and been fertile enough to sustain transient human occupation.

3.1.3 Climate

During the last glacial maximum (approximately 30,000-19,000 years ago), large ice sheets covered high latitude Europe and North America and the Antarctic ice sheet was more extensive than today. Sea levels stood some 120-130 metres lower than today (Lambeck et al 2002:343) and the earth's climate was distinctly different from that of the present interglacial conditions. As the ice began to melt climatic conditions began to alter (Lambeck et al 2002:343). This affected the movement and behaviour of past populations within their environs. Sea levels started to rise, with a corresponding increase in rainfall and temperature. Short's (2000:19-21) research suggests the change in climatic conditions reached its peak about 6,000 years ago.

Temperatures stabilised around 1,000 years ago and, consequently, the climate of the Project Areas for the past 1,000 years would probably have been much the same as present day, providing a year round habitable environment. New South Wales is described as being in the temperate zone, although the climate undergoes large variations depending on proximity to the coast and mountains (OEH 2012a: Online; SEWPC 2011: 146).

The Project Areas are located within the eastern sub-humid region of Australia (NSW NPWS 2000b: 3), which has erratic rainfall and no water surplus available for run-off. In the regional area, rainfall is typically well distributed geographically, however, long droughts and occasional high-intensity, short-duration storms are typical, resulting in an unreliable water source (Ward 1999: 18). Temperatures are at their highest in December (37.1^{o} Celsius) and January (37.3^{o} Celsius) with an average maximum of 28.0^{o} Celsius. The coldest month is July with the average maximum temperatures of 20.9ºCelsius (BOM 2012: Online).

3.1.4 Flora and Fauna

Although vegetation in the regional area has largely been cleared for agricultural and farming purposes, vegetation at the time of European settlement was partly dry sclerophyll forest and partly grassland (Ward 1999: 11). Remnant vegetation associated with these communities is observable in the vicinity of the Project Area.

In upland areas, tree species such as bimble box, white cypress pine, Blakely's red gum, white box, bull oak and wilga are typical, as are various species of wattle. Wire-grasses are also dominant in these areas, and rough speargrass and slender bamboo grass may also be present. On the alluvial plains, grassland is dominant, with typical species including curly windmill grass, nardoo, common rush, various species of roly-poly and wild turnip. A sparse tree population is also present; belah, a *Casuarina* species is prominent, though bimble box, silver-leaved ironbark, wilga, white cypress pine and bull oak are also typical. Along Galathera Creek, vegetation predominantly comprises common rush, while along the Namoi River, river red gum is common (Ward 1999: 11-12). A full ecological assessment for the Project Area has been prepared by RPS Ecology (RPS 2012a) as a companion to this report.

This vegetation community would have provided habitats for a variety of animals and would also have provided potential food and raw material sources for Aboriginal people.

3.1.5 Synthesis of Environmental Context

A review of environmental data indicates that, despite the landscape being highly disturbed by commercial and agricultural pursuits, prior to European occupation there would have been bountiful food, water and other resources available for exploitation by Aboriginal people and in sufficient quantities to sustain a local population.

This synthesis demonstrates that there is potential for Aboriginal cultural heritage sites to be present in the vicinity of the Project Areas.

4.0 Heritage Context

Heritage consists of those objects, sites and places that will be inherited by future generations. Australia has many rich and varied historic places and landscapes, both urban and rural. Identifying and understanding their particular qualities, and what these add to our lives, is central to our engagement with our history and culture.

4.1 Aboriginal Cultural Heritage

Aboriginal and Torres Strait Islander heritage is an important part of Australian heritage. Evidence of the occupation of Australia by Aboriginal and Torres Strait Islander peoples dates to approximately 40,000 to 60,000 years ago (Dorey 2012: Online).

4.1.1 Aboriginal Heritage Information Management System (AHIMS)

A search was undertaken of the Aboriginal Heritage Information Management System (AHIMS) for the Project Areas on 18 October 2012 in accordance with the Due Diligence Code (DECCW 2010:11). The searches were conducted with a one kilometre buffer for the following area, which encompassed all four Project Areas: GDA, Zone 55: Eastings 759420 – 769860 Northings 6606765 - 6612768.

The searches revealed that there are **no previously recorded Aboriginal sites** and **no previously declared Aboriginal places** in, or within, one kilometre of the Project Areas.

4.1.2 National Native Title Tribunal Registers

A search was undertaken of the National Native Title Tribunal (NNTT) registers on 15 October 2012 in accordance with the *ESG2: Environmental Impact Assessment Guidelines* (NSW Trade and Investment 2012: Online). The search was conducted for the Narrabri LGA (Search Reference: 5153/12sj).

This search identified one native title claimant, being the Gomeroi People. Their claim extends over an area of 111,340 square kilometres and includes the Narrabri Shire Council area. This claim was filed with the NNTT on 20 December 2011 and the notification completed on 15 August 2012. A former claim in 2007 by the Gomeroi Narrabri People was discontinued. Under the *Native Title Act 1993* the valid grant of a freehold estate (other than certain types of Aboriginal and Torres Strait Islander land) on or before 23 December 1996 is known as a 'previous exclusive possession act', meaning that native title has been extinguished over the area. The Project Areas are wholly situated within PEL 238. As PEL 238 was granted in 1980 the Project Areas cannot be subject to a native title claim.

4.1.1 Archaeology and Cultural Heritage Literature Review

A review of previous archaeological and heritage reports is required as part of the desktop assessment and has been undertaken in accordance with the code (DECCW 2010:13). The most relevant publications are outlined below.

Appleton, J. (2009), Narrabri Longwall Stage 2 Project: Aboriginal Heritage Assessment. Whitehaven Coal: Sydney.

This investigation was conducted pursuant to an extension to the Narrabri Coal Mine by Whitehaven Coal, located approximately 28 kilometres south of Narrabri, adjacent to the Kamilaroi Highway. The investigation entailed a desktop assessment and a survey over four main areas comprising the impact zones.

The survey identified a total of 121 sites across the four survey areas. The majority of sites were identified in the longwall panels 8-26 (69), followed by the area comprising longwall 1-7. The longwall locations were on a

variety of landscapes, but mostly on the eastern slopes of the Pilliga Forest. This area is fed by numerous ephemeral and permanent watercourses, including Pine Creek and Kurrajong Creek.

Overall, the sites comprised low density artefact scatters, with scatters of higher densities being associated with confluences of water courses. A scarred tree and a hearth were also identified in the longwall 1-7 area.

Trindall, E. (2007), Narrabri Coal Seam Gas Utilisation Project: Aboriginal Heritage Assessment, Santos Limited: Sydney.

This investigation was conducted ahead of the proposed construction of a gas gathering system, gas flow line and expansion of Wilga Park Power Station. The impact area of that project totalled approximately 36 hectares in the Pilliga East State Forest and open farmland in Narrabri Shire.

The investigation comprised a desktop assessment and a field survey to assess the impact of the proposed operations on the Aboriginal cultural heritage resource. Previous disturbances were variable, with the farmland being moderately disturbed, whilst the Pilliga Forest area had been subjected to varying levels of forestry, fires, grazing and mining exploration.

The survey identified one site, a scarred tree located between Dog Fence Road and Pilliga Forest Way. The tree was a Pilliga Box, one of less than 10 in the vicinity of the area surveyed. It was recommended that this tree be avoided by the proposed works.

Silcox, R. & Bowdler, S. (1982), An Archaeological Survey of a Proposed 132 Kv Transmission Line Route from Walgett to Narrabri Part 1. A Report to the National Parks and Wildlife Service of N.S.W. on behalf of the Electricity Commission of N.S.W. unpublished.

This investigation covered the physical examination (visual inspection) of a proposed 132 kilovolt (kv) transmission line route from Walgett to Narrabri. This report covers the first 87 kilometres of the 180 kilometre total route, which is proposed to contain an easement 45 metres wide. The second report, containing the Narrabri sector of the route was unable to be accessed.

Eight sites and seven isolated finds were identified during the course of the survey with visibility averaging 50%. The sites consisted of four scarred trees (two dead both ring barked (WN1 & WN2); two alive, standing, not ring barked (WN3 & WN4), two surface campsites and two scatters of baked clay ‘lumps’ (WN7 & WN8). The authors initially suggested that these were from hearths, however conceded later in the report that they were likely the result of European clearing and burning of timber.

4.1.2 Synthesis of Aboriginal Cultural Heritage Context

The AHIMS search conducted for the Project Areas returned a negative result, which may be partially explained by the lack of archaeological studies that have been undertaken in the immediate vicinity of the Project Areas to date; previous archaeological work in the region suggests that the broader regional area was utilised by past Aboriginal communities. This is in part due to the ready availability of food, water and other resources; the availability of water being a crucial factor in the frequency of occupation, as rivers and creeks are markers of community identity, traditional meeting places and the chosen location of settlements (NPWS 2000a: 36).

Trindall (2007: 5-11) observed the paucity of sites within the Pilliga Forest as being a direct consequence of the lack of reliable water, whilst areas outside the Pilliga and closer to permanent water contained a variety of site types. However, the potential for sites remaining must be tempered with previous land disturbances. The AHIMS search results together with previous land disturbances suggests that the potential for Aboriginal objects or places to be present within the Project Areas is low.

4.2 Historic Heritage Context

European land settlement commenced in NSW in 1788 when Governor Phillip claimed possession of the land now known as Australia for a penal colony on behalf of the British Government. The region was first visited by John Oxley, the explorer and then Surveyor General of NSW in 1817, who noted the presence of Aboriginal people and the suitability of the land for agriculture (NPWS 2000b: 133).

4.2.1 World Heritage

The World Heritage List is a register of sites considered to have outstanding universal value. A search of the World Heritage List revealed there to be 20 World Heritage listings (one listing may contain several properties) in Australia, six of which are in NSW. There are **no World Heritage** listings in the Narrabri LGA, and therefore no listings within the Project Areas themselves.

4.2.2 National Heritage

The National Heritage List is the lead statutory document for the protection of heritage places considered to have national importance. Listed places are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A search of the Australian Heritage Database with reference to the National Heritage List on 15 October 2012 indicates that there are no heritage items in the town of Narrabri or the Narrabri LGA, on the National Heritage List, and consequently **no national heritage items** within or near to the Project Areas.

Previously the Register of the National Estate was the primary document. While the Register of the National Estate still exists in archival form, items can no longer be registered and since February 2012 no longer has statutory status. However, the Minister is still required to consider the Register when making some decisions under the EPBC Act. A search of the Australian Heritage Database with reference to the Register of the National Estate on 15 October 2012 revealed six heritage sites within the Narrabri LGA on the Register of the National Estate. The searches revealed that **no heritage sites** on the Register of the National Estate are in, or near to, the Project Areas.

4.2.3 Commonwealth Heritage

The Commonwealth Heritage List is a list of natural, Indigenous and historic heritage places owned or controlled by the Australian Government. A search of the Australian Heritage Database with reference to the Commonwealth Heritage List, on 15 October 2012 revealed that one site in the town of Narrabri, the Narrabri Post Office and former Telegraph Office, is listed on the Commonwealth Heritage List. The Post Office and former Telegraph Office is located in Maitland Street, Narrabri, outside of the Project Areas. There are **no Commonwealth heritage items** in the Project Areas.

4.2.4 State Heritage

The NSW State Heritage Inventory (SHI) database is maintained by the Heritage Branch, Office of Environment and Heritage and lists items that have been identified as of State and/or local heritage significance throughout NSW. A search of the State Heritage Register on 15 October 2012 revealed one item of State Heritage Significance listed on the NSW State Heritage Register (Narrabri Gaol and Residence, Bowen Street, Narrabri) in the Narrabri LGA. The item is outside of the Project Areas and therefore there are **no heritage items of State Significance** in, or near to the Project Areas.

The searches also revealed **no heritage items** in the Narrabri LGA subject to an Interim, or Authorised Interim Heritage Order, and **no heritage items** subject to a s136 order.

4.2.5 Local Heritage

The *Narrabri Local Environmental Plan (LEP) 2012* lists a total of 40 local heritage items, 21 of which are located in Narrabri. A search of the SHI database on 8 January 2013 revealed that 23 items of local heritage significance have been listed by Local Government and State Agencies for the Narrabri LGA, 16 of which are included in the *Narrabri Local Environmental Plan 2012.* There are **no local heritage items** located in or near to the Project Area in either the SHI database or the *Narrabri LEP 2012*.

4.2.6 Synthesis of Historic Heritage Context

Although the Narrabri region has been settled for almost 200 years, the search results indicate that there are no known (i.e. reported, recorded or identified) historic heritage items within or near to the Project Areas. This is likely to be a consequence of recent landscape disturbance that has occurred in the regional area as part of agricultural, commercial and residential development, as well as the disturbance that has occurred in the general vicinity of the Project Areas. It is therefore considered that there are **no historic heritage constraints** associated with the project.

5.0 Visual Inspection and Field Results

A visual inspection of the Dewhurst 22-25 Project Areas and their associated access tracks was undertaken to identify whether Aboriginal objects are present on the ground surface or are likely to be present below the ground surface. In accordance with S4 of the Due Diligence Code a qualified archaeologist undertook the visual inspection (DECCW 2010:12-13).The visual inspection (pedestrian survey) of the Dewhurst 22-24 Project Areas was undertaken from 18 to 19 September 2012 by RPS Senior Archaeologist Sarah Ward in fine and sunny conditions. The visual inspection of the Dewhurst 25 Project Area was undertaken on 24 January 2013 by RPS Archaeologist Karyn Virgin.

Dewhurst 22 Project Area

The Dewhurst 22 Project Area is located approximately 170 metres to the south of Monument Road, which is an unsealed vehicle track. The general area has been partially disturbed by nearby track grading, vehicle access, and past vegetation clearance (Plate 1). The definition of 'disturbed land' used in this assessment conforms to the definition given by the Office of Environment and Heritage (OEH) (2010:18) and described in Section 6.0.

At the commencement of the archaeological investigation, the corners of the 100 metre x 100 metre lease area (Table 1) were programmed into a Garmin Oregon 450t unit. Following an inspection of the perimeter, the entire lease area was surveyed by way of pedestrian transects. These transects were walked at approximately five metre intervals, and particular attention was given to any ground surface exposures. The proposed access track for this pilot well is approximately 120 metres long with a 10 metre wide impact area, and was surveyed in a single five metre transect.

Table 1 : Dewhurst 22 Lease Area Corner Locations (UTM)

Corner	Eastings	Northings
D22-1	763754	6610099
D22-2	763754	6610199
D22-3	763654	6610099
D22-4	763654	6610199

Source: RPS 2012.

Vegetation in the Project Area was dominated by regrowth vegetation, though some mature trees were observed including ironbark and white cypress pine. Midstorey vegetation was sparse, and consisted primarily of wattle species. The closest water course was a minor tributary of Spring Creek, which was located less than 100 metres to the east, outside of the Project Area; no other water courses were noted in or near to the Project Area.

Despite some areas of exposure being present (25%), ground surface visibility was limited (less than 15%) due to heavy leaf litter. Both exposure and visibility were considerably higher along the access track (60%). Where visible, soils in the Project Area comprised yellow-orange sand topsoil (less than 5 centimetres deep), which overlaid B horizon orange clay subsoil. As it is not anticipated that artefacts would be contained within subsoil layers, the potential for intact archaeological deposits was assessed as low. No raw stone materials suitable for artefact or tool manufacture were present in the Project Area.

Dewhurst 23 Project Area

The Dewhurst 23 Project Area is located approximately 320 metres to the east of Yellow Springs Trail, an unsealed vehicle track, which leads south from Monument Road. The general area has been partially disturbed by nearby track grading, vehicle access, and past vegetation clearance (Plate 2). The definition of

'disturbed land' used in this assessment conforms to the definition given by the Office of Environment and Heritage (OEH) (2010:18) and described in Section 6.0.

At the commencement of the archaeological investigation, the corners of the 100 metre x 100 metre lease area (Table 2) were programmed into a Garmin Oregon 450t unit. Following an inspection of the perimeter, the entire lease area was surveyed by way of pedestrian transects. These transects were walked at approximately five metre intervals, and particular attention was given to any ground surface exposures. The proposed access track for this pilot well is approximately 320 metres long with a 10 metre wide impact area, and was surveyed in a single five metre transect (Plate 3).

Table 2 : Dewhurst 23 Lease Area Corner Locations (UTM)

Corner	Eastings	Northings
D23-1	764521	6609555
D23-2	764521	6609455
D23-3	764421	6609455
D23-4	764421	6609555

Source: RPS 2012.

Vegetation in the Project Area was dominated by thick regrowth vegetation, though some mature trees were observed including ironbark and white cypress pine (Plate 4). Midstorey vegetation was dense, and wattle was dominant. The closest water course was a minor tributary of Spring Creek, which was located less than 150 metres to the northeast, outside of the Project Area; no other water courses were noted in or near to the Project Area.

There were few areas of exposure (15%), and ground surface visibility was limited (less than 15%) due to heavy leaf litter and dense midstorey vegetation. Both exposure and visibility were considerably higher along the access track (50%). Where visible, soils in the Project Area comprised yellow-orange sand topsoil (less than 5 centimetres deep), which overlaid B horizon orange clay subsoil. As it is not anticipated that artefacts would be contained within subsoil layers, the potential for intact archaeological deposits was assessed as low. No raw stone materials suitable for artefact or tool manufacture were present in the Project Area.

Dewhurst 24 Project Area

The Dewhurst 24 Project Area is located approximately 290 metres to the north of Monument Road, which is an unsealed vehicle track. The general area has been partially disturbed by nearby track grading, vehicle access, and past vegetation clearance (Plate 5). The definition of 'disturbed land' used in this assessment conforms to the definition given by the Office of Environment and Heritage (OEH) (2010:18) and described in Section 6.0.

At the commencement of the archaeological investigation, the corners of the 100 metre x 100 metre lease area (Table 3) were programmed into a Garmin Oregon 450t unit. Following an inspection of the perimeter, the entire lease area was surveyed by way of pedestrian transects. These transects were walked at approximately five metre intervals, and particular attention was given to any ground surface exposures. The proposed access track for this pilot well is approximately 290 metres long with a 10 metre wide impact area, and was surveyed in a single five metre transect.

Table 3 : Dewhurst 24 Lease Area Corner Locations (UTM)

Corner	Eastings	Northings
D24-1	764075	6610481
D24-2	764075	6610581
D24-3	763975	6610581
D24-4	763975	6610481

Source: RPS 2012.

Vegetation in the Project Area was dominated by regrowth vegetation, though some mature trees were observed including ironbark and white cypress pine. Midstorey vegetation was moderately dense, with various species of wattle dominating. Spring Creek was observed to be active within the boundaries of the Project Area as it crosses the proposed access track, and was thoroughly inspected for Aboriginal artefacts; none were identified (Plate 6).This creek line intersected the proposed access track at location 763922E – 6610368N.

There were few areas of exposure (15%), and ground surface visibility was limited (less than 15%) due to heavy leaf litter and moderately dense midstorey vegetation. Both exposure and visibility were considerably higher along the access track (50%). Where visible, soils in the Project Area comprised yellow-orange sand topsoil (less than 5 centimetres deep), which overlaid B horizon orange clay subsoil. As it is not anticipated that artefacts would be contained within subsoil layers, the potential for intact archaeological deposits was assessed as low. No raw stone materials suitable for artefact or tool manufacture were present in the Project Area.

Dewhurst 25 Project Area

The Dewhurst 25 Project Area is located approximately 120 metres to the south of Monument Road, which is an unsealed vehicle track. The general area has been partially disturbed by nearby track grading, vehicle access, and past vegetation clearance (Plate 7). The definition of ‘disturbed land’ used in this assessment conforms with the definition given by the Office of Environment and Heritage (OEH) (2010:18) and described in Section 6.0.

At the commencement of the archaeological investigation, the corners of the 100 metre x 100 metre lease area (Table 4) were programmed into a Garmin GPSmap 62s. Following an inspection of the perimeter, the entire lease area was surveyed by way of pedestrian transects. These transects were walked at approximately five metre intervals, and particular attention was given to any ground surface exposures. The proposed access track for this pilot well is approximately 130 metres long with a 10 metre wide impact area, and was surveyed in a single five metre transect.

Table 4 : Dewhurst 25 Lease Area Corner Locations (UTM)

Corner	Eastings	Northings
D25-1	764627	6609887
D25-2	764627	6609787
D25-3	764727	6609887
D25-4	764727	6609787

Source: RPS 2012.

Vegetation in the Project Area was dominated by regrowth vegetation, though some mature trees were observed including eucalypts and white cypress pine (Plate 8). Midstorey vegetation was moderately dense in some areas. The closest water course was a tributary of Spring Creek, which was located less than 120

metres to the west, outside of the Project Area; no other water courses were noted in or near to the Project Area.

There were few areas of exposure (10%), and ground surface visibility was limited (less than 10%) due to heavy leaf litter and moderately dense midstorey vegetation (Plate 9). Where visible, soils in the Project Area comprised yellow-orange sand topsoil (less than 5 centimetres deep), which overlaid B horizon orange clay subsoil. As it is not anticipated that artefacts would be contained within subsoil layers, the potential for intact archaeological deposits was assessed as low. No raw stone materials suitable for artefact or tool manufacture were present in the Project Area.

5.1 Summary of Visual Inspection and Field Results

Although a number of creek lines run within close proximity of the Dewhurst 22-23 and 25 Project Areas, these are located outside of these Project Areas, and are ephemeral drainage lines active only in periods of high recharge. Spring Creek was observed within the Dewhurst 24 Project Area, intersecting the proposed access track and was active; however no Aboriginal objects or sites were identified in association with this sensitive landform. The Project Areas are therefore considered to have limited suitability for continuous habitation. The land may still have been used for transient or temporary purposes, though evidence of such use would not necessarily be left in the archaeological record. Further, past land uses such as grazing, land clearance and other agricultural and commercial pursuits may have damaged and/or destroyed any remnant evidence of such transient occupation. The archaeological potential for the Project Areas is therefore assessed as very low to nil.

No Aboriginal sites or objects were identified in the Dewhurst 22-25 Project Areas, and no historic heritage items or sites were identified. Additionally, no trees exhibiting evidence of cultural modification/scarring were observed and no vegetation with natural heritage significance was identified.

6.0 Impact Assessment

Although a number of creek lines run within close proximity of the Project Areas, these are located outside of these Project Areas, and are ephemeral drainage lines active only in periods of high recharge. Spring Creek was observed within the Dewhurst 24 Project Area, intersecting the proposed access track and was active, but no Aboriginal objects or sites were identified in association with this sensitive landscape feature. As aforementioned, vegetation was observed to comprise primarily regrowth vegetation, with a low number of mature trees present and no trees suitable for cultural modification or scarring identified.

As the sections of Monument Road and Yellow Springs Trail that will be impacted by the installation of the gathering system have been the subject of a previous cultural heritage assessment (RPS 2012b), they were not inspected as part of this Due Diligence Assessment. No Aboriginal sites or objects, historic heritage items, scarred or culturally modified trees, or vegetation with natural heritage significance were identified in or near to the proposed gathering system alignment during the previous assessment.

RPS description of the landscape conforms to the Office of Environment and Heritage (OEH) definition of disturbed land (2010:18):

> *Land is disturbed land if it has been the subject of human activity that has changed the land's surface, being changes that remain clear and observable. Examples include ploughing, construction of rural infrastructure (such as dams and fences), construction of roads, trails and tracks (including fire trails and tracks and walking tracks), clearing vegetation, construction of buildings and the erection of other structures, construction or installation of utilities and other similar services (such as above or below ground electrical infrastructure, water or sewerage pipelines, stormwater drainage and other similar infrastructure), substantial grazing involving the construction of rural infrastructure, and construction of earthworks associated with anything referred to above.*

In keeping with the Due Diligence Code (2010:11-12), the landscape investigated by RPS did possess sensitive landscape features which may indicate the presence of Aboriginal objects. The Due Diligence Code provides examples of these higher sensitivity landscape features which occur: within 200 metres of waters; within a sand dune system; on a ridge top, ridge line or headland; within 200 metres below or above a cliff face; within 20 metres of or in a cave, rock shelter or cave mouth; on land that is not disturbed. Although a number of creek lines run within close proximity to the Dewhurst 22-23 and 25 Project Areas, these are located outside of these Project Areas. The creek identified in the Dewhurst 24 Project Area, although considered to be a sensitive landscape feature, did not contain any evidence of Aboriginal objects or sites. The RPS assessment confirms the land to be disturbed and the archaeological sensitivity and research potential to be low to nil.

No Aboriginal places, sites or objects were identified within the Project Areas during the visual inspection. Likewise, no culturally modified trees were observed in the Project Areas. The extensive disturbance of the Project Areas due to past land uses and their distance from larger, more permanent water sources suggest that the potential for any Aboriginal cultural heritage material to be present within the Project Areas is low to nil.

The results of the AHIMS and historic heritage searches together with the visual inspection indicate that there are no identified Aboriginal objects or historic heritage sites in the Project Areas. As **there are no identified Aboriginal objects in the Project Areas it is assessed that there is no identified risk of harm to Aboriginal objects and an AHIP is not required for the proposed activity**.

Similarly, as **no historic heritage sites were identified within the Project Areas, there is no identified risk of harm to historic heritage and a Statement of Heritage Impact is not required**.

The proposed works can proceed within the Project Areas as planned.

7.0 Recommendations

This report has considered the available environmental and archaeological information for the Project Areas, the land condition, as well as, the nature of the proposed activities. The following recommendations must be followed for undertaking the proposed works.

RECOMMENDATIONS

The proposed works can proceed within the Project Area as planned.

Recommendation 1

All relevant Santos staff and contractors should be made aware of their statutory obligations for heritage under NSW *National Parks and Wildlife Act 1974* and the NSW *Heritage Act 1977,* which may be implemented as a heritage induction.

Recommendation 2

This due diligence report must be kept by Santos so that it can be presented, if needed, as a defence from prosecution.

Recommendation 3

If Aboriginal object/s are identified in the Project Areas during works, then all works in the immediate area must cease and the area cordoned off. The Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 so that the site can be adequately assessed and managed.

Recommendation 4

In the event that skeletal remains are uncovered, work must cease immediately in that area and the area cordoned off. Santos must contact the NSW Police with no further action taken until written advice is provided by the Police. If the remains are determined to be of Aboriginal origin, the Office of Environment and Heritage must be notified by ringing the Enviroline 131 555 and a management plan prior to works re-commencing must developed in consultation with the relevant Aboriginal stakeholders.

Recommendation 5

If, during the course of development works, suspected historic cultural heritage material is uncovered, work should cease in that area immediately. The Heritage Branch, Office of Environment and Heritage (Enviroline 131 555) should be notified and works only recommence when an approved management strategy developed and the relevant permits are in place.

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9.0 Plates



Plate 1 : View of the Dewhurst 22 Project Area



Plate 2 : View of the Dewhurst 23 Project Area



Plate 3 : View of the Dewhurst 23 Project Area access track



Plate 4 : View of the Dewhurst 23 Project Area showing vegetation



Plate 5 : View of the Dewhurst 24 Project Area



Plate 6 : View of the Dewhurst 24 Project Area showing the creek line



Plate 7 : Example of disturbance in the Dewhurst 25 Project Area



Plate 8 : Vegetation in the Dewhurst 25 Project Area



Plate 9 : Ground surface visibility in the Dewhurst 25 Project Area

10.0 Terms, Definitions, and Abbreviations

Aboriginal Object	"any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises NSW, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains" (DECCW 2010:18).
Aboriginal Place	"a place declared under s.84 of the NPW Act that, in the opinion of the Minister, is or was of special significance to Aboriginal culture" (DECCW 2010:18). Aboriginal places have been gazetted by the minister.
Aboriginal Culturally Modified Tree	"means a tree that, before or concurrent with (or both) the occupation of the area in which the tree is located by persons of non-Aboriginal extraction, has been scarred, carved or modified by an Aboriginal person by: (a) the deliberate removal, by traditional methods, of bark or wood from the tree; or (b) the deliberate modification, by traditional methods, of the wood of the tree" NPW Regulation 80B (3). Culturally Modified trees are sometimes referred to as scarred trees.
Activity	A project, development, or work (this term is used in its ordinary meaning and is not restricted to an activity as defined by Part 5 EP&A Act 1979).
AHIMS	Aboriginal Heritage Information Management System
AHIP	Aboriginal Heritage Impact Permit
DECCW	Department of Environment, Climate Change and Water (is now the Office of Environment and Heritage – OEH)
Disturbed Land	"Land is disturbed if it has been the subject of a human activity that has changed the land's surface, being changes that remain clear and observable." (DECCW 2010:18).
Due Diligence	"taking reasonable and practical steps to determine whether a person's actions will harm an Aboriginal object and, if so, what measures can be taken to avoid that harm" (DECCW 2010:18)
EP&A Act	*Environmental Planning and Assessment Act 1979 (NSW)*
GDA	Geodetic Datum Australia
Harm	"destroy, deface, damage an object, move an object from the land on which it is situated, cause or permit an object to be harmed." (DECCW 2010:18)
LEP	Local Environment Plan
NPWS	National Parks and Wildlife Service
NPW Act	*National Parks and Wildlife Act 1974* (NSW)
NPW Regulation	*National Parks and Wildlife Regulation 2009* (NSW)
OEH	Office of Environment and Heritage (formerly DECCW)
Project Area	Project Area is the area subject to the proposed activity
REF	Review of Environmental Factors

Appendix 1

Legislative Requirements

Summary of Statutory Controls

The following overview of the legal framework is provided solely for information purposes for the client, it should not be interpreted as legal advice. RPS will not be liable for any actions taken by any person, body or group as a result of this general overview, and recommend that specific legal advice be obtained from a qualified legal practitioner prior to any action being taken as a result of the summary below.

COMMONWEALTH

Aboriginal & Torres Strait Islander Heritage Protection Act 1984 (ATSIHIP Act)

The purpose of this Act is to preserve and protect all heritage places of particular significance to Aboriginal and Torres Strait Islander people. This Act applies to all sites and objects across Australia and in Australian waters (s4).

It would appear that the intention of this Act is to provide national baseline protection for Aboriginal places and objects where Stage legislation is absent. It is not to exclude or limit State laws (s7(1)). Should State legislation cover a matter already covered in the Commonwealth legislation, and a person contravenes that matter, that person may be prosecuted under either Act, but not both (s7(3)).

The Act provides for the preservation and protection of all Aboriginal objects and places from injury and/or desecration. A place is construed to be injured or desecrated if it is not treated consistently with the manner of Aboriginal tradition or is or likely to be adversely affected (s3).

Australian Heritage Commission Act 1975

The *Australian Heritage Commission Act (1975)* established the Australian Heritage Commission which assesses places to be included in the National Estate and maintains a register of those places. Places maintained in the register are those which are significant in terms of their association with particular community or social groups and they may be included for social, cultural or spiritual reasons. The Act does not include specific protective clauses.

The *Australian Heritage Council Act 2003,* together with the *Environment Protection & Biodiversity Conservation Act 1999,* includes a National Heritage List of places of National heritage significance, maintains a Commonwealth Heritage List of heritage places owned or managed by the Commonwealth and ongoing management of the Register of the National Estate.

STATE

It is incumbent on any land manager to adhere to state legislative requirements that protect Aboriginal Cultural heritage. The relevant legislation is NSW includes but is not limited to the summary below.

National Parks and Wildlife Act 1974 (NPW Act)

The NPW Act provides statutory protection for all Aboriginal heritage, places and objects (not being a handicraft made for sale), with penalties levied for breaches of the Act. This legislation is overseen by the Office of Environment and Heritage (OEH), and specifically the Chief Executive (formerly the Director-General) of OEH. Part 6 of this Act is the relevant part concerned with Aboriginal objects and places, with Section 86 and Section 90 being the most pertinent. In 2010, this Act was substantially amended, particularly with respect to Aboriginal cultural heritage requirements. Relevant sections include:

Section 86

This section now lists four major offences:

(4) A person must not harm an object that the person knows is an Aboriginal object;

(5) A person must not harm and Aboriginal object;

(6) For the purposes of s86, "circumstances of aggravation" include:

  (g) The offence being committed during the course of a commercial activity; or

  (h) That the offence was the second or subsequent offence committed by the person; and

(7) A person must not harm or desecrate an Aboriginal place.

Offences under s86 (2) and (4) are now strict liability offences, i.e. knowledge that the object or place harmed was an Aboriginal object or place needs to be proven. Penalties for all offences under Part 6 of this Act have also been substantially increased, depending on the nature and severity of the offence.

Section 87

This section now provides defences to the offences of s86. These offences chiefly consist of having an appropriate Aboriginal Heritage Impact Permit (AHIP), not contravening the conditions of the AHIP or demonstrating that due diligence was exercised prior to the alleged offence.

Section 87A & 87B

These sections provide exemptions from the operation of s86; Section 87A for authorities such as the Rural Fire Service, State Emergency Services and officers of the National Parks & Wildlife Service in the performance of their duties, and s87B for Aboriginal people performing traditional activities.

Section 89A

If a person knows of the location of an Aboriginal object or place that has not been previously registered and does not advise the Director-General (now Chief Executive) of that object or place within a reasonable period of time, then that person is guilty of an offence under this Section of the Act.

Section 90

This section authorises the Director-General (now Chief Executive) to issue and AHIP.

Section 90A-90R

These sections govern the requirements relating to applying for an AHIP. In addition to the amendments to the Act, OEH have issued three new policy documents clarifying OEH's requirements with regards to Aboriginal archaeological investigations: *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010, Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW and Code of Practice for Archaeological Investigations in NSW*. The Consultation Requirements formalise the consultation with Aboriginal community groups into four main stages, and includes details regarding the parties required to be consulted, advertisements inviting Aboriginal community groups to participate in the consultation process, requirements regarding the provision of methodologies, draft and final reports to the Aboriginal stakeholders and timetables for the four stages. The Due Diligence Code of Practice sets out the minimum requirements for investigation, with particular regard as to whether an AHIP is required. The Code of Practice for Archaeological Investigation sets out the minimum requirements for archaeological investigation of Aboriginal sites.

Aboriginal Heritage Impact Permits (AHIP)

OEH encourages consultation with relevant Aboriginal stakeholders for all Aboriginal Heritage Assessments. However, if an Aboriginal Heritage Impact Permit (AHIP) is required for an Aboriginal site, then specific OEH guidelines are triggered for Aboriginal consultation.

Aboriginal Cultural Heritage Consultation Requirements for Proponents

In 2010, the Aboriginal Cultural Heritage Consultation Requirements for Proponents (ACHCR's) were issued by OEH (12th April 2010). These consultation requirements replace the previously issued Interim Community Consultation Requirements (ICCR) for Applicants (Dec 2004). These guidelines apply to all AHIP applications prepared after 12th April 2010; for projects commenced prior to 12th April 2010, transitional arrangements have been stipulated in a supporting document, Questions and Answers 2: Transitional Arrangements.

The ACHCR's 2010 include a four stage Aboriginal consultation process and stipulate specific timeframes for each state. Stage 1 requires that Aboriginal people who hold cultural information are identified, notified and invited to register an expression of interest in the assessment. Stage 1 includes the identification of Aboriginal people who may have an interest in the Project Area and hold information relevant to determining the cultural significance of Aboriginal objects or places. This identification process should draw on reasonable sources of information including: the relevant OEH EPRG regional office, the relevant Local Aboriginal Land Council(s), the Registrar of Aboriginal Owners, Aboriginal Land Rights Act (1983), the Native Title Tribunal, Native Title Services Corporation Limited, the relevant local council(s), and the relevant catchment management authority. The identification process should also include an advertisement placed in a local newspaper circulating in the general location of the Project Area. Aboriginal organisations and/or individuals identified should be notified of the project and invited to register an expression of inters (EoI) for Aboriginal consultation. Once a list of Aboriginal stakeholders has been compiled from the EoI's, they need to be consulted in accordance with ACHCR's Stages 2, 3 and 4.

Environmental Planning & Assessment Act 1979 (EP&A Act)

This Act regulates a system of environmental planning and assessment for New South Wales. Land use planning requires that environmental impacts are considered, including the impact on cultural heritage and specifically Aboriginal heritage. Within the EP&A Act, Parts 3, 4 and 5 relate to Aboriginal heritage.

Part 3 regulates the preparation of planning policies and plans. Part 4 governs the manner in which consent authorities determine development applications and outlines those that require an environmental impact statement. Part 5 regulates government agencies that act as determining authorities for activities conducted by that agency or by authority from the agency. The National Parks & Wildlife Service is a Part 5 authority under the EP&A Act.

In brief, the NPW Act provides protection for Aboriginal objects or places, while the EP&A Act ensures that Aboriginal cultural heritage is properly assessed in land use planning and development.

Heritage Act 1977

This Act protects the natural and cultural history of NSW with emphasis on non-indigenous cultural heritage through protection provisions and the establishment of a Heritage Council. Although Aboriginal heritage sites and objects are primarily protected by the *National Parks & Wildlife Act 1974*, if an Aboriginal site, object or place is of great significance, it may be protected by a heritage order issued by the Minister subject to advice by the Heritage Council.

Other legislation of relevance to Aboriginal cultural heritage in NSW includes the *NSW Local Government Act 1993*. Local planning instruments also contain provisions relating to indigenous heritage and development conditions of consent.

Appendix 2

AHIMS Search Results

AHIMS Web Services (AWS)
Search Result

Your Ref Number : 114705

Client Service ID : 90655

RPS Australia East Pty Ltd Sydney CBD

Level 12 92 Pitt Street
Sydney New South Wales 2000

Attention: Karyn Virgin

Email: karyn.virgin@rpsgroup.com.au

Date: 29 January 2013

Dear Sir or Madam:

AHIMS Web Service search for the following area at Datum :GDA, Zone : 55, Eastings : 759420 - 769860, Northings : 6606765 - 6612768 with a Buffer of 1000 meters, conducted by Karyn Virgin on 29 January 2013.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.



A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

0	**Aboriginal sites are recorded in or near the above location.**
0	**Aboriginal places have been declared in or near the above location. ***

If your search shows Aboriginal sites or places what should you do?

- You must do an extensive search if AHIMS has shown that there are Aboriginal sites or places recorded in the search area.
- If you are checking AHIMS as a part of your due diligence, refer to the next steps of the Due Diligence Code of practice.
- You can get further information about Aboriginal places by looking at the gazettal notice that declared it. Aboriginal places gazetted after 2001 are available on the NSW Government Gazette (http://www.nsw.gov.au/gazette) website. Gazettal notices published prior to 2001 can be obtained from Office of Environment and Heritage's Aboriginal Heritage Information Unit upon request

Important information about your AHIMS search

- The information derived from the AHIMS search is only to be used for the purpose for which it was requested. It is not be made available to the public.
- AHIMS records information about Aboriginal sites that have been provided to Office of Environment and Heritage and Aboriginal places that have been declared by the Minister;
- Information recorded on AHIMS may vary in its accuracy and may not be up to date .Location details are recorded as grid references and it is important to note that there may be errors or omissions in these recordings,
- Some parts of New South Wales have not been investigated in detail and there may be fewer records of Aboriginal sites in those areas. These areas may contain Aboriginal sites which are not recorded on AHIMS.
- Aboriginal objects are protected under the National Parks and Wildlife Act 1974 even if they are not recorded as a site on AHIMS.
- This search can form part of your due diligence and remains valid for 12 months.

PO BOX 1967 Hurstville NSW 2220
43 Bridge Street HURSTVILLE NSW 2220
Tel: (02)9585 6345 (02)9585 6471 Fax: (02)9585 6094

ABN 30 841 387 271
Email: ahims@environment.nsw.gov.au
Web: www.environment.nsw.gov.au

Appendix 3

National Native Title Tribunal Search Results

National Native Title Tribunal

Sydney Office, Operations East
Level 16, Law Courts Building,
Queens Square
Sydney NSW 2000
GPO Box 9973
Sydney NSW 2000
Telephone (02) 9227 4000
Facsimile (02) 9227 4030

16 October 2012

Karyn Virgin
Graduate Archaeologist
RPS Australia East Pty Ltd
Level 9, 17 York Street
SYDNEY NSW 2000

Our Reference: 5153/12sj
Your Reference: PR113359-2, PR114737-2, PR114487-2, PR114695-2

Dear Karyn

Native Title Search Results of Narrabri Shire Local Government Area

Thank you for your search request of 15 October 2012 in relation to the above area.

Search Results
The results provided are based on the information you supplied and are derived from a search of the following Tribunal databases:

Register Type	NNTT Reference Numbers
Schedule of Applications (unregistered claimant applications)	Nil.
Register of Native Title Claims	NC2011/006
National Native Title Register	Nil.
Register of Indigenous Land Use Agreements	Nil.
Notified Indigenous Land Use Agreements	Nil.

I have included a Register Extract and NNTT Registers fact sheet to help you understand the search result.

Please note that there may be a delay between a native title determination application being lodged in the Federal Court and its transfer to the Tribunal. As a result, some native title determination applications recently filed in the Federal Court may not appear on the Tribunal's databases.

The search results are based on analysis against external boundaries of applications only. Native title applications commonly contain exclusions clauses which remove areas from within the

external boundary. To determine whether the areas described are in fact subject to claim, you need to refer to "Area covered by claim" section of the relevant Register Extract or Application Summary and any maps attached.

Search results and the existence of native title
Please note that the enclosed information from the Register of Native Title Claims and/or the Schedule of Applications is **not** confirmation of the existence of native title in this area. This cannot be confirmed until the Federal Court makes a determination that native title does or does not exist in relation to the area. Such determinations are registered on the National Native Title Register.

Tribunal accepts no liability for reliance placed on enclosed information
The enclosed information has been provided in good faith. Use of this information is at your sole risk. The National Native Title Tribunal makes no representative, either express or implied, as to the accuracy or suitability of the information enclosed for any particular purpose and accepts no liability for use of the information or reliance placed on it.

If you have any further queries, please contact me on 1800 640 501.

Yours sincerely



Sylvia Jagtman | SENIOR CASE MANAGEMENT ASSISTANT
National Native Title Tribunal | Sydney Office, Operations East
Telephone (02) 9227 4013 | Facsimile (02) 9227 4030 | Email sylvia.jagtman@nntt.gov.au
Freecall 1800 640 501 | www.nntt.gov.au

Facilitating timely and effective outcomes.

NATIONAL NATIVE TITLE TRIBUNAL

Application Information and Extract from the Register of Native Title Claims

Application Information

Application numbers:	Federal Court number: NNTT number:	NSD2308/11 NC11/6
Application name:	Gomeroi People	
Registration history:	Registered from 20/01/2012.	

Register Extract (pursuant to s.186 of the *Native Title Act 1993*)

Application filed with: Federal Court of Australia

Date application filed: 20/12/2011

Date claim entered on Register: 20/01/2012

Applicants: Ms Patricia Margaret Boney, Mr Norman McGrady, Ms Susan Smith, Mr Michael Anderson, Mr William Robinson, Mr Raymond Welsh, Mr Richard Green, Mr Greg Griffiths, Ms Elaine Binge, Mr Alfred Priestley, Mr Leslie Woodbridge, Mr Craig Trindall, Mr Burrul Galigabali, Mr Bob Weatherall, Ms Elizabeth Allan, Mr Ray Tighe, Mr Anthony Munro, Ms Madeline McGrady, Mr Jason Wilson

Address for service:
NTSCORP Limited
Unit 1a Suite 2.02
44-70 Rosehill Street
REDFERN NSW 2016
Phone: (02) 9310 3188
Fax: (02) 9310 4177

Additional Information:

Not Applicable

Area covered by the claim:

The area covered by the application ('the Application Area') comprises all the land and waters within the external boundaries described in Attachment B and depicted in the map at Attachment C.

The Application Area description and map have been prepared with the assistance of the Geo-Spatial Unit of the National Native Title Tribunal. The area covered by this application does not include the areas described at point B below.

(B) Areas within the external boundaries not covered by the application

1. The area covered by the application excludes any land and waters covered by past or present freehold title or by previous valid exclusive possession acts as defined by section 23B of the Native Title Act 1993 (Cth)

2. The area covered by the application excludes any land and waters which are:
a) a Scheduled interest;
b) a freehold estate;
c) a commercial lease that is neither an agricultural lease nor a pastoral lease;
d) an exclusive agricultural lease or an exclusive pastoral lease;
e) a residential lease;
f) a community purpose lease;
g) a lease dissected from a mining lease and referred to in s 23B(2)(c)(vii) of the Native Title Act (1993) (Cth); and
h) any lease (other than a mining lease) that confers a right of exclusive possession over particular land or waters.

3. Subject to paragraphs 5 and 6, the area covered by the application excludes any land or waters covered by the valid construction or establishment of any public work, where the construction or establishment of the public work commenced on or before 23 December 1996.

4. Subject to paragraphs 5 and 6, exclusive possession is not claimed over areas which are subject to valid previous non-exclusive possession acts done by the Commonwealth, State or Territory.

5. Subject to paragraph 7 below, where the act specified in paragraphs 2, 3 and 4 falls within the provisions of:
a) s 23B(9) Exclusion of acts benefiting Aboriginal Peoples or Torres Strait Islanders;
b) s 23B(9A) Establishment of a national park or state park;
c) s 23B(9B) Acts where legislation provides for non-extinguishment;
d) s 23B(9C) Exclusion of Crown to Crown grants; and
e) s 23B(10) Exclusion by regulation;
the area covered by the act is not excluded from the application.

6. Where an act specified in paragraphs 2, 3 and 4 affects or affected land or waters referred to in:
f) s 47 Pastoral leases etc covered by claimant application;
g) s 47A Reserves covered by claimant application;
h) s 47B Vacant Crown land covered by claimant application;
the area covered by the act is not excluded from the application.

7. The area covered by the application excludes land or waters where the native title rights and interests claimed have been otherwise extinguished.

Persons claiming to hold native title:

The Gomeroi People are the native title claim group on whose behalf the Applicant makes this application. The native title claim group comprises all the descendants of the following apical ancestors:
Thomas Pitt (who was born in 1838).
Billy Barlow (who was born in Tycannah in 1835)
Peter James Cutmore (who was born in Tycannah in 1849)
James Swan (who was born in Combadello in 1825)
Harriett Wyndham (who was born in Mungie Bundie in 1863)

William Levy (who was born in Terry Hie Hie in 1867)
Sally Nerang (who was born in Terry Hie Hie circa 1840)
Eliza Barlow (who was born in Terry Hie Hie circa 1860)
Kitty Dangar (who was born in Walgett in 1837)
William Clark (who was born in Collarenebri in 1845)
Murray Ippai (who was born in Collarenebri)
Mary Ann Ippai (who was born on the Barwon River)
Edward Morgan (who was born in Dungalear in 1855)
Nancy Morgan (who was born in Dungalear in 1861)
Robert Nicholls (who was born in Collarenebri in 1842)
Frank Mundy (who was born in Collymongle in 1872)
Lena Combo (who was born in Mogil Mogil in 1876)
Jack Thunderbolt (who was born in Walgett in 1847)
Betsy Yates (also known as Polly Yates and Polly Burras) (who was born on the Barwon River circa 1860)
Jenny (who was born in Walgett circa 1840)
Dick Silk (who was born in Walgett)
Fred Parker (who was born in Gingie in 1864)
Murray Rook (who was born in Collarenebri in 1865)
Ethel Tinker (who was born in Mercadool circa 1878)
Emily McPherson (who was born in Collarenebri in 1892)
Billy Whitford (who was born in 1828)
King Robert Cobbler (who was born in Mogil Mogil in 1855)
Billy Wightman (who was born in Kunopia in 1813)
John McGrady (who was born in Moree in 1853)
William Dennison (who was born in Kunopia in 1843)
Charlie Dennison (who was born circa 1846-1866)
Alice Dennison (who was born in Moree circa 1863 -1873)
Lucy Long (who was born in Boomi circa 1850)
Minnie Lance (who was born in Boomi circa 1868), Harry Denham
Charles Cubby (who was born on the Boomi River)
Sarah Wilson (also known as Sarah Murphy and Sarah Witman) (who was born in Kunopia in 1868)
Reuben Bartman (who was born in Boomi in 1876)
Billy Dunn (who was born in Mungindi)
William Edwards (who was born in Thallon)
Queen Susan (who was born in Welltown)
Phoebe Munday-Williams (who was born in Mungindi in 1864)
George Bennett (who was born in Mungindi in 1873)
Amelia Bell (also known as Amelia Brown) (who was born in Bingara in 1862)
William Snow (who was born in Tamworth or Moonbi in 1855)
Francis Snow (who was born in Tamworth in 1858)
Matilda Wyndham (who was born in Bingara in 1842)
Thomas Duke (who was born in Bingara in 1847)
Teasie Griffen (also known as Jessie Griffen and Ellen Griffen) (who was born in Barraba in 1859)
Mary Anne Hammond (who was born in Tamworth in 1836)
Elizabeth Guest (also known as Eliza Gillan) (who was born in Liverpool Plains in 1840)
Jane Maloney (who was born in Walhallow in 1838)
Mary Ann Healy (who was born in Murrurundi in 1829)
Thomas Taylor (who was born in Coolah in 1836)
Elizabeth Loder (also known as Elizabeth Bates) (who was born in Murrurundi in 1843)
Sarah Gatehouse (who was born in Aberdeen in 1835)
William Duncomb (who was born in Muswellbrook circa 1830)
John Morris Tighe (who was born in 1852)
Susan Bishop-Young (also known as Susan Dangar) (who was born in Warialda)
Sarah Murphy (who was born in 1846)
Thomas French (who was born in Scone in 1825)
John Thomas Bates (who was born on the Mooki River in 1840)
Alexander Nean (who was born in Liverpool Plains in 1843)

David Johnson (who was born in Cassilis circa 1838-1844)
Mary Orr (also known as Nellie Orr) (who was born in Garrawilla in 1853)
Julia Campbell (who was born on the Castlereagh River circa 1833-1834)
Annie Jendis (who was born in Burbagate in 1845)
Harriet Munro (who was born in Gunnedah in 1867), Alice Eliza Natty (who was born on the Namoi River near Boggabri in 1857)
James Tighe (who was born in Coonabarabran in 1842)
William Tighe (who was born in Toorawandi in 1844)
Patrick Tighe (who was born in Coonabarabran in 1852)
Jane Tighe (who was born in 1864)
Mary Jane Griffin (also known as 'Old Ibidah')
Susan Slater (who was born in Coonabarabran in 1839)
Thomas Leslie (who was born in Kirban circa 1850-1854)
James Leslie (who was born in born Armatree in 1853)
Ellen Fuller (who was born in Rockgidgiel in 1854)
Sarah Hughes (who was born in Coonabarabran circa 1834-1859)
James Cole (who was born in NSW in 1845)
Mary Ann Hall (who was born on the Castlereagh River in 1840)
Samuel Bruce Smith (who was born in Tambar Springs circa 1860 – 1863)
Elizabeth Ann Smith (who was born in Mullaley in 1866)
William Green (also known as William Edwards) (who was born in Kings Plains near Inverell in 1853)
Angus Landsborough (who was born in Newstead in 1867)
Patrick Landsborough (who was born in Newstead in 1872)
Alec Brown (who was born in Bundarra in 1873)
Margaret King (who was born in Gummin Gummin near Gulargambone circa 1854-1858)
William James King (who was born in Coonabarabran circa 1851-1853)
Florence May Blackman (also known as Louisa Florima Blackman) (who was born in Coonamble in 1846)
Euphemia Blackman (who was born on the Castlereagh River in 1851)
Henry Arthur Yates (who was born in Coonamble in 1860)
Betsy Yates (who was born in Wingadee in 1854)
Annie Day (who was born in Bullarora Station near Coonamble circa 1871-1876)
Army Toomey (who was born in Wingadee near Coonamble in 1886)
Maria Clare Hall (who was born in Gulargambone circa 1830-1833)
Thomas Carney (who was born in Tonderburine in 1852)
Jim Duncan (who was born in Coonamble in 1854)
Thomas Reid (who was born in Cuttabri in 1840)
Thomas John Blacklock (who was born in Terembone in 1851)
Thomas Dangar (who was born in Drilldool in 1857), Harry Doolan (who was born in Pilliga in 1855)
George Green (who was born in 1851)
Lucy Barr (who was born in Boggabri in 1851)
Peggy Reid (who was born in Cuttabri in 1836)
Julia Jane Saunders (who was born in Wee Waa in 1845)
William Newman (who was born in Cuttabri in 1807)
Emma Dingwell (who was born in Bograh Station near Narrabri in 1864)
Kate Purser (who was born in Narrabri in 1863)
Mary Ann Lucas (who was born in Millie in 1840)
Frank Maybury (who was born in Killarney Station near Narrabri circa 1840)
Charlotte Hagan (also known as Charlotte Keegan) (who was born in Narrabri circa 1850-1870)
Nellie Combo (who was born in Wallah Station near Narrabri in 1850)
Mary Peake (who was born in Narrabri in 1848)
Descendants include persons who are descendants by adoption according to traditional law and custom.
See further information attached and marked 'A'.

Registered native title rights and interests:

The following Native Title Rights & Interests were entered on the Register on 20/01/2012:

1. Where exclusive native title can be recognised (such as areas where there has been no prior extinguishment of native title or where s.238 and/or ss.47, 47A and 47B apply), the Gomeroi People as defined in Schedule A of this application, claim the right to possession, occupation, use and enjoyment of the lands and waters of the application area to the exclusion of all others subject to the valid laws of the Commonwealth and the State of New South Wales.
2. Where exclusive native title cannot be recognised, the Gomeroi People as defined in Schedule A of this application, claim the following non-exclusive rights and interests including the right to conduct activities necessary to give effect to them
(a) the right to access the application area;
(b) the right to use and enjoy the application area;
(c) the right to move about the application area;
(d) the right to camp on the application area;
(e) the right to erect shelters and other structures on the application area;
(f) the right to live being to enter and remain on the application area;
(g) the right to hold meetings on the application area;
(h) the right to hunt on the application area;
(i) the right to fish in the application area;
(j) the right to have access to and use the natural water resources of the application area;
(k) the right to gather and use the natural resources of the application area (including food, medicinal plants, timber, tubers, charcoal, wax, stone, ochre and resin as well as materials for fabricating tools, hunting implements, making artwork and musical instruments);
(m) the right to share and exchange resources derived from the land and waters within the application area;
(n) the right to participate in cultural and spiritual activities on the application area;
(o) the right to maintain and protect places of importance under traditional laws, customs and practices in the application area;
(p) the right to conduct ceremonies and rituals on the application area;
(q) the right to transmit traditional knowledge to members of the native title claim group including knowledge of particular sites on the application area;
3. The native title rights and interests referred to in paragraph 2 do not confer possession, occupation, use or enjoyment of the lands and waters of the application area to the exclusion of all others.
4. The native title rights and interests are subject to and exercisable in accordance with:
(a) the laws of the State of New South Wales and the Commonwealth of Australia including the common law;
(b) the rights (past or present) conferred upon persons pursuant to the laws of the Commonwealth and the laws of the State of New South Wales; and
(c) the traditional laws and customs of the Gomeroi People for personal, domestic and communal purposes (including social, cultural, religious, spiritual and ceremonial purposes).

Register attachments:

1. Map of the area covered by the application , Attachment C of the Application, 1 page - A4 , 20/12/2011.
2. Description of area covered by the application, Attachment B of the Application, 5 pages - A4 , 20/12/2011.

Note: The Register may, in accordance with s.188 of the Native Title Act 1993, contain confidential information that will not appear on the Extract.

Searching the NNTT Registers in New South Wales

Search service
On request the National Native Title Tribunal will search its public registers for you. A search may assist you in finding out whether any native title applications (claims), determinations or agreements exist over a particular area of land or water.

In New South Wales native title cannot exist on privately owned land including family homes or farms.

What information can a search provide?
A search can confirm whether any applications, agreements or determinations are registered in a local government area. Relevant information, including register extracts and application summaries, will be provided.

In NSW because we cannot search the registers in relation to individual parcels of land we search by local government area.

Most native title applications do not identify each parcel of land claimed. They have an external boundary and then identify the areas not claimed within the boundary by reference to types of land tenure e.g., freehold, agricultural leasehold, public works.

What if the search shows no current applications?
If there is no application covering the local government area this only indicates that at the time of the search either the Federal Court had not received any claims in relation to the local government area or the Tribunal had not yet been notified of any new native title claims.

It does not mean that native title does not exist in the area.

Native title may exist over an area of land or waters whether or not a claim for native title has been made.

Where the information is found
The information you are seeking is held in three registers and on an applications database.

National Native Title Register
The National Native Title Register contains determinations of native title by the High Court, Federal Court and other courts.

Register of Native Title Claims
The Register of Native Title Claims contains applications for native title that have passed a registration test.

Registered claims attract rights, including the right to negotiate about some types of proposed developments.

Register of Indigenous Land Use Agreements
The Register of Indigenous Land Use Agreements contains agreements made with people who hold or assert native title in an area.

The register identifies development activities that have been agreed by the parties.

Application summaries
An application summary contains a description of the location, content and status of a native title claim.

This information may be different to the information on the Register of Native Title Claims, e.g., because an amendment has not yet been tested.

How do you request a search?

A search request form is available on the Tribunal's web site at:
http://www.nntt.gov.au/registers/search.html
Mail, fax or email your request to the Tribunal's Sydney registry, identifying the local government area/s you want searched.

Email: NSWEnquiries@nntt.gov.au
Fax: (02) 9227 4030
Address: GPO Box 9973, Sydney NSW 2001
Phone: (02) 9227 4000

Appendix 9

Groundwater assessment
Halcrow

Dewhurst 22-25 Pilot

Narrabri Gas Project

Santos Ltd

13 December 2012

A CH2M HILL COMPANY

Halcrow

Dewhurst 22-25 Pilot

Document: 462587A Version: 2

Narrabri Gas Project

Santos Ltd

13 December 2012

Halcrow Pacific Pty Limited
Level 19, 215 Adelaide Street, Brisbane, Queensland
QLD 4000, Australia
tel +61 7 3169 2900 fax +61 7 3169 2999
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Document history

Dewhurst 22-25 Pilot

Narrabri Gas Project

Santos Ltd

This document has been issued and amended as follows:

Version	Date	Description	Created by	Verified by	Approved by
0	28/11/12	Draft	Thomas Neame	Thomas Neame	
1	30/11/12	Draft	Thomas Neame	Thomas Neame	
2	13/12/12	Final	Thomas Neame	Tom Henderson	Camilla West

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Appendix

1 Introduction

1.1 Dewhurst 22-25 Pilot

Santos Ltd (Santos) is in the process of preparing a Review of Environmental Factors (REF) for the production of Coal Seam Gas (CSG) as part of exploration activities for the Dewhurst 22-25 Pilot to inform the development of the Narrabri Gas Project. A Groundwater Impact Assessment (GIA) is required for the proposed pilot as part of this REF.

Halcrow Australasia Pty Ltd (Halcrow, a CH2M Hill company) provided its fee proposal to conduct exploration phase numerical groundwater flow modelling work for Santos in its letter of 31 October 2012. Instruction to proceed with the proposed work was granted by Santos by means of its purchase order no. 920534-157, dated 7 November 2012.

1.2 Scope of work

The scope of work was prepared to meet the requirements for groundwater impact assessment within the context of a REF. The *ESG2: Environmental Impact Assessment Guidelines for exploration, mining and petroleum activities subject to Part 5 of the Environmental Planning and Assessment Act 1979* (DTIRIS 2012) indicates that cognisance should be given to the assessment of impact to groundwater, without providing explicit guidance. However, the draft *Additional Part 5 REF Requirements for Petroleum Prospecting* (DTIRIS 2011) indicates the following requirements:

1. Describe and quantify any proposed extraction of groundwater
2. Describe any potential for aquifer interference (including changes to inter-aquifer connectivity)
3. Assess the impact of that extraction or interference on existing groundwater resources, including groundwater dependent ecosystems.
   Note: Depending on the type of activity, volume of extraction proposed and potential for cumulative impacts, hydro-geological modeling may be required to assess these impacts.
4. Quantify the potential impacts on users of these groundwater resources.

To meet these requirements, Halcrow defined a scope comprising the numerical re-modeling of the locality of the proposed pilot using its existing Narrabri groundwater flow model to yield the following data:

1. An estimate of the volume of water to be extracted from the coal seam targets during the pilot trial;

2. The potential water level drawdown in solid strata and superficial deposits overlying the coal seam targets associated with the proposed exploration activities; and

3. The potential flux of water induced between formations, specifically the groundwater sources specified in the Aquifer Interference Policy

   Note: this report documents the impacts of CSG water extraction but does not consider the potential changes to aquifer interconnectivity wrought by CSG wells installation or operation.

1.3 Limitations

This report has been prepared for the exclusive use of Santos QNT Pty Ltd (the Client) in accordance with the Scope of Work agreed between Halcrow/CH2M HILL and the Client. No warranty, expressed or implied, is made. There are no beneficiaries to this report other than the Client, and no other person or entity is entitled to rely upon this report without the written consent of Halcrow/CH2M HILL, and a written agreement limiting Halcrow/CH2M HILL's liability.

This report is based, in part, on unverified information supplied to Halcrow/CH2M HILL from several sources. Halcrow/CH2M HILL does not guarantee the completeness or accuracy of this information, and assumes no responsibility for errors or omissions related to this externally supplied information.

Groundwater data are likely to vary spatially and to fluctuate with time. Interpretations have been made based on incomplete data and partial knowledge of the subsurface and of the groundwater conditions therein. The interpretations made in this report are based on the data supplied and alternative interpretations may be applicable following the realisation of new or additional data.

2 Background

2.1 Narrabri Gas Project

The Narrabri Gas Project is located approximately 16 km southwest of the township of Narrabri and approximately 13 km west of Baan Baa in New South Wales (NSW), as shown in Figure 2-1.

The Project lies within Petroleum Exploration License (PEL) 238 and Petroleum Assessment Lease (PAL) 2, both held by Santos, as illustrated in Figure 2-1. The Project will primarily target CSG reserves associated with Early Permian coal seams of the Maules Creek Formation, located at depth in the northern portion of the Gunnedah Basin.

2.2 Previous Work

A groundwater impact assessment (GIA) has been prepared for the Narrabri Gas Project. In order to predict impacts to groundwater, a numerical groundwater flow model was constructed, calibrated and subsequently used for simulating CSG water extraction. The Narrabri Gas Project numerical groundwater flow model simulated a CSG well field of approximately 390 wells spread across the project area. This study utilises the numerical model developed as a part of the Narrabri Gas Project GIA. Wells representing the Dewhurst 22-25 Pilot were included as part of this initial model.

2.3 Dewhurst 22-25 Pilot

The Dewhurst 22-25 Pilot is located within the north eastern corner of the Narrabri Gas Project study area as illustrated in Figure 2-1. The pilot consists of five surface positions comprising three vertical wells (Dewhurst 22, Dewhurst 24 and Dewhurst 6) and two directionally-drilled wells which extend laterally in-seam. Dewhurst 25 is a single lateral well which will intersect Dewhurst 24, whilst Dewhurst 23 consists of a stacked triple-lateral well which will intersect Dewhurst 22. Dewhurst 6 is an existing vertical well located in the middle of the surface positions of the remaining four pilot wells. The locations of wells included in this pilot are presented in Table 2-1.

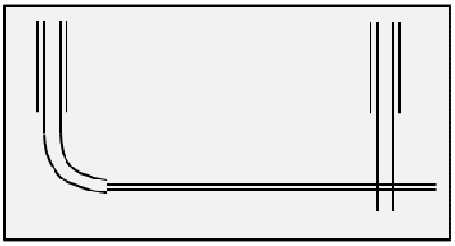
Table 2-1: Pilot wells

Well name	Easting	Northing	Type	Target
Dewhurst 6	764249	6610018	Vertical	Bohena
Dewhurst 22	763704	6610149	Vertical	Bohena Namoi Parkes
Dewhurst 23	764471	6609505	Lateral - triple	
Dewhurst 24	764025	6610531	Vertical	Bohena
Dewhurst 25	764792	6609888	Lateral - single	

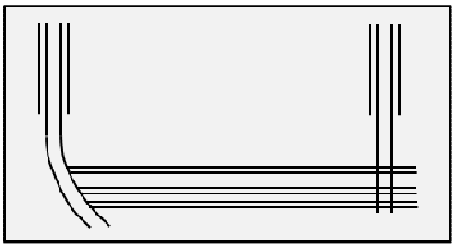
(Surface location in MGA Zone 55 Projection)

The "build zone" where the initially-vertical well is incrementally inclined to penetrate the seam and continue in-seam laterally is understood to consist of approximately 200m horizontal distance. Each lateral is designed to continue in-seam beyond the intersection with its corresponding vertical counterpart by approximately 100m.

Single-lateral well arrangement



Stacked triple-lateral well arrangement



In order to conduct the pilot, water will be extracted from the target seam(s) from both paired pilot wells simultaneously. Water production will rise to a rate slightly over 250m^3/day within the first 30 days of inception of the pilot, whereupon it will be maintained at an average rate of approximately 263m^3/day for the duration of the trial. The trial is anticipated to be continued for 1096 days (3 years). A hydrograph of the proposed extraction rate is presented in Figure 2-2.

The water extraction rate for Dewhurst 6 is predicted to be negligible as a consequence of its central position between the two lateral wells and hence extraction from this well has not been included within the numerical modelling.

Note that the water extraction rate is raised steadily over the first 30 days of the trial intentionally in order to protect the integrity of the well bore and casing.

2.4 Environmental Values

The pilot is located within the Pilliga Forest. There are a range of Environmental Values (EVs), to which the potential impacts from the pilot CSG water extraction must be considered. These include registered groundwater extraction bores, Groundwater Dependent Ecosystems (GDEs) and the aquifers which support these EVs.

Figure 2-3 illustrates the distribution of registered bores within the vicinity of the Narrabri Gas Project. The majority of these bores are completed within, and extract water from, the alluvial deposits of the Lower and Upper Namoi Alluvium, which together form the NSW Upper and Lower Namoi groundwater source. A limited number are completed within, and extract water from, the Pilliga Sandstone which in this area belongs to the NSW GAB groundwater source. To the east of the Narrabri Gas Project, a few bores are completed within, and extract water from, the Triassic strata, principally the Napperby Formation, which forms part of the NSW Murray Darling Basin Porous Rock groundwater source, the same groundwater source from which the CSG water extraction is proposed to occur.

Figure 2-4 illustrates the locations of Groundwater Dependent Ecosystems within the vicinity of the Narrabri Gas Project area. Both Eather Spring and Hardy's Spring 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 at this interface. Hence fluctuations within the strata underlying the Purlewaugh Formation are unlikely to be able to influence the characteristics of flow in either spring.

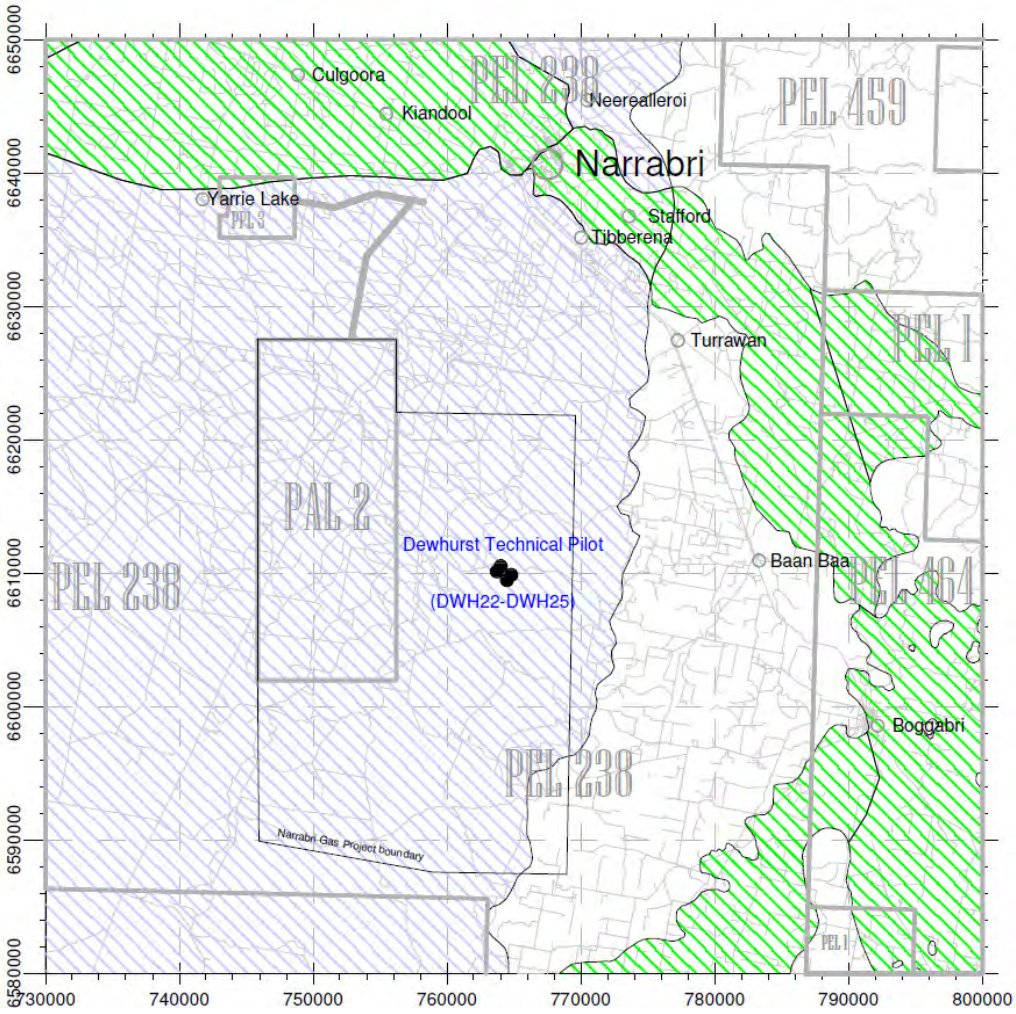


Figure 2-1: Site location plan

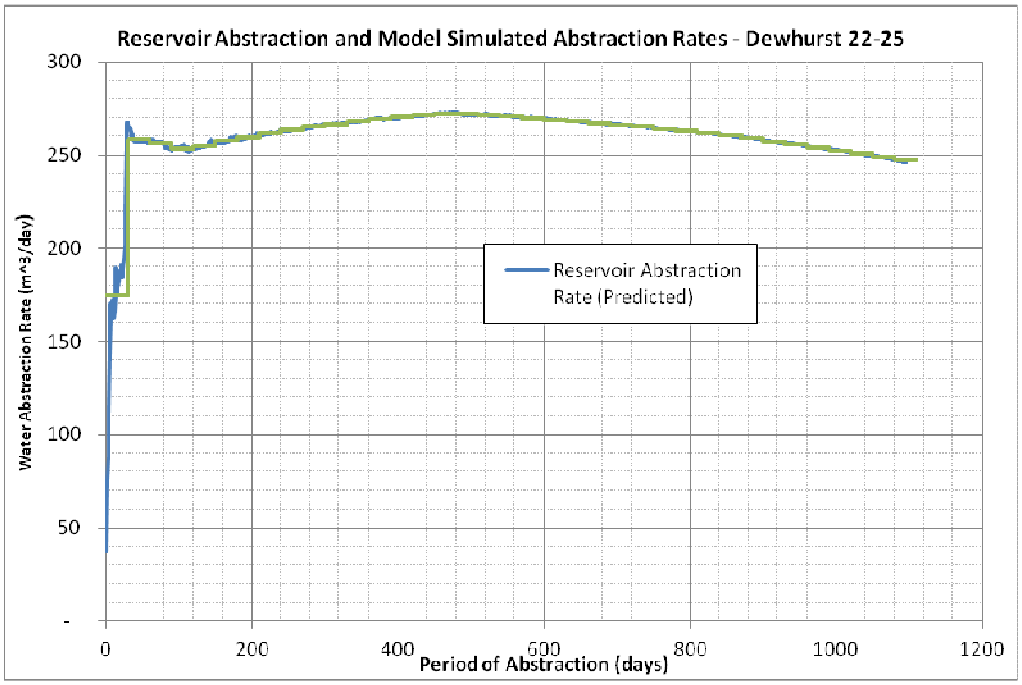


Figure 2-2: Predicted water curve: Dewhurst 22-25 Pilot

(Data provided by Santos)

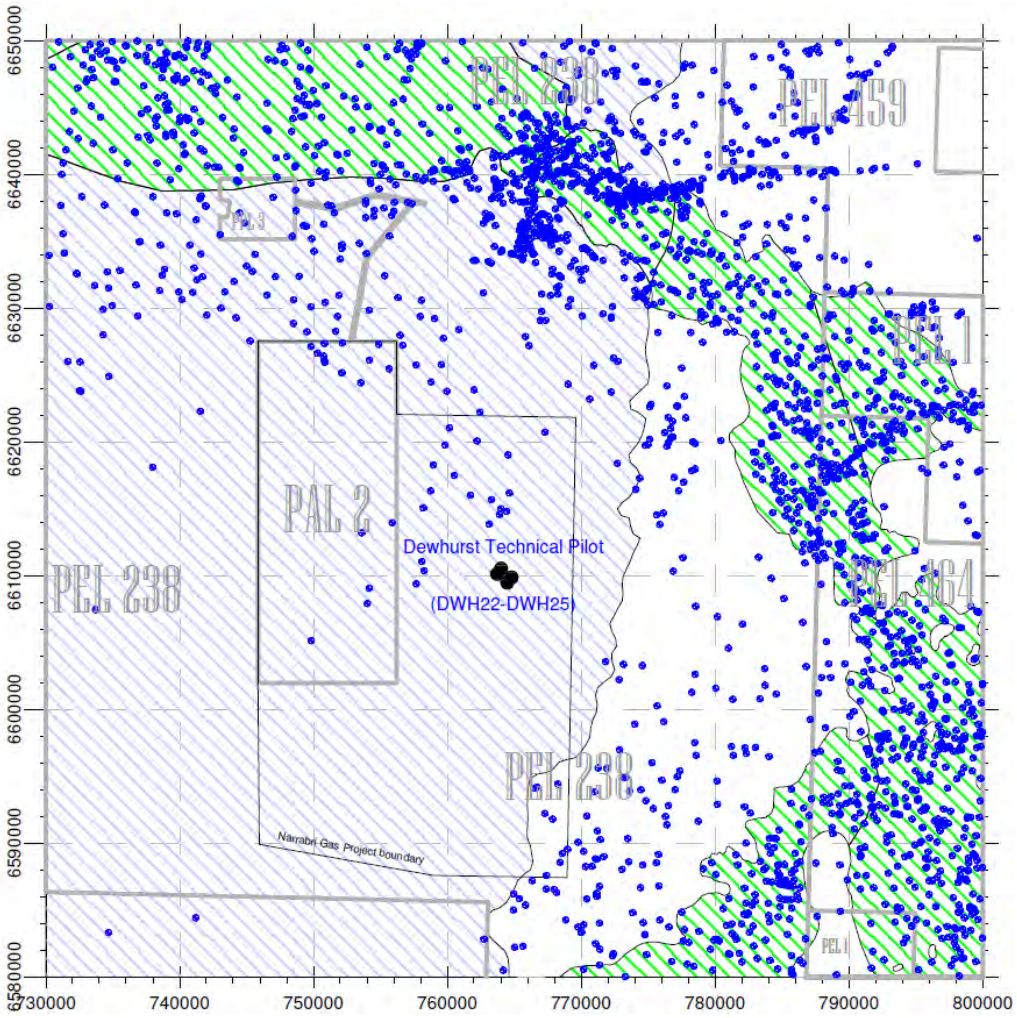


Figure 2-3: Location of Registered Groundwater Extraction Bores (showing water sharing plan boundaries)

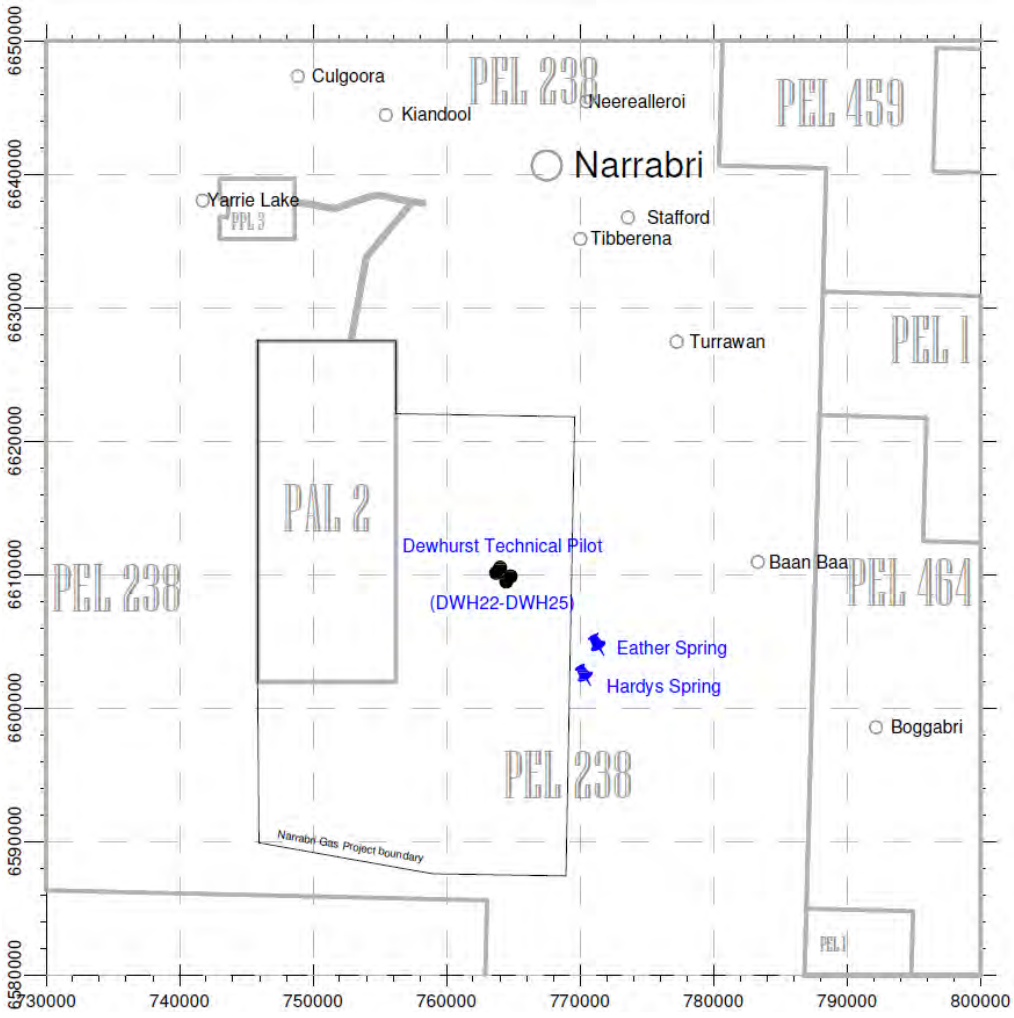


Figure 2-4: Location of Groundwater Dependent Ecosystems

3 Water Management relevant to the Exploration Assessment

3.1 Water Management Act 2000

The *Water Management Act 2000* dictates how both surface and groundwater resources are managed in NSW. Its main objective is to ensure the future and present supply of water sources at a state level, and protect, develop and restore water resources in the region. It controls the extraction of water, how water can be used, the construction of works such as dams and weirs and the carrying out of activities on or near water sources.

The main tool the Act provides for in managing the State's water resources are Water Sharing Plans (WSP). The Act will generally apply to surface and groundwater sources in areas where a WSP is in place (and outlined in Section 3.2 below). In areas where there is no WSP, the *Water Act 1912* applies. A number of WSPs apply to the Narrabri Gas Project area and surrounding region.

An amendment to the Act requires new mining and petroleum exploration activities that take more than three megalitres per year from groundwater sources to hold a water access licence.

A water licence is required under the Act where any aquifer interference activity (discussed further in Section 3.3) causes:

- the removal of water from a water source; or
- the movement of water from one part of an aquifer to another part of an aquifer; or
- the movement of water from one water source to another water source, such as:
  - From an aquifer to an adjacent aquifer; or
  - From an aquifer to a river/ lake; or
  - From a river/ lake to an aquifer.

3.2 Water Sharing Plans

Water Sharing Plans (WSPs) are legally prepared documents currently used to manage water resources in NSW. They establish the rules for sharing water between different water users (including the environment) and between different types of users. WSPs also set rules for water trading, and dealing with access licences and access regimes for the extraction of water from the groundwater and surface water systems. WSPs set out the overall limit on surface and ground water that can be extracted from the source and the circumstances in which access licences can be granted.

WSPs for the various groundwater sources relevant to the Narrabri Gas Project area are illustrated in Figure 3-1 and outlined as follows:

3.2.1 NSW Great Artesian Basin Groundwater Sources WSP

The plan covers all water contained in the sandstone aquifers of the NSW portion of the GAB. The basin has been divided into five groundwater sources – the Eastern and Southern Recharge Groundwater Sources in the non-artesian eastern fringes of the basin, and the Surat, Warrego and Central Groundwater Sources in the artesian western part of the basin, where water flows naturally to the surface.

The pilot study area is defined as being within the Southern Recharge Groundwater Source of the GAB. The Permian strata from which the CSG extraction is targeted underlie the GAB and are excluded from this WSP. However, the proposed exploration activities have the potential to affect the groundwater resources addressed under this WSP through induced vertical leakage of groundwater from the overlaying GAB formations due to vertical propagation of depressurisation effects from the Permian coal measures.

3.2.2 NSW Murray-Darling Basin Porous Rock Groundwater WSP

The *Porous Rock Groundwater WSP* covers porous rock aquifers within the MDB not already included in other WSPs. In particular, this WSP establishes the framework for licensing and allocation of groundwater resources within the Gunnedah-Oxley Basin porous rock formations, and sets limits on the long-term abstraction rates. The WSP includes an allowance for additional entitlements for aquifer water access licences to allow CSG activities to proceed in catchments which are subject to the WSP.

The pilot study area overlies this WSP domain and water will be extracted from Early Permian Maules Creek Formation strata forming a part of the Gunnedah Basin which is managed under the terms of this WSP.

3.2.3 NSW Murray-Darling Basin Fractured Rock Groundwater WSP

The *Fractured Rock Groundwater WSP* has designated water management areas in the fractured rock aquifers of the MDB. These cover basalts and fold belts that have groundwater flow due to the fractures within the rock. Three water sources within this plan fall within the Namoi catchment and at or beyond the limits of the model domain surrounding the Narrabri Gas Project study area. These water sources are associated with the fractured rocks of the New England Fold Belt, Liverpool Ranges Basalt and Warrumbungle Basalt.

There is a very limited extent of basalt in the Bohena Sub-basin and as such it is considered unlikely that depressurisation associated with the exploration activities will extend to any of these fractured rock management areas.

3.2.4 NSW Upper and Lower Namoi Groundwater Sources WSP

This WSP covers the Upper and Lower Namoi Groundwater Sources including all water contained in the unconsolidated alluvial aquifers associated with the Namoi River and its tributaries. These deposits are present at surface in the vicinity of the pilot study area. The current WSP aims to reduce the Available Water Determinations (AWD) for Supplementary Water Access Licences as well as reducing the extraction limit. This is in response to the observed decline in groundwater levels in the Upper and Lower Namoi alluvium.

3.2.5 NSW Great Artesian Basin Shallow Groundwater Sources WSP

This WSP covers groundwater resources associated with the alluvial formations and all other formations to a maximum depth of 60 metres below the surface of the ground which overly the NSW GAB formations and are not included in any other WSP. Of the sources identified, the GAB Surat Shallow Groundwater extends across the north-western quarter of the Narrabri Gas Project area. This WSP allows for granting of water access licences as part of a controlled allocation order made in relation to any unassigned water in this water source.

3.2.6 Upper Namoi and Lower Namoi Regulated River WSP

This plan applies to two water sources – the Upper Namoi including the regulated river sections between Split Rock Dam and Keepit Dam and the Lower Namoi including the regulated river sections downstream of Keepit Dam to the Barwon River, including the regulated sections of the Gunidgera/ Pian system.

While not directly relevant to the Narrabri Gas Project, this WSP would apply if CSG extraction or CSG water management activities were found to have an impact on these surface water sources. However, it is considered unlikely that depressurisation associated with the exploration activities will extend to any of these management areas.

3.3 NSW Aquifer Interference Policy

The purpose of the *NSW Aquifer Interference Policy* is to explain the water licensing and approval processes and requirements for aquifer interference activities under the *Water Act 1912* and the *Water Management Act 2000*, and other relevant legislative frameworks.

The Policy adopts the definition of an aquifer interference activity from the *Water Management Act 2000*, which includes any of the following:

- the penetration of an aquifer;
- the interference with water in an aquifer;
- the obstruction of the flow of water in an aquifer;
- the taking of water from an aquifer in the course of carrying out mining, or any other activity prescribed by the regulations; and
- the disposal of water taken from an aquifer (for example, as a consequence of mining or CSG activities).

The Policy specifies that the volume of water taken from a water source(s) as a result of an activity is required to be predicted prior to the granting of water access licences and aquifer interference approvals. Aquifer interference approvals will not be granted unless the Minister is satisfied that adequate arrangements are in force to ensure that no more than minimal harm will be done to an aquifer or its dependent ecosystems. The volume of water to be produced during the pilot is stated in Section 4.5.

"Minimal impact consideration" criteria are specified in the policy for highly productive and less productive groundwater sources. The Pilliga Sandstone and the Upper and Lower Namoi Alluvium groundwater sources are considered to be

"Highly Productive" groundwater sources. The Permo-Triassic Gunnedah Basin strata groundwater sources are considered to be "Less Productive" groundwater sources.

The criteria determining minimal impact for highly productive alluvial groundwater sources are:

for the water table: "*Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water-sharing-plan' variations, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule to the relevant water sharing plan; or a maximum of a 2 m decline cumulatively at any water supply work*".

for water pressure: "*A cumulative pressure head decline of not more than 40% of the 'post-water-sharing-plan' pressure head above the base of the water source to a maximum of a 2 m decline, at any water supply work".*

The criteria determining minimal impact for highly productive porous rock groundwater sources are:

for the water table: "*Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water-sharing-plan' variations, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule to the relevant water sharing plan; or a maximum of a 2 m decline cumulatively at any water supply work*".

for water pressure: "*A cumulative pressure head decline of not more than a 2 m decline, at any water supply work".*

The criteria determining minimal impact for highly productive GAB Southern Recharge groundwater source are:

for the water table: "*Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water-sharing-plan' variations, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule to the relevant water sharing plan; or a maximum of a 2 m decline cumulatively at any water supply work*".

for water pressure: "*Less than 0.2 m cumulative variation in the groundwater pressure, allowing for typical climatic 'post-water-sharing-plan' variations, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule to the relevant water sharing plan; or a cumulative pressure level decline of not more than 15 m allowing for typical climatic 'post-water-sharing-plan' variations".*

The criteria determining minimal impact for less productive porous rock groundwater sources are:

for the water table: "*Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic 'post-water-sharing-plan' variations, 40 m from any high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule to the relevant water sharing plan; or a maximum of a 2 m decline cumulatively at any water supply work*".

for water pressure: "*A cumulative pressure head decline of not more than a 2 m decline, at any water supply work".*

The method of determining the magnitude of the cumulative variation percentages, "allowing for typical climatic 'post-water-sharing-plan' variations" and the data with which to establish the percentages remain unclear. Consequently, thresholds of significance of water level decline or pressure head decline of 0.5 metres and 2.0 metres have been considered by which to determine significant impact on highly productive and less productive groundwater sources, respectively, in this assessment. Where no impact is considered likely, this has been stated.

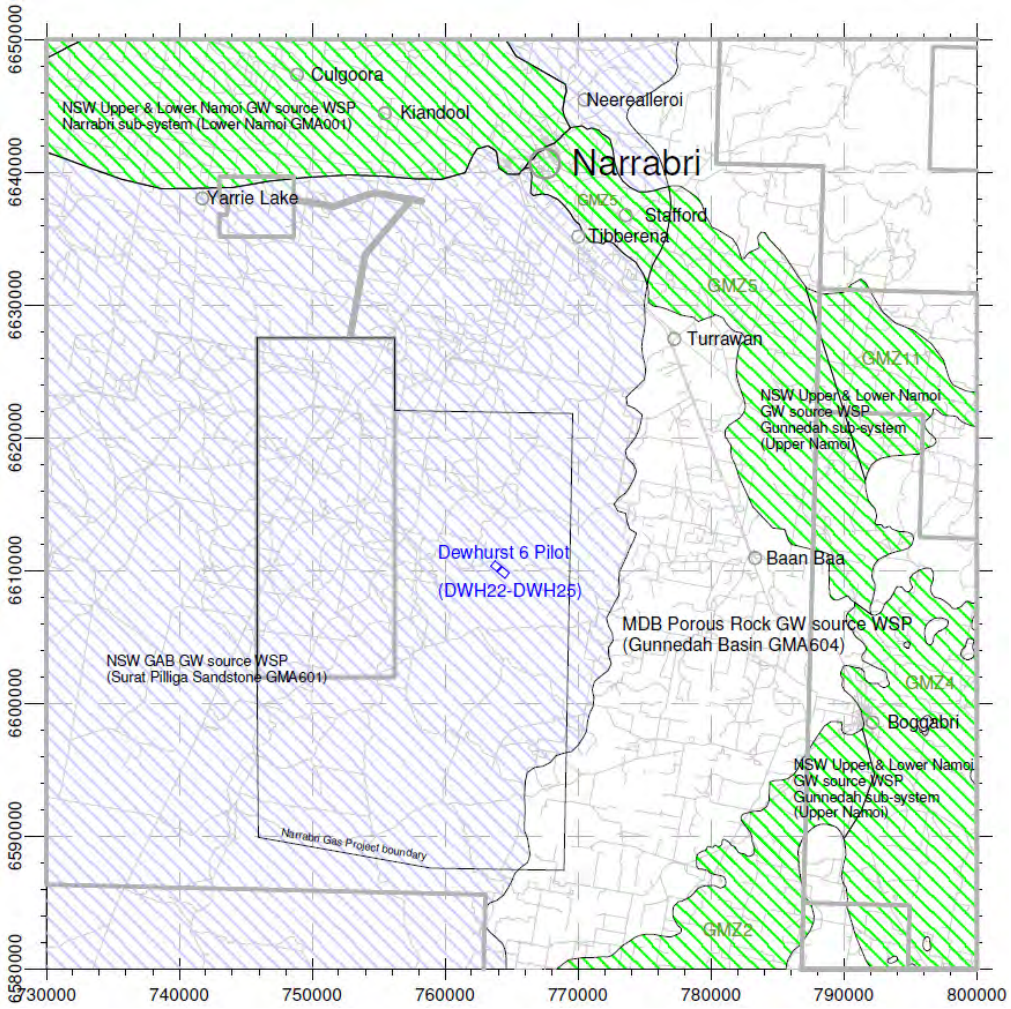


Figure 3-1: Water Sharing Plans relevant to Dewhurst 22-25 Pilot

4 Methodology for the predictive modelling

4.1 Hydrogeological Conceptual Model

The Dewhurst 22-25 Pilot occupies a small area within the north eastern corner of the Narrabri Gas Project area (Figure 2-1) and as such, the same hydrogeological conceptual model applies as that described for the Narrabri Gas Project groundwater impact assessment, and précised below.

CSG extraction is proposed from the Early Permian coal seams of the Maules Creek Formation. The Maules Creek Formation rests within the base of a basement depression known as the Bohena Trough and strata of this formation onlap onto the sides of the trough (Figure 4-1). Overlying the Maules Creek Formation are strata belonging to the Middle Permian Porcupine and Watermark Formations of the Millie Group, successively overlain by Late Permian Black Jack Group strata and the Triassic Digby, Napperby and Deriah Formations infilling the Bohena Trough. The Triassic strata outcrop to the east of the Narrabri Gas Project area in the vicinity of Baan Baa. Together, the Permo-Triassic strata represent the Gunnedah Basin sediments and comprise the NSW Murray darling Basin Porous Rock Water Sharing Plan referred to in Section 3.

Overlying the Permo-Triassic strata across almost the entire Narrabri Gas Project area and including the vicinity of the Dewhurst 22-25 Pilot lie strata belonging to the Jurassic period comprising sediments of the southern extension of the Surat Basin known as the Coonamble Embayment, including the Purlewaugh Formation and the Pilliga Sandstone. The Pilliga Sandstone comprises over 200m of sandstones with intercalated terrigenous clastic strata and is considered to represent the basal intake beds of the Great Artesian Basin. It is referred to as the Southern Recharge Beds of the Great Artesian Basin in the area south of Moree. The Purlewaugh Formation comprises up to 100m of claystone and siltstone and is considered to represent a barrier to vertical groundwater flow between the Pilliga Sandstone aquifer and the underlying Permo-Triassic strata.

Incised into both the Gunnedah Basin deposits to the east and the Surat Basin deposits to the west and north of the Narrabri Project Area are Quaternary sediments belonging to the Upper Namoi Alluvium and Lower Namoi Alluvium respectively. Weakly consolidated or unconsolidated sediments of the successively shallower Cubbaroo, Gunnedah and Narrabri formations occupy the palaeochannel of the River Namoi flowing northwards in the east and westwards in the north of the Project Area. The Upper and Lower Namoi Alluvium together constitute the NSW Upper and Lower Namoi Groundwater Sources Water Sharing Plan, although it is subdivided into the Gunnedah sub-system south of Narrabri (effectively the Upper Namoi Alluvium) and the Narrabri sub-system west of Narrabri (effectively the Lower Namoi Alluvium).

Drill Stem Test evidence across the area encompassing the Narrabri Gas Project area indicates that strata at depth are over-pressured by comparison with shallower strata, such that a hydraulic gradient exists from strata within the Maules Creek Formation upwards through the Black Jack Group into the Triassic strata and overlying Pilliga Sandstone. This overpressuring is understood to originate from recharge of the basement around Mt Katapur to the east of the Bohena Trough and to be maintained by the successively overlying layers of strata exhibiting low hydraulic conductivity.

4.2 Existing Numerical Model

A quasi-3-dimensional numerical groundwater flow model was constructed using MODFLOW-2005 and the graphical user interface Groundwater Vistas ™ interface V6.22 Build 2 and calibrated in order to provide a basis for predictive simulations for the CSG water extraction relating to the Narrabri Gas Project. A comprehensive description of the modelling process undertaken to conduct simulations for the Narrabri Gas Project is contained within the Narrabri Gas Project Groundwater Impact Assessment (Halcrow, 2012). However, to provide clarity of reference for this document, Table 4-1 illustrates the relationship between stratigraphy and model layering.

Table 4-1: Stratigraphy and model layering correlation table

Epoch	Hydrostratigraphic unit	Model layer
Quaternary	Alluvium	1
Jurassic	Pilliga Sandstone	2 and 3
	Purlewaugh Fm	4
	Garrawill Volcanics	
Triassic	Deriah Fm	5 and 6
	Napperby Fm	
	Digby Fm	
Permian	Black Jack Group	7, 8 and 9
	Millie Group (Porcupine Fm & Watermark Fm)	10
	Upper Maules Creek Fm	11
	Target coal seam	12
	Lower Maules Creek Fm	13
Pre-Permian	Basement	14

The Dewhurst 22-25 Pilot lies entirely within the domain of the Narrabri Gas Project model and the same hydrogeological conceptual model applies and as such it was seen as appropriate to adopt the Narrabri Gas Project numerical groundwater flow model to conduct simulations specifically for this pilot.

4.3 Grid refinement

The cell spacing of the regional groundwater flow model discussed above included a minimum cell spacing of 500 m by 500 m. It was considered appropriate to facilitate more accurate representation of the curvature of the water table, in the vicinity of the localised hydraulic stress imposed by the Dewhurst 22-25 Pilot, to refine the model grid in the vicinity of the pilot wells. Hence, in the vicinity of the pilot, the model cells have been refined horizontally to 50 m by 50 m.

4.4 Configuration of Pilot Trial

As described in Section 2, the pilot includes two well pairs consisting of a single lateral well (Dewhurst 25) and a vertical intersecting counterpart (Dewhurst 24) and a

triple lateral (Dewhurst 23) and a vertical intersecting counterpart (Dewhurst 22), together with a centrally located vertical well (Dewhurst 6).

Within the Narrabri Gas Project GIA, four potential target seams were recognised within the Maules Creek Formation including the Bohena seam, the primary target, and the Namoi, Rutley and Parkes seams, additional targets.

Within the regional numerical model, these seams were subsumed into one layer, equal in thickness to the sum of the thickness of each of the four seams. Hence the single lateral and triple lateral CSG pilot wells have been represented in the model in a similar manner. The in-seam extent of each lateral well was identified and MODFLOW well boundaries applied to the respective cells in Layer 11 of the model, corresponding to the Bohena Seam / Maules Creek coals. Figure 4-2 illustrates schematically the pilot model representation. Individual MODFLOW well nodes are illustrated in yellow shading, whilst the grey circles and emanating lines indicate the pilot well ground locations and in-seam trajectories. Hence each well pair consists of 14 well boundary nodes.

4.5 Abstraction rates

The regional groundwater flow model included 430 MODFLOW well boundaries to represent an approximation to the proposed field development plan and from which to extract water in accordance with the proposed water curve. These were removed and the water curve illustrated in Figure 2-2 used to describe the extraction schedule for the pilot wells.

The abstraction schedule was divided into 37 equal duration stress periods, each of 1 month duration, equating to the 1096 day duration of the pilot programme. The mean extraction rate calculated for each stress period was divided equally between the 28 well boundary cells (14 for each pilot well pair). The extraction rates applied to individual well nodes during each stress period are listed in Figure 4-2.

The total quantity of water proposed to be abstracted during the pilot is estimated as 288 ML (288,600 m^3), equating to an average of 263 m^3/day over the 1096 day duration of the proposed pilot.

4.6 Initial conditions

The regional numerical groundwater flow model was calibrated to steady-state conditions. However, in order to provide an appropriate array of initial head conditions within the refined grid model developed for the Dewhurst 22-25 Pilot modelling, the model was re-run under steady-state conditions with no extraction simulated. This produced a revised calibrated steady-state model (DWH22-25_TRANS_NoFlux) similar to the original regional model but with head values calculated in each layer for all additional model cells created through the grid refinement process.

The calculated steady-state heads were used as the initial conditions from which to commence transient simulations of CSG water extraction (DWH22-25_TRANS_wel).

4.7 Model simulation duration

The duration of the pilot was understood from the extraction schedule to be 1096 days, equivalent to 3 years. Consequently the well nodes within the model simulation

were active for the same duration. Following 1096 days, the well nodes were switched off and the hydraulic heads within the model domain allowed to recover over a period of 537 years, equating to the simulation period of the regional Narrabri Gas Project model that formed the basis of this modelling exercise.

The duration of recovery was designed to ensure that impacts arising due to releases from aquifer storage at late times, delayed yield, induced by greater-than-negligible drawdown due to water extraction, could be captured.

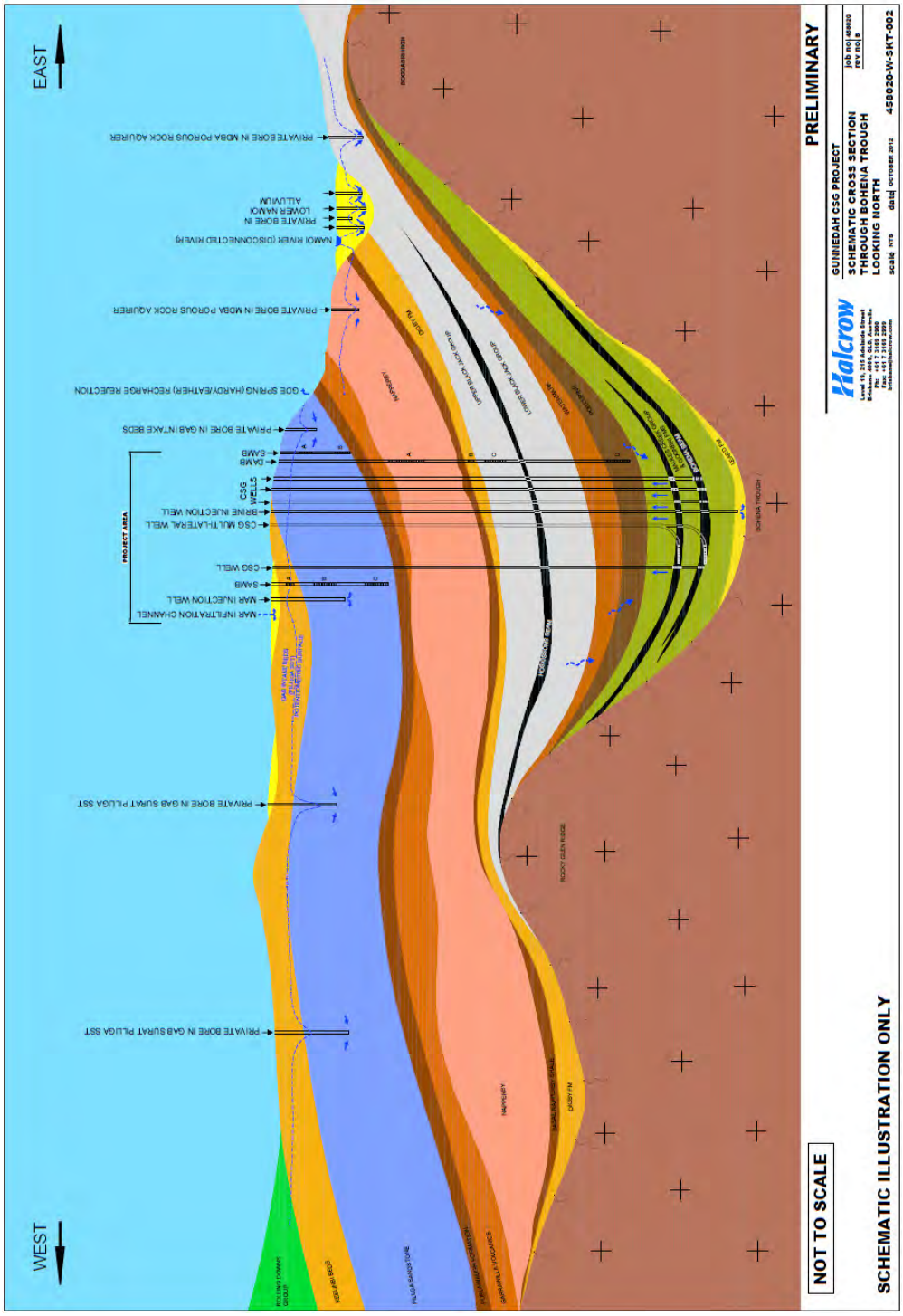


Figure 4-1: Schematic W-E cross-section through the Bohena Trough (not to scale)

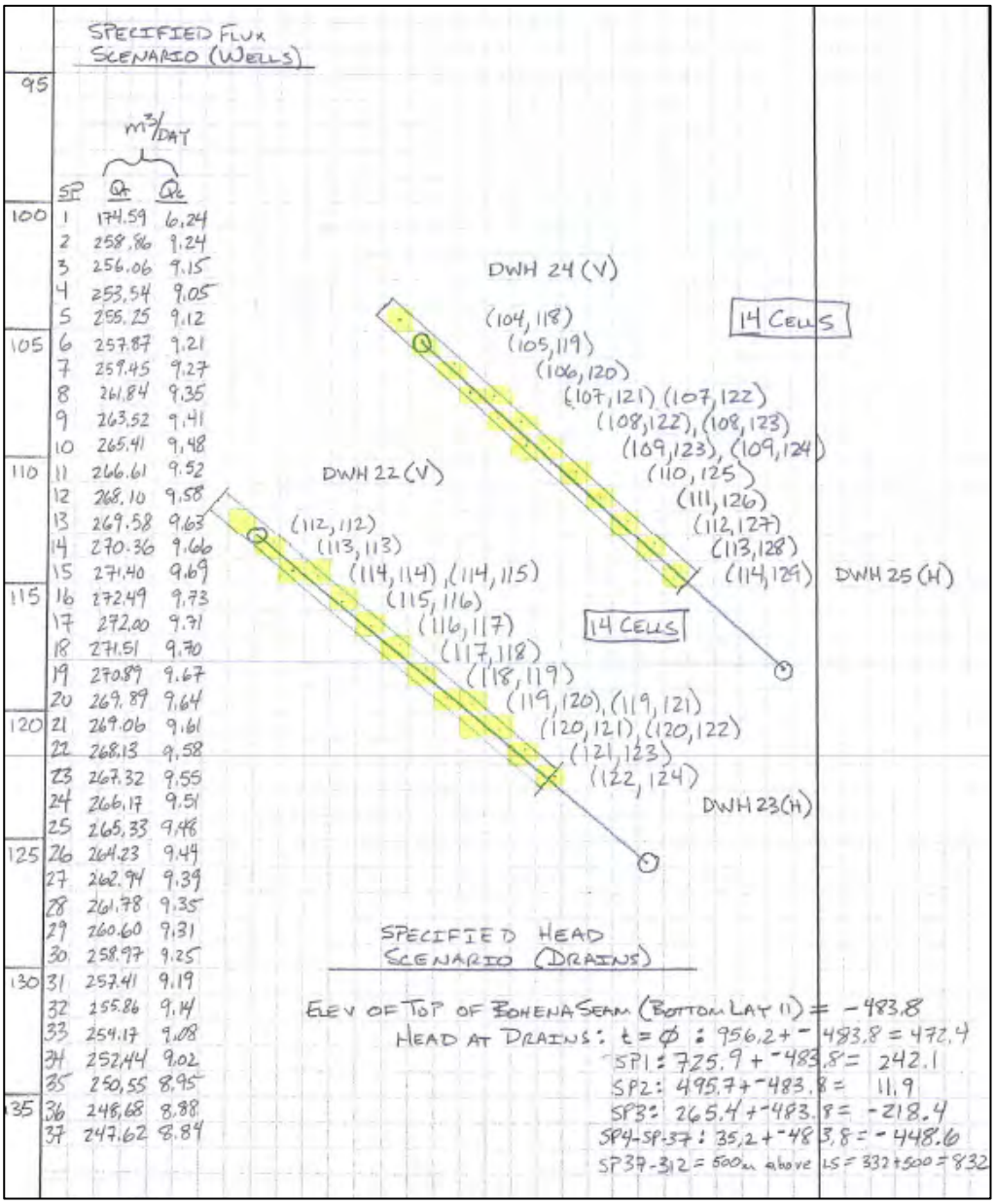


Figure 4-2: Dewhurst 22-25 Pilot – concept model arrangement

5 Simulation outcomes

5.1 Depressurisation

Depressurisation due to CSG water extraction from the two pilot well pairs, represented in the model as 28 well nodes, was observed to occur rapidly, achieving a maximum simulated drawdown of 860 metres in the target model layer representing the Maules Creek coal seams (Layer 12) by the end of the extraction period but achieving 845 metres of drawdown within the first year (Figure 5-1). Following the end of the extraction period (1096 days, or 3 years), recovery within Layer 12 occurred rapidly, reaching greater than 90% recovery (residual drawdown 74.6 m) after 1641 days (or 4.5 years) from the cessation of water extraction.

Reflecting the delay in response to depressurisation of the adjacent layers in accordance with the principal of delayed yield referred to in Section 4.7, overlying layers responded more slowly.

Layer 10, corresponding to the Middle Permian Millie Group Porcupine and Watermark Formations, exhibited a drawdown of 0.98 metres by the end of the pilot CSG water extraction period (1096 days), reaching a maximum drawdown of 3.35 metres after 7300 days (20 years) from initiation of pilot CSG water extraction. Recovery was much slower in this layer, reflecting the low hydraulic conductivity and hence low rate of replenishment of depleted storage, with 85% recovery (residual drawdown 0.52 m) at the end of the simulation (after 540 years).

However, no other model layers exhibited drawdown approaching 0.5 metres within the duration of the model simulation. Whilst it is recognised that depressurisation will propagate beyond Layer 10 after longer time periods than considered in the model simulation, the magnitude of the hydraulic gradient developed between Layer 10 and overlying layers is only a fraction of that exhibited between Layer 10 and Layer 11 and between Layer 11 and Layer 12 (the target extraction layer). Hence it is considered unlikely to be possible for drawdown in excess of 0.5 m to develop in overlying layers including the Pilliga Sandstone (Layers 2 and 3) or the Namoi Alluvium (Layer 1, but not present in the vicinity of the pilot).

5.2 Predicted fluxes

During the GIA conducted for the Narrabri Gas Project, it was found that a hydraulic gradient extended from the deeper strata to the shallower strata, evidenced by DST data which indicated higher hydraulic pressures at greater burial depths within the Bohena Trough. Consequently, it was recognised that fluxes exist in the pre-CSG water extraction state whereby water flows may be occurring naturally from deeper strata into shallower strata. The magnitude of these flows, or fluxes, was likely to be small but not necessarily negligible. This would imply that comparison of inter-formational fluxes initiated by CSG water extraction with a steady-state condition may not accurately represent the balance of flows within the basin.

To address this potential discrepancy, the transient simulation with pilot well extraction (DWH22-25_TRANS_wel) was run for the full simulation period of 20 years and a second simulation run over the same timeframe but with the pilot wells switched off (DWH22-25_TRANS_NoFlux). Comparison of the fluxes induced solely by CSG water extraction for the pilot could then be made between the two

simulations at any given stress period (elapsed time within the model simulation). Figure 5-2 illustrates the detailed mass balances for each of the two model simulations referred to above, at the end of stress period 36, 1094 days after the start of the pilot.

In Figure 5-2, each layer is considered in isolation, with exchanges between layers represented by coloured arrows and text and changes in storage within the layer represented by circles. Fluxes out of the layer are indicated by red arrows and adjacent text whilst fluxes into the layer are indicated by blue arrows and adjacent text. The net change across either the upper surface of the layer or the lower surface of the layer is indicated by a green triangle (delta symbol) and a corresponding value (in black for a net layer gain and in green for a net layer loss). The net change in layer storage is illustrated by a simple traffic light scheme. The pilot extraction from Layer 12 is indicated by the black arrow.

This figure indicates that there is a consistent upward flux through the model in the simulation without pilot extraction (DWH22-25_TRANS_NoFlux), in accordance with the hydrogeological conceptual model and supporting the inferences made from DST data. After three years of pilot operation (DWH22-25_TRANS_wel), the water extraction from Layer 12 (-222.03 m^3/day) is supplied by a net loss from Layer 12 storage of 28.05 m^3/day, a net increase in inflow from Layer 13 (2886 - 2794 = 92 m^3/day) and a net decrease in outflow to Layer 11 (2794 – 2692 = 102 m^3/day).

As indicated above, the impacts of depressurisation of the Maules Creek coal seams are confined to the Early Permian (Maules Creek Formation, Layers 11, 12 and 13) and Middle Permian (Porcupine and Watermark Formations, Layer 10). Fluxes originating from layers above Layer 10 are negligible, as illustrated in Figure 5-3, at the end of the pilot extraction period of three years and Figure 5-4, after 20 years from the start of depressurisation.

Figure 5-2 illustrates the case for Layer 10 in detail, confirming no net change in inflow/outflow across the top of the layer (2794 – 2794 = 0 m^3/day), a net decrease in layer storage of 13.91 m^3/day and a decrease in inflow from the underlying layer (2794 -2780 = 14 m^3/day).

The Maules Creek Formation (Layers 11 and 13), the coals within (Layer 12) and the Porcupine and Watermark Formations (Layer 10), together with the unaffected overlying Black Jack Group (Layers 9 to 7) and Triassic Digby-Napperby-Deriah Formations (Layers 6 and 5) all form part of the MDB Porous Rock groundwater source Water Sharing Plan (Gunnedah Basin).

No measurable flux is induced between the MDB Porous Rock groundwater source and the NSW GAB groundwater source.

5.3 Predicted impacts

The predicted impacts occur in different layers at different times, as illustrated in Figure 5-1. Layer 12 develops maximum drawdown after 3 years, after which the zone of influence of the depressurisation within the layer shrinks as the pilot extraction ceases and inflows to the layer continue. The impact on hydraulic head in Layer 10, however, is continuing to develop at three years, having reached only 0.98 metres drawdown. Figure 5-1 illustrates that the maximum drawdown in Layer 10, the model equivalent to the Porcupine and Watermark Formations of the Middle

Permian Millie Group, reaches a maximum of 3.35 metres only after 20 years from the commencement of the pilot, 17 years after pilot extraction has ceased.

Consequently, the extent of impact in these affected layers is best illustrated on the occasions of maximum drawdown in the respective layers. Figure 5-5 illustrates the maximum extent of drawdown in Layer 12 (at 3 years from pilot start) and Figure 5-6 illustrates the maximum extent of drawdown in Layer 10 (at 20 years from pilot start). As has been discussed in Section 5.2 and illustrated in Figures 5-3 and 5-4, no other layer exhibits equal to or greater than 0.5 metres of drawdown during the 540 year long simulation.

Figure 5-5 illustrates how the zone of influence of the pilot CSG water extraction, very close to the end of the pilot extraction period and when Figure 5-1 confirms drawdown has reached its maximum, has only relatively limited spatial extent. Figure 5-6 comprises a close-up of the area, illustrating the potentiometric contours of drawdown (0.5 m, 10 m, 50 m, 100 m and in 100 metre increments thereafter).

Figure 5-7 illustrates the zone of influence in the Porcupine and Watermark Formations (Layer 10) and Figure 5-8 comprises a close-up of the same area, illustrating the potentiometric contours of drawdown (0.5 m, 1.0 m, 1.5 m, 2.0 m and 3.0 m). Potentiometric contours of drawdown in Layers 9 to 1 have not been prepared as each would comprise zero drawdown.

5.4 Outcomes related to the Aquifer Interference Policy

The outcomes of the simulations have been considered in the context of the Aquifer Interference Policy (AIP) minimal harm consideration criteria described in Section 3.3.

The alluvial groundwater sources of the Upper and Lower Namoi Alluvium (NSW Upper and Lower Namoi groundwater source WSP) are considered within the context of the AIP to be highly productive alluvial groundwater sources. These deposits are represented in the model as Layer 1 and no decline in water table level or change in flux is indicated by the detailed comparison of simulations described in Section 5-2 and illustrated in Table 5-2. Hence no aquifer interference to this groundwater source is indicated by the modelling of the pilot CSG water extraction activities.

The porous rock groundwater source of the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is considered within the context of the AIP to be a highly productive porous rock groundwater source. These strata are represented in the model as Layers 2 & 3. The Purlewaugh Formation (represented in the model as Layer 4, with the Garrawilla Volcanics) also forms part of the same WSP although it is considered to constitute a non-aquifer. No decline in water table level or change in flux in Layers 2, 3 or 4 is indicated by the detailed comparison of simulations described in Section 5-2 and illustrated in Table 5-2. Hence no aquifer interference to this groundwater source is indicated by the modelling of the pilot CSG water extraction activities.

The porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP), comprising the Triassic strata of the Digby, Napperby and Deriah Formations (Layers 5 and 6) and the Permian strata of the Black Jack Group (Layers 7, 8 and 9) down to and including the Maules Creek Group

(Layers 11, 12 and 13), is considered within the context of the AIP to be a less productive porous rock groundwater source. These combined strata are represented in the model as Layers 5 to 13, with the CSG water extraction occurring in Layer 12. No decline in water table level or change in flux in Layers 5, 6, 7, 8 and 9 is indicated by the detailed comparison of simulations described in Section 5-2 and illustrated in Table 5-2. However, given that the pilot CSG water extraction will occur within this AIP-classified water source, the impact on hydraulic (pressure) head within the combined group of layers (5-13) and the fluxes developed within the groundwater source to meet the pilot CSG water demand are interpreted to comprise an aquifer interference and will require licensing.

As described in Section 2.4, the two high priority GDEs identified in the vicinity of the Narrabri Gas Project, Hardy's Spring and Eather Spring, are understood to be hydrogeologically associated with the Pilliga Sandstone. As stated above, the Pilliga Sandstone forms part of the NSW GAB groundwater source WSP but modelling has indicated no decline in water table level or change in flux in the relevant model layers and hence no impact on either of these GDEs is predicted to occur.

Figures 5-5 to 5-8 illustrate the extent of drawdown in the target seam (Layer 12) and the Millie Group: Porcupine and Watermark Formations (Layer 10). The zones of influence illustrated in these four figures remain within the Narrabri Gas Project boundary and west of the outcrop of the Gunnedah Basin: Permo-Triassic strata. Figure 5-2 illustrates that Layers 9 and above experience no impact in flux and thus the effects of CSG water extraction from Layer 12 are confined to Layers 10-13 only. Hence the bores illustrated in Figure 2-3 within the region of the MDB Porous Rock (Gunnedah Basin GMA604) groundwater source WSP which extract from this groundwater source will not be impacted by the pilot CSG water extraction. Those bores illustrated in Figure 2-3 that also lie within the zones of influence shown in Figures 5-5 to 5-8 are positioned on the outcrop of the Pilliga Sandstone and highly likely to be completed within this groundwater source only and will therefore experience no impact.

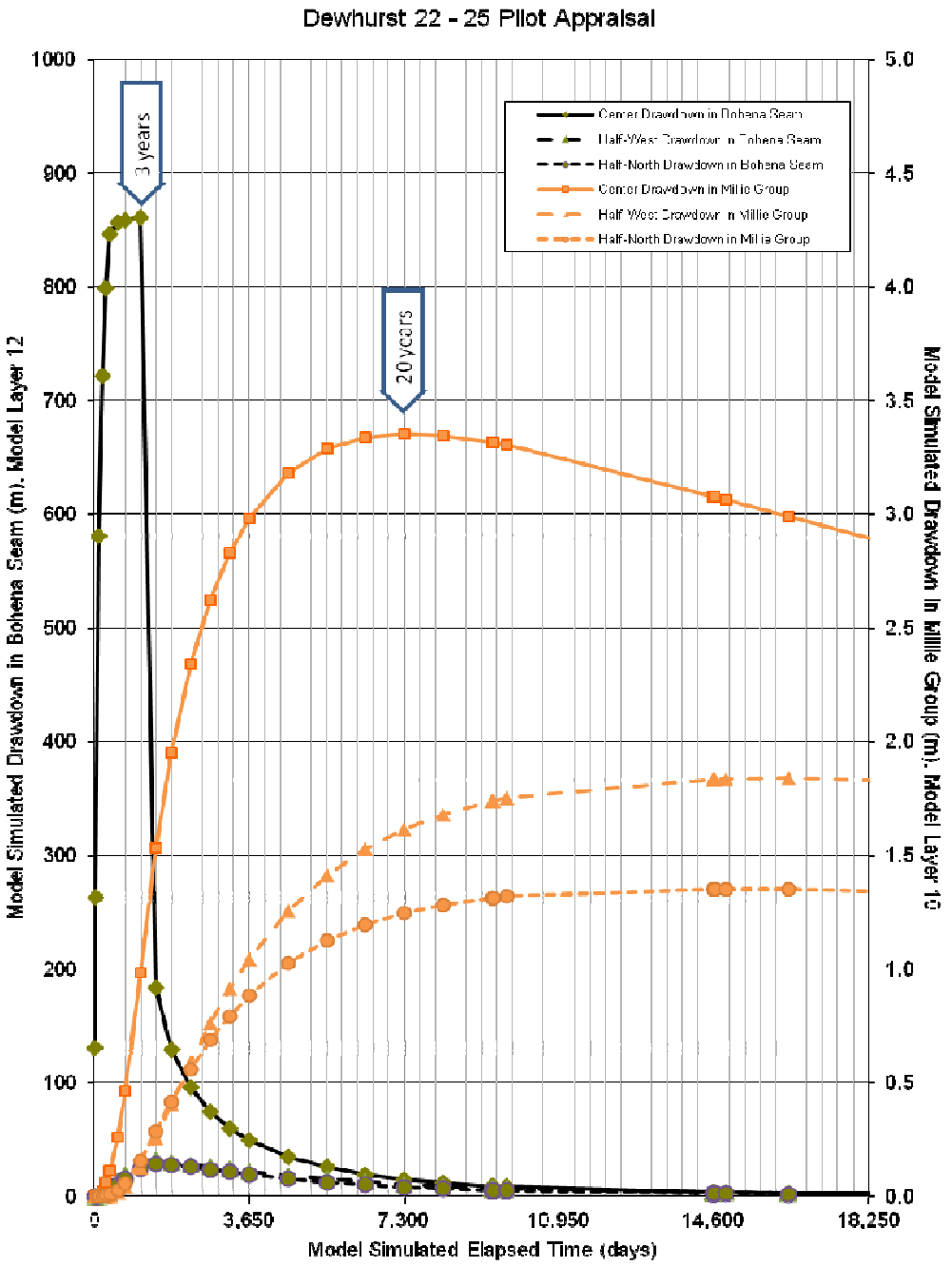


Figure 5-1: Hydrograph of drawdown during first 20 years of simulation (Simulation DWH22-25_TRANS_wel) (Layers 1-9 not shown because predicted drawdown = zero)

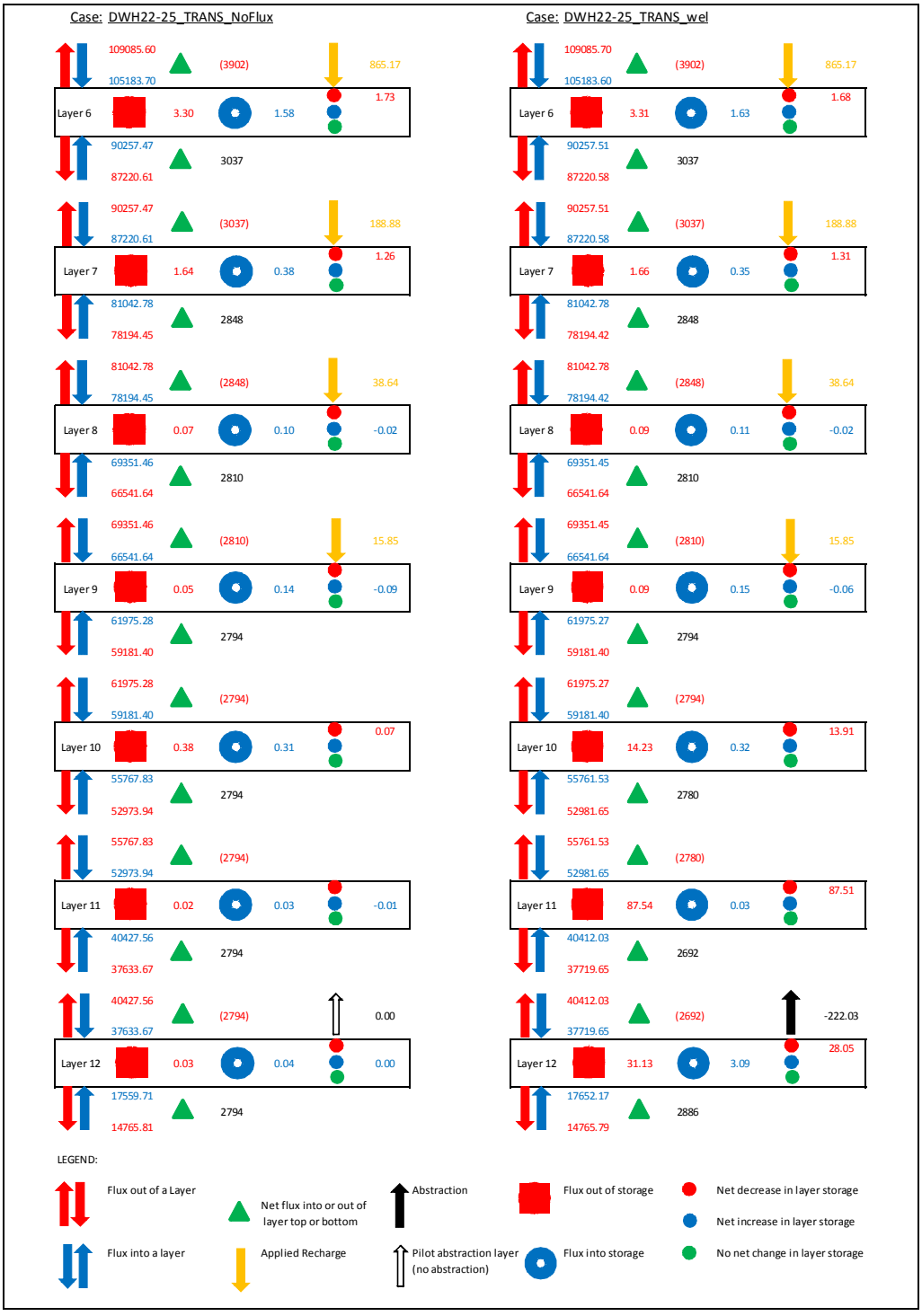
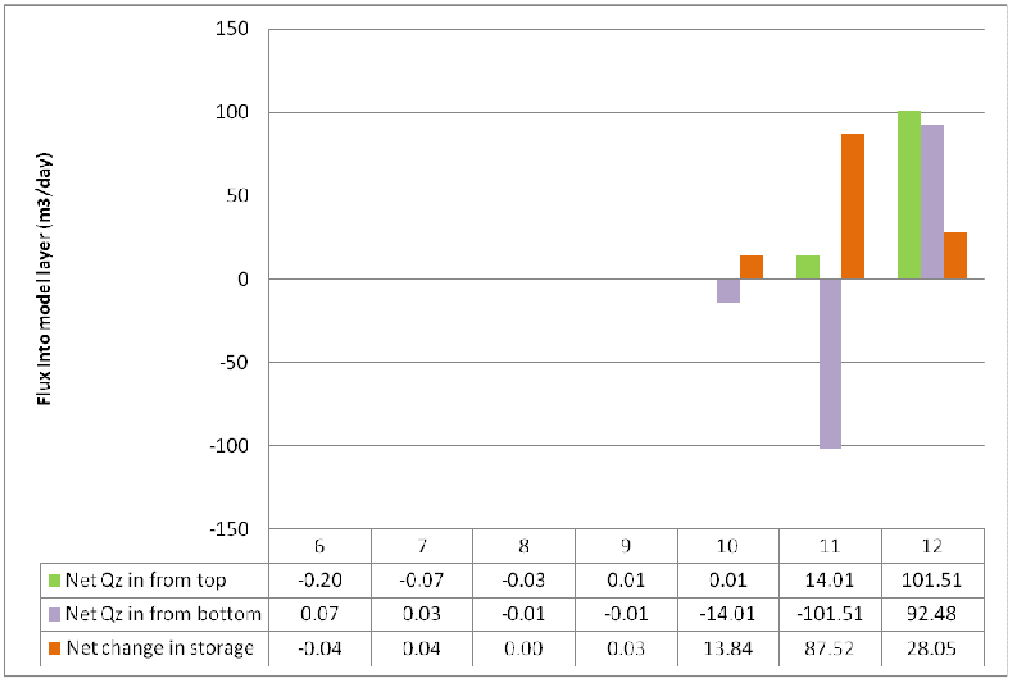
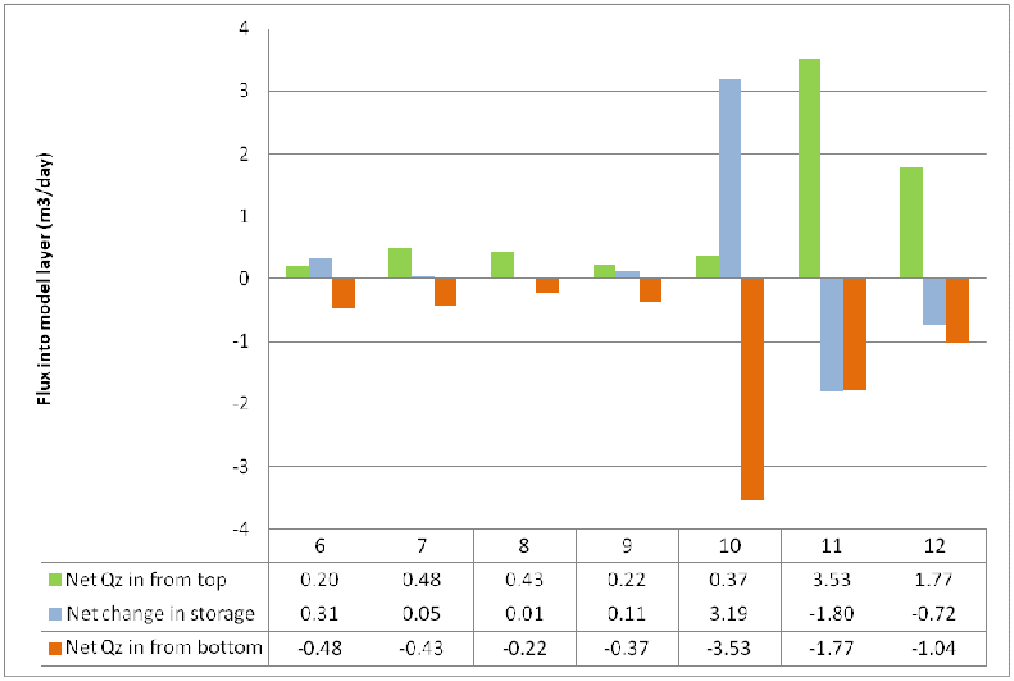


Figure 5-2: Mass balance comparison of simulations with and without pilot extraction (m^3/day)



	6	7	8	9	10	11	12
Net Qz in from top	-0.20	-0.07	-0.03	0.01	0.01	14.01	101.51
Net Qz in from bottom	0.07	0.03	-0.01	-0.01	-14.01	-101.51	92.48
Net change in storage	-0.04	0.04	0.00	0.03	13.84	87.52	28.05

Figure 5-3: Mass balance summary by model layer, 3 years from start of pilot (Simulation DWH22-25_TRANS_wel)



	6	7	8	9	10	11	12
Net Qz in from top	0.20	0.48	0.43	0.22	0.37	3.53	1.77
Net change in storage	0.31	0.05	0.01	0.11	3.19	-1.80	-0.72
Net Qz in from bottom	-0.48	-0.43	-0.22	-0.37	-3.53	-1.77	-1.04

Figure 5-4: Mass balance summary by model layer, 20 years from start of pilot (Simulation DWH22-25_TRANS_wel)

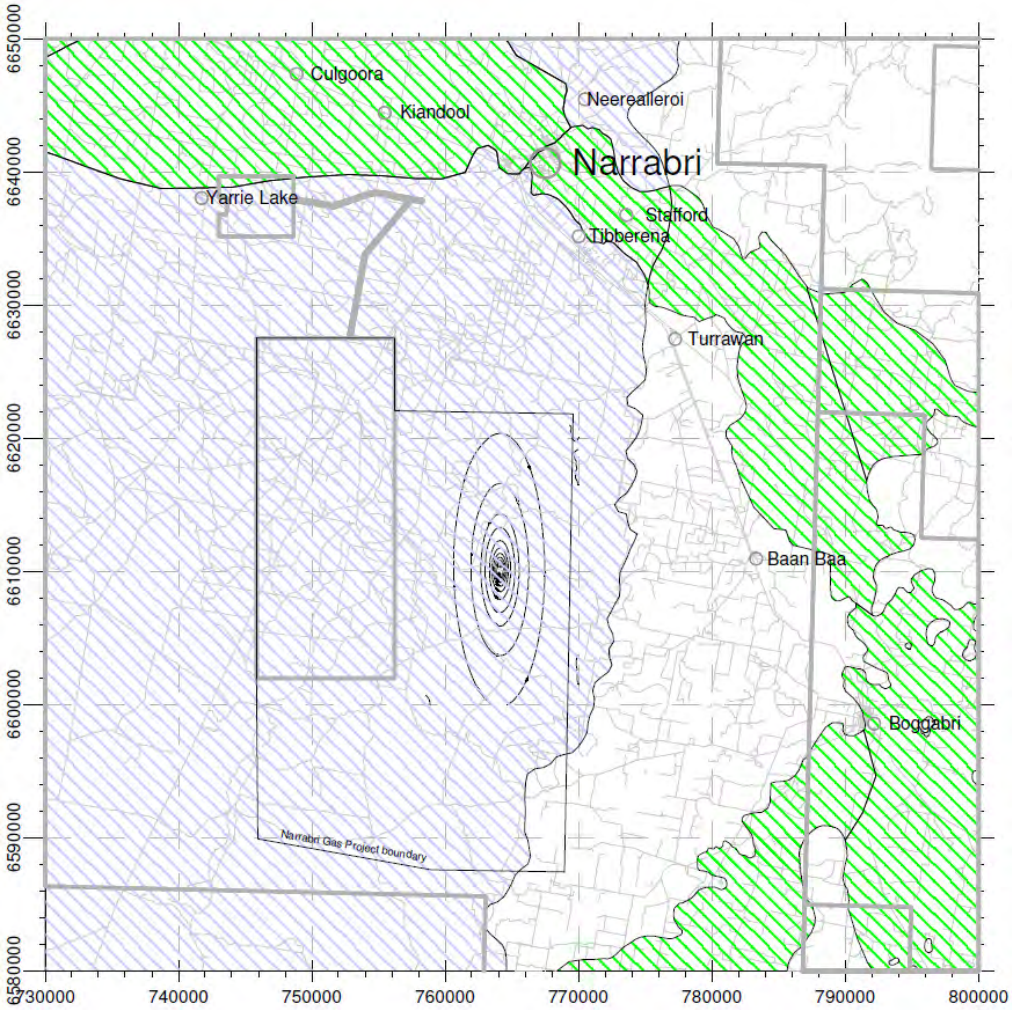


Figure 5-5: Potentiometric map of drawdown in Bohena seam (Layer 12) at 3 years from pilot start (occurrence of maximum drawdown in model layer)

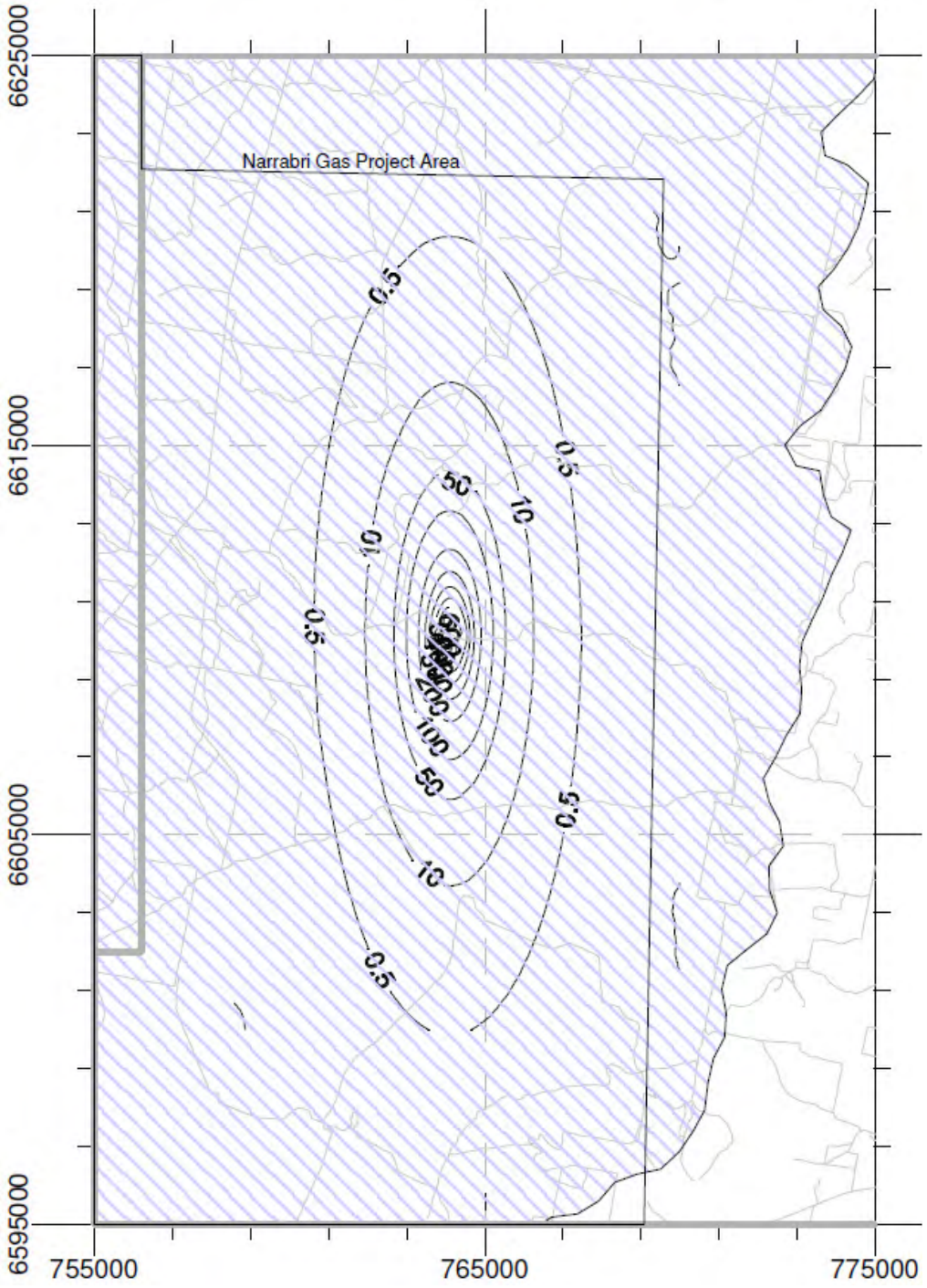


Figure 5-6: Close up of impacted area within Bohena Seam (Layer 12) at 3 years from pilot start (occurrence of maximum drawdown in model layer)

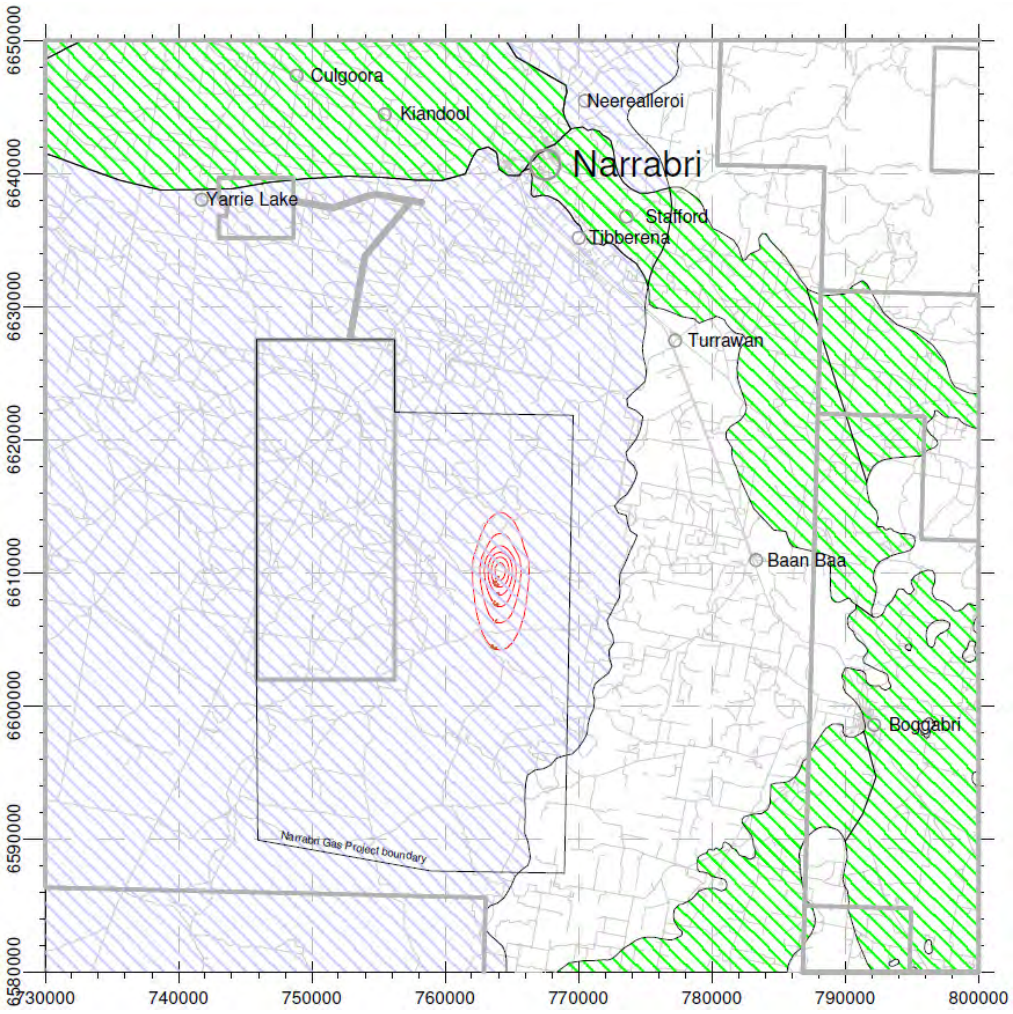


Figure 5-7: Potentiometric map of drawdown in Porcupine and Watermark Formations (Layer 10) at 20 years from pilot start (occurrence of maximum drawdown in model layer)

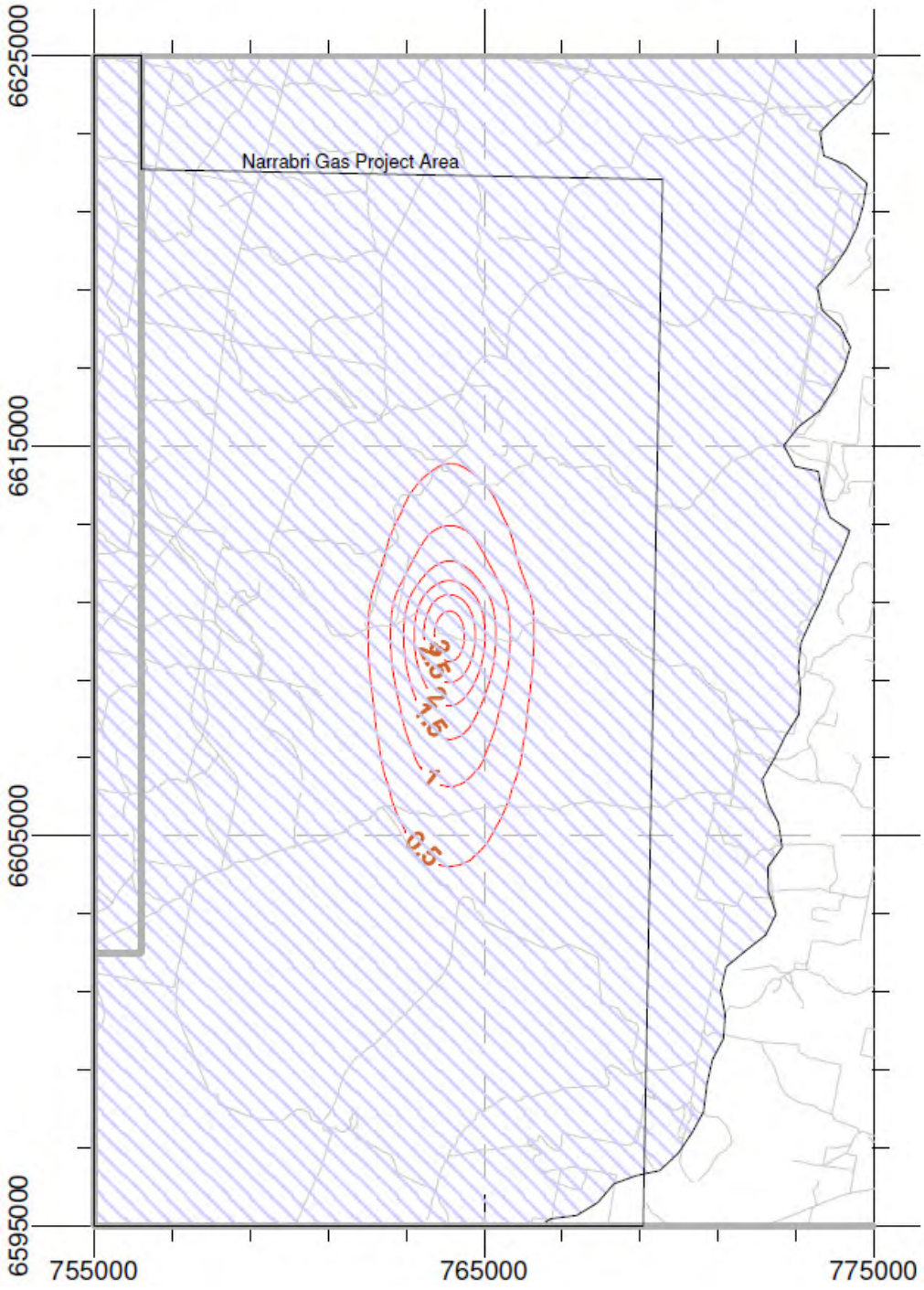


Figure 5-8: Close up of impacted area within Porcupine and Watermark Formations (Layer 10) at 20 years from pilot start (occurrence of maximum drawdown in model layer)

6 Mitigation

Detailed numerical groundwater flow modelling of the Dewhurst 22-25 Pilot has been conducted and the simulations have indicated that no impact as a consequence of the pilot CSG water extraction is likely to be experienced:

1. Within the alluvial groundwater sources associated with the NSW Upper and Lower Namoi groundwater source WSP also identified within the context of the Aquifer Interference Policy as highly productive groundwater sources;
2. Within the porous rock groundwater sources associated with the NSW GAB groundwater source WSP also identified within the context of the Aquifer Interference Policy as highly productive groundwater sources;
3. At any high priority GDE within the vicinity of the Narrabri Gas Project; and,
4. At any water supply work within the vicinity of the Narrabri Gas Project.

The same modelling has indicated that all fluxes and water level or pressure impacts associated with the pilot CSG water extraction will be limited to the porous rock groundwater sources associated with the NSW MDB Porous Rock (Gunnedah Basin) groundwater source WSP also identified within the context of the Aquifer Interference Policy as less productive groundwater sources. The extent of the impacts will be limited in extent as illustrated in Figures 5-5 to 5-8. Recovery of water pressures and return of fluxes to pre-CSG pilot conditions will occur through very slow leakage over timescales longer than the maximum simulation period of 540 years. The magnitude of these leakage fluxes will be negligible in the context of seasonal fluctuations and the pressure changes so induced will also be negligible.

It is therefore considered unnecessary to instigate mitigation measures in relation to the proposed Dewhurst 22-25 Pilot.

7 Summary

A CSG exploration pilot is proposed at Dewhurst 22-25 Pilot site, comprising a single lateral and counterpart vertical well together with a triple lateral and a corresponding counterpart vertical well and a single central vertical well.

The CSG pilot wells will be extracting CSG from the coal seams of the Maules Creek Formation towards the base of the Permo-Triassic geological sequence of strata in the Bohena trough, a sub-basin of the Gunnedah Basin.

In order to recover CSG from the coal seams it is necessary to depressurise the seam by lowering the hydraulic head through the extraction of CSG water.

This assessment has considered the characteristics of the proposed water extraction in the context of the hydrogeological setting of the Bohena Trough / Gunnedah Basin to assess the impact of the extraction on groundwater.

The existing numerical model developed for the Narrabri Gas Project groundwater impact assessment has been modified to permit detailed modelling of the Dewhurst 22-25 Pilot by refining the model grid in the vicinity of the proposed pilot and by replacement of the scheme of CSG wells proposed for the wider Narrabri Gas Project with a model representation of the wells pertaining only to this pilot.

A transient simulation was conducted without CSG water extraction to quantify background fluxes between individual model layers (DWH22-25_TRANS_NoFlux) and this was then followed by a simulation of the pilot water extraction (DWH22-25_TRANS_wel). Both simulations were conducted for a period of 540 years, comprising 3 years of CSG pilot water extraction and a further 537 years to investigate hydraulic head recovery.

The development of drawdown in each model layer was analysed to determine the timing and maximum extent of impact arising from the water extraction and fluxes were calculated between the respective model layers.

The modelling and subsequent post-processing analysis indicates that the depressurisation will be largely limited to model layers 10-13, corresponding to the Middle and Early Permian strata at the base of the Bohena Trough.

No significant impact on hydraulic head is indicated for model layers 9 (Black Jack Group) or above and hence no significant impact on hydraulic head is indicated for the Pilliga Sandstone or Namoi Alluvium.

The instigation of significant fluxes by CSG water extraction are limited to the same layers, 10-13 and no significant quantifiable flux is predicted to occur from the overlying NSW GAB groundwater source to the MDB Porous Rock groundwater source within the period of the simulation.

The CSG water extraction is sourced from aquifer storage within the impacted model layers identified and recovery of hydraulic heads continues beyond the end of the modelling period through induced minor increased rates of recharge from the base of the model, Layer 14.

8 Conclusions

- The total quantity of water proposed to be abstracted during the pilot is estimated as 288 ML (288,600 m^3), equating to an average of 263 m^3/day over the 1096 day (3 year) duration of the proposed pilot;
- No aquifer interference to either the alluvial groundwater sources of the Upper and Lower Namoi Alluvium (NSW Upper and Lower Namoi groundwater source WSP) or the GAB Surat Pilliga Sandstone (NSW GAB groundwater source WSP) is indicated by the modelling of the pilot CSG water extraction activities;
- Although no decline in water table level, water pressure or change in flux is indicated for the majority, upper part of the porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP), the impact on hydraulic (pressure) head and the fluxes developed within the lower part of the groundwater source to meet the pilot CSG water demand are interpreted to comprise an aquifer interference within the combined groundwater source and will require licensing;
- No impact on either high priority GDEs identified in the vicinity of the Narrabri Gas Project area is predicted to occur as a consequence of the Dewhurst 22-25 Pilot;
- No impact on any registered water extraction bores identified in the vicinity of the Narrabri Gas Project area is predicted to occur as a consequence of the Dewhurst 22-25 Pilot; and
- It is therefore considered unnecessary to instigate mitigation measures in relation to the proposed Dewhurst 22-25 Pilot.

References

Appendix A References

Halcrow, 2012. Narrabri Gas Project Groundwater Impact Assessment.