Dewhurst Gas Exploration Pilot Expansion

Environmental Impact Statement (EIS)

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Name	Signature	Date
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Declaration:	I declare that the information contained in this Environmental Impact Statement is neither false nor misleading. Name: Neale House, Santos NSW (Eastern) Pty Ltd for and on behalf of the titleholders of PEL 238. Signature: Date: 30/10/13

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Executive Summary

Overview

Santos NSW (Eastern) Pty Ltd (Santos), as the coal seam gas (CSG) operator of Petroleum Exploration Licence 238 (PEL 238), is seeking consent to expand operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operate both expanded pilots for up to three years (the proposed activity). The proposed activity will occur at two pilot sites:

- the existing Dewhurst 13-18H Pilot, located on freehold land and Crown Land road reserve, approximately 25 kilometres south of Narrabri
- the proposed Dewhurst 26-31 Pilot, located in the Pilliga East State Forest, approximately 44 kilometres south of Narrabri.

The proposed activity will be conducted on behalf of the titleholders of PEL 238, Santos NSW Pty Ltd and EnergyAustralia Narrabri Gas Pty Ltd.

The proposed activity is classified as State Significant Development (SSD) under the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP). Under schedule 1 of the SRD SEPP development for the purpose of drilling or operating petroleum exploration wells, not including 'a set of 5 or fewer wells that is more than 3 kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title' is SSD.

The development of the proposed activity is for the purpose of drilling and operating a set of more than five wells within a three kilometre radius within PEL 238 and is therefore deemed to be SSD under the SRD SEPP.

RPS Australia East Pty Ltd (RPS) has prepared this Environmental Impact Statement (EIS) to assess the potential environmental impacts of the proposed activity, in accordance with section 78A(8A) of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

The proposed activity

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The proposed activity includes drilling an additional two horizontal wells at each of the Dewhurst 16H, 17H and 18H pilot wells to target additional coal seams, installing surface infrastructure (including a flare at Dewhurst 14) and operating the whole pilot set for up to three years.

Dewhurst 26-29 is a four well pilot approved under Part 5 of the EP&A Act and is scheduled to be drilled in the fourth quarter of 2013. It is proposed to add two additional wells, Dewhurst 30 and 31, to this pilot which are proposed to be drilled in the second or third quarter of 2014 should approval be granted. The proposed activity includes drilling the two additional pilot wells (Dewhurst 30 and 31), installing surface infrastructure (including a flare at Dewhurst 28) and operating the six pilot well set for up to three years.

The proposed activity includes:

- construction: site preparation activities at existing and new well lease areas; establishment of necessary equipment, temporary structures and facilities on the lease areas to enable drilling; re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells at Dewhurst 13-18H; drilling one vertical well (Dewhurst 30) and one triple-stacked horizontal well (Dewhurst 31); construction of a flare at Dewhurst 14 and 28; and construction of associated surface facilities and gathering systems
- operation: operating the expanded Dewhurst 13-18H and Dewhurst 26-31 pilots for a period of up to three

years, management of the water and gas produced during operation and general maintenance activities

- post operation and rehabilitation: decommissioning and rehabilitation of pilot wells and ancillary infrastructure or suspension of wells for potential future use.

The construction footprint for Dewhurst 13-18H is 5.37 hectares which includes the existing lease areas at Dewhurst 14, 16H, 17H and 18H and the proposed gathering system. Approximately 0.24 hectares of vegetation will be cleared from within the construction footprint at Dewhurst 13-18H.

The construction footprint for Dewhurst 26-31 is 3.52 hectares including the lease area at Dewhurst 28 (which will already have been established but which a flare is to be constructed on as part of the proposed activity), the proposed lease areas at Dewhurst 30 and 31 and the proposed service corridor for Dewhurst 30 and 31. Approximately 2.2 hectares of vegetation will be cleared from within the construction footprint at Dewhurst 26-31 as part of the proposed activity.

The proposed activity forms part of the Energy NSW CSG Exploration and Appraisal Program (E&A Program). The program consists of a series of CSG exploration and appraisal activities within PEL 238 and PAL 2 including recommencing operation of a number of existing pilot wells, drilling and operating new pilot wells and constructing and operating water and gas management facilities to support the program.

The E&A Program is necessary for the ongoing exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and Petroleum Appraisal Lease 2 (PAL 2). It will assist in gaining further knowledge of coal fines, gas composition and flow rates, the deliverability of the reservoir, and investigating well design, drilling and completion technologies. This information is essential to determine whether commercial gas production is viable and would be used in development planning for a potential commercial gas production project within the areas of PEL 238 and PAL 2.

Assessment under Part 4 of the EP&A Act

As the proposed activity is SSD under the SRD SEPP, Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) applies to the proposed activity.

This EIS assesses the potential environmental impacts of the proposed activity in accordance with clauses 6 and 7 of Schedule 2 of the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and the Director-General's Requirements (DGRs) issued by the NSW Department of Planning and Infrastructure (DP&I) on 22 July 2013. The DGRs were issued in accordance with clause 3 of Schedule 2 of the EP&A Regulation.

Benefits of the proposed activity

The proposed activity is consistent with *NSW 2021: A Plan to Make NSW Number One* (DPC, 2011), the *New England North West Regional Action Plan* (DPC, 2012), the *Strategic Regional Land Use Policy* (SRLUP) and the *Energy White Paper 2012* (DRET, 2012).

The proposed activity, as part of the E&A Program, has the potential to play a role in the delivery of a secure supply of domestic gas for NSW, as well as alleviate potential gas supply shortages which may expose NSW to significant energy price increases if approvals for production are sought and granted.

The local and regional economy will benefit through direct and indirect employment opportunities. Approximately 13.2 full time equivalent jobs (11.2 during construction and two during operation) will be created. The proposed activity will also create an economic multiplier of $8.1 million or the creation of a further 16 indirect jobs in the local and wider economy.

Environmental impact assessment

The DGRs together with the results of an environmental risk assessment, guided the preparation of the EIS. An overview of the key environmental issues assessed in the EIS is provided below.

Land resources

The Dewhurst 13-18H Pilot is predominantly located on land that has been mostly cleared for low intensity stock grazing activities. No commercial farming activity currently takes place on the site. The pilot site is adjacent to the Jacks Creek State Forest, and small areas of uncleared land on the property comprise vegetation that is consistent with the Pilliga scrub. The Dewhurst 26-31 Pilot is located on uncleared land within the Pilliga East State Forest.

The nearest residence is a dwelling located approximately 500 metres south of the Dewhurst 13 lease area; however this is being leased by Santos until December 2015, and will remain vacant until that time. The next closest sensitive receiver to Dewhurst 13-18H is a residence situated approximately 1.8 kilometres south-west. The nearest residences to Dewhurst 26-31 are located approximately 11 kilometres north, outside of the Pilliga East State Forest.

Surface geology mapping indicates that the location of the proposed activity is underlain by a single geological formation known as Orallo formation, with a Quaternary alluvial channel intersecting the Dewhurst 26-31 Pilot. Soil characteristics of the two pilot sites indicate moderate to severe limitations with low plant-available water capacity, low nutrient levels and sodicity that all limit agricultural production.

The two pilot sites are not located on or near Biophysical Strategic Agricultural Land (BSAL) and/or a Critical Industry Cluster (CIC) as defined in the *Strategic Regional Land Use Plan – New England North West* (DP&I, 2012a). The nearest mapped BSAL is approximately 10 kilometres east of Dewhurst 13-18H and no CIC has been identified in the New England North West Region.

The proposed activity is considered low risk and will not have an adverse impact on the current or future agricultural production capacity (including forestry) or land resources in the Narrabri local government area (LGA). There will be little change to the surface area and erosion and sediment control measures will remain in place during operation. Drilling activities will produce drilling fluid and drill cuttings. These materials are unlikely to present an erosion hazard as drilling fluid and cuttings will be contained appropriately.

Water Resources

Groundwater

During operation, the expected groundwater extraction is estimated to be 331,121 and 413,801 cubic metres over three years for the operation of Dewhurst 13-18H and Dewhurst 26-31 pilots, respectively. The maximum rate of extraction is expected to be approximately 448 cubic metres per day (at Dewhurst 26-31), with the average 302 and 378 cubic metres per day, respectively. The target coal seams are located at a depth of approximately 900 to 1000 metres.

A cumulative groundwater impact assessment for the E&A Program, incorporating the Dewhurst 13-18H and Dewhurst 26-31 pilots, was undertaken assuming concurrent operation of all existing and proposed pilot wells. No significant decline in groundwater level or change in flux within the alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi groundwater source water sharing plan) or the Great Artesian Basin (GAB) Surat Pilliga Sandstone (NSW GAB groundwater source water sharing plan) is indicated by the modelling of the CSG water extraction activities.

Surface water

No surface water will be utilised for the proposed activity nor will any produced water be discharged into receiving waters. Potential impacts posed by soil erosion will be managed with the implementation of a range of erosion and sediment control mitigation measures.

Ongoing monitoring

A water monitoring program (surface and groundwater) is in the process of being implemented and will continue for the duration of the E&A Program. For groundwater it will include sampling and testing at registered bores as well as the installation of a number of both deep and shallow monitoring bores. Once installed, the aquifer monitoring bores will measure groundwater pressure and temperature within various strata and enable groundwater levels and flows to be monitored.

Surface water baseline data samples are collected monthly (when flows are present and sampling is possible) at a range of locations within the Upper Namoi Catchment, both upstream and downstream of the proposed activity.

Biodiversity

Approximately 2.44 hectares of White Cypress Pine – Bulloak – ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion will be cleared due to the proposed activity. This vegetation community is not commensurate with any threatened ecological communities listed under the *Threatened Species Conservation Act 1995* (TSC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

There is potential for indirect impacts during both the construction and operational phases of the proposed activity, in particular the removal of foraging, breeding or roosting/sheltering habitat. However, provided appropriate mitigation measures are implemented, there will be no significant direct or indirect impacts upon threatened fauna species or their habitats as a result of the proposed activity.

Threatened flora (*Tylophora linearis*, *Pterostylis cobarensis* and *Polygala linariifolia)* individuals will be cleared due to the proposed activity. Detailed targeted surveys within the broader Pilliga East State Forest have identified significant population of these threatened species. Assessments under the TSC and EPBC Acts concluded that, despite the clearance, the proposed activity is not likely to have a significant impact on these species.

A number of flora and fauna species (including migratory species) listed under the TSC and EPBC Act are considered to have the potential to occur within the two pilot sites and their immediate surrounds. A seven-part test and an Assessment of Significance were applied to those species listed under the TSC and EPBC Act, respectively. The assessments concluded that the proposed activity is not likely to have a significant impact on any of these species.

Air quality

Dust generated during construction will have the greatest potential impact on air quality and will be managed through the implementation of appropriate mitigation measures. Other emissions will occur from the exhaust of plant equipment required for drilling. These emissions are generally considered to be too low to generate any significant pollutant concentrations in the vicinity of the two pilot sites and will not impact the sensitive receivers nearby.

Emissions of carbon monoxide (CO) and nitrogen dioxide (NO_2) can be expected from the combustion and flaring of gas onsite during operation. However these emissions are significantly below targets outlined in the

Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC, 2005) and impacts on air quality are predicted to be insignificant.

Greenhouse gases

The proposed activity will generate Scope 1 (direct) and Scope 3 (indirect) greenhouse gas (GHG) emissions as defined by *GHG Protocol Corporate Standard* (WBCSD and WRI, 2004). These will occur both during construction and operation.

During construction 1,905 Tonnes CO_2^e Scope 1 emissions will be produced, while during operation 131,189 Tonnes CO_2^e/year will be produced. Scope 2 (indirect GHG) emissions will not occur as there will be no purchases of electricity from the grid. Scope 3 emissions are minor during construction (328 Tonnes CO_2^e) and very minor during operation (less than one Tonne CO_2^e/year is expected).

Likely greenhouse gas emissions from the proposed activity are not considered to have a significant impact on State or National emissions reduction targets. In addition, ongoing emissions associated with the proposed activity will be formally monitored and reported in accordance with legislative requirements

Noise

Noise levels generated during construction and operation will be below the relevant criteria at all but two sensitive receivers.

Under windy conditions during construction, the predicted noise levels at the two closest receivers to Dewhurst 13-18H are above the criteria for intrusive and night-time construction noise. The predicted noise levels at the nearest residence during operation are just above the criteria for intrusive noise in all climatic scenarios, as well as sleep disturbance during windy conditions. However, soft ground conditions (trees, grass) were not incorporated into the modelling. These conditions can significantly reduce sound transmission from drilling and construction activities, as well as the operation of the pilot wells.

Noise impacts from traffic generated by the proposed activity during both construction and operation are considered negligible to minor, and will meet the *NSW Road Noise Policy* (DECCW, 2011).

Traffic and transport

It is anticipated that there will be a minor increase (average 24 vehicles trips per day, rising to 66 vehicles trips per day during peak periods) in local traffic during the construction phase of the activity as a result of delivery and collection of plant, equipment and materials and personnel transport. Operational traffic movements will be minimal, with one vehicle arriving to and departing from site each day.

These anticipated traffic volumes will present a negligible impact on existing traffic using State Forest roads and the Newell Highway and will not impact the capacity, functionality, efficiency or safety of the local road network.

Waste

The main wastes generated during construction will be drilling fluid (approximately 825 cubic metres) and drill cuttings (approximately 350 cubic metres). Drilling fluids will the transported to the Santos operated Fluid Treatment Facility (FTF) in Narrabri for treatment and storage for future re-use in subsequent drilling activities. Should the FTF not be approved, drilling fluids will be transported to an alternative licensed facility.

Waste generated during operation of the two Dewhurst pilots will consist predominantly of produced water. This will be stored at the Leewood Produced Water Facility for future treatment.

Waste management measures implemented for the proposed activity will encourage efficient resource use alternatives, re-use and recycling. Waste that cannot be re-used or recycled will be disposed of in accordance with statutory requirements.

Hazards

The proposed activity will require the use of chemicals, fuels and oils, particularly during drilling activities. No chemicals with added benzene, toluene, ethyl benzene, and xylenes (BTEX) will be used, nor will any fracking take place.

Diesel will be stored temporarily onsite for use during drilling. Diesel is classed as an Australian Dangerous Goods Code 3 and as such is subject to the requirements under State Environmental Planning Policy 33. However given the relatively small volumes, the proposed activity is not defined as a potentially hazardous or offensive activity or industry.

Any impacts associated with hazardous materials are expected to be minor.

Social and Economic

The proposed activity will result in a number of positive economic impacts for the local, regional and State economies. This includes a mix of both local and fly in fly out jobs over the course of the proposed activity. The development of the proposed activity is in line with the goals and outcomes of both the *Narrabri Shire Economic Development Strategy* (AEC Group, 2011) and the *Strategic Regional Land Use Plan – New England North West* (DP&I, 2012a).

Santos is implementing a comprehensive community and stakeholder engagement program. This has involved a range of activities including: government and stakeholder forums, site tours, information sessions, establishment of a community consultation committee, one on one meetings and formal correspondence. Community feedback on the proposed activity has informed the development of the EIS.

Santos holds a Permit to Occupy in the Pilliga East Forest from the Forestry Corporation of NSW (as the landowner), while a land access and compensation agreement is currently in place with the landowner of Lot 32 DP 757104.

Other impacts

A range of other impacts were considered during the impact assessment. This included cultural and non-Aboriginal heritage, water quality, impacts to stygofauna and bushfire impacts. Impacts associated with all of these issues were considered negligible.

Cumulative impacts

The proposed activity has been assessed in conjunction with other E&A Program activities within PEL 238 and PAL 2. In the case of biodiversity, this has also included consideration of previous CSG activities within the Pilliga and Bibblewindi Forests over the previous ten years.

For all environmental aspects the E&A Program is expected to have a negligible to minimal impact on the environment.

Conclusion

The proposed activity is temporary and minor in scale. The two proposed activity sites have been selected to avoid significant environmental constraints, and to minimise 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 however will contribute to the local and regional community through job creation and economic activity.

PART A

1.0 The Project

1.1 Proposed activity overview

Santos NSW (Eastern) Pty Ltd (Santos), as the coal seam gas (CSG) operator of Petroleum Exploration Licence (PEL) 238, is seeking consent for the Dewhurst Gas Exploration Pilot Expansion (proposed activity). The proposed activity will occur at two pilot sites:

- the existing Dewhurst 13-18H Pilot, located on freehold land and Crown Land road reserve, approximately 25 kilometres south of Narrabri
- the proposed Dewhurst 26-31 Pilot, located in the Pilliga East State Forest, approximately 44 kilometres south of Narrabri.

The proposed activity involves the expansion of operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operation of both pilots for up to three years. Works at Dewhurst 13-18H involve re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells. Works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas to expand the pilot from four to six wells.

The Environmental Impact Statement (EIS), prepared by RPS Australia East Pty Ltd (RPS) in accordance with Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), assesses the impacts associated with the proposed activity.

1.2 Assessment under Part 4

The proposed activity is "State Significant Development" (SSD) to which Division 4.1 of Part 4 of the EP&A Act applies in accordance with the *State Environmental Planning Policy (State and Regional Development) 2011* (SRD SEPP).

The EIS considers the potential environmental impacts of the proposed activity in accordance with clauses 6 and 7 in Schedule 2 of the NSW *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and the Director-General's Requirements (DGRs) issued by the NSW Department of Planning and Infrastructure (DP&I) on 22 July 2013. The DGRs were issued in accordance with clause 3 of Schedule 2 of the EP&A Regulation. Appendix 1 provides a summary of the DGRs and cross references where each requirement is addressed within the EIS.

1.3 Proponent

The proponent for the proposed activity is Santos NSW (Eastern) Pty Ltd (Santos), as the CSG operator, on behalf of the titleholders of PEL 238, Santos NSW Pty Ltd and EnergyAustralia Narrabri Gas Pty Ltd.

1.4 Existing approvals

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The NSW Department of Primary Industries (DPI) approved construction, drilling and operation of Dewhurst 13, 14, 15, 16H, 17H and 18H on 21 July 2009 following an REF assessment under Part 5 of the EP&A Act. The proposed activity involves drilling an additional two horizontal wells at each of the Dewhurst 16H, 17H and 18H pilot wells to target additional coal seams, installing surface infrastructure and gathering system, and operating the whole pilot set for up to three years.

Table 1-1 outlines key project elements and proposed changes from the approved *Dewhurst 8 Lateral Production Pilot* REF (ESG, 2009), now referred to as the Dewhurst 13-18H Pilot.

Table 1-1 Changes from approved REF (Dewhurst 13-18H)

Project element	Change
Lease Area	No change.
Drilling	Drilling will occur to convert single horizontal wells to triple-stacked horizontal wells. Approach to drilling has become more environmentally sophisticated since the original REF with systems using less harmful chemicals, and capture and reuse of drilling fluid occurring.
Gathering System	The alignment of the gathering system has changed. While longer in length, it parallels existing roads and utilises disturbed areas.
Produced Water management	Produced water will slightly increase with the addition of triple-stacked horizontal wells. Rather than treating water onsite at Dewhurst 14, produced water will be temporarily stored in a water balance tank onsite before being transferred to the Leewood Produced Water Facility. Existing ponds have been rehabilitated as per original REF.
Produced Gas Management	Excess gas will be flared however flare capacity has increased from 2 million m^3 to 5 million m^3.
Wells	Wells will target three seams rather than one; however there is no change to well heads.
Surface infrastructure	No change.
Rehabilitation	No change.

Dewhurst 26-29 is a four well pilot which was approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) on 16 August 2013 following a REF assessment under Part 5 of the EP&A Act. Dewhurst 26-29 is scheduled to be drilled in the third quarter of 2013.

It is proposed to add two additional wells, Dewhurst 30 and 31, to this pilot in the second or third quarter of 2014. The proposed activity involves establishing two new lease areas for these wells, drilling the wells, installing surface infrastructure and gathering system, installing a flare with increased capacity (than was approved by DTIRIS under Part 5 of the EP&A Act) on the Dewhurst 28 lease area, and operating the combined six pilot well set for up to three years.

1.5 Background

Santos Limited is an Australian petroleum company established in 1954, which has been supplying natural gas to NSW since 1976. Santos Limited and its subsidiary companies have been involved in CSG activities in Queensland for 20 years and commenced CSG exploration in the north-west of NSW in 2008.

In November 2011, Santos Limited acquired Eastern Star Gas Limited (ESG) who was the operator of PEL 238, Petroleum Assessment Lease (PAL) 2 and Petroleum Production Lease (PPL) 3. Santos (the proponent), then became the operator of these tenements.

At the time of acquisition, ESG's operations included six appraisal pilots, including the Dewhurst 13-18H Pilot (previously referred to as the Dewhurst-8 Lateral Production Pilot), numerous water storage ponds, the Bibblewindi Water Treatment Facility, Wilga Park Power Station (WPPS), and ancillary infrastructure in and around the Pilliga forest.

Following the acquisition, Santos carried out a full review of ESG's operations which identified a number of practices and infrastructure that did not meet Santos Operational standards. Santos suspended operations and commenced a program of decommissioning and rehabilitation works. These works included plugging and abandoning wells no longer needed, decommissioning and rehabilitating water storage ponds, decommissioning the reverse osmosis plant at the Bibblewindi Water Treatment Facility (now known as the Bibblewindi Water Transfer Facility (WTF)) and commencing rehabilitation of approximately 30 hectares of land.

Santos purchased a property, known as Leewood, outside of the State forests for the purpose of developing a new water management facility. The new facility will have state of the art technology, monitoring and environmental protection systems that meet Santos standards. DTIRIS approved the Leewood Produced Water Facility in March 2013 under Part 5 of the EP&A Act. The approval included construction of a water storage facility and associated infrastructure, transfer of produced water and brine stored at Bibblewindi to Leewood, and ongoing operation of the facility to store water from the pilot wells once returned to operation.

Santos plans to continue exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2 and has developed the Energy NSW CSG Exploration and Appraisal Program (E&A Program). The E&A Program will assist in gaining further knowledge of coal fines, gas composition, flow rates and deliverability, well design, drilling and completion technologies. The E&A Program will be conducted over the next two to three years in stages and is proposed to include, subject to obtaining the necessary approvals:

- operation of the existing Dewhurst 13-18H Pilot and the construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H – 18H (the proposed activity, subject of the EIS)
- construction, drilling and operation of the Dewhurst 26-29 Pilot and the expansion of the pilot by adding two wells, Dewhurst 30 and 31, and operating the combined six well set (incorporates the proposed activity, partially subject of the EIS)
- construction, drilling and operation of the Dewhurst 22-25 Pilot
- operation of the existing Bibblewindi Multi-Lateral Pilot, and the construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32) from existing well leases within the pilot
- operation of the existing Bibblewindi West Pilot
- operation of the existing Tintsfield Pilot
- construction of the Dewhurst Northern Water and Gas Flow Lines and operation the Dewhurst Northern Water Flow Line
- construction of the Dewhurst Southern Water and Gas Flow Lines and operation of the Dewhurst Southern Water Flow Line
- construction and operation of the Leewood Produced Water Facility and ancillary infrastructure
- gas and water management during operation of the E&A Program.

Unless noted above, these activities are subject to separate environmental assessment and approval processes.

1.6 Structure of the EIS

The EIS has been structured into three sections as follows:

- Part A (Chapters 1-7). This section introduces the activity, justification and need and summarises consultation and legislative requirements. It provides background and context, and describes in detail each element of construction, operation and post-operation and rehabilitation
- Part B (Chapters 8-19). This section provides an overview of the potential impacts of the proposed activity across a range of environmental issues identified in the DGRs, the environmental risk assessment or raised during consultation. It describes the baseline conditions, identifies the magnitude and scale of impacts and lists proposed mitigation measures. Assessment has been undertaken for the proposed activity and cumulatively for the E&A Program
- Part C (Chapters 20-21). This section provides a concluding statement regarding the proposed activity and a draft Statement of Commitments
- Appendices. This section provides the DGRs, including a cross-reference to where each requirement is addressed within the EIS, as well as the specialist assessments undertaken to support the EIS.

2.0 Need and Justification

2.1 Energy needs in NSW

NSW meets most of its energy demands from non-renewable sources including coal, petroleum and gas. Figure 2-1 compares energy consumption by sector and fuel type. Energy consumption is expected to grow in all sectors however it is expected that the mix of fuel types will change, moving away from a reliance on coal (Environment Protection Authority (EPA), 2012). According to forecasts developed by the Australian Energy Market Operator (AEMO, 2011), gas is increasingly being used for electricity generation and the fuels share of electricity generation could increase from around 11 to 37 per cent by 2030-31.

NSW currently sources 95 per cent of its gas from interstate. Contracted supplies are predicted to fall from 2014 and reach significantly low levels in 2017 due to a combination of factors including a strong demand for gas in other states, decreasing reserves and constraints on infrastructure.

The NSW government recognises the importance of a domestic gas supply and the need to access affordable gas through the development of the State's reserves. In its submission on the Commonwealth's Energy White Paper the NSW Government stated:

'further delay in gas developments in NSW will contribute to a supply shortfall as early as 2014 and could have a direct impact on the State's consumers, through gas supply challenges and higher energy costs'.

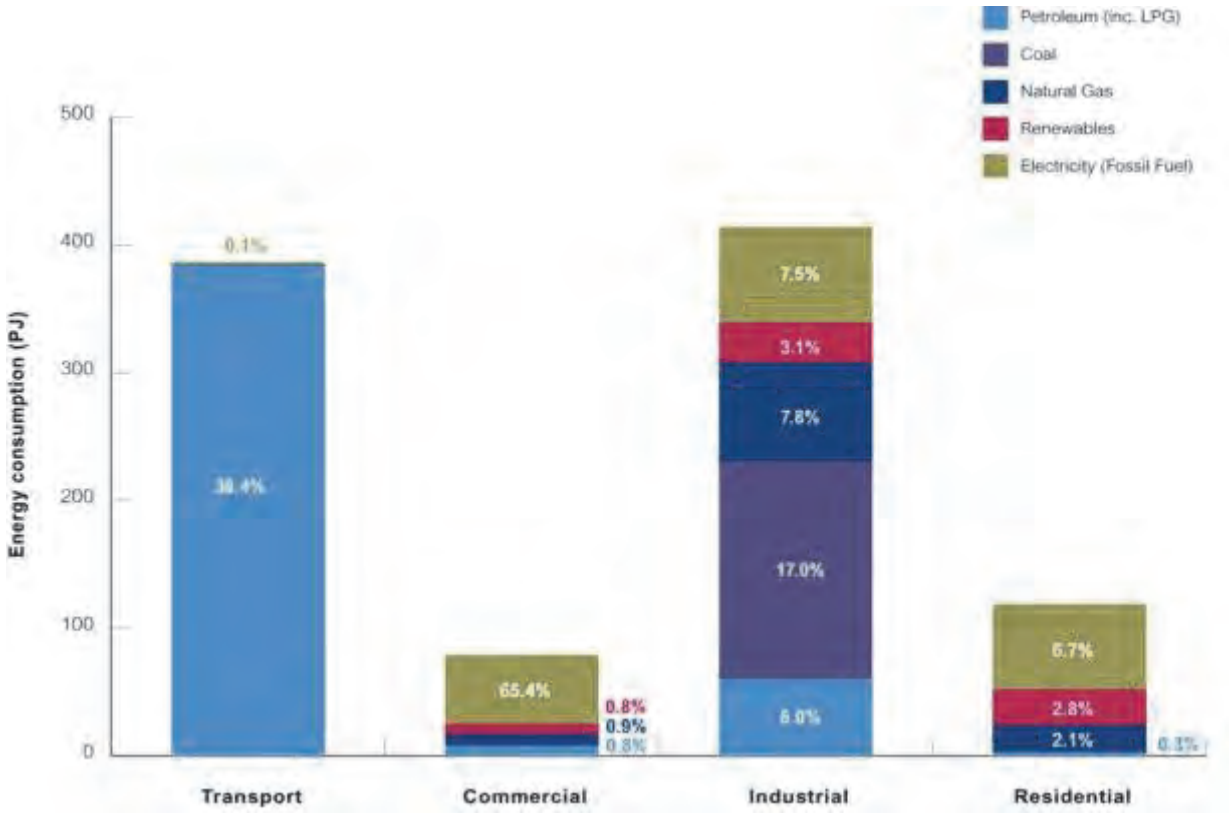


Figure 2-1 Fuel consumption in NSW

Source: NSW Statement of the Environment 2012

2.2 Interaction with key strategic planning and policy documents

2.2.1 NSW State Plan 2021

NSW 2021: A Plan to Make NSW Number One (DPC, 2011) (NSW State Plan 2021) presents the NSW Government's strategy to move the State forward over the next ten years and is based on five principal strategies with underlying goals. The five strategies are:

- rebuilding the economy
- returning quality services to NSW
- renovating infrastructure
- restore accountability to government
- strengthening the local environment and community.

Included in the government's NSW State Plan 2021 are 19 regional action plans. These plans were created to support the action plan by identifying key priorities to be addressed and implemented across all 19 regions.

The *New England North West Regional Action Plan* (DPC, 2012) includes the Gunnedah and Narrabri local government areas (LGAs). The communities within the region identified six priorities. Two of these priorities include the need to focus on growth and diversity of the region's economy and investment in regional and local infrastructure.

The development of the proposed activity within the Narrabri LGA will support these strategies and goals by providing both capital investment and economic benefits. It will provide a financial injection for the local economy both directly and indirectly and as part of the broader E&A Program.

The local and regional economy will benefit through direct employment opportunities as well as indirect employment. The proposed activity will see approximately 13.2 full time equivalent jobs (11.2 during construction and two during operation) created. An economic multiplier of $8.1 million is expected that could lead to the creation of a further 16 indirect jobs in the local and wider economy.

During the construction phase it is expected that some materials will be purchased and supplied locally. By sourcing local materials and contractors for the proposed activity it is estimated that a further $0.8 million will be spent locally on goods and services including vehicle leases, maintenance and fuel. This expenditure is likely to contribute both to the Narrabri economy and the wider northwest NSW region.

2.2.2 Commonwealth Energy White Paper 2012

The *Energy White Paper 2012* (DRET, 2012) sets out a strategic policy framework to address the challenges in Australia's energy sector and position it for long term transformation in the way we produce and use energy.

The policy framework is based on building a secure, resilient and efficient energy system that:

- provides accessible, reliable and competitively priced energy for all Australians
- enhances Australia's domestic and export growth potential
- delivers clean and sustainable energy.

The proposed activity as part of the E&A Program has the potential to play a role in the delivery of a secure supply of domestic gas for NSW, as well as alleviate potential gas supply shortages which may expose NSW to significant energy price increases.

In addition, further benefits can be realised through the use of gas in power stations. Gas has a significantly lower emissions profile compared to more traditional coal-fired power stations (an emissions intensity of 51.33 kg CO_2^e/GJ compared to 88.43 kg CO_2^e/GJ for coal). Substituting coal for gas equates to an annual emissions reduction in the order of 68,500 tonnes of greenhouse gases (GHG) for 20 megawatts of power.

2.2.3 Strategic Regional Land Use Policy

The NSW Government's *Strategic Regional Land Use Policy* (SRLUP) sets out a range of initiatives to better balance growth in the CSG industry with the need to protect important agricultural land and water resources. The *Strategic Regional Land Use Plan – New England North West* (DP&I, 2012a) identifies the key challenges in the region and clear action to address these challenges.

The proposed activity is consistent with DP&I (2012a), which recognises the region's potential for CSG production and identifies the two pilot sites 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.

Strategic Agricultural Land (SAL) is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DP&I, 2012a). Based on this definition there are two categories of SAL: Critical Industry Clusters (CIC) and Biophysical Strategic Agricultural Land (BSAL).

According to the DP&I (2012a) SAL mapping, the additional Dewhurst exploration wells and their surrounds are not classified as BSAL, with the closest BSAL 10 kilometres east of Dewhurst 13-18H and 13 kilometres east of Dewhurst 26-31. No CIC has been identified in the New England North West Region.

A site verification report has been prepared and is provided in conjunction with this EIS. Recent amendments to the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) include the application for verification of whether land is BSAL, as defined in the SRLUP, for the purposes of the Mining SEPP. Santos has lodged the site verification report to DP&I (to satisfy the DGRs) as part of the overall EIS submission. The DP&I will then undertake the site verification assessment as part of the overall assessment.

2.3 Justification

2.3.1 Need for an exploration and appraisal program

CSG exploration and appraisal is required to inform the production planning process. As shown in Figure 2-2, there are many stages before a gas supply is proven and gas reaches the domestic market.

The E&A Program that has been developed for PEL 238 and PAL 2 is necessary for the ongoing exploration, appraisal and evaluation of the CSG hydrocarbon potential within the tenements. The E&A Program will assist in gaining further knowledge of coal fines, gas composition and flow rates, the deliverability of the reservoir, and investigating well design, drilling and completion technologies. This information is essential to determine whether commercial gas production is viable and will be used in development planning for a potential commercial gas production project within the PEL 238 and PAL 2 areas.

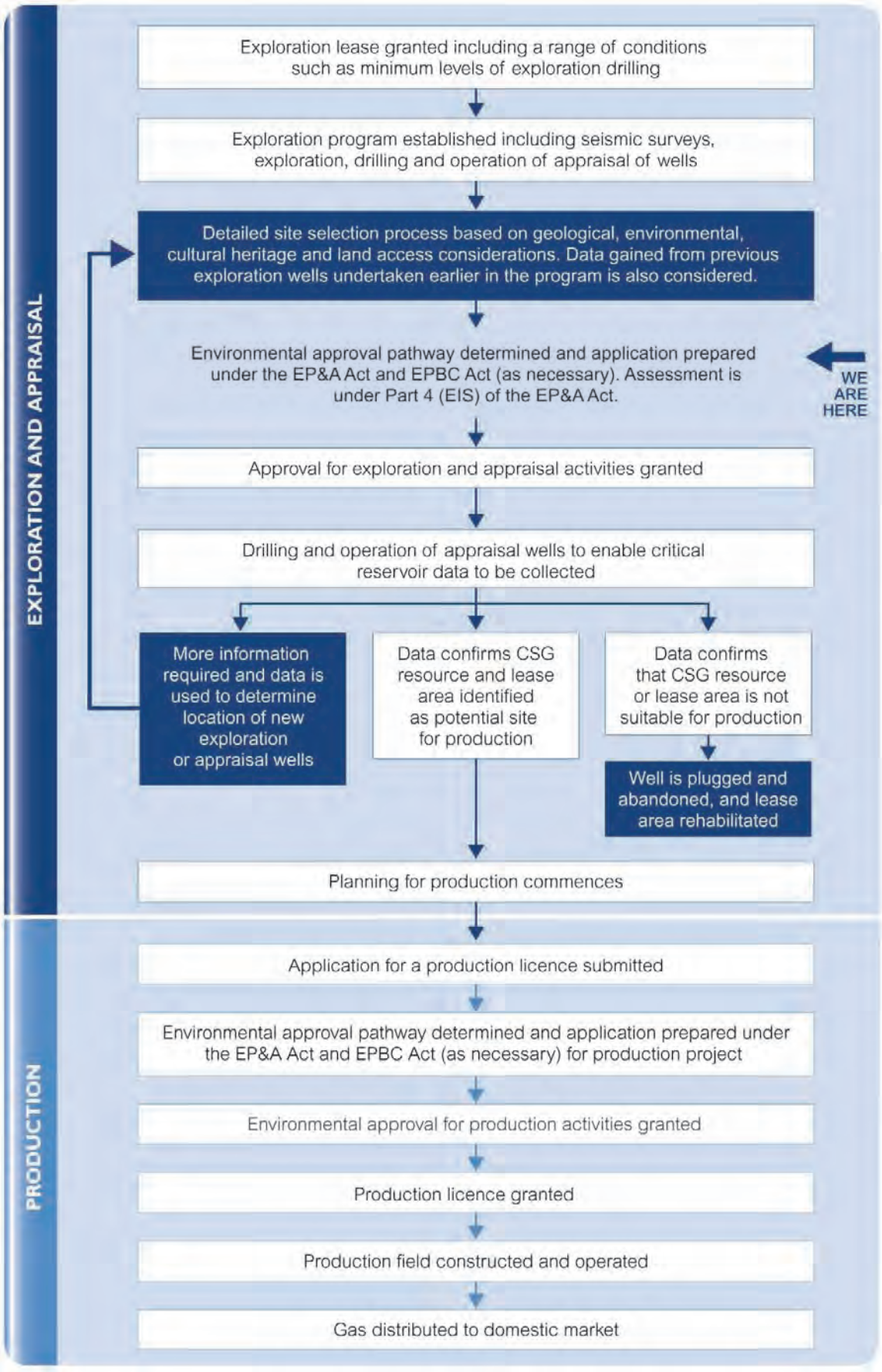


Figure 2-2 Stage of proposed activity with CSG exploration, appraisal and production planning process

2.3.2 Need for the proposed activity

The existing Dewhurst 13-18H wells target only the Bohena coal seam, however there is limited previous targeted drilling in this area of the Gunnedah Basin for the Namoi and Rutley seams. Establishing wells to target these seams is essential to gain knowledge of the gas content and composition, which can then inform gas production potential.

It is proposed to target the Namoi and Rutley seams through establishing additional horizontal wells within three existing wells at Dewhurst 16H, 17H and 18H. The benefit of such an approach is that it utilises existing infrastructure and access tracks, and removes the need for additional land and vegetation clearing.

The existing gas and water gathering system at the Dewhurst 13-18H Pilot does not currently meet Santos standards due to shallow burial depths and needs to be replaced. It is proposed to upgrade the gathering system and to include links from the Dewhurst 16H, 17H and 18H wells to a central gas and water facility to be installed at Dewhurst 14. The proposed new gathering system will be installed adjacent to the existing access tracks to minimise vegetation impacts.

The addition of the Dewhurst 30 and 31 pilot wells to the Dewhurst 26-31 Pilot improves the efficiency of water and gas recovery and enables the water and gas to be managed through new infrastructure proposed to support the E&A Program. The proposed Dewhurst 30 and 31 pilot wells will complement and expand on the operations of the planned Dewhurst 26-29 pilot wells and are located in a geologically favourable area.

The data collected from the pilot wells require a minimum distance within the coal seam and have been positioned accordingly, while the gathering system that links the wells is located adjacent to the proposed access tracks and Beehive Road to minimise vegetation clearing.

The triple-stacked horizontal wells will be drilled to test and assess the technical ability of this type of well while pumping and producing gas and water from three separate coal seams. This technology is commonly used in Canada and USA, and its use will reduce the likelihood of dependence on hydraulic fracturing techniques to obtain gas from the coal seams.

Safety and potential hazards for the activity will be managed through Santos standard risk and safety protocols including the Santos Emergency Response Plan.

The proposed activity is consistent with the principles of ecologically sustainable development (ESD) as described in Table 2-1. ESD is a primary objective 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* (POEA Act).

Table 2-1 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. Based on an environmental risk assessment and in combination with the DGRs, the EIS includes investigation into a range of issues to determine the full potential impacts of the proposed activity. This included commissioning groundwater, ecological, air quality, noise, traffic and economic and social technical studies, and drawing on information from technical specialists including geologists, drilling engineers and process engineers. Conservative 'worst case' scenarios are considered as part of the EIS. A range of mitigation measures will be put in place to minimise or prevent any environmental degradation. Refer to Chapter 20.
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 extracted during operation, but modelling indicates that this will have no significant impact on the upper aquifers including the Pilliga sandstone, registered bore users or groundwater dependent ecosystems (GDEs). Following drilling, lease areas will be rehabilitated back to 30 x 30 m in size. If testing activities indicate that commercial CSG production is not viable, the wells will be cemented, plugged and abandoned in accordance with the *NSW Code of Practice Coal for Seam Gas Well Integrity* (DTIRIS, 2012) and the lease areas will be fully rehabilitated.
Conservation of biological diversity and ecological integrity	At Dewhurst 13-18H, existing wells will be re-entered in preference to creating new lease areas and well sites that would require vegetation clearing. At Dewhurst 30 and 31, the locations of the lease areas were selected to avoid potential impacts to biodiversity and ecological integrity as much as possible. Micro-siting of lease areas and service corridors locations will be undertaken at Dewhurst 30 and 31 to minimise impacts of the proposed activity. 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, or to critical habitat.
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.

2.4 Alternatives considered

Alternatives considered for the proposed activity included do nothing, alternative drilling locations or establishment of a new pilot in the vicinity of Dewhurst 13-18H. On balance the proposed activity best meets the needs of the E&A Program while reducing surface disturbance. These alternatives are briefly discussed below.

2.4.1 Do nothing

There is limited previous targeted drilling in this area of the Gunnedah Basin that is sufficiently deep for petroleum exploration purposes, particularly with regards to the Namoi and Rutley seams. Doing nothing would not achieve the objectives of proposed activity or the overall E&A Program and is not a viable option.

2.4.2 Alternative location

At Dewhurst 13-18H, the proposed drilling and surface facility construction activities are located within existing lease areas. Any alternative location would require the establishment of new lease areas, wells and surface infrastructure. Re-entering of existing wells eliminates any additional surface impacts.

The existing water gathering system at Dewhurst 13-18H does not meet Santos standards and needs to be replaced. This created the opportunity to augment the gathering system to include Dewhurst 16H, Dewhurst 17H and Dewhurst 18H. The alignment was modified from the approved alignment (which has not been constructed) in order to follow the roadway. Paralleling the existing road and access tracks provides the most logical alignment as it reduces the required footprint, and hence minimises vegetation impacts, as the existing road can be used for access during construction.

The site selection process for the Dewhurst 30 and 31 lease areas was based on the principles of impact avoidance and harm minimisation. They were broadly identified by Santos' geologists and refined in consultation with the Forestry Corporation of NSW and with the assistance of cultural heritage, ecological and environmental consultants. Service corridors were located to avoid hollow bearing trees, targeting areas of greatest disturbance.

Efforts have been made to locate the Dewhurst 30 and 31 pilot wells outside of areas of 'very high' or 'high' ecological sensitivity (see Figure 2-3) and to use existing access from Beehive Road to minimise vegetation clearing. The Dewhurst 30 and 31 wells will utilise the Dewhurst 26-29 gas and water gathering system (with extensions to the Dewhurst 30 and 31 well sites), minimising the need for additional new infrastructure.

2.4.3 Establishment of a new pilot

Establishment of a new pilot in the vicinity of Dewhurst 13-18H would require the establishment of lease areas (approximately one hectare in size), access tracks and supporting gas and water management facilities. This would require vegetation clearing and potential impacts on biodiversity and heritage. This was also considered not viable.

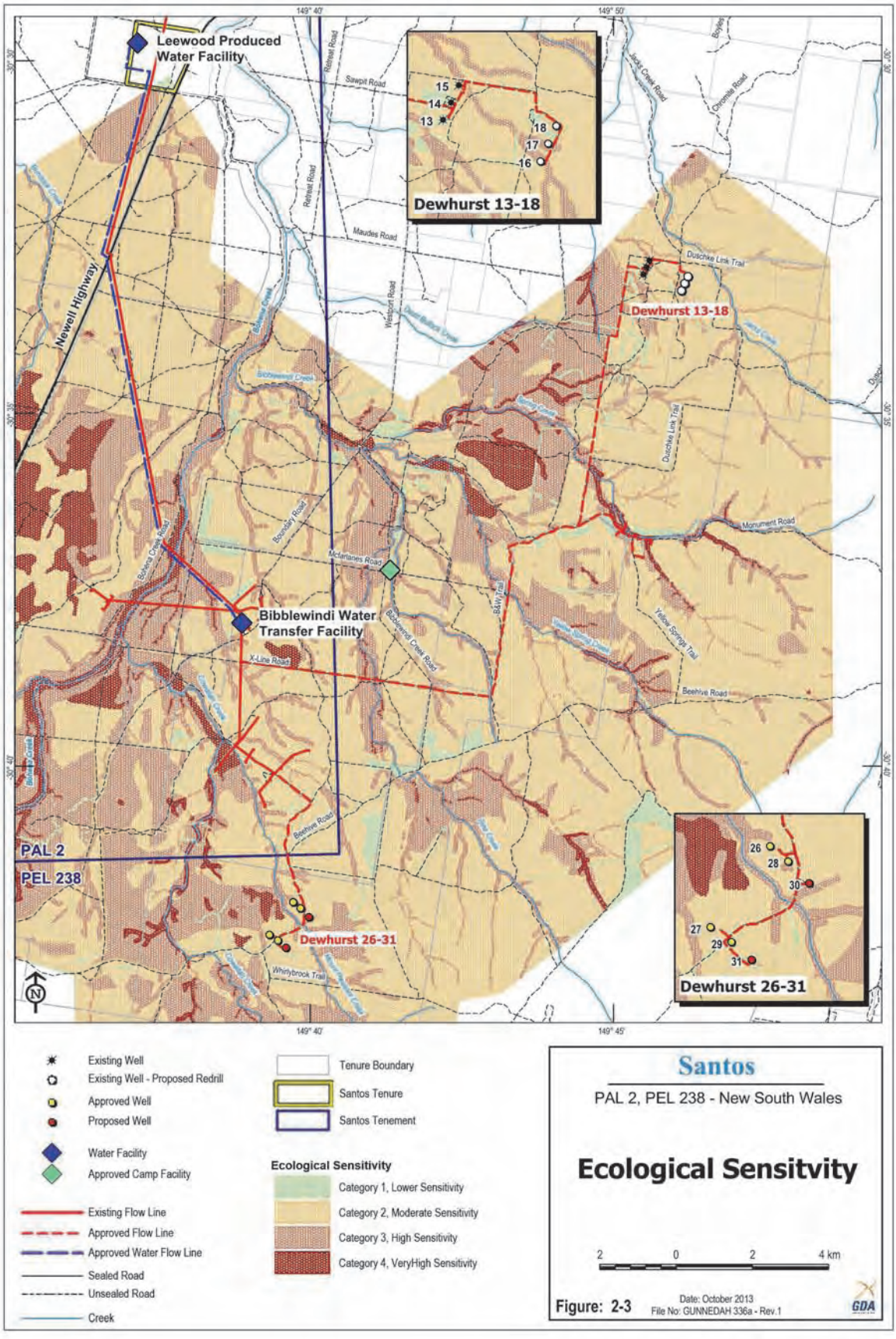


Figure 2-3 Ecological sensitivity – Dewhurst 30 and 31

3.0 The Site and Context

3.1 Overview

3.1.1 Site footprint

The proposed activity will take place at two pilot sites – Dewhurst 13-18H and Dewhurst 26-31. The site plans for the two pilots are shown in Figure 3-1 and Figure 3-2, respectively.

The Dewhurst 13-18H Pilot is located off an unnamed road to the north of the Pilliga forest (refer to Figure 3-1). Access to the site will be via the Newell Highway, X-Line Road, Garlands Road, Westport Road and Killara Road.

The construction footprint for Dewhurst 13-18H is 5.37 hectares which includes the existing lease areas at Dewhurst 14, 16H, 17H and 18H and the proposed gathering system. The new gathering system runs adjacent to interconnecting access tracks and a public road within a 10 metre wide corridor. Approximately 0.24 hectares of vegetation will be cleared from within the construction footprint at Dewhurst 13-18H.

The Dewhurst 26-31 Pilot is located off Beehive Road (refer to Figure 3-2). Access to the site will be via the Newell Highway, X-Line Road, Tighes Gully Road and Beehive Road.

The construction footprint for Dewhurst 26-31 is 3.52 hectares including the lease area at Dewhurst 28 (which will already have been established but which a flare is to be constructed on as part of the proposed activity), the proposed lease areas at Dewhurst 30 and 31 and the proposed service corridor (incorporating both the access track and gathering system) for Dewhurst 30 and 31. Approximately 2.2 hectares of vegetation will be cleared from within the construction footprint at Dewhurst 26-31 as part of the proposed activity. The proposed Dewhurst 30 and 31 lease areas are shown in Figure 3-3 and Figure 3-4, respectively.

The site footprint and total area of vegetation clearance for the proposed activity is 8.89 hectares and 2.44 hectares, respectively.

The location of the lease areas and service corridors at Dewhurst 30 and 31 will be subject to micro-siting during detailed design and pre-clearance survey activities. The final location of the facilities may be moved as a result of this process to minimise impacts of the proposed activity.

Coordinates for the Dewhurst 16H, 17H, 18H, 30 and 31 pilot wells, at which drilling works will be undertaken, are listed in Table 3-1.

Table 3-1 Approximate well locations (MGA 94 Zone 55)

Well	Easting	Northing	Lot description
Dewhurst 16H	765592	6616503	Lot 32 DP 757104
Dewhurst 17H	765681	6616690	Lot 32 DP 757104
Dewhurst 18H	765766	6616870	Lot 32 DP 757104
Dewhurst 30	755385	6600331	Crown Land State Forest
Dewhurst 31	754759	6599547	Crown Land State Forest

Plates 3-1 to 3-10 show existing conditions at the two pilot sites.



Figure 3-1 Site plan – Dewhurst 13-18H

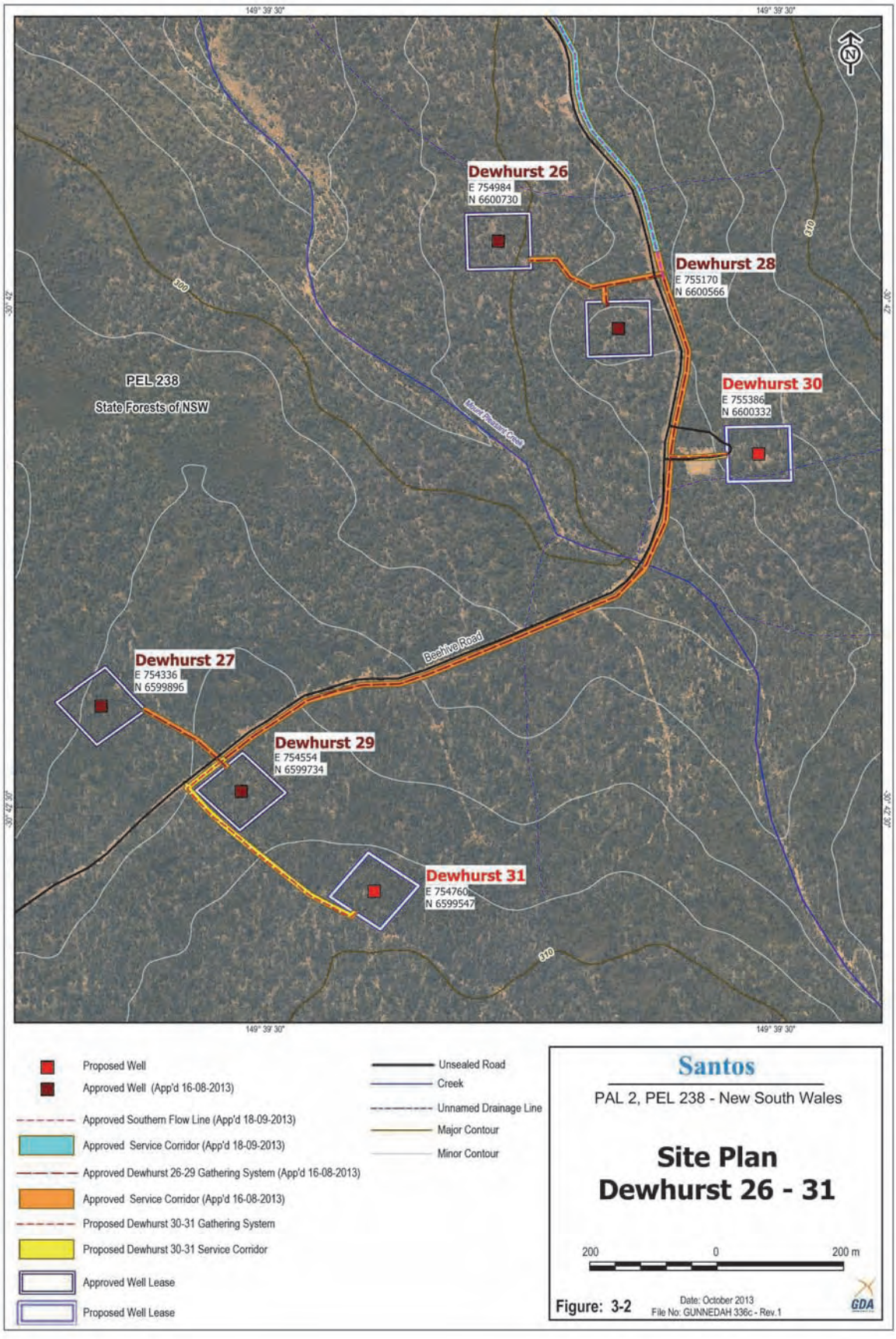


Figure 3-2 Site plan – Dewhurst 26 to 31



Figure 3-3 Dewhurst 30 lease area



Figure 3-4 Dewhurst 31 lease area



Plate 3-1 Dewhurst 14 lease area



Plate 3-2 Dewhurst 16H lease area



Plate 3-3 Dewhurst 17H lease area



Plate 3-4 Dewhurst 18H lease area



Plate 3-5 Proposed gathering system corridor route between Dewhurst 13 and 14 lease areas



Plate 3-6 Proposed gathering system corridor route between Dewhurst 15 lease area and unnamed road



Plate 3-7 Proposed gathering system corridor route adjacent to unnamed road



Plate 3-8 Proposed gathering system corridor route between Dewhurst 16 and 18 lease areas



Plate 3-9 Proposed Dewhurst 30 lease area



Plate 3-10 Proposed Dewhurst 31 lease area

3.1.2 Existing infrastructure onsite

The existing Dewhurst 13-18H Pilot consists of six wells. Each well is situated on a well lease area of approximately 0.8 hectares (100 by 80 metres). Surface infrastructure at the lease areas includes well heads metering skids, separators, generators and telemetry units. The well lease areas are connected via a series of access tracks branching off an unnamed road to the north.

Subsurface infrastructure comprises a water gathering system and an electrical cable between Dewhurst 13, 14 and 15 which follows the existing access tracks and collects at Dewhurst 14. Production water tanks and reverse osmosis plant were previously located at Dewhurst 14 but have now been decommissioned, removed and the land rehabilitated.

There is no existing onsite infrastructure at the Dewhurst 26-31 Pilot, however prior to undertaking the proposed activity, construction and drilling of the approved Dewhurst 26-29 wells and associated infrastructure will have occurred as this is to be installed in the fourth quarter of 2013. The following infrastructure will be present:

- surface infrastructure on the Dewhurst 26-29 lease areas, including separators, metering skids, power generation equipment, telemetry units and variable speed drivers
- a water transfer tank and pumps adjacent to the Dewhurst 28 lease area
- a water and gas gathering system parallel to the access tracks and Beehive Road to the associated piping, tank and pump, and proposed flare adjacent to Dewhurst 28.

3.1.3 Land ownership

The Dewhurst 13-18H lease areas are located on private, freehold land (Lot 32 DP 757104). A land access and compensation agreement is currently in place with the landowner of Lot 32 DP 757104.

The gathering system is located partly on Lot 32 DP757104 and partly within Crown Land road reserve held under an enclosure permit (EP 46419) by the landowner of Lot 32 DP 757104, as shown in Figure 3-5.

As part of the gathering system is to be installed under Crown land road reserve, an access arrangement will be required. The DPI administers these leases and licences under Section 34 of the *Crown Lands Act 1989* (CL Act).

An application has been made by the adjacent landowner to close the road and is currently being processed by the DPI Crown Lands Division. If the road is closed, but not purchased, the road will vest in the Crown and remain Crown land. However, if the road is purchased, the title will vest in the purchaser and the land access and compensation will need to be amended accordingly.

The proposed activity at Dewhurst 26-31 is located entirely on land dedicated as State forest and managed by Forestry Corporation of NSW (Forestry NSW). Santos holds a Permit to Occupy from Forestry NSW and the State of NSW, issued under section 31 of the *Forestry Act* 1916. The Permit to Occupy constitutes an access agreement with Forestry NSW under the *Petroleum (Onshore) Act* 1991 (Petroleum Act). It outlines a range of environmental mitigation strategies that Santos must implement as part of the agreement.



Figure 3-5 Dewhurst 13-18H land ownership

3.1.4 Natural features of the site

3.1.4.1 Climate

The Bureau of Meteorology (BoM) weather station considered the most representative of the region is Narrabri West Post Office (station 053030, opened 1891). Climate in this area is regarded as semi-arid, due to hot summers and mild winters. Average (1900 – 2013) monthly maximum temperatures range from 18°C (July) to 35°C (January). 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 May. Table 3-2 describes climatic conditions recorded for the region.

Average annual rainfall at Narrabri West is 651 millimetres. Pan evaporation exceeds rainfall throughout the year, indicating the regions reliance on irrigation and soil water storage during fallow (the time when land is plowed but left unseeded).

Table 3-2 Climate statistics Narrabri West for years 1900 to 2013, weather station 53030 (DSITIA, 2013).

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	82	68	55	37	46	48	45	39	40	55	63	73
Maximum Temperature (°C)	35	34	31	27	22	19	18	20	24	28	31	34
Minimum Temperature (°C)	19	19	16	11	8	5	3	4	7	11	15	18
Pan Evaporation (mm)	279	224	203	137	91	64	68	97	136	192	237	282

3.1.4.2 Topography

The topography of the two pilot sites and surrounds is shown in Figure 3-6. The regional topography is characterised by flat to very flat (approximately 1:1000), gently sloping land with little or no vertical relief.

At Dewhurst 13-18H, the topography is flat to undulating and the land rises generally to the south east, with elevations ranging from approximately 286 to 294 metres Australian Height Datum (AHD).

At Dewhurst 30 and 31, the topography is gently undulating, with no identifying topographic features. Individual topographic characteristics of the proposed lease areas are as follows:

- Dewhurst 30 – generally slopes in a south-west direction, with elevations ranging between approximately 304.3 and 306.6 metres AHD
- Dewhurst 31 – generally slopes to the north, with elevations ranging between approximately 308.8 and 310.4 metres AHD.

3.1.4.3 Drainage

According to regional mapping, the closest watercourses to the Dewhurst 13-18H Pilot include an unnamed tributary of Tuppiari Creek that flows from east to west across the site, crossing over the proposed gathering system between Dewhurst 16H and 17H (see Figure 3-1). However this drainage line was not observed during site investigations. Jacks Creek, an ephemeral creek, is located approximately 500 metres north-east of the pilot. An unnamed tributary of Tuppiari Creek flows in a north-west direction approximately 240 metres south of Dewhurst 13.

An unnamed tributary of Mount Pleasant Creek is mapped across the southern section of the proposed lease area for Dewhurst 30 (see Figure 3-2). Again, this drainage line was not observed during site investigations. The closest watercourse is Mt Pleasant Creek extending between Dewhurst 30 and 31. The creek is 200 metres south-west of Dewhurst 30, and 700 metres north-east of Dewhurst 31.

3.1.4.4 Stratigraphy

The two pilot sites are located in the central portion of the Gunnedah Basin where Jurassic and Cretaceous Surat Basin sediments unconformably overlie Permo-Triassic Gunnedah Basin sediments. The stratigraphy of the Gunnedah Basin is illustrated in Figure 3-7.

Detailed surface geology mapping indicates that the pilot sites are underlain by a geological formation described as the Orallo Formation (often referred to as Keelindi Beds), with a Quaternary alluvial channel intersecting the Dewhurst 26-31 Pilot (Geosciences Australia, 2011). The Mesozoic – Cretaceous age Orallo Formation consist of colluvial polymictic gravel, sand, silt and clay and may include some eluvial *in situ* regolith deposits overlying off-white, fine to coarse grained, poorly to well sorted, quartzose sandstone, pebbly sandstone and conglomerate interbedded with minor shale.

3.1.4.5 Vegetation

The existing well leases and access tracks at Dewhurst 13-18H are clear of vegetation. A few native and exotic grasses have recolonised small patches of the lease areas, however the existing lease areas can be characterised as cleared areas.

One vegetation community, the Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest, was identified at both pilot sites during ecological field surveys. This community is in remnant condition with a high level of disturbance in the vicinity of Dewhurst 13-18H, while at Dewhurst 30 and 31 it is also considered to be remnant, but in generally good condition.

This community does not constitute a Threatened Ecological Community (TEC) listed under the *Threatened Species Conservation Act 1995* (TSC Act) or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). This community is commensurate with the Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion (Benson *et al.*, 2006).

The Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest vegetation community present onsite is discussed in greater details in Section 11.1.1.

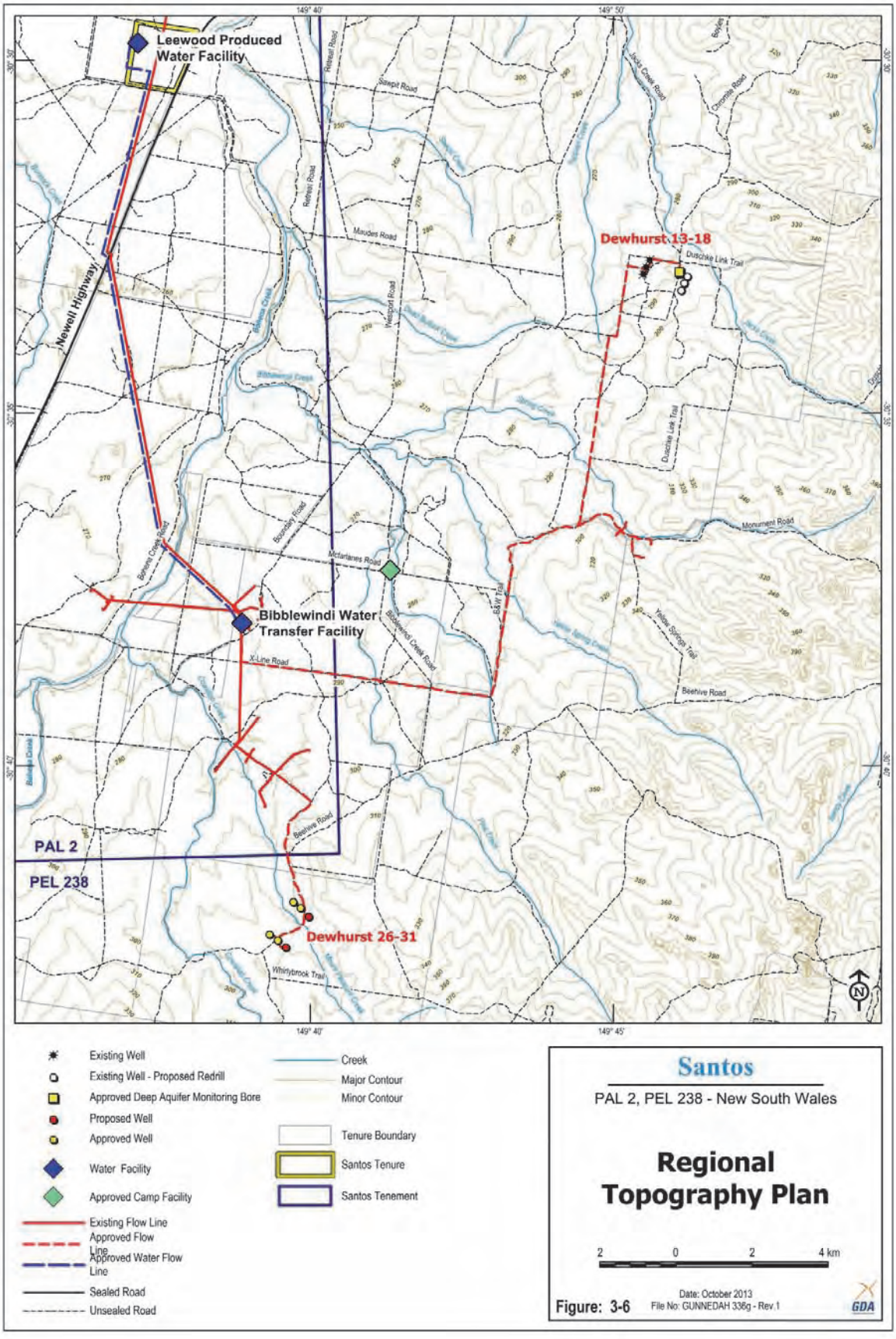


Figure 3-6 Regional topography

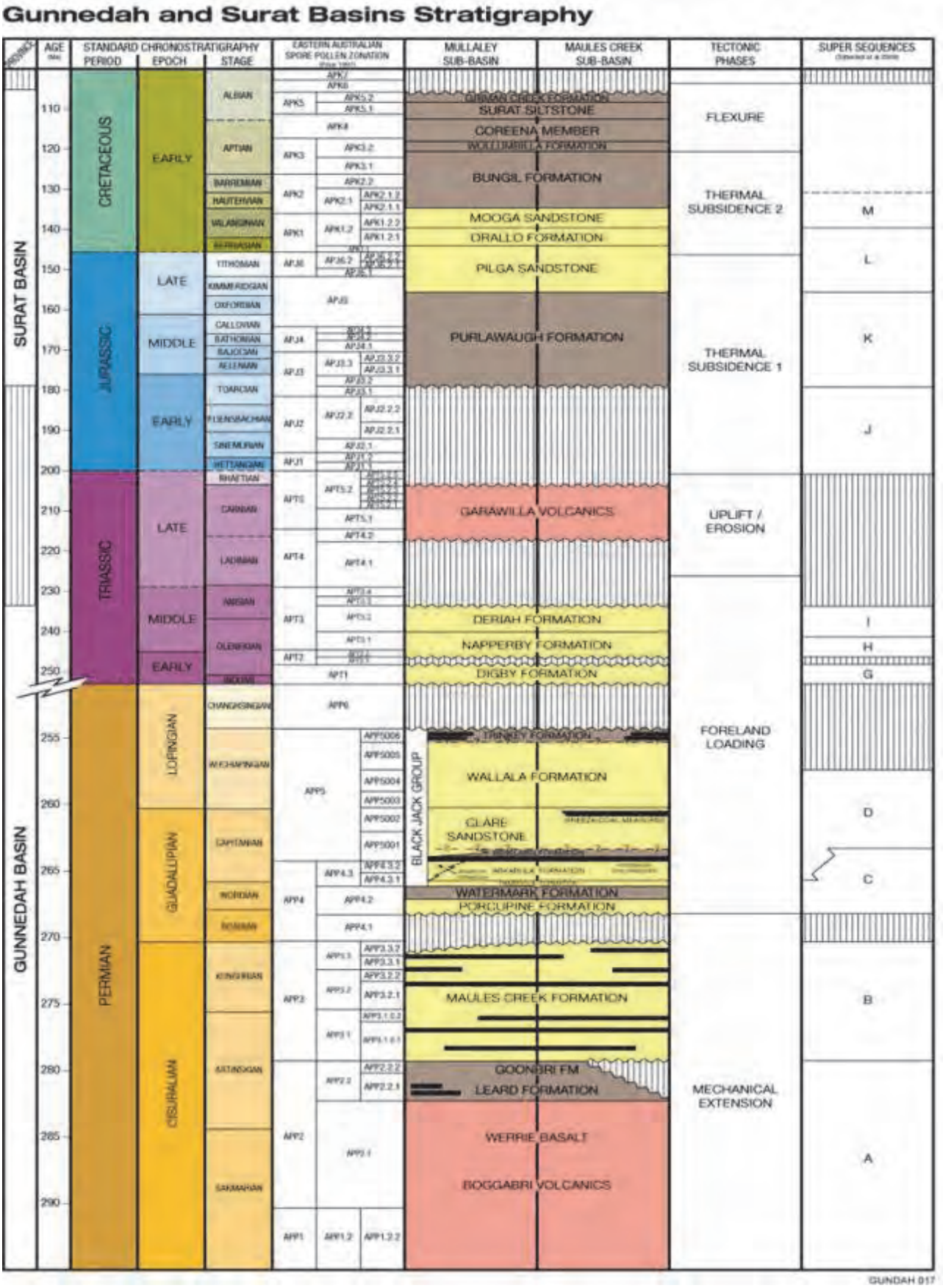


Figure 3-7 Stratigraphy of the Gunnedah Basin

3.2 Regional context

The two pilot sites are located in the eastern section of PEL 238. PEL 238 covers an area of approximately 7,915 square kilometres and extends across the Narrabri Shire, Warrumbungle Shire and Gunnedah Shire LGAs on the northwest slopes of NSW. The sites are located within the Narrabri Shire LGA and are not located in, or within two kilometres of, a residential zone.

The Newell Highway, a major transport route connecting Coonabarabran with Narrabri, is approximately 11 kilometres from the closest pilot site (Dewhurst 26-31).

The Dewhurst 26-31 Pilot is located approximately 44 kilometres south of Narrabri and 37 kilometres west of Boggabri in the Pilliga East State Forest (see Figure 3-8). The Pilliga East State Forest forms part of a large tract of bushland referred to as the Pilliga scrub. The Pilliga scrub takes in numerous delineated areas including the Pilliga Nature Reserve, Pilliga East State Forest, Pilliga East State Conservation Area, Jacks Creek State Forest, Rutley State Forest, Kerringle State Forest and Willala Aboriginal Area.

The Dewhurst 13-18H Pilot is located on land that has been mostly cleared for low intensity stock grazing activities, approximately 25 kilometres south of Narrabri (see Figure 3-8). No commercial farming activity currently takes place on the lot containing the pilot site but some grazing of domestic stock still occurs. The Dewhurst 13-18H site is adjacent to the Jacks Creek State Forest, and small areas of uncleared land on the property comprise vegetation that is consistent with the Pilliga scrub.

The nearest residences are shown in Table 3-3 and Figure 3-9. There is a residential dwelling located approximately 500 metres south of the Dewhurst 13 lease area, however the dwelling is being leased by Santos until December 2015, and will remain vacant until that time. This dwelling has not been considered as a sensitive receiver for the purposes of construction phase impact assessment. The next closest sensitive receiver to Dewhurst 13-18H is a residence situated approximately 1.8 kilometres south-west of the Dewhurst 13 lease area. The nearest residences to Dewhurst 26-31 are located approximately 11 kilometres north, outside of the Pilliga East State Forest (shown as RR10 to RR14 in Figure 3-9).

Table 3-3 Distance from nearest receivers to the two pilot sites

Resident ID	Nearest well	Distance from the nearest well (km)
RR1	13	3.6
RR2	13	3.4
RR3	13	2.5
RR4	13	0.5
RR5	13	3.0
RR6	15	3.5
RR7	15	3.5
RR8	13	4.2
RR9	13	1.8

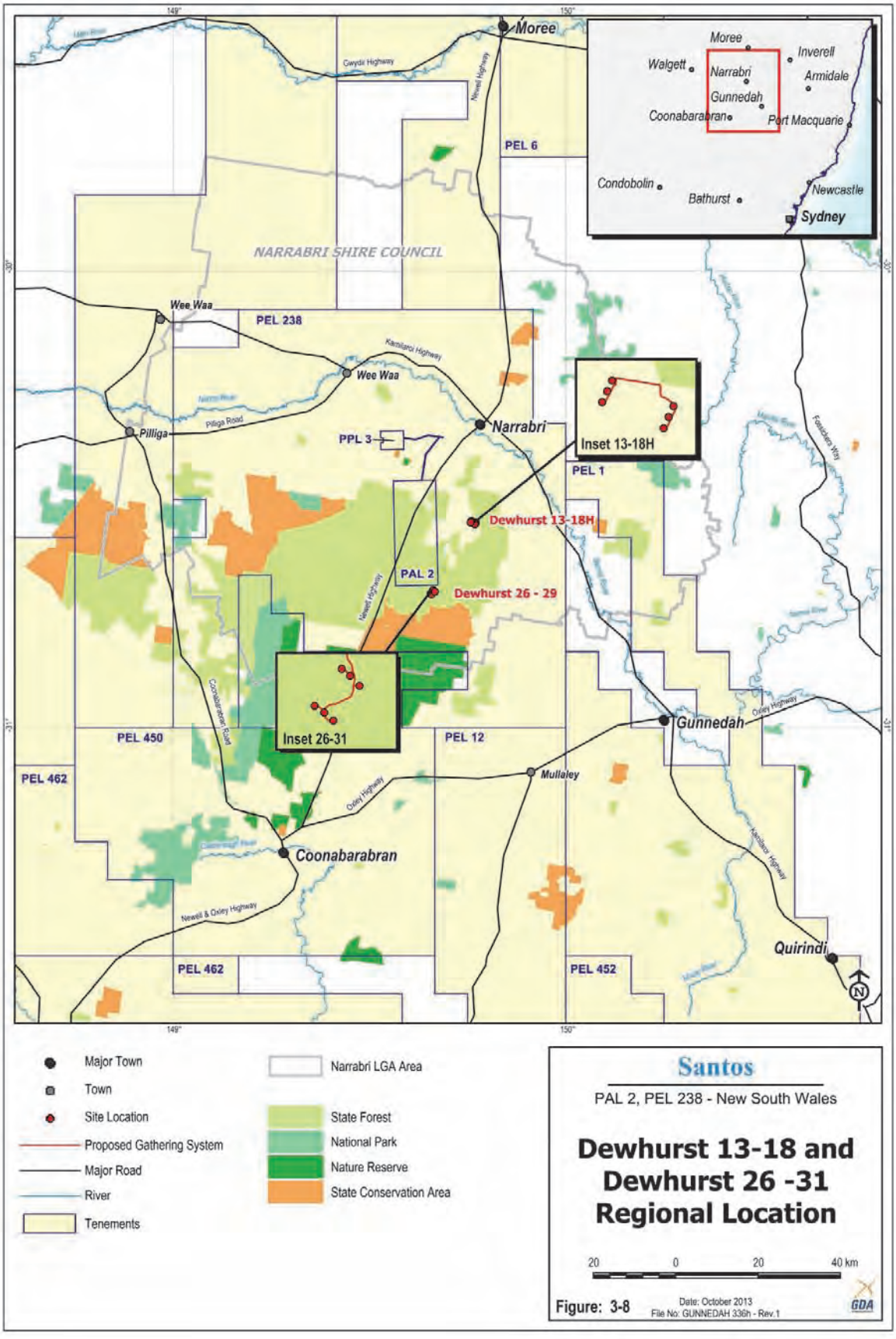


Figure 3-8 Regional location

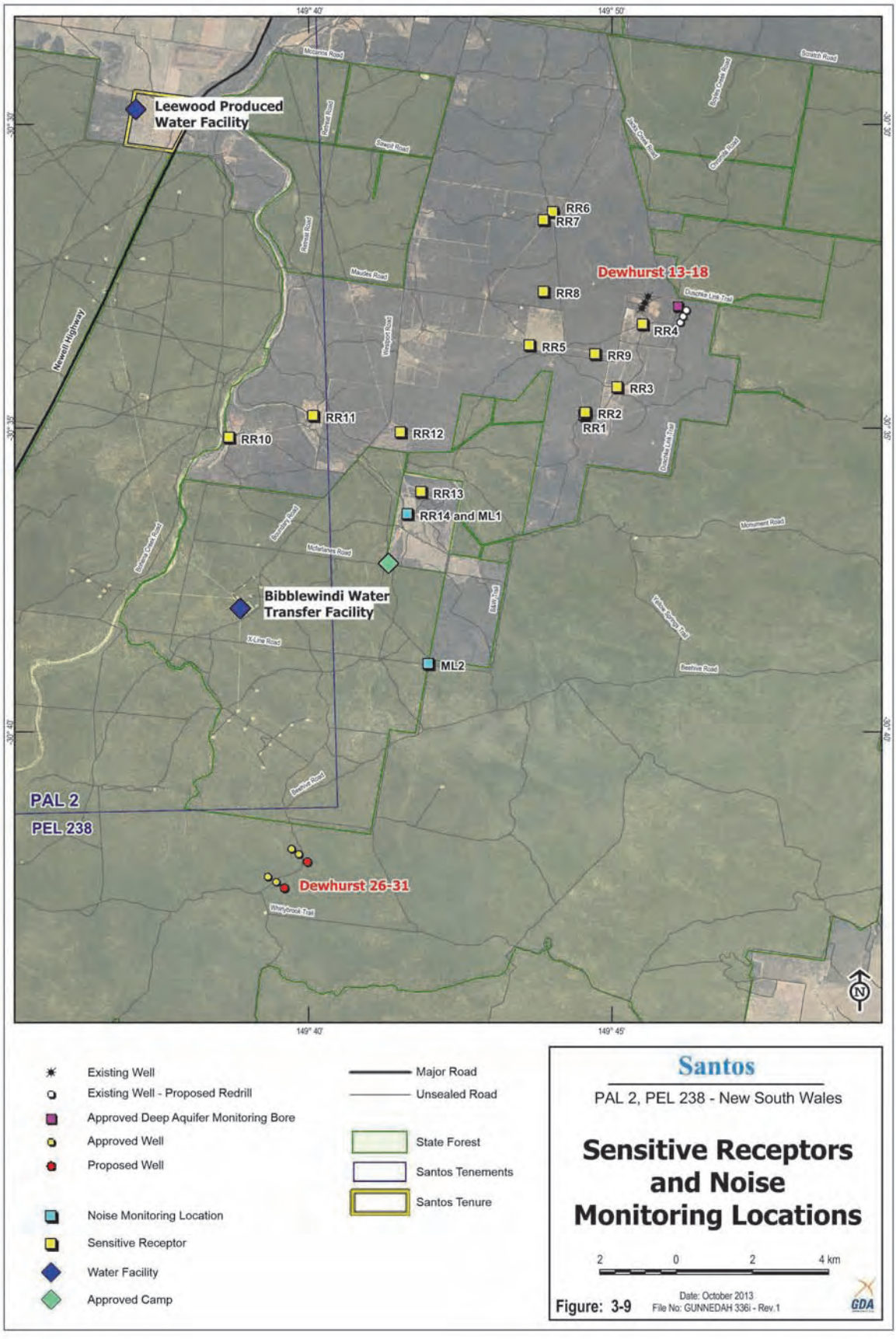


Figure 3-9 Sensitive receivers

3.2.1 Regional CSG infrastructure

Regional CSG infrastructure consists of a series of pilots, plugged and abandoned wells, and water and gas management facilities. CSG infrastructure in PEL 238 and PAL 2 as it relates to the proposed activity is described below, with Figure 3-10 indicating infrastructure in the vicinity of the proposed activity.

3.2.1.1 Bibblewindi Water Transfer and Leewood Produced Water Facilities

The Bibblewindi Water Transfer Tank, Leewood Water Pipeline and Leewood Produced Water Facility were approved by the NSW Division of Resources and Energy (DRE), DTIRIS under Part 5 of the EP&A Act in March 2013. The Produced Water Management Plan for PEL 238, PAL 2 and PPL 3, prepared by Santos in consultation with the NSW Office of Water (NOW) and approved by the DRE, sets out the proposed use of a produced water storage facility at Leewood to allow appraisal activities to recommence.

The produced water will flow to the Bibblewindi Water Transfer Tank (capacity five megalitre) located at the Bibblewindi WTF. The Water Transfer Tank provides a short buffer (24 hours) period before produced water is transferred to the Leewood Produced Water Facility.

At the Leewood Produced Water Facility, produced water will be stored in one of two 300 megalitre ponds. The ponds will be double lined and have a leak collection system. The liner system will comprise a primary polyethylene geomembrane liner, underlain by a leak detection system, underlain by a secondary liner. The secondary liner will be underlain by 300 millimetres of smooth clayey material, free from obstructions or protrusions.

The leak collection system will transfer any produced water collected below the liner directly back into the pond. The system will include an alarm to notify operational staff of any sudden changes in pump operational trends. The water level of each pond will be monitored continuously. Level sensors will be installed for management of pump controls and to provide protection against pond overflow. It is expected the sensor system will be monitored by means of telemetry.

3.2.1.2 Dewhurst Northern and Southern Water and Gas Flow Lines

The Office of Coal Seam Gas (OCSG) approved the construction and operation of the Dewhurst Northern and Southern Water and Gas Flow Lines under Part 5 of the EP&A Act on 18 September 2013.

The Dewhurst Northern Water and Gas Flow Lines will be approximately 22.8 kilometres in length and will link the existing Dewhurst 13-18H pilot and the approved Dewhurst 22-25 pilot to the Bibblewindi WTF. The Dewhurst Southern Flow Lines will be approximately 4.5 kilometres in length and will link the Dewhurst 26-31 Pilot within PEL 238 and the Bibblewindi Multi-lateral Pilot within PAL 2.

3.2.1.3 Narrabri Operations Centre

The Narrabri Operations Centre (NOC) is located five kilometres west of the Narrabri town centre at 300 Yarrie Lake Road, Narrabri. Development consent for the construction and operation of the NOC was issued to Santos by Narrabri Shire Council in 2007. In April 2013 development consent was granted to expand the existing operations to include a warehouse, storage building and additional office space, a hardstand pipe casing wash and storage area. The NOC will also include the Fluids Treatment Facility (FTF) subject to planning approval and obtaining an Environment Protection Licence (EPL). The FTF will treat and store drilling fluids for future re-use in drilling activities.

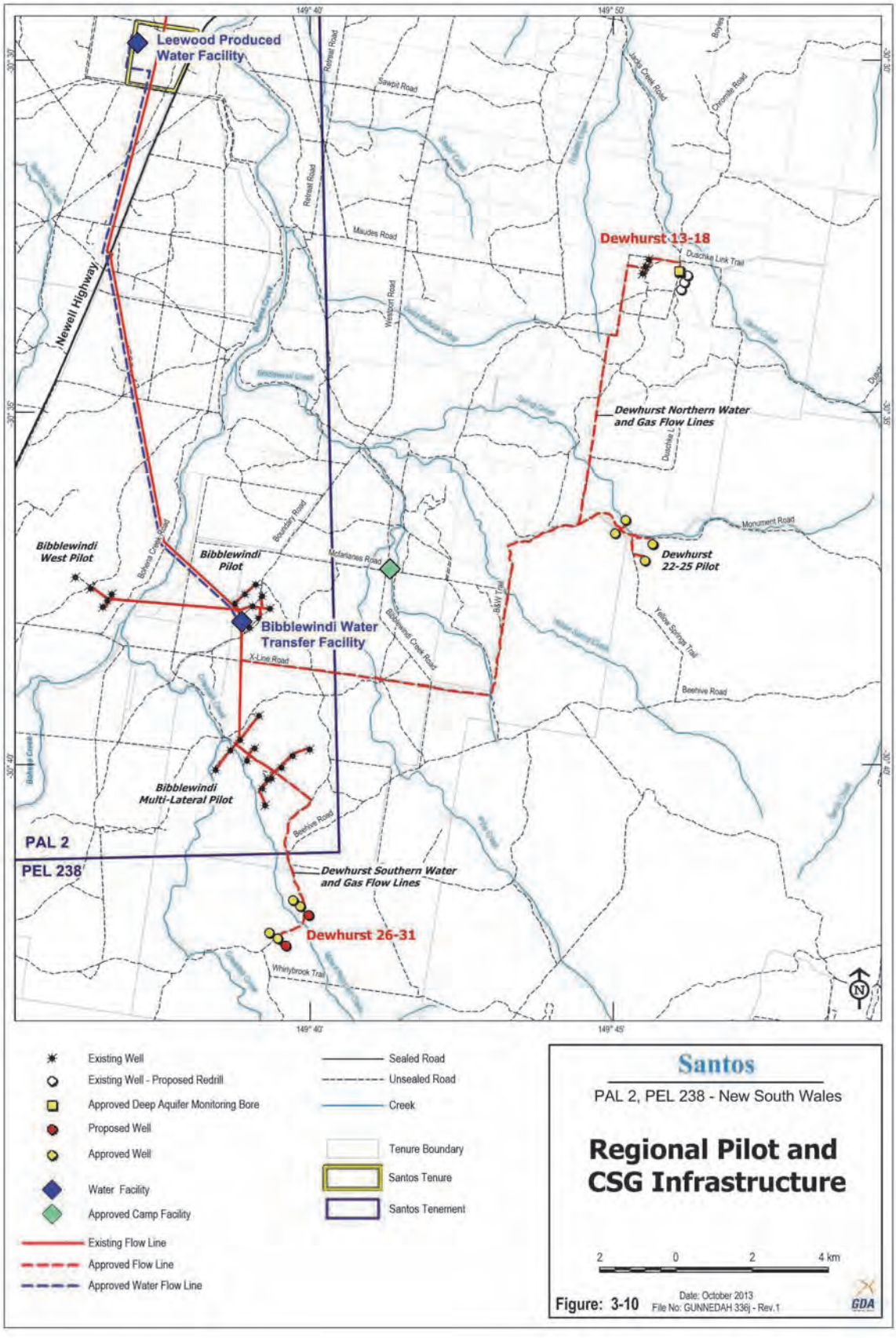


Figure 3-10 Dewhurst 13-18H and 26-31 pilots and surrounding CSG infrastructure

3.2.1.4 Westport Drillers Camp

Westport drillers' camp is located approximately 30 kilometres south west of Narrabri between the two pilots on Westport Road. Development consent was issued in December 2012. The camp will accommodate between 24 and 64 persons at the site for up to 4 years. The camp will be used as needed for any activities to occur as part of the E&A Program.

3.2.1.5 Existing water and gas flow lines

Existing water flow lines connect the Bibblewindi Multi-Lateral Pilot to the Bibblewindi WTF while gas flow lines connect to the WPPS via the Bibblewindi WTF. Water and gas produced during operation of the E&A Program will flow via these existing flow lines.

3.2.1.6 Other Pilots within the E&A Program

Other pilots within the E&A Program located near the Dewhurst 13-18H Pilot and the Dewhurst 26-31 Pilot include:

- Dewhurst 22-25 Pilot, approximately 6.5 kilometres south of Dewhurst 13-18H and 13 kilometres north east of Dewhurst 26-31
- Bibblewindi Multi-Lateral Pilot, approximately 15.5 kilometres south west of Dewhurst 13-18H and 3.5 kilometres north of Dewhurst 26-31
- Bibblewindi West Pilot, approximately 16.5 kilometres south west of Dewhurst 13-18H and 9.5 kilometres north west of Dewhurst 26-31.

4.0 Description of the Proposed Activity

4.1 Overview

The proposed activity includes:

Site preparation

- establishing two 10 metre wide service corridors between Beehive Road and the Dewhurst 30 and 31 lease areas (including clearing of approximately 0.2 hectares of vegetation)
- constructing access roads within the two service corridors at Dewhurst 30 and 31
- establishing the Dewhurst 30 and Dewhurst 31 lease areas each up to approximately one hectare in size (including approximately two hectares of vegetation clearing)
- removing the existing water gathering system and electrical cable connecting Dewhurst 13, 14 and Dewhurst 15 wells
- preparing the sites and establishing necessary equipment, temporary structures and facilities on the existing well leases Dewhurst 16H, 17H and 18H and on the new lease areas Dewhurst 30 and 31 to enable drilling.

Drilling

- drilling an additional two horizontals from existing casing within Dewhurst 16H, 17H and 18H to convert each well from a single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley coal seams
- drilling one vertical (Dewhurst 30) and one triple-stacked horizontal (Dewhurst 31) well to target coal seams within the Maules Creek Formation.

Surface and subsurface facility construction

- preparing the site on the existing well lease Dewhurst 14 to enable installation of a gas flare and water balance tank
- constructing a new gas and water gathering system connecting all the wells within the Dewhurst 13-18H Pilot to the existing Dewhurst 14 well lease area (including clearing of approximately 0.24 hectares of disturbed vegetation)
- extending the existing water and gas gathering system for Dewhurst 26-29 within the service corridors to Dewhurst 30 and 31
- installing surface and sub-surface infrastructure within the lease areas to connect the wells to the Dewhurst 13-18H and Dewhurst 26-31 gas and water gathering system
- installing a gas flare and water balance tank at the existing Dewhurst 14 lease area and a gas flare at the Dewhurst 28 lease area.

Operation

- operating the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot for up to three years from the commencement of operations at each pilot respectively
- managing the water and gas produced during operation
- undertaking occasional maintenance of the pilots.

Post operation

- on completion of operations, suspending the wells and ancillary infrastructure or decommissioning them and rehabilitating the well leases.

The works proposed during each stage, and timing, are summarised in Table 4-1.

Table 4-1 Approximate duration of construction and operation activities

Activity	Approximate duration	Estimated timing
Construction		
Site preparation – Dewhurst 13-18H	30 days	Q2 2014
Site preparation – Dewhurst 30/31	20 days	Q2 2014
Drilling and completion – Dewhurst 13-18H	65 days	Q2/Q3 2014
Drilling and completion – Dewhurst 30/31	60 days	Q2/Q3 2014
Surface facilities – Dewhurst 13-18H	65 days (including gathering system construction)	Q3/Q4 2014
Surface facilities – Dewhurst 30/31	60 days	Q3/Q4 2014
Operation		
Operation of the pilot	up to 3 years	2014 to 2017
Post operation and Rehabilitation		
Post operation/rehabilitation	approximately six months after well abandonment where practicable and considering external factors such as weather	on completion of pilot activities

4.2 Design considerations

4.2.1 Pilot wells – Dewhurst 16H to 18H

The augmented wells will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012).

Table 4-2 summaries the key design criteria for each of the wells, while Figure 4-1 shows the interaction between a representative vertical and triple-stacked horizontal well.

Table 4-2 Well design parameters – Dewhurst 16H to 18H

Design criteria	Dewhurst 16H	Dewhurst 17H	Dewhurst 18H
Well pair	Dewhurst 13	Dewhurst 14	Dewhurst 15
Direction	Horizontal		
Approximate true vertical depth	No change (897 – 975m)		
Additional target coal seam	Namoi, Rutley. Both located just above the Bohena seam		
Drilling technique	Rotary drilling		
Number of horizontal hole sections	3 (including 1 existing)		
Horizontal length	1000 – 1200 m		
Well head pump	electrical submersible pump (ESP)		

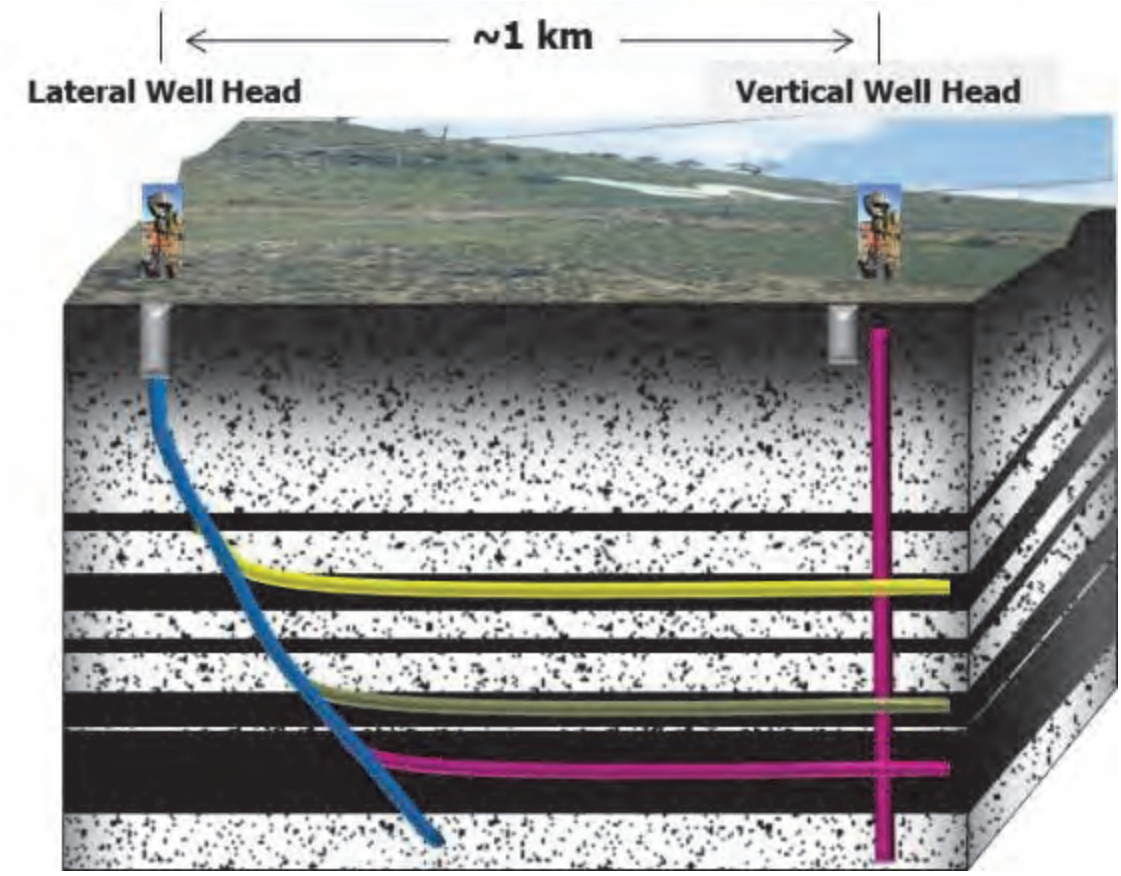


Figure 4-1 Well schematic showing indicative example of triple-stacked horizontal and vertical well interception

4.2.2 Pilot wells – Dewhurst 30 and 31

Dewhurst 30 and 31 will be designed and constructed in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012).

Dewhurst 30 will be constructed as a vertical well with a below ground level of approximately 1050 metres.

Dewhurst 31 will be a triple-stacked horizontal well and will have below ground level of approximately 940 to 1000 metres and a measured depth of approximately 2100 metres (total length of the well, including horizontal section). The 'build zone', where the initially vertically drilled well is inclined to penetrate the target coal seam horizontally will occur between:

- 978 and 990 metres below ground level (Bohena coal seam)
- 950 and 955 metres below ground level (Namoi coal seam)
- 945 and 948 metres below ground level (Rutley coal seam).

From here, the well will continue horizontally in-seam for a distance of approximately 1000 to 1200 metres, where it will intercept Dewhurst 30, including a short distance past Dewhurst 30.

Table 4-3 summaries the key design criteria for each of the wells.

Table 4-3 Well design parameters – Dewhurst 30 and 31

Design criteria	Dewhurst 30	Dewhurst 31
Direction	Vertical	Horizontal
Approximate true vertical depth	1050 m TVD[1]	940-1000 m TVD 2100 m MD[2]
Target coal seam	Bohena, Namoi, Rutley	Bohena, Namoi, Rutley
Drilling technique	Rotary drilling	Rotary drilling
Well pair	Dewhurst 31	Dewhurst 30
Number of horizontal wells	-	3
Horizontal length	-	1000 – 1200 m
Well head pump	Progressive capacity pump (PCP)	ESP

Notes: 1. m TVD = metres True Vertical Depth
2. m MD = metres Measured Depth

4.2.3 Well head and surface facilities

A wellhead separator and metering skids with associated power generation equipment (gas and diesel), pump, variable speed drives and telemetry units will be installed at each pilot well. The wellhead separator at each well will be connected to the proposed gas and water gathering systems for the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot. The tie-in point to the buried gathering system will be on the existing Dewhurst 16-18H lease areas and the new Dewhurst 30 and 31 lease areas.

A typical wellhead separator and metering skid is shown in Plate 4-1.



Plate 4-1 Typical wellhead separator and metering skid

4.2.4 Gathering system

It is proposed to upgrade the existing gas and water gathering system at the Dewhurst 13-18H Pilot, as the existing gas and water gathering system does not meet Santos standards due to shallow burial depths and needs to be replaced. The upgraded gathering system (shown in Figure 3-1) will consist of separate buried water and gas flow lines between the Dewhurst 16H, 17H and 18H wells and a central gas and water facility (including a new water balance tank and flare) to be installed at Dewhurst 14.

The proposed gas and water gathering system at the Dewhurst 26-31 Pilot (shown in Figure 3-2) will comprise separate buried, low pressure flowlines for gas and water linking the Dewhurst 30 and 31 pilot wells to the Dewhurst 26-29 gathering system.

The design parameters of the gathering system are provided in Table 4-4.

Table 4-4 Gathering system design parameters

Parameter	Gathering system design[1]	
	Dewhurst 13-18H	Dewhurst 30-31
Pipe diameter (outer) (mm)	Up to 315	Up to 250
Material	High Density Polyethylene (PE100)	High Density Polyethylene (PE100)
Static pressure rating	To AS4130	To AS4130
Depth of cover	Minimum 750 mm cover (typical)	Minimum 750 mm cover (typical)
Length (km)	2.17[2]	

Notes:
1. Indicative parameters only, based on preliminary engineering design
2. The approved gathering system as part of the original REF is 1.7km

There is sufficient capacity within the proposed gathering systems to carry the water and gas produced by these upgraded pilots.

4.2.5 Onsite flares

A flare was previously approved at Dewhurst 14 but was never constructed. It is now proposed to construct the flare but with an increased capacity. The flare that was approved at Dewhurst 28 for operation of the Dewhurst 26-29 pilot will also need to be increased in capacity to accommodate gas from the two additional wells.

The flares will combust methane in the absence of any significant quantities of oxygen and will therefore burn with a low intensity, with minimum rates of combustion between 90 to 95 per cent. The flare will operate as required 24 hours a day and seven days per week, and it may be turned off during periods of high fire danger.

The flare designs are robust and can handle fluctuations in the volumes, gas compositions and meteorological conditions.

4.2.5.1 Concept design

The proposed flare systems will comprise a pressure regulator, flowmeter and aboveground steel piping (approximately 23 metres in length). Typical flaring equipment for fixed stack design is shown in Plate 4-2.

Tables 4-5 and 4-6 compare the key design features of the proposed flares with the previously approved flares at Dewhurst 14 and 28, respectively. The flare, sterile zone and exclusion zone can be accommodated within the existing or approved lease areas.

Table 4-5 Design features of proposed Dewhurst 14 flare

Design feature	Previously approved flare	Proposed flare
Average flare height	Not specified	0.3 to 0.6 m
Design flow rate	Up to 2 million standard cubic feet per day (MMSCFD)	Up to 5 MMSCFD
Average flow rate	Not specified	0.25 to 1.5 MMSCFD
Stack height	Not specified	Up to 4.5 m
Exclusion zone (from stack base)	Up to 30 m	Up to 35 m[1]
Sterile zone (from stack base)	Not specified	Up to 10 m

Notes

1. Based on a preliminary hazard area classification and radiation design limits taking into consideration the following Australian and International standards: AS/NZS 60079.10.1 (2009), AS/NZS 60079.20.1 (2012), AS/NZS 2381.1 (2005), IP 15 (Edition 3 – July 2005)

Table 4-6 Design features of proposed Dewhurst 28 flare

Design feature	Previously approved flare	Proposed flare
Average flare height	0.3 to 0.6 m	0.3 to 0.6 m
Design flow rate	Up to 2 MMSCFD	Up to 3 MMSCFD
Average flow rate	0.25 to 0.75 MMSCFD	0.25 to 1.5 MMSCFD
Stack height	Up to 4 m	Up to 4.5 m
Exclusion zone (from stack base)	25 m[1]	Up to 35 m[1]
Sterile zone (from stack base)	5 m	Up to 10 m

Notes

1. Based on a preliminary hazard area classification and radiation design limits taking into consideration the following Australian and International standards: AS/NZS 60079.10.1 (2009), AS/NZS 60079.20.1 (2012), AS/NZS 2381.1 (2005), IP 15 (Edition 3 – July 2005)

A flow metre will monitor the gas flow rate from the gathering system. Adjustable back pressure regulators will be installed to suit operational requirements.



Plate 4-2 Typical flare assembly

4.3 Construction and drilling activities

4.3.1 Service corridor and access track establishment – Dewhurst 30 and 31

Two service corridors will be established between Beehive Road and the lease areas for Dewhurst 30 and 31 to provide vehicular access during drilling/construction and operation, and for the installation of the gas and water gathering system infrastructure. This will involve clearing vegetation within a 10 metre wide corridor between Beehive Road and the lease areas.

The service corridor dimensions are outlined in Table 4-7.

Table 4-7 Estimated service corridor dimensions

Lease area	Service corridor width	Service corridor length	Total disturbance area
Dewhurst 30	10 m	90 m	900 m^2 (0.09 ha)
Dewhurst 31	10 m	431 m	4,310 m^2 (0.43 ha)
TOTAL			**5,210 m^2 (0.52 ha)**

Construction of the service corridors will involve:

- surveying each corridor by a registered surveyor before any preparatory activities take place
- clearing and stockpiling vegetation at agreed locations determined during negotiation of the access agreement with Forestry NSW.

A six-metre wide access track will then be established within each service corridor to allow vehicle and equipment access to each lease area from Beehive Road. Construction of the tracks will include:

- grading along the access track to produce a six metre wide formed roadway
- where required, top dressing with gravel to reduce dust and provide all weather access.

Neither of the access tracks will cross any waterways.

4.3.2 Lease area establishment – Dewhurst 30 and 31

The lease areas will be up to approximately 100 by 100 metres in size.

Given the flat nature of the site and the need for clearing of vegetation, the lease areas for Dewhurst 30 and 31 may be established using traditional lease construction methods. Santos is currently evaluating the viability of using industrial matting as an alternative. The industrial matting consists of impervious, non-absorbent material which could be placed directly onto slashed vegetation. This would reduce the need for topsoil removal and earthworks.

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
- laying industrial matting down to create a continuous solid surface to stand plant, machinery and storage areas on
- fencing the lease area
- retrieval of the industrial matting after the drilling operation is completed.

Traditional lease construction methods will 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
- fencing the lease area.

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
- installing purpose-built bunds to collect runoff and potential spills, which will be pumped to an onsite waste fluid tank (32 cubic metres); potential excess drilling fluid and cement will also be pumped to the waste fluid tank
- setting up portable amenities and buildings onsite
- excavating a standard cellar pit (13.5 cubic metres) in the location of the pilot well
- excavating a cuttings pit and, where there is a risk of contamination, lining with heavy grade impermeable plastic sheeting
- stockpiling spoil from the cellar and cutting pits in a designated stockpile area
- installing and cementing a 14 inch conductor casing (typical) at approximately eight to 20 metres depth ahead of the rig arriving onsite
- Temporary venting and flaring facilities will be located at each site during drilling and pump testing, but will be removed at the end of drilling activities.

4.3.3 Lease area preparation and gathering system removal – Dewhurst 13-18H

Drilling and surface facility construction activities will take place on the existing lease areas at Dewhurst 13-18H. No further ground disturbance or vegetation clearance is required for these activities. The existing access tracks and road network will be used for access during construction.

Various works will be undertaken to prepare the sites for the proposed activity, including re-establishing temporary buildings, above-ground storage tanks and other facilities on the lease areas, and positioning the drill rig, as outlined in Sections 4.3.2 and 4.3.7. The majority of equipment will be located at Dewhurst 16-18H.

The existing water gathering system and electrical cable that is situated between Dewhurst 13, 14 and 15 will be dug up and removed. The removed high-density polyethylene (HDPE) piping and cable will be disposed of at a licensed recycling facility.

4.3.4 Flare installation – Dewhurst 14 and 28

Following site establishment, a HDPE liner will be laid over the proposed 10 metre sterile zone surrounding the flare and covered with up to 300 millimetres of compacted soil and blue metal aggregate. This will ensure protection against heat. Topsoil will be left in place where practicable.

4.3.5 Water balance tank installation – Dewhurst 14

A 40 cubic metre produced water balance tank with associated water transfer pump and associated piping will be installed within the existing disturbed area at Dewhurst 14.

The purpose of this tank is to allow minor amounts of entrained gas in the produced water to break out and render it non-hazardous, prior to transfer offsite and allow the water to be transferred based on elevation changes.

The tank will be contained within a HDPE liner, and will include level sensors and transmitters to:

- alert operators in the event of a tank high level and to initiate operator intervention
- close the tank discharge valve in the event of low tank level to avoid air entrainment and pump damage
- modulate discharge flow rate to maintain a tank level setpoint.

4.3.6 Gathering system construction

Figures 3-1 and 3-2 show the site plans for the proposed activity, including the route for the gathering system, topography contours, Lot and DP number and existing public roads.

At the Dewhurst 13-18H Pilot, the alignment has been amended from the originally approved alignment to one that parallels existing access tracks and roads to reduce the cumulative area of vegetation impacted by the works. The total area to be disturbed for the gathering system is approximately 2.17 hectares with vegetation cleared approximately 0.24 hectares.

At Dewhurst 30 and 31, the gathering system will be located parallel to the access roads within the cleared service corridors or along Beehive Road. Construction activities for the gathering system will be wholly located within the service corridor.

The gathering systems for both pilots will be located within a 10 metre corridor and will start and finish at the riser located at the edge of each lease area. The 10 metre corridor will accommodate construction activities and permit the adequate segregation of mulch, topsoil and subsoil stockpiles.

The construction of the gathering system between the pilot wells is as follows:

- surveying the gas and water gathering system 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 the landowner
- ploughing into a common trench 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. It is expected that the entire gathering system length will be bonded together before the ploughing team start work
  - » 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.

While 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 construction.

4.3.7 Drilling

4.3.7.1 Plant and equipment

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

- drilling rig and supporting equipment (such as pipe handler and drilling fluid pump)
- surface 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
- vent tank to capture any fluids and gas vented
- flaring facilities.

Figure 4-2 shows a typical layout for a lease area during drilling.

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 30 days each (depending on the profile of the well). While most equipment will be located at the drill site, some equipment will be located at the paired receiving wells.

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. 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.

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

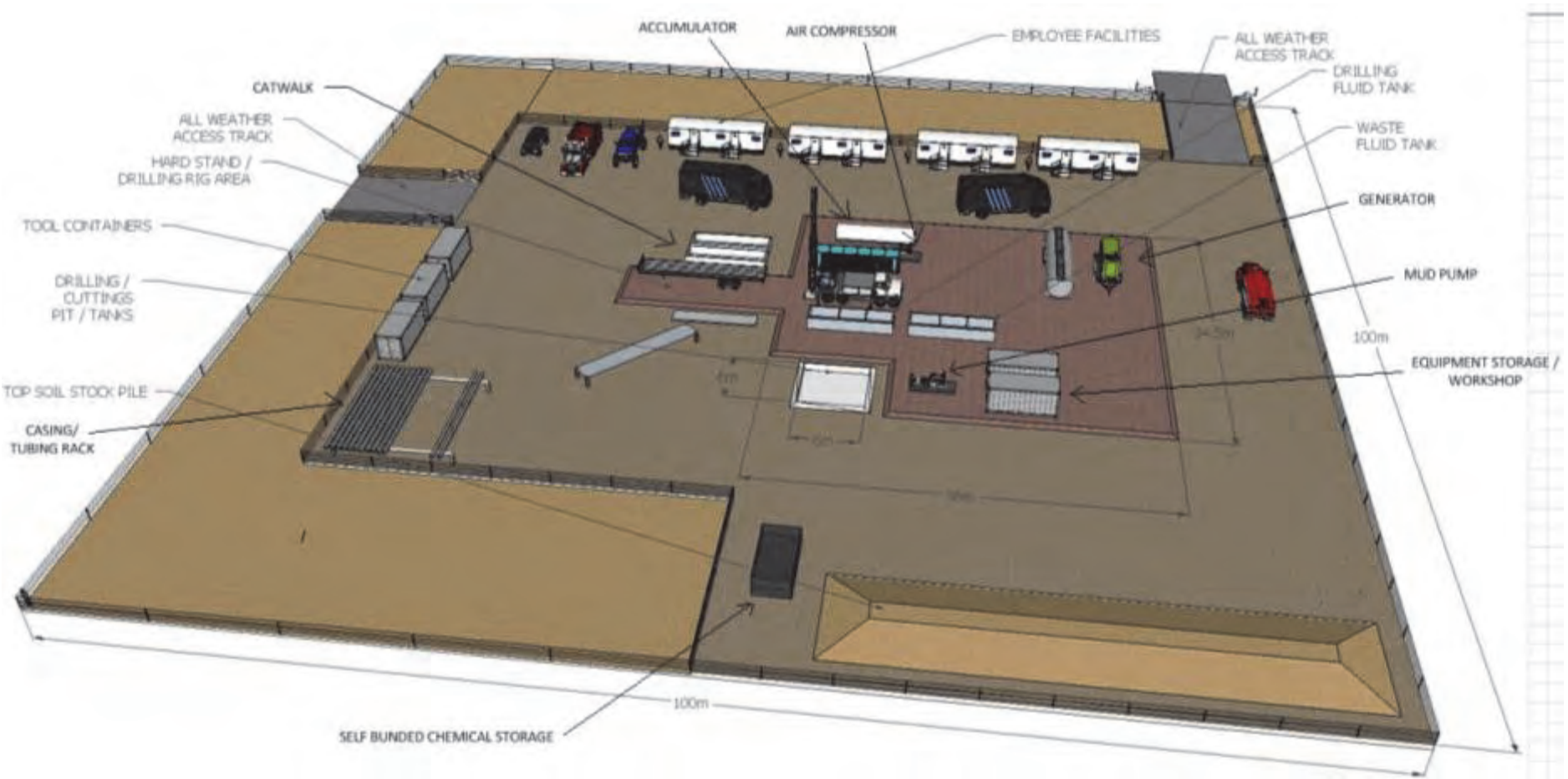


Figure 4-2 Conceptual lease layout during drilling

4.3.7.2 Re-entry drilling process – Dewhurst 16H to 18H

Re-entry drilling will involve the milling of two holes in the seven inch casing at each of the Dewhurst 16H-18H wells to facilitate the drilling of two additional 6-1/8 inch horizontal wells towards their respective target Dewhurst 13-15 pair. Each pair of additional horizontal wells will be drilled in the Namoi and Rutley coal seams of the Maules Creek Formation, approximately 65 and 80 metres vertically above the existing horizontal well in the Bohena coal seam respectively.

4.3.7.3 Drilling process – Dewhurst 30 and 31

Dewhurst 30 will be drilled first, followed by Dewhurst 31. Drilling and construction of the two wells will involve:

- drilling an open hole with an approximate diameter of 12-1/4 inches through alluvial and/or weathered rock material into competent rock (Purlawaugh Formation)
- installing 9-5/8 inch steel casing and cementing in place back to surface. The surface casing will be set approximately 260 to 280 metres below ground level
- installing a Blow Out Preventer (BOP) on top of the casing
- drilling out the 9-5/8 inch casing shoe using an 8-1/2 inch rotary drilling assembly and drilling to the planned depth
- installing and cementing seven inch production casing to the planned total depth
- Dewhurst 31 will have three holes milled in the seven inch casing to facilitate the drilling of the three 6-1/8 inch horizontal wells, each in different coal seams, towards the target intercept well Dewhurst 30.

4.3.7.4 Drilling fluid and additives

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

- clear rock fragments and other solids (drill cuttings) from the pilot well and bring them to the 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.

The circulating drilling fluid establishes a wall cake and maintains pressure on the various aquifers intercepted. This will prevent the ingress of groundwater to the well and discharge of groundwater to the surface. It will also limit the ingress of drilling fluid into the aquifers within the immediate vicinity of the well.

Drilling fluids used for drilling the wells will be predominantly water-based and made up of two main drilling additives, salts and gels. Salts such as potassium sulphate (K_2S0_4) are used as a weighting agent to help control swelling clays, while gels such as CR-650 are used to lubricate and increase the viscosity of the drilling fluid.

Potential sources of make-up water for the drilling fluid include the Narrabri's 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.

Chemicals will be mixed with the drilling fluid at the FTF prior to being transported to site (subject to planning approval and obtaining an EPL for the FTF). This will reduce the volume of chemicals required to be stored onsite during drilling. The drilling fluid will be transported to the site in a trailer prior to the commencement of drilling and stored in surface tanks onsite. Chemicals onsite will be stored in an elevated, bunded trailer for protection in the event of heavy rains or site flooding.

Chemicals that may be held onsite during the drilling process are provided in Table 4-8.

Table 4-8 Drilling chemical additives

Chemical trade name	Description	Purpose
Potassium Sulphate (K_2S0_4)	Sulphuric Dipotassium, Salt, Sulphate of Potash, Potash of Sulfur, Arcanite	Helps to keep the drilled clays dry and less sticky
Calcium Chloride 74-77%, Calcium Dichloride	Calcium Chloride ($CaCl_2$)	Speeds up setting of cement and reduces waiting time
Xanthan Gum P, Flowzan	Corn Based biopolymer (polysaccharide)	Thickens the mud so it can carry the drilled rock out of the hole
Quickseal Medium, Kwikseal	Cellophane/wood /nutshells	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	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	Partially Hydrolised Poly Acrylamide (PHPA)	Helps to keep the drilled clays dry and less sticky
Idcide – 20	Tetrakis Hydroxymethyl Phosponium Sulfate (THPS)	Prevents micro-organisms from attacking the mud and stops the sump from going green and starting to smell
Sodium Bicarbonate	Sodium Hydrogen Carbonate ($NaHCO_3$)	Treats against cement contamination of the drilling mud
Citric Acid	Citric Acid	Reduces pH
Soda Ash	Sodium Carbonate (Na_2CO_3)	Controls Calcium Hardness
Fracseal (various grades) Fine	Micronised Cellulose fibre	Deposits against the wall of the hole to prevent or reduce mud lost down the hole
Sodium Formate	Formic Acid, Sodium Salt	Provides weight in the fluid and provide some clay inhibition
DEFOAM – E	Polyoxyethylene polyoxypropylene block copolymer	Prevents foaming of mud and problems with pumps
Barite, Rheobar, Aus-Bar	Barite, Barium Sulfate. Naturally occurring, insoluble mineral	Prevents hole collapsing and high pressure gas or water from escaping (legal requirement for well control)
STARCH-B	Natural corn or potato starch	Reduces the amount of fluid seepage from the mud into the ground which can cause the hole to become sticky, unstable and less productive
Potassium Chloride	KCl	Helps to keep the drilled clays dry and less sticky
RHEOLUBE	Vegetable oil-based surfactants	Reduces friction on the drill pipe
Salt	Sodium Chloride (NaCl)	Increases the specific gravity of the fluid (well control)
Sugar	Soluble carbohydrates	Prevents cement setting

The Safety Data Sheets (SDS) for these chemicals are provided on the Santos website: http://www.santos.com/exploration-acreage/nsw-csg/reports-and-publications.aspx.

During drilling, the drilling fluid will mix with naturally occurring rock and soil (referred to as drill cuttings) and return these to the surface. The drilling fluid will pass through mechanical vibrating screens to separate out drill cuttings. The liquid component of the drilling fluid will flow into surface tanks for recirculation throughout the drilling process. Drill cuttings will be stored onsite until drilling is completed.

Table 4-9 outlines the expected drilling fluids required for each well.

Table 4-9 Estimated drilling fluid transported to and from site

	Dewhurst 16H	Dewhurst 17H	Dewhurst 18H	Dewhurst 30	Dewhurst 31
Drill cuttings generated (m^3)	50	50	50	85	115
Drill fluid transported to site (m^3)	75	75	75	225	250
Drill fluid transported from rig to FTF (m^3)	150	150	150	175	200

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

4.3.7.5 Drilling fluid management

During drilling, used fluids will be separated into liquids and solids (cuttings) and fluids will be continuously reused throughout the drilling process. Once the well has been drilled the drilling fluid is displaced from the well by the cementation process or by production fluids.

Once drilling of the wells is complete, Santos is proposing to transport and treat drilling fluid at the FTF. It is expected that the FTF will be licenced and operational by the time Dewhurst 16H, 17H, 18H, 30 and 31 are drilled. Drilling fluids will be mixed at the FTF and then transported to site. This will reduce wastes associated with mixing chemicals onsite (such as chemical containers). Approximately two to six tankers will be required to transport the drilling fluid to site prior to drilling each well.

Where the FTF is operational the residual volume of fluid will be tested prior to being removed from the well lease sites by a contractor licensed under the POEO Act to transport trackable wastes. It will be transported to a subsequent well for re-use or back to the FTF for storage and treatment. Before drilling fluid is used on a subsequent well the chemical and physical properties are tested and the fluid amended as required.

Advice from the EPA indicates that a resource recovery exemption will not be required where drilling fluid is reused in the drilling process (i.e. at a new drill site).

There will be a residual amount of waste from the treatment facility in Narrabri which will eventually need to be disposed of at a licensed waste facility.

In the event that the FTF at the NOC is not approved or operational, drilling fluid will be mixed in tanks on the well lease sites prior to drilling. Make-up water will be transported to the site from a licensed source in the area. Additives (potassium sulphate or potassium chloride, and polymers) will be transported to site from the supplier's warehouse in Roma or Brisbane. Approximately six tankers will be required to truck the make-up water from its source to the site prior to drilling each well. One truck will be required to transport drilling additives from the warehouse to site at the start of drilling each well.

If the FTF is not operational, used drilling fluids will be disposed of at Transpacific Industries' liquid and hazardous waste management facility in Newcastle, NSW or another appropriately licenced facility. Approximately eight tankers will be required to transport the used drilling fluid from each well to the facility and required waste tracking requirements will be undertaken.

Additional tankers will be required to truck either drilling fluids or make-up water throughout the drilling of each well (equivalent to approximately three to seven tankers, well design dependant, over the drilling period).

4.3.7.6 Drill cutting management

It is expected that drill cuttings will consist of Naturally Excavated Material (NEM) and can be used in site rehabilitation under the *Resource Recovery Exemption for Naturally Excavated Material* (NEM exemption) issued by the EPA on 19 October 2012.

Advice from the EPA indicates that where excavated material generated as part of well establishment or drilling is re-used onsite from which it was generated, the activity will not trigger any waste licensing requirements. Therefore, a resource recovery exemption is not required in this case.

Drill cuttings will however be tested, if required. Typically, drill cuttings will be reused onsite for backfilling or site shaping. This will reduce the need to import additional fill and will reduce material which may otherwise go to landfill.

4.3.8 Cementing

Cementing operations for Dewhurst 30 and 31 will be in compliance with Section 4.3 of the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012) so as to:

- prevent groundwater migration paths and isolate the targeted zone from other formations
- protect beneficial aquifers from contamination
- maintain aquifer pressures and quality
- obtain and maintain well integrity
- protect the casing from corrosion.

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.

To ensure compliance with the Code of Practice, all casing strings will be cemented to surface. All batches of cement used in the cementing operation and associated chemicals for the recipe are tested prior to use in the wells to ensure that the cement has the right properties (i.e. setting time and compressive strength).

All cementing programs are designed, reviewed and signed-off by senior Santos drilling personnel and submitted, as part of the Well Drilling Program (Notification to Drill), to the OCSG for approval at least 30 days before the well can be commenced.

In addition, cementing reports, including all materials and compressive strength versus time graphs, cement pump charts and pressure records, logging reports and details of centraliser placing must be completed and submitted to the OCSG with the Well Completion Reports.

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.

4.3.9 Casing the well

Geophysical wire-line logs will be run over the entire length of the hole (or as far as practicable in Dewhurst 16H, 17H, 18H and 31) to identify major stratigraphic units, intersected coal seam depth and seam thickness. Further well testing may follow after completion of logging.

In the vertical Dewhurst 30 well, a combination of steel and fibreglass 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 horizontal holes drilled from Dewhurst 16H, 17H, 18H and 31, the wells will intercept the fibreglass casing in the vertical wells over the target coal seams. Steel seven inch casing will be placed over the coal seams in the 40 degree inclination 'Motherwell' 8-1/2 inch hole section. Windows will be cut at specific depths to facilitate the drilling of each of the three 6-1/8 inch horizontal hole sections in different coal seams. The horizontal hole sections will be left open and uncased.

All casing design shall comply with the Santos Drilling Operations Manual in accordance with Santos (and other) oil industry standards to cater for potential casing failure mechanisms.

4.3.10 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.

4.3.11 Partial rehabilitation of lease areas (except Dewhurst 14)

Once the drilling activities are complete, the lease areas will be rehabilitated in stages to an extent of approximately 30 by 30 metres around each well head (including a clear vehicle driving pathway for access and a fire break), 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.

Temporary construction facilities and plant will be removed from site, including any plastic lining from the cuttings pit which will be disposed of at an appropriately licensed facility. The cuttings and cellar pits will be backfilled.

4.3.12 Construction site access

For the majority of vehicles and equipment access to the two pilot sites will be from the Newell Highway and X-Line Road. Vehicles and equipment will either travel from the Newell Highway via X-Line Road and then south along Tighes Gully Road and Beehive Road for Dewhurst 30-31; or from the Newell Highway via X-Line Road and then north along Garlands Road, Westport Road and Killara Road for Dewhurst 13-18H.

Employees based at the drillers' camp will also access the two pilot sites from State forest roads including Middle Road and Tighes Gully Road south, or Westport Road and Killara Road north.

Travel to and from Narrabri and the NOC/FTF will be via the Newell Highway, Mooloobar Street and Yarrie Lake Road once within Narrabri.

4.3.13 Construction staff and hours

The number of employees present onsite at any one time is expected to be approximately 20 with short peaks during shift changeover. Drillers will be based at the Westport driller's camp with travel to and from site by minibus. Employees engaged in surface facility-related construction activities will travel from nearby townships, as they will be locally based.

Construction hours will 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.

4.3.14 Site water requirements

Drilling activities will require approximately 0.25 megalitres of water at Dewhurst 16H, 17H and 18H respectively and 0.2 megalitres at each of Dewhurst 30 and 31. In addition, approximately 0.02 megalitres per day of potable water will be required for facilities during construction. This will be sourced from Narrabri's town water supply or local industrial licensed water bores and trucked to site. Alternatively, produced water from pilot wells will be used when available for the preparation of drilling fluid.

Water licensing requirements are discussed in Section 6.2.3.

4.4 Operation of the pilots

4.4.1 Pilot testing

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 onsite 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, including fencing, will also be installed.

The pilot wells will have automated shutdown systems that are triggered by preset operating envelopes. These operating envelopes are designed to minimise or prevent environmental, health or safety incidents.

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

4.4.2 Water management

4.4.2.1 Onsite water management

A simple site water balance assessment was undertaken as there is no onsite water demand during general operation of the two pilots. There will be some minimal onsite water demand during workovers, as discussed below. For the majority of the time, the only water onsite will be the groundwater lifted from the wells during operation of the pilots.

For the vertical wells, a progressive cavity pump (PCP) will be installed just above the coal seam to transfer water to the surface through the well tubing. For the horizontal wells, an electrical submersible pump (ESP) will be located just above the depth of the target coal seams.

In order to operate the pilots, water will be extracted from the target seams from all the pilot wells simultaneously. The lifted water will be captured at each well head and transferred via the water gathering system to a water balance tank at the Dewhurst 14 and Dewhurst 28 lease areas. This water will be disposed of from site through a network of pipes and treated, as outlined in Section 4.4.2.2. There will be no discharge to local receiving waters within the vicinity of the two pilot sites.

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 estimated volumes of groundwater lifted at the two pilots are outlined in Table 4-10.

Table 4-10 Estimated groundwater extraction rates for Dewhurst 13-18H and Dewhurst 26-31 pilots

Pilot	Total Extraction (m^3)	Max Extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13-18 Pilot	331,121	397	302
Dewhurst 26-31 Pilot	413,801	448	378

Table 4-11 shows the likely produced water composition based on existing water sampling data from existing wells drilled within Maules Creek Formation coal seams in the Narrabri region. As a baseline, rainwater typically has 20 milligrams per litre or less total dissolved solids (TDS). 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 CSG water would be considered in the high brackish range and unsuitable for irrigation or drinking water without treatment.

Table 4-11 Quality of formation water from coal seams within the Maules Creek Formation (based on data taken from existing wells within PEL 238)

Parameter	Units	Minimum	Average	Maximum
Total Dissolved Solids (TDS)	Mg/L	8,960	16,095	23,040
Temperature	°C	22.5	22.8	23.4
pH		7.1	7.5	8.0

The only onsite water demand during operation will potentially occur during work overs associated with maintenance activities, when the well is first killed (flushed with higher density fluid to prevent water rising), and then during the actual work over activities. Approximately three to four trailer-loads (75 to 100 cubic metres) of weighted brine from the FTF may be required to kill the well. The additional water will be sourced from the Narrabri's town water supply, local industrial licensed water bores or the Leewood Produced Water Facility and trucked to site.

Approximately three to five trailer-loads (75 to 125 cubic metres) of groundwater may also be lifted during workover activities. This produced water will be trucked to the Leewood Produced Water Facility.

4.4.2.2 Water transfer and treatment

The water transfer and treatment process will be as follows:

- at each well, the produced water (average extraction of 300 cubic metres per day for Dewhurst 13-18H and 380 cubic metres per day for Dewhurst 26-31) will be pumped through the water gathering system to the Bibblewindi WTF, via the Dewhurst Northern and Southern Water and Gas Flow Lines (under construction)
- the Bibblewindi Water Transfer Tank located at the Bibblewindi WTF will be used to provide a short buffer (up to 24 hours) prior to the produced water being pumped to the Leewood Produced Water Facility via the Leewood Water Pipeline
- once at the Leewood Produced Water Facility, produced water will be stored in one of the 300 megalitre ponds.

Produced water from the Leewood Produced Water Facility will be transported by road tankers to an appropriately licensed facility in the Sydney metropolitan area for treatment, reuse and/or disposal.

Santos is currently investigating the economic and technical feasibility of treating the produced water at the Leewood Produced Water Facility by reverse osmosis or other methods instead of transporting produced water from Leewood to a licensed facility. If Santos decides to operate a water treatment facility at Leewood, this would be the subject of further applications for approvals from the NSW Government.

4.4.3 Gas management

Recovered gas from the wells will flow up the well annulus (separate to the water) with the gas stream entering the wellhead separator to remove any entrained water. Gas will collect at a central location at Dewhurst 14 and Dewhurst 28. A portion of the produced gas will be diverted to the local fuel gas skid for conditioning and use within the well site power generators (approximately 10 per cent).

Any gas surplus to the requirements for onsite power generation will be flared onsite within the Dewhurst 14 or Dewhurst 28 lease areas. This will ensure no direct venting of methane to atmosphere for the duration of the pilot well testing.

The flares 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.

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. In the event of a fire, the wells will be remotely isolated.

4.4.4 Maintenance activities

Well maintenance and work-over activities will occur from time to time at the wells for corrosion monitoring, mechanical repairs or other interventions as required. Work over activities could include maintenance of completion equipment, well cleanouts and/or repairs. All works will be undertaken within the access tracks and lease area.

Regular maintenance of the gathering system will also be undertaken, as required. The works will be undertaken within the 10 metre gathering system corridor.

4.4.5 Maintenance staff and hours

During operation, staff movements to the two pilot sites will be minimal. It is expected that the pilots will be visited by up to one vehicle per day for monitoring and minor maintenance. During well work-over activities, an increase in staff may occur for a short period, particularly if a workover rig is required.

Generally monitoring and maintenance will occur during daylight hours although in some instances or should an incident occur, 24 hour operations may be required.

4.5 Post operation and rehabilitation

On completion of operations, wells and ancillary infrastructure will either be decommissioned with lease areas rehabilitated or suspended. Options considered include:

- Suspension for future use: exploration activities confirm the CSG resource as commercially viable. If this occurred, production activities would be subject to further environmental assessment and government approvals. In the event that Santos decides to seek approval for a commercial gas production project, the wells would be suspended until determination of the role, if any, the wells would play in that project
- Decommissioning and rehabilitation: This would occur in the event that Santos does not pursue commercial gas production, or a well or supporting infrastructure is not a part of a commercial gas production activity for which approval is sought. In this scenario the wells and supporting infrastructure would be decommissioned and rehabilitated.

4.5.1 Pilot well decommissioning

Decommissioning of the wells will be in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012). This includes:

- 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 heads and casing at a depth of greater than 1.5 metres below surface and installing a well head marker.

Surface infrastructure will be removed. Buried surface infrastructure, including the gathering systems, will be flushed, capped at each end and left in-situ in accordance with legislative requirements.

4.5.2 Lease area and gathering system rehabilitation

4.5.2.1 Rehabilitation objectives

The objectives for the rehabilitation program are to:

- stabilise the site to minimise erosion
- return the disturbed areas to a self-sustaining native forest condition, typical of adjacent reference forest ecosystems
- rehabilitate the disturbed areas to the satisfaction of the landowner (Forestry NSW, DPI or private)
- facilitate natural re-vegetation.

EcoLogical Australia recently conducted a review of the success of natural revegetation approach to rehabilitation. As part of the review, six sites were identified along the Wilga Park Gas Flow Line route that was constructed in 2007/8 and four lease areas (Dewhurst 2, Dewhurst 19, Bibblewindi 25 and Jacks Creek 1). The effectiveness of rehabilitation was measured in 2012 and again in 2013. At all locations, the number of native

species increased over the year and were generally within 30 per cent of the numbers observed in the reference sites. This demonstrates the rehabilitated areas are capable of sustaining reproducing populations of the species necessary for its continued stability and development within relatively short timeframes.

4.5.2.2 Rehabilitation methodology

Rehabilitation of well leases will include:

- identifying reference sites to assist in monitoring success
- removing perimeter fencing and all other infrastructure
- replacing sub-soil across the well leases, contouring to the landscape and partially compacting
- placing top-soil uniformly across the well leases, and grading to natural levels
- revegetating well leases with native species from existing seed bank within top soil
- surface contouring, through ploughing and the creation of 'hummock' and low relief features similar to the surrounding area
- spreading of retained woody material
- blocking of access tracks with timber to minimise disturbance of the site by vehicles and to maximise natural regeneration
- removing perimeter fencing
- controlling weeds
- ongoing monitoring of success through comparison to identified reference sites.

Assisted planting will be considered in the event that natural regeneration is unsuccessful, to augment the recolonisation process. Any assisted revegetation will utilise species that:

- are locally available to eliminate the introduction and establishment of foreign species from other areas of the Pilliga and/or weeds
- reduce erosion of sediment by wind or water by root mass created in rehabilitated soils
- enhance the speed of plant colonisation of rehabilitated soils beyond that expected from surrounding areas alone
- provide microsites for further natural species ingress into the rehabilitated areas, especially tree species which require some immediate low-level shelter, soil moisture and organic content
- provide wildlife habitat in the rehabilitated areas.

The gathering system will be flushed, capped at each end and left in the ground. The surface will be rehabilitated through natural regeneration and planting of suitable native perennial grasses and shrub species that will assist in the stabilisation of the soils as agreed with the relevant landowner (Forestry NSW, DPI or private). A rehabilitation strategy will be developed in conjunction with these landowners, and taking into consideration the conditions within PEL 234 and the Permit to Occupy. The final landuse will be consistent with the surrounding area as agricultural land and State forest

4.5.2.3 Rehabilitation completion criteria

Rehabilitation success will be assessed by establishing and assessing monitoring sites with reference to the existing (pre-disturbance) vegetation characteristics, outlined in Table 4-12 (referred to as the reference condition).

Table 4-12 Vegetation characteristics (reference condition)

Description	Corresponding community	Characteristics		
		Canopy	**Shrub**	**Ground**
Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest	Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion	Variable height of 8-20 m with 15 – 20% projected foliage cover. The dominant species is *Eucalyptus crebra* (Narrow-leaved Ironbark).	Variable height of 1-10 m with less than 5% cover. Dominated by *Allocasuarina luehmannii* (Buloke), *Callitris glaucophylla* (White Cypress-pine), *Acacia deanei subsp. deanei* (Green Wattle) and *Acacia caroleae* (Wattle).	Variable height of 0.3-1 m with less than 10% cover. The ground layer was scattered and sparse and was dominated by *Panicum decompositum* (Native Millet), *Acacia pravifolia* (Coil-pod Wattle), *Lomandra multiflora* (Many-flowered Mat-rush), *Pultenaea foliolosa* and *Aristida jerichoensis var. jerichoensis* (Jericho Wiregrass)

Rehabilitation performance and completion criteria for the E&A Program have been developed based on PEL 238 conditions and the Permit to Occupy. These are summarised in Table 4-13.

Table 4-13 Rehabilitation performance criteria

Phase		Activity	Timing	Completion criteria
Decommissioning of site infrastructure	Lease areas (including flare and water balance tank)	All plant, equipment, containers, waste materials and temporary buildings removed from the two pilot sites. Fencing removed.	Within 6 months of abandonment.	Pilot sites cleared.
	Gathering system	Pipes flushed and capped each end, remain *in situ*.	Within 6 months of abandonment.	Decommissioning in accordance with APIA Code of Practice, Upstream PE Gathering Networks – CSG Industry, Version 2.0.
Landform establishment		Site graded and reshaped to reinstate, as far as practicable, the original contour and drainage. Erosion and sediment control implemented to minimise runoff channelling/erosion.	Within 6 months of abandonment.	No areas of instability or slumping. No areas of active erosion. Site landform established that is suitable for final land use and compatible with surrounding landscape.
Ecological restoration	Flora recolonisation	Restoration activities by natural recolonisation of plants. If required, assisted restoration by seeding and/or planting where natural recolonisation does not meet requirements within stated period.	Within 2 years of abandonment by natural recolonisation. Where natural recolonisation has produced no evidence of soil stabilisation after 6 months of rehabilitation, commence assisted restoration.	Moderate level of native species diversity restored. Groundcover restored to within 75% of reference condition.
	Fauna habitat restoration	Restore lengths of fallen logs and woody debris in accordance with advice from a suitably qualified ecologist.	Within 6 months of abandonment.	Fauna habitat complexity increased, leading to return and survival of established species.
Weed management		Infestations of noxious weeds in right of way managed in accordance with requirements of *Noxious Weeds Act 1993*.	Until ground cover achieves target rehabilitation performance criteria, as per above.	Weeds do not dominate after disturbance or after rain.
Monitoring and reporting		Report to be submitted to OCSG within DTIRIS following the completion of all rehabilitation activities (civil works, waste removal, etc.) in accordance with condition 3 of PAL 2.	At completion of rehabilitation.	Report submitted.

5.0 Community and stakeholder consultation

5.1 Consultation objectives

Santos understands the importance of proactive and effective engagement with communities and stakeholders and is well established within the local community, with a local office and resident employees. To this end, Santos has started implementing a consultation strategy for the E&A Program.

Through this consultation, Santos aims to:

- increase overall awareness and understanding of the CSG industry and in particular the proposed activity
- identify and keep informed landowners, neighbours, residents, and relevant local and state government agencies
- build and maintain effective relationships with stakeholders and communities based on open communication, trust and understanding of the E&A Program
- ensure the interests of stakeholders are considered in the proposed activity design and implementation
- provide timely, accurate and credible information to stakeholders and the broader community
- identify potential issues and/or risks and strategies for mitigation and resolution.

Targeted consultation with the landowners for the proposed activity commenced in April 2013.

5.2 The consultation and community involvement process

Santos has developed a community engagement and consultation framework to specifically target the different needs and requirements of stakeholders and the community to inform and consult on the E&A Program, including the proposed activity, and the CSG industry more broadly.

To achieve the consultation objectives, the framework is based on the following approach:

- E&A Program initiation and communication
- ongoing identification of key stakeholders and review and evaluation of developed relationships
- risk management
- monitoring of stakeholder issues and responses
- adherence to relevant legislative framework requirements.

Santos uses four levels of targeted engagement and consultation:

- Inform – aimed at community, business and industry in the broader regional and state-wide context.
- Involve – aimed at community groups, industry, business and residents not directly involved but living and operating within the local area. This includes residents of Narrabri, Gunnedah, Boggabri, Wee Waa and surrounding villages; landowners; government departments; non-government organisations; local industry and business.
- Consult – aimed at key stakeholder groups directly involved. This includes neighbouring landowners, government departments listed as referral agencies, non-government organisations, community groups, local contractors and businesses.
- Collaborate – aimed at individuals and entities that are directly impacted by the project and/or involved in project decisions. This includes landowners, government departments responsible for assessments and approvals, Narrabri Shire Council, native title claimant groups and community consultative committees.

5.3 Stakeholder identification and communication tools

Santos uses a wide range of consultation tools to engage with various stakeholders as part of its overall consultation program. Implementation has included the provision of general information through the Santos website and media announcements, shopfronts at Narrabri and Gunnedah, monthly community site tours, information stands at local agricultural shows and community events, and implementation of a sponsorship program which supports community and sporting groups.

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 onsite meetings where required.

Table 5-1 identifies relevant stakeholder groups and the consultation tools utilised.

Table 5-1 Stakeholder identification and consultation tools

Stakeholder	Consultation tools							
	Website	1800 number	One on one meetings	Project information centre	Workshop	Formal correspondence	Information sessions and community tours	Community consultation committee
Government Agencies	●		●		●	●	●	
Landowner (Forestry NSW)	●		●		●	●	●	
Landowner (private)	●		●	●		●	●	
Adjacent landowners	●	●	●			●	●	●
Indigenous community	●	●				●	●	
Special interest groups (e.g. environment and conservation groups)	●	●					●	●
Local business and contractors	●	●	●		●		●	●
Broader community	●	●		●			●	●

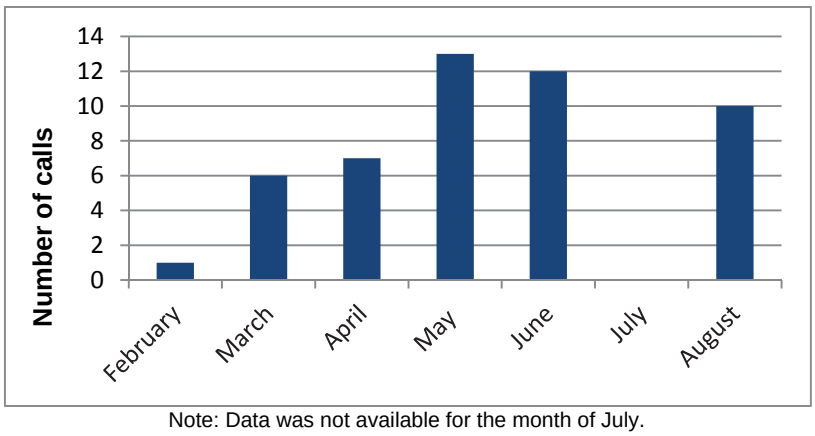
5.3.1 Santos project website

Santos maintains a project website which identifies its activities in NSW – http://www.santos.com/exploration-acreage/new-south-wales.aspx. The website is regularly updated with general project information, photos and frequently asked questions.

5.3.2 Santos project 1800 number and email address

Santos maintains a free information and enquiries line (1800 071 278) and project email address (energy.nsw@santos.com).

The number of calls recorded between February and August 2013 is shown in Figure 5-1.



Note: Data was not available for the month of July.

Figure 5-1 Record of calls to 1800 line (Feb – Aug 2013).

5.3.3 Santos Narrabri office and project information centre

Santos has an office and project information centre at 125 Maitland Street, Narrabri, which members of the community can visit and request information about the E&A Program. The office is attended from 9 am to 5 pm Monday to Friday.

5.3.4 Stakeholder and government agency workshops

Regular meetings are held with key stakeholders to provide information on current and ongoing activities. Meetings and workshops held in 2013 include the following.

5.3.4.1 Government Agencies

- Ongoing consultation with the Commonwealth Department of the Environment (formerly Department of Sustainability, Environment, Water, Population and Communities).

  Santos undertook consultation with the Department over May 2013, prior to submission of an EPBC Referral for the E&A Program activities, including the proposed activity, within the Pilliga forest. There has been continued liaison during and post-assessment of the EPBC Referral.

- Government Information Forum in Narrabri on 20 June 2013.

  Santos presented general information on the potential production project with specific information on the activities within the E&A Program, including the location and scope of the proposed activity. The presentation was followed by a field tour of the Leewood Produced Water Facility and the Bibblewindi WTF. Twenty-five government officers were in attendance, the majority of whom were locally or regionally based, with representation from:

  - OCSG
  - DPI
  - NOW
  - NSW Environment Protection Authority (EPA)
  - NSW Roads and Maritime Services (RMS)
  - NSW Rural Fire Service
  - Forestry Corporation of NSW
  - NSW Department of Trade and Investment (Crown Lands)
  - Namoi Catchment Management Authority

  - North West Livestock Health and Pest Authority
  - Narrabri Shire Council.

  The Land and Water Commissioner also attended the Forum, as did industry representatives from the Australian Petroleum Production and Exploration Association (APPEA). An invitation was issued to NSW Health and NSW Parks and Wildlife Service but representatives were unable to attend. Both agencies indicated an interest in attending future Forums that may be held.

- Government Agency workshop in Sydney on 5 July 2013.

  Santos provided information on the E&A Program via a presentation followed by a question and answer session. This was attended by the DP&I, NSW Health, OCSG, NOW, RMS, EPA and Office of Environment and Heritage (OEH).

- Site visit with the NSW Office of the Chief Scientist and Engineer on 10 July 2013.

  The Chief Scientist undertook a tour, accompanied by three staff from her office and a representative from EPA. The purpose of this visit was specifically to inspect rehabilitation activities within the Pilliga Forest; however the accompanying briefing also provided information on the E&A Program.

- Site visit with Narrabri Shire Council on 19 July 2013.

  While the purpose of the site visit was to inspect the Northern and Southern Water and Gas Flow Lines, the activity also provided opportunity to discuss the E&A Program.

- Site visit with Forestry Corporation on 19 September 2013.

  While the purpose of the site visit was to inspect the Northern and Southern Water and Gas Flow Lines, the activity also provided opportunity to discuss the E&A Program.

- Government Information Forum onsite at Leewood on 19 September 2013.

  Santos presented information on the Leewood Produced Water Facility and specific information on the Dewhurst Northern and Southern Water and Gas Flow Lines, as well as the proposed activity. Eight government officers were in attendance, the majority of whom were locally or regionally based, with representation from:

  - OCSG
  - EPA
  - DPI
  - NOW
  - NSW Health
  - NSW Parks and Wildlife Service
  - Namoi Catchment Management Authority.

5.3.4.2 Indigenous Community

- Indigenous community forum held in Narrabri on 17 January 2013.

  Santos provided information on the CSG industry and the principles and approach to the E&A Program via a presentation followed by a question and answer session. The forum was attended by the Narrabri Local Aboriginal Land Council (LALC), 13 of the 19 native title applicants and NTSCORP Ltd, the Native Title Service Provider for Aboriginal Traditional Owners in NSW.

- Site tour with Narrabri LALC on 13 March 2013.

  A site tour was conducted for the Narrabri LALC including the Leewood site and the WPPS to provide information on the E&A Program.

- Meetings held with the Narrabri LALC on 19 July 2013 and 5 August 2013.

  The meetings discussed the issue of establishing a Memorandum of Understanding between Narrabri LALC and Santos around the sharing of cultural heritage information as it relates to Santos work in the Narrabri area.

5.3.4.3 Industry Groups

- Site tour with The NSW Farmers Association on 3 July 2013.

  A field trip was undertaken with four representatives from the NSW Farmers Association to inspect the Leewood Produced Water facility, rehabilitation areas within the forest and the Bibblewindi WTF. The purpose of this meeting was to provide information and answer questions in relation to the E&A Program and rehabilitation of sites within the forest.

- Site visit with representatives from the Australian Workforce Productivity Agency and the NSW Country Women's Association on 5 September 2013.

  The purpose of this visit was to provide a general overview of Santos operations in the Narrabri Region and provide information and answer questions on the E&A Program.

5.3.5 Community information sessions and forums

Monthly site tours are held for the general community to present information on the E&A Program. Site tours are advertised in the local newspaper and the number of attendees each month is usually between 20 to 30 people. To date, there has been a broad representation of local business owners, landowners, community groups and other interested residents.

In addition, a Farmer's Forum was held in Narrabri on 23 May 2013 to brief attendees on the potential gas development project as well as the E&A Program. Attendance at the Forum was limited to fourteen due to weather conditions.

A Contractor Information Forum was held on 16 July 2013 for local businesses and contractors to provide information on the E&A Program and the rehabilitation of sites within the forest. There were approximately 85 business and contractor representatives in attendance. Santos has a commitment to work with local contractors, businesses and community groups where possible to ensure that economic benefits from project investment are realised by the communities in which Santos operates.

Two onsite meetings have been held with Leewood neighbouring landowners on 12 July and 30 August 2013. The purpose of these meetings has been to provide information to them on activities being undertaken at Leewood, as well as provide an opportunity to discuss and ask questions in relation to the broader E&A Program.

5.3.6 Community Consultation Committee

Santos has an independently chaired Community Consultative Committee (CCC) that meets on a monthly basis in Narrabri with representation from a cross section of interested parties within the community. Minutes and actions arising from these meetings are uploaded to the Santos website and are also distributed by participants across their networks for broader community dissemination.

Meetings to date have focused on providing information relevant to the E&A Program with an emphasis on the overview of the CSG industry, drilling activities including well integrity, the environmental assessment process, activities that form part of the E&A Program and hydrogeological information. There has also been extensive information dissemination and discussion in relation to water management.

5.3.7 Landowner meetings

Regular meetings have been held with Forestry NSW since 2011. Weekly and monthly reports are sent to Forestry NSW representatives to provide information on activities proposed in the Forest.

A field trip was undertaken with two representatives of Forestry NSW to inspect the Dewhurst 26-31pilot site on 4 July 2013 and a meeting was held with senior Forestry NSW officers in Sydney on 1 May 2013 to brief on planned activities in the Pilliga East and Bibblewindi State Forests.

Ten meetings have been held with the Dewhurst 13–18H (Lot 32 DP 757104) landowner since December 2011, with regular telephone contact during this period. Key issues raised by the landowner include property access and security, the bore monitoring program and rehabilitation works. A land access and compensation agreement exists with the landowner.

5.3.8 Other

Meetings have also been held with the Commonwealth Department of the Environment (DoE) regarding the E&A Program.

5.4 Summary of issues raised during consultation

5.4.1 Government agencies and stakeholders

Key issues raised by government agencies and stakeholders are summarised in Table 5-2.

Table 5-2 Summary of issues raised by government agencies and councils

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
Office of Agricultural Sustainability and Food Security	●		Water use and impact on agriculture	An Agricultural Impact Statement (AIS) has been prepared as part of the EIS, NOW has been consulted on water requirements, and Santos is in the process of seeking a water access licence (WAL).	Appendix 2, Section 6.2.3
			Impact on apiary industry	The potential impact of the proposed activity on the apiary industry has been assessed in the AIS; with no significant impact predicted.	Appendix 2, Section 8.2.1
			Offsite impacts i.e. erosion, bushfires and contamination	Erosion and sediment controls, site safety protocols, incident management and emergency procedures will be implemented during the construction and drilling works, in accordance with best management practices. A bushfire management plan will be prepared for the proposed activity.	Sections 8.2.2 and 17.3.2
Department of Primary Industries (Fisheries NSW and NSW Office of Water)	●		Need for an aquatic assessment including a description of waterways, habitat and any identified impacts	The proposed activity will not significantly impact on any waterways and there will be no removal of any riparian or aquatic habitat. According to regional mapping, an unnamed tributary crosses over the existing Dewhurst 14 lease area and the proposed gathering system route, while an unnamed tributary runs through the southern section of the proposed Dewhurst 30 lease area. Neither of these drainage lines was observed during site investigations. During operation, there is a small risk of a leak or spill that may impact on surrounding waterways however measures will be implemented (pressure gauges and automatic shutdowns) to limit any impact to the immediate area.	Section 11.3.3
	●	●	Need to comply with relevant legislation, policies and guidelines	The EIS has considered all relevant legislation for the proposed activity, including the *Crown Lands Act 1989* and the *Water Management Act 2000*.	Chapter 6
	●		Risk of fragmentation of native vegetation and impacts to native fauna	Habitat fragmentation is considered to be minimal due to the linear construction of the proposed activity and the use of existing roads where possible to reduce fragmentation. No patches of habitat would be isolated as a result of the proposed activity.	Section 11.3.2
	●		Impact on water sharing plan (WSP)	The Bohena and Eulah Creek sub-catchments form the Bohena Creek and Eulah Creek Water Sources under the WSP for the Namoi Unregulated and Alluvial Water Sources, respectively. A search of NOW's website indicated that there are currently no records of any WALs under the *Water Management Act 2000* within these water sources (NOW, 2013). CH2MHill has completed a groundwater impact assessment and flow model for the proposed activity. This has concluded that there will be no significant impact on the NSW Upper and Lower Namoi Groundwater Source WSP or the NSW Great Artesian Basin (GAB) Groundwater Source WSP areas.	Sections 9.4 and 10.5

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
NSW Environment Protection Authority	●		Waste Management – water minimisation and opportunities to reuse and recycle	Santos has plans to develop a FTF at its existing operations centre in Narrabri. Drilling fluids will be mixed at the FTF and then transported to site. This will reduce wastes associated with mixing chemicals onsite (such as chemical containers).	Section 16.4.1
Hunter New England Local Health District	●	●	Groundwater and the management of produced water. The need for appropriate mitigation measures to prevent spills	At each well, produced water will be pumped through the water gathering system to the Bibblewindi WTF, via the Northern and Southern Water Flow Lines. The Bibblewindi Water Transfer Tank located at the Bibblewindi WTF will be used to provide a short buffer (up to 24 hours) prior to the produced water being pumped to the Leewood Produced Water Facility via the Leewood Water Pipeline. Once at the Leewood Produced Water Facility, produced water will be stored in one of the 300 ML ponds. A range of mitigation measures are proposed to minimise any environmental incidents.	Section 4.4.2, Chapter 20
	●		Impact of chemicals used in drilling	Chemicals that may be used in the drilling process have been identified in the EIS. No chemicals with added benzene, toluene, ethylbenzene, and xylenes (BTEX) will be used.	Section 4.3.7 and 17.3.1
	●		Noise impacts on sensitive receivers given 24 hour drilling	A noise impact assessment has been prepared and in general there will be no impact on any sensitive receivers. Under windy conditions, there is potential for the two closest receivers to be effected by noise associated with drilling activities.	Chapter 14 and Appendix 6
	●		Psychological impacts associated with the perception of the proposed activity representing a significant expansion of the industry	The proposed activity is relatively minor in scale.	N/A
	●		Effectiveness of consultation	Santos is implementing a comprehensive consultation program.	Chapter 5
Office of Environment and Heritage	●		Cultural heritage	No Aboriginal objects, sites, places of significance or culturally modified trees were identified within the two pilot sites or immediate surrounds. No Aboriginal objects or places recorded on the Aboriginal Heritage Information Management System (AHIMS) were identified within 10 km of the two sites. The potential for any previously unidentified Aboriginal objects or sites to be located within the sites or immediate surrounds is considered to be nil to low.	Section 19.1
	●		Biodiversity and the need for the assessment to consider the bio-banking assessment methodology	Following consideration of the avoidance, minimisation and mitigation measures proposed, biobanking is not considered necessary due to the relatively small magnitude of impact, the short timeframe of the operation of the proposed activity and the recommended rehabilitation following completion of operations.	Chapter 11, Appendix 4

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
Roads and Maritime Services	●		Traffic impacts during construction and operation including internal movements within the forest	Impacts to the road network are considered negligible given the very low volumes of traffic generated by the proposed activity. No upgrade works will be required.	Chapter 15, Appendix 7
Narrabri Shire Council	●		Single SSD application for the E&A Program	Application process has been staggered to reflect the drilling program and the evolving exploration and appraisal program. The two Dewhurst pilots have been grouped as the final projects that make up the E&A Program. The recently submitted BIbblewindi project was submitted as a separate application as it is a low impact activity involving drilling on existing pads with no vegetation clearing.	N/A
	●		Environmental performance of the CSG industry, the size of the industry, number of environmental incidents and any controls put in place to minimise incidents	A range of mitigation measures are proposed for the proposed activity. Santos is committed to minimising any environmental impacts associated with CSG and is in the process of implementing a comprehensive rehabilitation program. A key feature of Santos activities is relocation of water management facilities outside the forest.	Chapter 20
	●		Hazards and risks associated with drilling chemicals and fuel	An assessment against *State Environmental Planning Policy 33 – Hazardous and Offensive Development* (SEPP 33) has been undertaken.	Chapter 17
Namoi CMA	●		Consideration of noted key NRM planning documents	An environmental risk assessment for the proposed activity has been undertaken as part of the EIS, in line with the *Extractive Industries Policy for the Namoi Catchment* (NCMA, 2009). The *Namoi Catchment Action Plan 2010-2020* (NCMA, 2011) identifies biodiversity, land, water and people as the major natural resource management assets of the catchment. With the implementation of management and mitigation measures outlined in the EIS, no significant impact to biodiversity, land water or people is anticipated.	N/A
			Impacts on soils and land capability	The potential impact of the proposed activity on soil and land capability was assessed in the AIS; no significant impact is predicted.	Appendix 2, Section 8.2
Heritage Council of NSW	●		No issues raised	N/A	N/A

Agency	Corresp.	Workshops	Issue Raised	Response	Location of further information
Raised by more than one agency (including OCSG) or in general discussion during workshops	●	●	Cumulative impacts	Cumulative impacts have been assessed as part of the EIS and to support the E&A Program. The E&A Program will not have a significant impact. Discussion is included in each chapter of Part B of the EIS.	Chapter 8 to 19
	●	●	Impacts on local aquifers, including water quality, and details on monitoring program	CH2MHill has completed a groundwater impact assessment and flow model for the proposed activity. This has concluded that there will be no significant impact on local bore users or GDEs. A detailed surface and groundwater monitoring program is being implemented.	Appendix 3, Chapter 9
	●	●	Surface water impacts, including water quality	An assessment of surface water impacts has been undertaken and there will be minimal impacts.	Chapter 10
		●	Timing of stage 2 of Leewood addressing water treatment	The Leewood ponds (under construction) have a total storage capacity of 600 ML, being 2 ponds with 300 ML storage each. The total predicted groundwater extraction for the E&A Program is just over 1,400 ML. Produced water from the Leewood Produced Water Facility will be transported by road tankers to an appropriately licensed facility in the Sydney metropolitan area for treatment, reuse and/or disposal. Santos is currently investigating the economic and technical feasibility of treating the produced water at the Leewood Produced Water Facility by reverse osmosis or other methods instead of transporting produced water from Leewood to a licensed facility. If Santos decides to operate a water treatment facility at Leewood, this would be the subject of further applications for approvals from the NSW Government.	N/A
		●	The provision of biodiversity offsets	Offsets are currently being investigated by Santos however the cumulative impact assessment has concluded that there will be no significant impact on any listed species or ecological communities.	N/A
	●		Rehabilitation process	A rehabilitation strategy will be developed in conjunction with the affected landowners, and taking into consideration the conditions within PEL 238 and the Permit to Occupy.	Section 4.5
	●		Air quality impacts and mitigation measures during construction and operation	Air quality and GHG impact assessments have been undertaken. Air pollutants at sensitive receptors will remain below guideline levels. GHGs produced represent less than 0.02% and 0.08% of the National and State emissions profiles respectively.	Chapters 12 and 13, and Appendix 5

5.4.2 Community

Key issues raised during the consultation process are summarised in Table 5-3.

Table 5-3 Summary of issues raised by the community

Use	Response	Location of further information
Chemicals used during drilling and potential for loss into the aquifer	Chemicals that may be used in the drilling process have been identified in the EIS. No chemicals with added benzene, toluene, ethylbenzene, and xylenes (BTEX) will be used. All wells will be drilled in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012) and accepted practices in the oil, gas and water well industries.	Section 4.3.7
Potential for fluid loss into the aquifers during drilling	Losing drilling fluid is undesirable as it is the primary means of controlling the drilled hole. In the event that losses are detected, a LCM will be mixed into the fluid to prevent further losses. LCM is made of cellulose or other natural material and works by blocking the pores in the permeable/fractured rock.	Section 4.3.7
Risks of loss of drilling fluid in upper section of the pilot well	The risk of potential contamination of upper aquifers will be minimised as all wells will be drilled in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012) and accepted practices in the oil, gas and water well industries.	Section 4.3.7
Contamination of groundwater sources that are used for stock and domestic purposes	CH2MHill has completed a groundwater impact assessment and flow model for the proposed activity. This has concluded that there will be no significant impact on local bore users or GDEs. A detailed surface and groundwater monitoring program is being implemented.	Appendix 3, Sections 9.4.4, 9.4.5 and 9.5.3, and Table 10-4
The need for the location of wells and lease areas to be better communicated	Discussions on the justification and potential alternate locations for the proposed activities are provided as part of the environmental assessment documentation.	Chapter 2
Asset protection zones within the forest to assist in managing bushfire risks	Following completion of drilling, only partial rehabilitation of the lease areas will occur to ensure the maintenance of asset protection zones during operation. A bushfire management plan will be prepared for the proposed activity.	Section 17.3.1 and 17.5.2
Is there a possibility for hydrant rises being installed along the fresh water pipe to allow greater water availability during fire operations?	This will be considered during design and in the context of the bushfire management plan.	N/A
Area impacted for an exploration well	The proposed re-entering activity will occur on already cleared lease areas at Dewhurst 13-18H. The Dewhurst 30 and 31 wells will be located on two new lease areas approximately 1 ha in size.	N/A

5.5 Future and ongoing consultation

5.5.1 EIS exhibition

The EIS will be on public exhibition for a minimum of 30 days in accordance with the requirements of Part 4 of the *EP&A Act*.

DP&I is responsible for the public exhibition of the EIS. Concurrently, Santos will make available the EIS on its website, at the NOC and project information centres in Narrabri and Gunnedah.

5.5.2 Consultation during construction

Consultation during construction will include:

- newspaper advertisements
- community updates and newsletters
- fact sheets
- community information sessions and display materials
- stakeholder meetings
- 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 CCC meetings
- continued operation of the Narrabri Office and Information Centre.

Table 5-4 identifies specific consultation activities which will be carried out prior to the proposed activity commencing.

Table 5-4 Specific consultation prior to commencement of proposed activity

Activity	Description	Planning timing
Landowners (Forestry NSW, DPI and private)	Regular contact is maintained with the landowners and prior to the commencement of the proposed activity written advice will be provided to the landowners.	Advice to landowners will be provided 14 days prior to the proposed activity commencing
Neighbouring landowners	Continuing consultation is held with the landowners whose property is directly adjacent to the proposed activity. Letters will be sent to adjoining landowners to notify of the proposed activity. The letter will include a description of the activities to be undertaken, and contact details are provided for the landowner to ask questions relating to the proposed activity.	Advice will be provided to relevant landowners that may be impacted by the activity 14 days prior to the proposed activity commencing
Narrabri Shire Council	The Narrabri Shire Council will continue to be consulted, provided with regularly updates and a six monthly look-ahead schedule.	Monthly
Broader community	Updates on the proposed activity will be provided to the Narrabri CCC.	Monthly
Advertisements	Advertisements will be placed in the local media of the up-coming exploration and drilling activities.	Monthly
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

6.0 Planning and Statutory Framework

6.1 Assessment framework

6.1.1 State significant development

Section 89C(2) of the EP&A Act provides that a State Environmental Planning Policy (SEPP) may declare any development or any class or description of development, to be SSD. The SRD SEPP identifies development which is SSD for this purpose. Clause 8 of the SRD SEPP provides that development is SSD if the development is not permissible without development consent under Part 4 of the EP&A Act, and the development is specified in Schedule 1 or 2 of the SRD SEPP.

Clause 6 of Schedule 1 of the SRD SEPP identifies 'Petroleum (oil and gas)' and classifies 'development for the purpose of drilling and operating petroleum exploration wells, not including… a set of five or fewer wells that is more than three kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title' as SSD.

Under clause 7(2) of the Mining SEPP, development consent is required for the purposes of drilling or operating a set of more than five wells that is more than three kilometres from any other petroleum well (other than an abandoned petroleum well) in the same petroleum title.

Works and modifications to the existing Dewhurst 13-18H Pilot, including the two additional lateral wells within three of the existing horizontal wells, is development for the purpose of drilling and operation of a set of more than five wells located within a three kilometre radius within the same petroleum title. The establishment of the Dewhurst 30 and 31 pilot wells, as part of the Dewhurst 26-31 Pilot will also create more than five wells within a three kilometre radius within PEL 238. As such, the proposed activity is SSD.

6.1.2 Director-General's Requirements

The DGRs for the proposed activity were issued on 20 May 2013 and are provided in Appendix 1 including cross references to sections within the EIS where each has been addressed. A draft Statement of Commitments is provided in Chapter 20.

The EIS process described in Division 4.1 of Part 4 of the EP&A Act is shown in Figure 6-1.

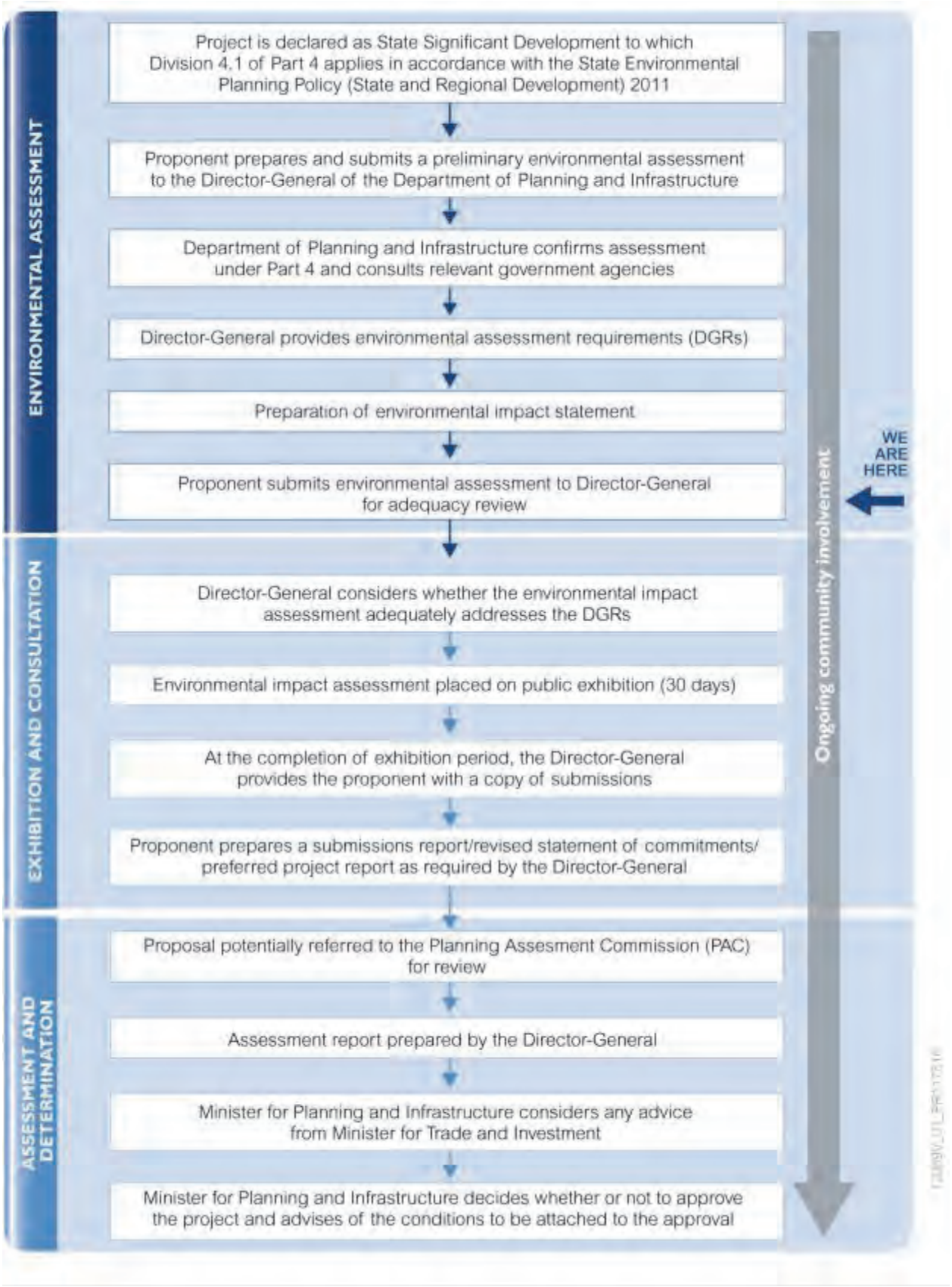


Figure 6-1 The environmental impact assessment process

6.1.3 Section 79C requirements

Section 79C of the EP&A Act applies to the determination of SSD and requires the consent authority to take into consideration a range of matters as identified in Table 6-1.

Development consent may not be granted if the development is wholly prohibited by an environmental planning instrument. The activity is not prohibited by any environmental planning instruments.

Table 6-1 Matters for consideration under section 79C of EP&A Act

Matter for consideration	Response
(i) any environmental planning instrument	The EIS considers all relevant matters within applicable environmental planning instruments. These are discussed within the following sections of this chapter.
(ii) any proposed instrument that is or has been the subject of public consultation under this Act and that has been notified to the consent authority	Not applicable.
(iii) any development control plan	In accordance with section 11 of the SRD SEPP, development control plans do not apply to the activity as it is deemed to be SSD.
(iiia) any planning agreement that has been entered into under section 93F, or any draft planning agreement that a developer has offered to enter into under section 93F	No planning agreements or draft planning agreements have been entered into for the activity.
(iv) the regulations	There are no relevant matters prescribed by the regulations.
(v) any coastal zone management plan (within the meaning of the Coastal Protection Act 1979), that apply to the land to which the development application relates	The two pilot sites are not within a coastal zone. Therefore, no coastal zone management plans apply.
(a) the likely impacts of that development, including environmental impacts on both the natural and built environments, and social and economic impacts in the locality	Impacts of the proposed activity on natural and built environment, and social and economic impacts are assessed, and measures identified in Chapter 8 to 19.
(b) the suitability of the site for the development	Justification for selecting the two pilot sites are provided in Chapter 2.
(c) any submissions made in accordance with this Act or the regulations	Any submissions received during the statutory exhibition period will be considered by the Minister prior to determination of the application.
(d) the public interest.	The public interest will be served through the application of all relevant planning controls and objectives, as well as the production of natural gas for the domestic market.

6.2 NSW legislation

6.2.1 Petroleum (Onshore) Act 1991

The 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 a petroleum exploration licence has the right to prospect for petroleum on the land within the lease area. The proposed activity is situated within PEL 238 granted under the Petroleum Act. Under PEL 238, there are three categories of prospecting operations that may be undertaken. The category considered relevant for the proposed activity is Category 3, which is detailed below.

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 licence area
- any other prospecting operations not listed in Category 1 prospecting operations or Category 2 prospecting operations.

Under Condition 2 of PEL 238 the licence holder must obtain approval from the Resources Minister prior to carrying out any Category 3 prospecting operations on the exploration licence area. Approval will be required under section 70 of the Petroleum Act for the parts of the operations within the State Forest.

6.2.2 Environmental Planning and Assessment Act 1979

Section 89C(2) of the EP&A Act provides that a SEPP may declare any development or any class or description of development, to be SSD. As outlined in Section 6.1.1, the proposed activity is SSD. Under section 89D of the EP&A Act, the Minister for Planning and Infrastructure (or its delegate) is the consent authority for SSD.

Section 78(8A) of the EP&A Act requires an EIS assessing the proposed activity to be submitted. This document has been prepared for the purpose of assessing the potential environmental impacts of the proposed activity.

6.2.3 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 (WSP) is in place, the WMA governs the issuing of water access licences (WALs) and water management and activity approvals. As WSPs are in place for the surface and groundwater sources at or surrounding the two pilot sites, the WMA applies to the proposed activity.

6.2.3.1 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 Framework Document* (DLWC, 1997) 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 following WSPs apply to water sources beneath or in the vicinity of the two pilot sites:

- WSP for the NSW Great Artesian Basin (GAB) Groundwater Sources 2008
- WSP for the NSW Murray-Darling Basin (MDB) Porous Rock Groundwater 2011
- WSP for the NSW MDB Fractured Rock Groundwater 2011
- WSP for the Upper and Lower Namoi Groundwater Sources 2003
- WSP for the NSW GAB Shallow Groundwater Sources 2011
- WSP for the Namoi Unregulated and Alluvial Water Sources 2012
- WSP for the Upper Namoi and Lower Namoi Regulated River Water Sources 2003.

The proposed activity will need to comply with the rules developed for the affected water sources within the relevant WSPs outlined above.

6.2.3.2 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 WAL.

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

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 megalitres per year from groundwater sources will need to hold a WAL.

The volume of water to be extracted during operation of the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot is estimated to be approximately 331 and 414 megalitres of groundwater over three years from the Gunnedah-Oxley Basin groundwater source, respectively. Santos will apply for a WAL for this water take.

6.2.3.3 Aquifer interference approvals

Under section 91F of the WMA, it is an offence to carry out an aquifer interference activity without an aquifer interference approval. Aquifer interference activities include 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
- the disposal of water taken from an aquifer.

However, section 91F of the WMA does not currently apply. Section 88A provides that Part 3 of Chapter 3 (including section 91F) 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 the EIS, 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. However the Aquifer Interference Policy (DPI, 2012) still applies and an assessment of the proposed activity against the requirements of the policy has been provided in Appendix 3 and summarised in Section 9.4 of the EIS.

6.2.3.4 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 Water Act or a WMA 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 provides that any land that was designated as a floodplain under section 166A of the Water Act is taken to be a floodplain for the purposes of the WMA.

There are a number of floodplains declared under the Water Act located nearby but not on either of the pilot sites. The closest is the Namoi River: Narrabri to Wee Waa floodplain located approximately 28 kilometres to the north of Dewhurst 13-18H. 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.

6.2.3.5 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 *Water Management (General) Regulation* 2011 (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.

6.2.3.6 Water supply work approval

Under section 90 of the WMA, a water supply work approval is required to construct and use a specified water supply work at a specified location. Water supply works are defined within the WMA and includes works (such as a water pump or water bores) that are constructed or used for the purpose of taking water from a water source.

Under section 89J of the EP&A Act, a water supply work approval is not required for SSD for which development has been granted. Therefore a water supply work approval will not be required for the proposed activity.

6.2.4 Protection of the Environment Operations Act 1997

One of the primary objectives of the 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 EPLs be obtained for the carrying out of 'scheduled activities' or to pollute waters.

All CSG exploration, assessment and production titles and activities are required to hold an EPL. Santos has applied for an EPL for the E&A Program, and will apply for a modification to the EPL to incorporate the proposed activity into the EPL should development consent for the proposed activity be granted.

6.2.5 Roads Act 1993

The proposed activity will occur partially on Crown land road reserve at Dewhurst 13-18H. Under section 138 of the *Roads Act 1993* consent is required for construction within the road reserve. Consent will be required from the Minister for Primary Industries as the Minister administering the *Crown Lands Act 1989* (CL Act) for construction of facilities within this Crown land. As the gathering system is to be installed under the road reserve, an access arrangement will need to be entered into. The DPI administers these leases and licences under section 34 of the CL Act.

6.2.6 Additional NSW legislation

Additional NSW legislation that must be applied consistently to the proposed activity is presented in Table 6-2.

Table 6-2 Additional NSW legislation to be considered for the proposed activity

Legislation	Purpose	Application to proposed activity
Brigalow and Nandewar Community Conservation Area Act 2005 (BNCCA Act)	The BNCCA Act was established to reserve forested land in the Brigalow and Nandewar area and provide for permanent conservation of land, protection of areas of natural and cultural heritage significance to Aboriginal people and sustainable forestry, mining and other appropriate uses.	The Pilliga East State Forest is included within Zone 4 – *Forestry, recreation and mineral extraction*, under the BNCCA Act. The strategic aims for this zone, as identified by the *Brigalow and Nandewar Community Conservation Area Agreement*, include '*Provide for exploration, mining, petroleum production and extractive industry in accordance with the* Mining Act 1992 *and the* Petroleum (Onshore) Act 1991 *and associated Regulations and guidelines'.* The proposed activity is consistent with the intended use of Zone 4 land.
Contaminated Land Management Act 2008	To promote the better management of contaminated land.	The proposed activity is not expected to be carried out on contaminated land.
Crown Lands Act 1989	To provide for the administration and management of Crown land in NSW.	Santos has entered into a Permit to Occupy agreement with Forestry NSW.

Legislation	Purpose	Application to proposed activity
Dangerous Goods (Road and Rail Transport) Act 2008.	To provide conditions for safety in the transport of dangerous goods by road and rail as part of the system of nationally consistent road and rail transport laws.	Any dangerous goods will be transported according to regulatory requirements.
Fisheries Management Act 1994	To conserve key fish habitats including permanent and semi-permanent freshwater habitats.	The creeks in the vicinity of the proposed activity are ephemeral. They do not support the endangered Murray Cod (*Maccullochella peelii*), as this species prefers slow flowing deep watercourses. The ephemeral nature of these creeks would likely only support common fish species during migration and breeding.
Forestry Act 2012	To provide for the dedication, management and use of State forests and other Crown-timber land for forestry and other purposes.	Proposed works within the State forest will be undertaken in accordance with the existing Permit to Occupy held by Santos and administered by Forestry NSW.
Heritage Act 1977	To encourage the conservation of the heritage of NSW.	No items of heritage significance listed under either the Narrabri LEP or on the NSW State Heritage Register occur at the two pilot sites.
National Parks and Wildlife Act 1974 (NPW Act)	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 does not apply where an action is essential for the carrying out of development in accordance with an approval of a determining authority under Part 4 of the EP&A Act, where the determining authority has complied with Part 4. This EIS has been prepared to assist the determining authority to comply with Part 4 of the EP&A Act.
	To conserve places, objects and features of significance to Aboriginal people.	No Aboriginal objects, sites, places of significance or culturally modified trees were identified within the two pilot sites or immediate surrounds. No Aboriginal objects or places recorded on the AHIMS were identified within 1 km of either pilot sites. The potential for any previously unidentified Aboriginal objects or sites to be located within the sites or their immediate surrounds is considered to be nil to low. All staff will be made aware of their obligations under the NPW Act and Heritage Act with all works to comply with Part 6 of the NPW Act.
Native Vegetation Act 2003 (NV Act)	To encourage revegetation and rehabilitation of land with appropriate native vegetation.	Under section 25(m), the NV Act does not apply to any clearing authorised under the Petroleum Act.
Noxious Weeds Act 1993	To ensure that the Act is complied with within their boundaries, the landowner has an obligation under the Noxious Weeds Act to control any declared weed on their property.	One noxious weed species (*Opuntia stricta*) was identified during the field survey as part of the Ecological Assessment. As this is a Class 4 weed under the Act, 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.

Legislation	Purpose	Application to proposed activity
Threatened Species Conservation Act 1995 (TSC Act)	To provide a framework for the listing of threatened species, populations and ecological communities, and key threatening processes (KTPs) in NSW, and the preparation and implementation of recovery plans and threat abatement plans.	The proposed activity involves the clearing of approximately 2.44 ha of vegetation. Application of the 7-part test concluded that the proposed activity is not likely to have a significant impact on the 4 threatened flora and 33 threatened fauna species listed under the TSC Act that are considered to have the potential to occur within the two pilot sites and surrounding 10 m buffer. Further details are provided in Chapter 11.
Waste Avoidance and Resource Recovery Act 2001	To provide a legal framework concerning the minimisation, recycling and reuse of waste in NSW.	All wastes generated by the proposed activity will be collected, classified and removed from site for recycling or disposal at a licensed waste facility if required. Given the short term nature of the construction, only minor quantities of waste will be produced.
Work Health and Safety Act 2011	To secure the health, safety and welfare of persons at work.	The proposed activity will be carried out in accordance with all health and safety requirements.

6.2.7 State and local environmental planning policies

6.2.7.1 Strategic Regional Land Use Policy

The SRLUP identifies and protects more than two million hectares of SAL, protects valuable water resources, and provides greater certainty for companies wanting to invest in mining and CSG projects in regional NSW.

As a result of this policy, all State significant mining and CSG proposals that extend beyond an existing lease area on SAL must go through an independent, scientific assessment of their potential agricultural land and water impacts before a development application can be lodged.

Two types of SAL exist. The proposed activity is not located on BSAL or a CIC mapped under DP&I (2012a) and is unlikely to impact on agricultural resources.

A site verification report has been prepared and Santos has lodged the site verification report to DP&I (to satisfy the DGRs) as part of the overall EIS submission. The DP&I will then undertake the site verification assessment as part of the overall assessment.

6.2.7.2 State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007

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 7 of the Mining SEPP relates to development that is permissible with development consent. As the proposed activity will result in more than five wells within three kilometres (other than an abandoned petroleum well) in the same petroleum title, Clause 7 applies and development consent is required. As outlined above, the proposed activity is also classified as SSD, and requires development consent under Part 4, Division 4.1, of the EP&A Act.

The proposed activity will not be carried out on an environmentally sensitive area of State significance.

Recent amendments to the mining SEPP include the establishment of a new Gateway process for State significant mining and petroleum activities located on SAL defined in DP&I (2012a). While the proposed activity will not be carried out on SAL, a site verification report has been prepared and submitted with the EIS.

6.2.7.3 Other SEPPS

Other SEPPs relevant to the proposed activity are summarised in Table 6-3.

Table 6-3 Additional SEPPs relevant to the proposed activity

SEPP	Purpose	Application to proposed activity
SEPP 44 Koala habitat protection	To support the conservation and management of koala habitat	The two pilot sites and their immediate surrounds do not support any tree species which are listed in Schedule 2 of SEPP 44 as feed tree species. Therefore, the areas do not constitute potential Koala habitat.
SEPP 55 Remediation of Land	To ensure land is developed appropriately and contaminated land is managed.	A search of the contaminated land record database maintained by the EPA indicated records of seven contaminated sites within the Narrabri Shire LGA. None of these contaminated sites are located near either pilot site.
SEPP 33 Hazardous and Offensive Development	To present a systematic approach to planning and assessing potentially hazardous and offensive development.	Diesel will be stored temporarily onsite for use during drilling. Diesel is classified under the Australian Dangerous Goods Code 3 and is subject to the requirements under SEPP 33. However given the relatively small volumes, the proposed activity is not defined as a potentially hazardous or offensive activity or industry. Section 17.2 provides more detail on the assessment. The gas produced as part of the proposed activity is not classified under the Australian Dangerous Goods Code 3. It is therefore not subject to the requirements under SEPP 33.

6.2.7.4 Narrabri Local Environmental Plan 2012

As the project is deemed SSD, development consent is granted under Part 4, Division 4.1, of the EP&A Act. Nevertheless, consideration has been given to the relevant land use zone objectives under the Narrabri LEP. The pilot sites are zoned RU1 Primary Production and RU3 Forestry zone at Dewhurst 13-18H and Dewhurst 26-31, respectively.

The proposed activity is a non-primary production and non-forestry use that will not restrict the use of other land for agricultural or forestry purposes. The natural resource base relied upon by the industries within the area will not be significantly affected by the proposed activity. The proposed activity will not significantly affect the development of agriculture, agricultural-related enterprises, forestry or forestry-related enterprises in the area nor will it result in significant fragmentation or alienation of resource lands. The proposed activity will not result in conflict between land uses within the RU1 Primary Production zone, RU3 Forestry zone or land uses within adjoining zones. Therefore, the proposed activity is considered to be a suitable activity within the RU1 Primary Production and RU3 Forestry zones.

6.3 Commonwealth legislation

6.3.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act provides for the protection of certain Matters of National Environmental Significance (MNES) listed under the 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
- water resources from CSG development and large coal mining development.

Under the EPBC Act, Commonwealth approval is required from the Minister for the Environment (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 a controlled action must refer the proposed development to the Minister for determination. A person proposing to take an action that the person thinks is not a controlled action may refer the proposed development to the Minister for the Minister's decision whether or not the action is a controlled action.

An EPBC Act Protected Matters Search was undertaken using the online database to generate a list of those MNES species potentially occurring within the two pilot sites and surrounding 50 kilometres (DoE, 2013a). This data, combined with other local knowledge and records, was used to assess whether the proposed activities will have, or are likely to have, a significant impact on MNES. The findings of this assessment are outlined in Table 6-4 and discussed further in Chapter 11.0.

Table 6-4 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 a RAMSAR listed wetland area.
Nationally listed threatened species and ecological communities	No TEC listed under the EPBC Act are located in the vicinity of the two pilot sites. An Assessment of Significance was completed for the 2 flora and 7 fauna species listed under the EPBC Act that are considered to have potential to occur onsite. The assessments determined that the species are unlikely to be significantly impacted upon due to the proposed activity.
Migratory species	Five migratory bird species listed under the EPBC Act were identified as having potential to occur onsite – the Regent Honeyeater, White-bellied Sea Eagle, White-throated Needletail, Rainbow Bee-eater and Fork-tailed Swift. An Assessment of Significance was completed for each of these species, and determined that they are unlikely to be significantly impacted upon due to the proposed activity.
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.
Water Resources from CSG development and large coal mining development	The cumulative groundwater impact assessment indicates that depressurisation of the target coal seam as a result of pilot activities will not produce a significant decline in water levels (less than 0.5 m) within the Namoi Alluvium and the Pilliga Sandstone groundwater sources. Consequently there will be no significant impact on GDEs, GDE terrestrial vegetation or registered water supply bores.

While assessed as unlikely to significantly impact any MNES, Santos referred E&A Program activities within the Pilliga forest (including the proposed activity), to the Commonwealth government for a decision under the EPBC Act in June 2013. On 1 October 2013, the Minister made the decision that the proposed action is not a controlled action if undertaken in a particular manner.

6.3.2 Native Title Act 1993

The objectives of the *Native Title Act 1993* (Native Title Act) are to:

- recognise native title rights and sets out basic principles in relation to native title in Australia
- provide for the validation of past acts which may be invalid because of the existence of native title
- provide for a future act regime in which native title rights are protected and conditions imposed on acts affecting native title land and waters
- provide a process by which native title rights can be established and compensation determined
- provide processes for negotiations and determinations about whether future acts, including grants and activities carried out under those grants, can be done over native title land and waters
- provides for a range of other matters, including the establishment of a National Aboriginal and Torres Strait Islander Land Fund.

In the area of PEL 238 the relevant native title claimant is the Gomeroi People (NSD2308/2011). As PEL 238 was granted prior to the commencement of the Native Title Act, no further native title process is required for activities authorised under PEL 238. Should Santos apply for a production lease in the area of PEL 238 where native title continues to exist, Santos understands that the Native Title Act requires completing the right to negotiate process under Subdivision P of Division 3 of Part 2 of the Act or concluding an Indigenous Land Use Agreement with the Gomeroi People.

6.4 Summary of approval requirements

The proposed activity requires the following approvals:

- assessment and determination of the proposed activity including development consent under Part 4 of the EP&A Act
- an EPL under the *Protection of the Environment Operations Act 1997*
- a WAL under the *Water Management Act 2000*
- a section 138 approval under the *Roads Act 1993*
- an approval under section 70 of the *Petroleum (Onshore) Act 1991*.

7.0 Environmental risk analysis

7.1 Risk assessment methodology

A preliminary environmental risk assessment of the proposed activity was undertaken to identify and prioritise issues requiring further assessment in the EIS. Potential environmental issues associated with the proposed activity were identified based on desktop investigations, preliminary ecological and archaeological field investigations, knowledge of the statutory planning and regulatory requirements, and considering the nature and scale of the proposed activity.

The risk assessment was conducted by a multi-disciplinary project team in accordance with Santos risk assessment framework. The focus is on the inter-relationship between people, equipment, methods of work, the environment and the community. Risks are identified from health and safety, natural environment, reputation and financial perspectives. In particular, environmental risks were identified for each environmental aspect during key stages of the proposed activity. Each risk was given an inherent risk ranking of 1 to 5 based on the likelihood and potential consequences of the risk with and without mitigation measures being applied. The risk matrix used to determine the rankings is shown in Table 7-1.

Table 7-1 Risk assessment matrix

			Consequences				
			Negligible	Minor	Moderate	Major	Critical
			1	2	3	4	5
Likelihood	Almost certain	1	2	3	4	5	5
	Likely	2	1	3	3	4	5
	Possible	3	1	2	3	3	4
	Unlikely	4	1	1	2	2	3
	Remote	5	1	1	1	1	2

Risks were considered in relation to the following aspects:

- land resources
- water resources
- biodiversity
- air quality
- greenhouse gases
- noise
- traffic and transport
- waste management
- hazards to the community
- social and economic environment
- cultural heritage.

7.2 Environmental risk findings

Table 7-2 outlines the key risks during construction. Mitigation measures have been identified to address risks with the resultant risk rating shown in the table. The potential for a traffic accident and community and reputational risks associated with ineffective community engagement are considered the major risks for the proposed activity. All other risks can be mitigated to a risk rating of two or less based on detailed technical studies and implementation of the mitigation measures outlined in the following sections of this report.

Table 7-3 outlines key risks during operation. The main risk is associated with the potential for a bushfire. All other risks can be mitigated to a risk rating of two or less.

Table 7-2 Key identified risks during construction

Risk Area	Cause	Impact	Assessment	Mitigation	Risk Rating[1]
Traffic and transport	Increase in traffic on local road network	Reduced road safety for community/other road users leading to accidents	Chapter 15 Appendix 7	Traffic movements to be minimised, staff bussed to site.	3
Other	Community not appropriately consulted	Poor community relations; community backlash	Chapter 5	Community engagement program to be implemented as outlined in Chapter 5.	3
Land resources	Chemical, fuel or oil spills	Soil contamination	Chapter 8 Appendix 2	Amount of fuels and chemicals onsite to be minimised, fuels and chemicals to be stored above ground and spill kits made available.	2
Land resources	Vegetation clearing and earthworks	Erosion of topsoil and subsoil	Chapter 8 Appendix 2	Use of industrial matting as the preferred lease establishment method for Dewhurst 30 and 31, as an alternative to clearing and levelling. Erosion and sediment controls to be implemented in accordance with industry best practice.	2
Water resources – groundwater	Loss of drilling fluid into the formation	Reduction of groundwater quality	Chapter 9 Appendix 3	Wells to be drilled in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012).	2
Water resources – surface water	Saline water being released from the formation and discharging into drainage lines or waterways	Degradation of surface water	Chapter 10	Surface tanks installed to capture any fluids that are released during drilling.	2
Water resources – surface water	Altered surface flows within drainage lines onsite	Localised flooding, scouring or sediment deposit within the drainage lines	Chapter 10	Erosion and sediment controls to be implemented in accordance with industry best practice.	2
Biodiversity	Native vegetation clearing	Loss of biodiversity, including threatened species	Chapter 11 Appendix 4	At Dewhurst 13-18H, the proposed drilling and surface facility construction activities are located within existing lease areas, eliminating the need for additional clearance. The proposed gathering system parallels the existing road and access tracks, minimising vegetation impacts. The Dewhurst 30 and 31 pilot wells are sited outside of areas of 'very high' or 'high' ecological sensitivity and use existing access from Beehive Road to minimise vegetation clearing.	2
Biodiversity	Spread of weeds by construction activities	Weed infestation and loss of biodiversity	Chapter 11 Appendix 4	Vehicles to be washed and cleaned where exposed to noxious weeds or unwanted plants.	2

Risk Area	Cause	Impact	Assessment	Mitigation	Risk Rating[1]
Biodiversity	Drilling through aquifers where stygofauna may be present	Impact to stygofauna	Chapter 11 Appendix 4	Wells to be drilled in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012).	2
Air quality	Construction activities including vehicle movement	Reduction in air quality at nearby sensitive receivers	Chapter 12 Appendix 5	Dust suppression measures to be implemented in accordance with industry best practice.	2
Traffic and transport	Increase in traffic on local road network	Wear and tear on the road surface	Chapter 15 Appendix 7	Traffic movements to be minimised, staff bussed to site, where possible.	2
Traffic and transport	Increase in traffic on local road network	Reduced road safety for community/other road users leading to fatality	Chapter 15 Appendix 7	Traffic movements to be minimised, staff bussed to site, where possible.	2
Waste	Illegal dumping of waste or lack of suitable containment of waste	Pollution, contamination and/or littering of land or water	Chapter 16	All waste to be classified onsite, and if required disposed at an appropriately licenced facility.	2
Waste	Generation and mismanagement of potentially hazardous wastes	Contamination of land or water, human health effects	Chapter 16	Amount of fuels and chemicals onsite to be minimised, fuels and chemicals to be stored above ground and spill kits made available.	2
Hazards	Accidental ignition during construction activities	Bushfire resulting in loss of life, property or biodiversity	Chapter 17	All vehicles to remain within cleared service corridors, access tracks and lease areas.	2
Hazards	Introduction of chemicals to the environment	Build-up of chemicals in groundwater, surface water, soils, flora or fauna, exposure of chemicals to humans and potential toxicological effects	Chapter 17	Wells to be drilled in accordance with *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012).	2
Heritage	Disturbance of previously unidentified Aboriginal heritage items	Loss of heritage values	Chapter 19	A Preliminary Heritage Assessment has been prepared for the two pilot sites, which incorporated a visual inspection (pedestrian survey) of the sites undertaken on 14 November 2012 and 31 January 2013. No objects, places, landscape features or culturally modified trees were identified. All staff are to be made aware of their obligations under the NPW Act and Heritage Act with all works to comply with Part 6 of the NPW Act.	2
Heritage	Indirect impacts to identified Aboriginal heritage sites	Loss of heritage values	Chapter 19		2
Other	Disturbance beyond authorised area of impact	Non-compliance with approval	Chapter 8	Site to be fenced to clearly delineate work area.	2

Notes: 1. with mitigation measures

Table 7-3 Key identified risks during operation

Risk Name	Cause	Impact	Assessment	Mitigation	Risk Rating[1]
Hazards	Accidental ignition as a result of inadequate bushfire protection zones for flares	Bushfire resulting in loss of life, property or biodiversity	Chapter 17	Exclusion zone to be maintained at flare. Sterile zone to be covered with blue aggregate to minimise sparking.	3
Land resources	Changing land use	Incompatible land use with surrounding area	Chapter 8 Appendix 2	On-going consultation with Forestry NSW, DPI and private landowner to identify and resolve any issues if they emerge.	2
Land resources	Major infrastructure failure (pipes and tanks)	Contamination of land, water, vegetation dieback	Chapter 8 Appendix 2	Pressure gauges and remote monitoring to measure any changes at the well head and transfer tanks. Remote shut down facilities to be incorporated into design.	2
Water resources – groundwater	Water production during pilot operation	Negative impacts on environmental values i.e. registered users and GDEs due to drawdown effects, water quality, etc	Chapter 9 Appendix 3	Water modelling has indicated that there will be no significant impact to GDEs and registered bore users. Ongoing monitoring program to be implemented.	2
Water resources – surface water	Altered surface flows within drainage lines onsite	Localised flooding, scouring or sediment deposit within the drainage lines	Chapter 10	Erosion and sediment controls to be implemented in accordance with industry best practice.	2
Biodiversity	Ongoing habitat fragmentation and edge effects	Longer term reduction in ecosystem functions	Chapter 11 Appendix 4	Partial rehabilitation to occur where possible.	2
Air quality	Flaring of gas or infrastructure failure	Reduction in air quality at nearby sensitive receivers	Chapter 12 Appendix 5	Monitoring and maintenance of equipment and pipes, as well as emissions monitoring to be undertaken.	2
Greenhouse Gases	Flaring of gas or infrastructure failure	Increase in accountable greenhouse gas emissions	Chapter 13	Monitoring and maintenance of equipment and pipes, as well as emissions monitoring to be undertaken.	2
Noise	Operation of pilot wells or maintenance of surface infrastructure	Negative impact on nearby sensitive receivers	Chapter 14 Appendix 6	In the event of a noise complaint, the effectiveness of noise mitigation measures to be assessed and additional feasible and reasonable measures to be implemented.	2
Traffic and transport	Increase in traffic on local road network	Reduced road safety for community/other road users leading to accident or fatality	Chapter 15 Appendix 7	Santos vehicles to be fitted with an in-vehicle monitoring system to influence driver behaviour.	2

Risk Name	Cause	Impact	Assessment	Mitigation	Risk Rating[1]
Waste	Illegal dumping of waste or lack of suitable containment of waste	Pollution, contamination and/or littering of land or water	Chapter 16	Produced water to be stored at the Leewood Produced Water Facility. Sufficient capacity exists within the ponds to accommodate expected volumes from the proposed activity.	2
Hazards	Minor infrastructure failure (pipes and tanks) i.e. small leak	Contamination of land, water, vegetation dieback	Chapter 17	Pressure gauges and remote monitoring to measure any changes at the well head and transfer tanks. Remote shut down facilities to be incorporated into design.	2
Community	Community not appropriately consulted	Poor community relations; community backlash	Chapter 5	Ongoing consultation to occur through Santos exploration and appraisal consultation program.	2

Notes: 1. with mitigation measures

7.3 Approach to assessment

Assessment of impacts as a result of the proposed activity has been based on a combination of key risks and the DGRs. The assessment has separated impacts associated with construction and drilling (up to approximately 160 days) and operation (up to 3 years) as the duration of activities is a key input to identifying the level of impact.

While the majority of impacts occur during drilling when the intensity of activity is greatest, this is a short term activity and generally confined to the lease area. Key issues during construction and drilling include:

- clearance of native vegetation and ground disturbance
- potential spills of chemicals or fuels
- minor earthworks during construction of the lease areas, gathering systems, cellar pit and drill cuttings pit
- drilling through multiple aquifers
- use of chemicals during drilling
- noise and emissions of vehicles and equipment
- traffic movements
- waste management
- hazards and public safety.

During operation, the intensity of activity is much less, with the lease areas visited daily by one vehicle. Key issues include:

- groundwater extraction
- accidental ignition at the flares
- greenhouse gas emissions
- air quality at the flares.

A cumulative impact assessment has been undertaken for the E&A Program described in Section 1.5 for all environmental aspects. Given that many of the impacts are localised and wells are dispersed (see Figure 7-1), cumulative impacts are generally minor and the discussion provided is brief. The exception is groundwater, biodiversity and GHG emissions. A groundwater model has been developed and is described further in Section 9.2. Biodiversity impacts have been assessed based on vegetation cleared as a result of previous and proposed CSG activities. The results of this assessment are provided in Section 11.4. Greenhouse gas emissions are discussed in Section 13.4.

A range of mitigation measures are proposed to address identified potential impacts. These are outlined within each section and summarised in Chapter 20.0.

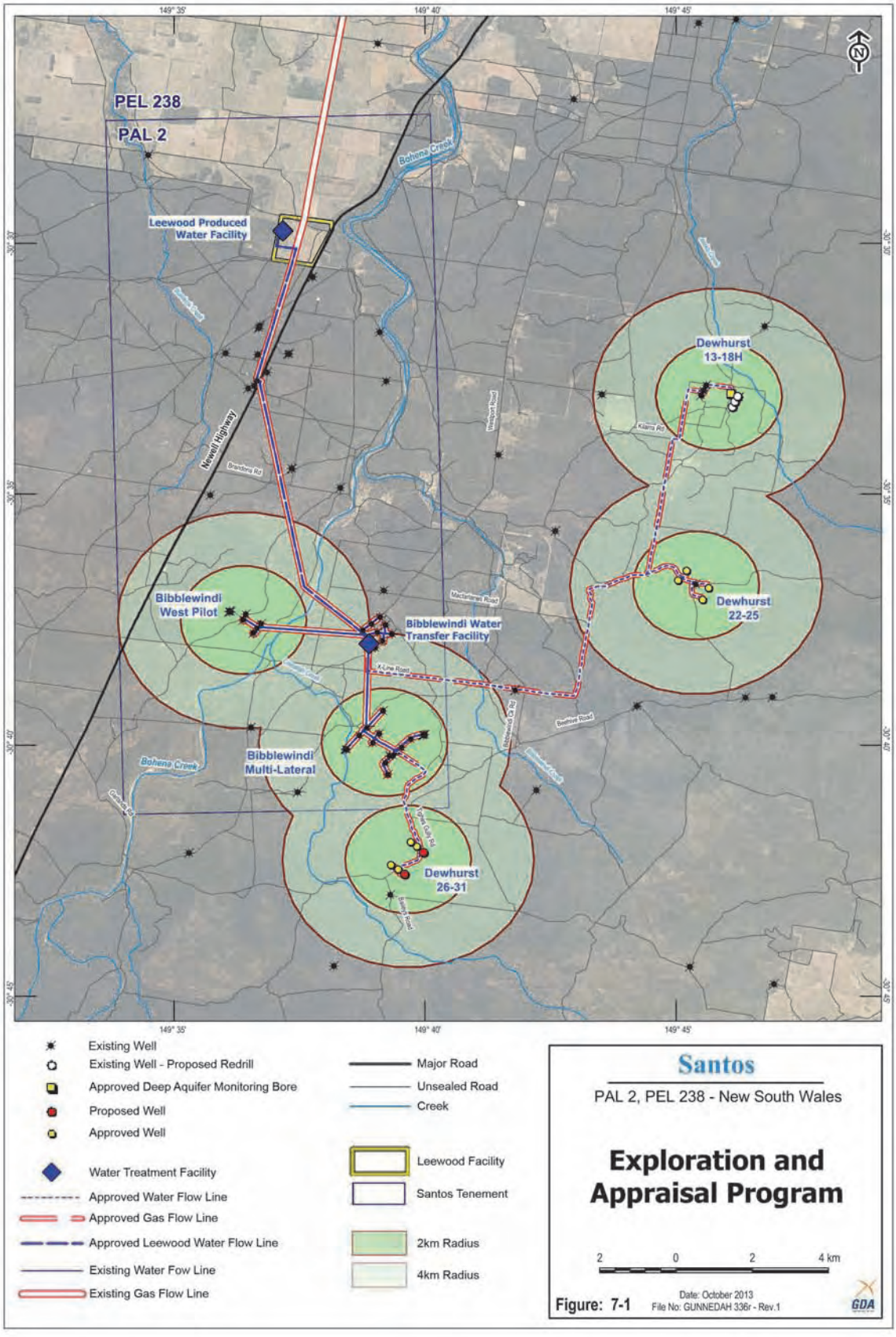


Figure 7-1 Proximity of activities within the E&A Program

PART B

8.0 Land Resources

An *Agricultural Impact Statement* (AIS) has been prepared by RPS in accordance with the requirements of *Guidelines for agricultural impact statements* (DP&I, 2012b) and *Guidelines for agricultural impact statements at the exploration stage (*DP&I, 2012c) and is provided in Appendix 2. The following chapter summarises relevant findings from the AIS.

8.1 Existing environment

The Dewhurst 13-18H pilot is located on private freehold and Crown land, adjacent to Jacks Creek State Forest. The surrounding land use is agriculture and forestry. The property has previously been used for low intensity stock grazing activities; however no commercial agricultural activity currently takes place. Some grazing of domestic stock still occurs.

The Dewhurst 26-31 pilot is located within the Pilliga East State Forest with surrounding land used for forestry purposes. This includes recreational activities such as bushwalking, camping and bird watching and other minor activities such as apiary uses (beekeeping) and timber harvesting. The site and its surrounds comprise similar landscapes offering minimal land use value for intensive agricultural purposes.

Figure 8-1 describes the land and soil capability of the two pilot sites.

DP&I (2012) identifies the two pilot sites and surrounding land as having high CSG resources and underground coal exploration potential. Both CSG and coal mining are growing industries within the region with numerous existing CSG wells, and a number of existing mines located within 100 kilometres of the pilot sites.

Extensive areas of land reserved for conservation and forestry lie in the middle of the catchment south of Narrabri. The proposed activity is not located within a conservation zone or an environmentally sensitive area of state significance, as described in Figure 8-2. Dewhurst 26-31 is not located within any mining titles, while Dewhurst 13-18H is located within Coal Authorisation 216, held by DTIRIS on behalf of the Crown.

8.1.1 Agriculture enterprise and resources

The dominant land use in the Namoi catchment is sheep and cattle grazing (51 per cent). Other agricultural activities within the surrounding Narrabri LGA include wheat, cotton and other broad acre crops which are commonly grown along the alluvial floodplains in the area.

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 been established in the Narrabri Shire (DP&I, 2012a), including:

- livestock selling centre
- farm management services
- grain and cotton processing centres
- grain and field bean merchant wholesalers
- agricultural research facilities
- crop harvesting selling centres.

The proposed activity is not located on or in the vicinity of any travelling stock routes (TSR). The nearest TSR is located approximately 11.5 kilometres north-west of Dewhurst 13-18H and 20.5 kilometres north of Dewhurst 26-31.

8.1.2 Soils

The soils across the region vary depending on the local sediment source. Australian Soils Classification (ASC) mapping identify the two pilot sites and much of the surrounding area as being dominated by Sodosols, with some occurrence of Rudosols/Tenosols. Sodosols are typical of those derived from the Pilliga Sandstone and are described as being highly siliceous with poor soil nutrient status, and low Plant Available Water Capacity (PAWC). Rudosols/Tenosols are mapped as occurring on and around the Dewhurst 27 lease area and are described as having a generally weak pedologic organisation.

Separate soil profiles collected by ESG and RPS at various locations between approximately one and twelve kilometres from the proposed activity also found soils to be either Rudosols/Tenosols or Sodosols.

In terms of erosional and sediment transport qualities, the AIS reports that a test site located 13.5 kilometres to the west of Dewhurst 13-18H was found to have slightly dispersive surface soil, while subsoils were found to be slightly to moderately dispersive. The nearest test site to Dewhurst 26-31 is located 10 kilometres north, with slight surface dispersivity, and high to very high subsoil dispersivity.

According to the *Draft Inherent Soil Fertility mapping of the New England – North West region* (OEH, 2012a), the inherent soil fertility of the two pilot sites is moderately low to low.

Soil characteristics of the pilot sites indicate moderate to severe limitations as the features of Sodosals, Tenosols and Rudosols such as low PAWC, low nutrient levels and sodicity all limit agricultural production.

Neither pilot site is expected to be contaminated. No spills or other incidents are known to have occurred during construction and previous operation of the Dewhurst 13-18H pilot that may have caused contamination. The Dewhurst 26-31 pilot is located on undeveloped forested land.

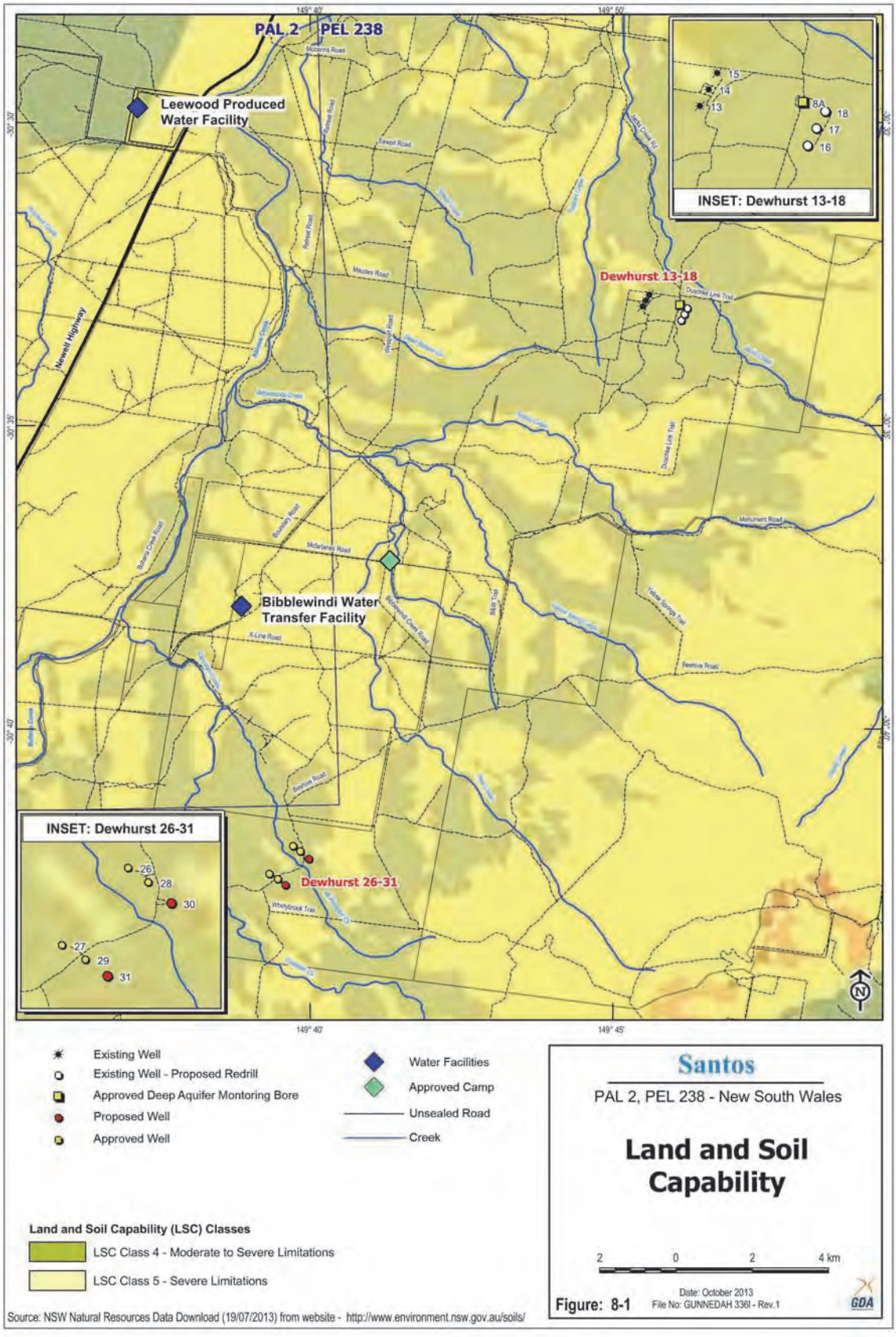


Figure 8-1 Land and soil capability

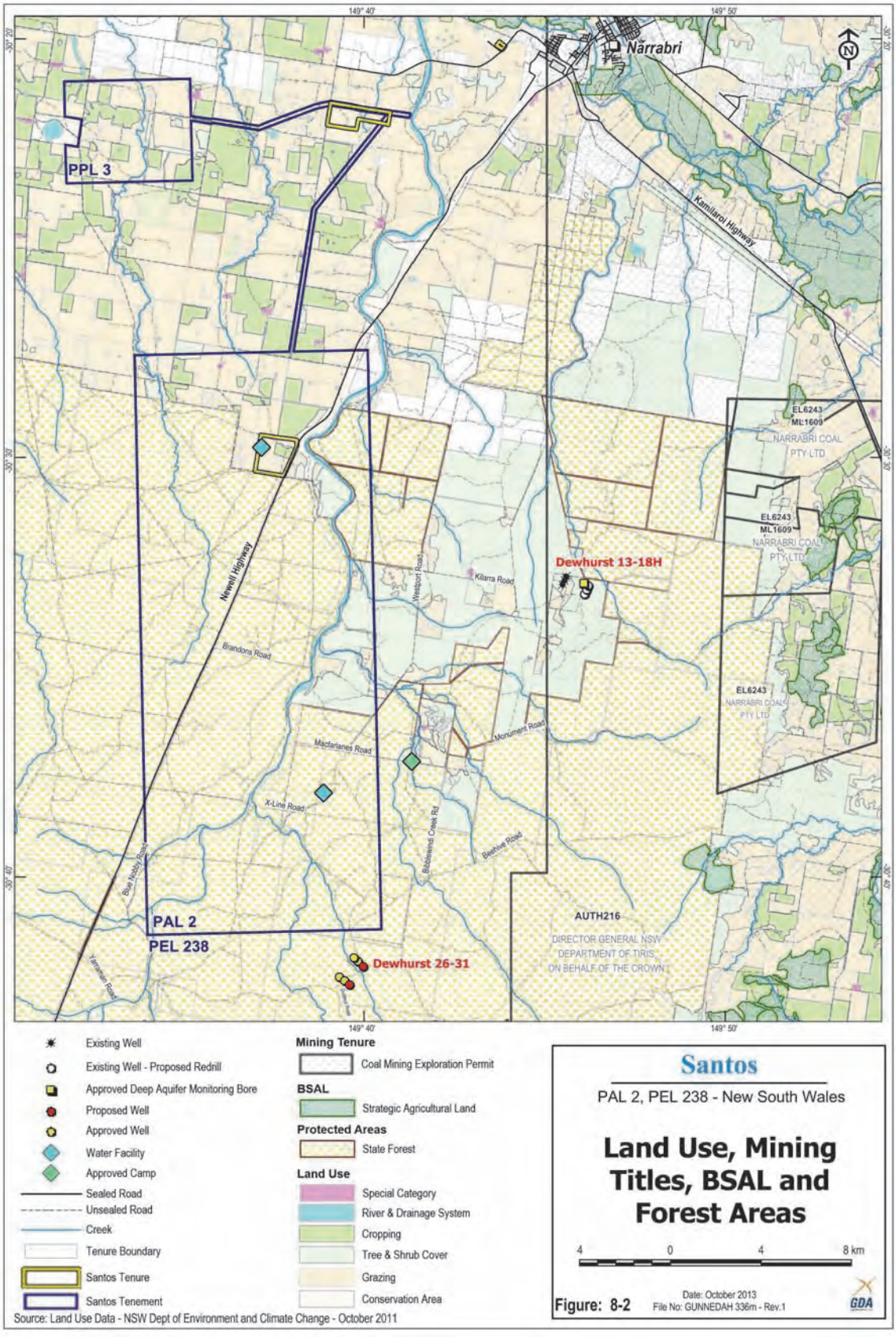


Figure 8-2 Land use, mining titles, BSAL and forest areas

8.1.3 Land and soil capability

SAL is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DP&I, 2012a). BSAL is land with the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity with minimal management practices (DP&I, 2012a). 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 (DP&I, 2012a).

As shown in Figure 8-2, neither pilot site is located within land mapped as BSAL or CIC under DP&I (2012). Based on the broad scale mapping provided in DP&I (2012), the nearest BSAL is located approximately 10 and 13 kilometres east of Dewhurst 13-18H and Dewhurst 26-31, respectively.

In NSW, LSCs 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), while class 8 represents land that can only sustain very low impact land uses (e.g. nature conservation).

The two pilot sites and surrounds have been mapped as LSC Class 4 and 5 (Figure 8-1). Lands in LSC Class 4 are described as having moderate to severe limitations and are generally not capable of sustaining high impact land uses unless using specialised land management practices with high level of knowledge, expertise, inputs, investment and technology. Lands in LSC Class 5 are described as having severe limitations and are not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (e.g. high value crops). The soil limitations are consistent with BSAL and Land and Soil Capability (LSC) Class mapping for the pilot sites.

8.2 Potential impacts

8.2.1 Land use

While the Dewhurst 13-18H pilot is located within a property used for agricultural activities, the proposed activity occurs within areas previously disturbed for CSG activities. In addition, no intensive agricultural activities are currently undertaken within the property, and the land on which it is located has low potential for commercial agricultural land use. All surface disturbance areas will be fully rehabilitated in consultation with the landowner and where applicable the permit to occupy, and as such there will be no permanent land capability reduction of agricultural resources.

As the proposed activity at Dewhurst 26-31 lies within a State Forest, it will not prohibit any agricultural production within the region, and there will not be any consequent reduction in the permanent land capability of agricultural resources. Furthermore, moderate to severe limitation of the site for agricultural production and its location within the State Forest means that it is highly unlikely that the site would be used for agricultural production in the long term. Production forestry is mapped within PEL 238, incorporating State forest used for timber harvesting and nature reserves. Timber harvesting within the Pilliga Scrub, including within the Jacks Creek or Pilliga East State forests has been reduced largely due to conservation efforts. Therefore such enterprises are not considered significant. The area to be disturbed at Dewhurst 30-31 (3.52 hectares) is negligible when compared to the extent of State forest remaining (over 190,000 hectares), available for timber harvesting or conservation purposes.

The proposed activity at Dewhurst 13-18H is predominantly located on existing lease areas that are previously cleared, and hence do not harbour honey tree species. 0.24 hectares and 2.2 hectares of Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest (containing potential honey trees) require clearing at Dewhurst 13-18H and Dewhurst 26-31, respectively. Due to the minimal clearance of potential

honey trees and the availability of these trees in the surrounding vegetation, the proposed activity is anticipated to have a negligible impact on the apiary industry.

Similarly there will be no change to existing recreational tourism opportunities in the Jacks Creek or Pilliga East State forests such as hiking, camping and bird watching. The presence of equipment and small stockpiles during the construction stage of the proposed activity will result in some visual clutter however this is unlikely to be noticeable other than by private landowners and forest users in the immediate area. During operation, the well heads and related surface infrastructure, including flares may be visible from the unnamed road to the north of Dewhurst 13-18H, Killara Road and Beehive Road. Due to vegetation cover, the Dewhurst 13-18H pilot (including the flare at Dewhurst 14) will not be visible from the residential dwelling located approximately 500 metres south of the Dewhurst 13 lease area.

8.2.2 Soil quality and land stability

8.2.2.1 Erosion

At Dewhurst 13-18H, the proposed activity will require minimal vegetation clearing, top soil removal and minor earthworks associated with construction of the gathering system corridor. Minor earthworks (approximately 30 square metres) will also be required at the existing well lease areas as part of drilling activities to establish the cellar pit near the location of the wells and the installation of subsurface infrastructure to connect the well to the new gathering system. The site footprint at Dewhurst 13-18H is approximately 5.37 hectares, of which 5.13 hectares is already disturbed.

At Dewhurst 30 and 31, the proposed activity will require vegetation clearing, top soil removal and earthworks for establishment of the lease areas and construction of the service corridors. The site footprint at Dewhurst 26-31 is approximately 3.52 hectares, of which 1.2 hectares will be disturbed. Micro-siting of lease areas and service corridors locations will be undertaken at Dewhurst 30 and 31 to minimise impacts of the proposed activity.

Any topsoil and spoil generated during site preparation activities will be stockpiled onsite for the duration of site preparation, drilling, testing and completion activities.

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. Potential impacts to surface waters are further discussed in Chapter 10.0.

The surrounding area at Dewhurst 13-18H is highly disturbed due to clearing for livestock grazing and existing CSG activities and the proposed activity is consistent with the surrounding area. The proposed disturbance to the ground surface occurs predominantly within existing lease areas, access tracks and along a public road, and as such the site is not considered to be overly sensitive to disturbance.

The ground surface at Dewhurst 30-31 may be sensitive to the disturbance due to the proposed activity, as it is greater than the current level of disturbance observed onsite. However, historically the site has been subject to varying disturbances including forestry activities, mining exploration, and disturbances from feral animals.

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

Delivery trucks and personnel vehicles entering the Newell Highway from unsealed roads may track sediment onto the highway. Erosion and sedimentation will be reduced through the measures identified in Section 8.4.

Potential erosion impacts are greatest during the site establishment, drilling and construction phases of the activity. During operation, the pilot sites will be rehabilitated to reduce erosion potential. Incomplete or inadequate rehabilitation of the pilot sites could create long term erosion and land stability issues.

Ongoing erosion impacts during operation associated with the existing Dewhurst 13-18H lease areas were assessed as part of previous approvals. Sediment controls already exist at each of these lease areas.

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

8.2.2.2 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 fluid as this will be water-based and will contain non-toxic additives. Drilling fluids and cuttings are therefore unlikely to be contaminated.

There is a risk that a line failure could occur within the gathering system that transfers lifted groundwater between the wells to the transfer tanks at each pilot. 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.

8.2.2.3 Community use of natural resources

As the proposed activity at Dewhurst 13-18H is predominantly being undertaken on already cleared land, it will not restrict agricultural activities within the property. Regardless, no commercial agricultural production currently occurs at the property on which the site is located.

The proposed activity at Dewhurst 30 and 31 will prohibit forestry activities on up to approximately 3.52 hectares during site establishment and drilling within the Pilliga East State Forest. This area will be reduced significantly during operation and only represents a small portion of the total size of State forests in the region (over 190,000 hectares).

Natural resources required for the proposed activity include diesel for operation of plant and machinery. Quantities of fuel will not be significant. These are discussed in Chapter 17.0.

The proposed activity will not impact on existing coal mining operations. No coal mines are known to be planned at the two pilot sites. It is expected that the proposed activity will pose no threat to future coal mining operations.

8.2.2.4 Soil diseases

The proposed activity may contribute to the spread of soil diseases, particularly *Phytopthora.* These potential impacts will be managed through the measures identified in Section 8.4.

8.3 Cumulative impacts

The area of land that is proposed for exploration activities in the E&A Program within PEL 238 and PAL 2 is approximately 107 hectares, which includes 28 hectares of existing infrastructure and well sites to be retained and 79 hectares of proposed infrastructure and well sites. This is approximately 0.013 per cent of land within PEL 238 and PAL 2.

The current extent of agricultural land use within PEL 238 and PAL 2 is approximately 791,478 hectares. None of the activities planned as part of the E&A Program are located on prime agricultural land (in terms of major agricultural industries e.g. cropping, grazing, horticulture and plantations). Although production forestry is mapped within PEL 238 and PAL 2, there are minimal exotic plantations. Rather, these areas include State forest used for timber harvesting and nature reserves (accounting for an additional 190,462 hectares). Timber harvesting within the Pilliga has been reduced largely due to conservation efforts; therefore any impact on such enterprises are not considered significant.

Cumulative impacts of the E&A Program to natural resources will be negligible as the majority of agricultural land and State forest will be fully rehabilitated and available for agricultural and forestry activities following completion of exploration activities. The E&A Program will also not quarantine any BSAL or CIC areas.

8.4 Mitigation measures

8.4.1 Construction

- Excess topsoil and subsoil generated during site preparation activities will be stockpiled onsite and used as backfill following completion of drilling.
- 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').
- Erosion and sediment controls will be implemented where necessary during construction activities, in accordance with best management practices (such as the Blue Book). These controls will be maintained until disturbed areas of the site are stabilised.
- The quantity of chemicals, fuels and oils stored onsite will be minimised, where practicable.
- All additives, chemicals, fuels and oils stored onsite will be kept in an appropriately secured, bunded storage shed in accordance with the relevant SDS.
- Where there is a risk of contamination pits will be lined or material will be stored in surface tanks or metal bins.
- An SDS register of all chemicals used or stored onsite will be maintained.
- Maintenance of vehicles, plant and equipment will occur offsite at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance onsite.
- 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 placed in a bag and removed from site for disposal at a licensed waste facility.
- Plant and equipment will be inspected daily to ensure these are properly maintained.

8.4.2 Operation

- Ongoing management and maintenance of remaining infrastructure onsite will occur, including water transfer area and well heads.
- The gathering system water pressure will be monitored. Should line failure occur between the wells to the transfer tanks at Dewhurst 14 and Dewhurst 28, operation of the well will be suspended until the problem is rectified.

8.4.3 Post-operation

The two pilot sites will be rehabilitated in accordance with Section 4.5 of the EIS.

9.0 Groundwater

A *Groundwater Impact Technical Report* has been completed by CH2MHill for the proposed activity (Appendix 3), and the assessment is summarised below.

9.1 Existing environment

9.1.1 Hydrogeological setting

The Upper Namoi and Lower Namoi Alluvium form the principal aquifers of the Namoi River Catchment. According to the relevant WSPs for the region, neither of the pilot sites are located within any mapped Upper Namoi and Lower Namoi Alluvium.

The Dewhurst 13-18H Pilot is located within the Eulah Creek sub-catchment while the Dewhurst 26-31 Pilot is located within the Bohena Creek sub-catchment, refer Section 10.1.1. AGE (2006) indicates that Bohena Creek is associated with an alluvial aquifer, 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 seven 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 watertable 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 a minimum 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 underlying the two pilot sites are associated with underlying basement rock units, and include the following:

- Southern Recharge groundwater source, under the WSP for the NSW GAB Groundwater Sources
- Gunnedah-Oxley Basin MDB buried groundwater source, under the WSP for the NSW MDB Porous Rock Groundwater Sources
- Lachlan Fold Belt MDB buried groundwater source, under the WSP for the NSW MDB Fractured Rock Groundwater Sources.

The southern recharge zone of the GAB underlies the two sites. The GAB covers 1.7 million square kilometres and contains 8,700 million megalitres 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 two sites, and underlies the area at a relatively shallow depth (20 to 30 metres). The Southern Recharge groundwater source, in which the sites lie, is characterised by better quality groundwater than other zones of the GAB.

The Gunnedah-Oxley Basin MDB Groundwater Source covers a subcrop area of 28,600 square kilometres. 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
- low to moderately permeable coal seams which are the prime water bearing strata within the Permian sequence.

The primary target CSG bearing seams for the proposed activity are the Bohena, Namoi and Rutley seams; lower Permian coals within the Maules Creek Formation as shown in Figure 9-1. Figure 9-1 provides a conceptual hydrogeological model of the Bohena trough, indicating the placement of CSG wells and associated monitoring bores in the various hydrogeological strata.

Groundwater pressures determined from Drill Stem Tests (DSTs) during exploration by ESG indicated groundwater levels between 247 to 385 metres AHD within the Maules Creek Formation (including the Bohena Seam). All the groundwater levels derived from DST were found to be artesian and were significantly higher than groundwater levels in the alluvium (Golder, 2011). There was no coherent groundwater flow direction apparent from the DST-derived head measurements, partly due to the varied zones over which the DSTs have been conducted and also because the likely lack of discharge from the formation.

The Lachlan Fold Belt MDB Groundwater Source covers an area of 167,220 square kilometres. 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 GAB 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). The aquifers that make up this groundwater source are located lower than the coal seams targeted as part of the proposed activity.

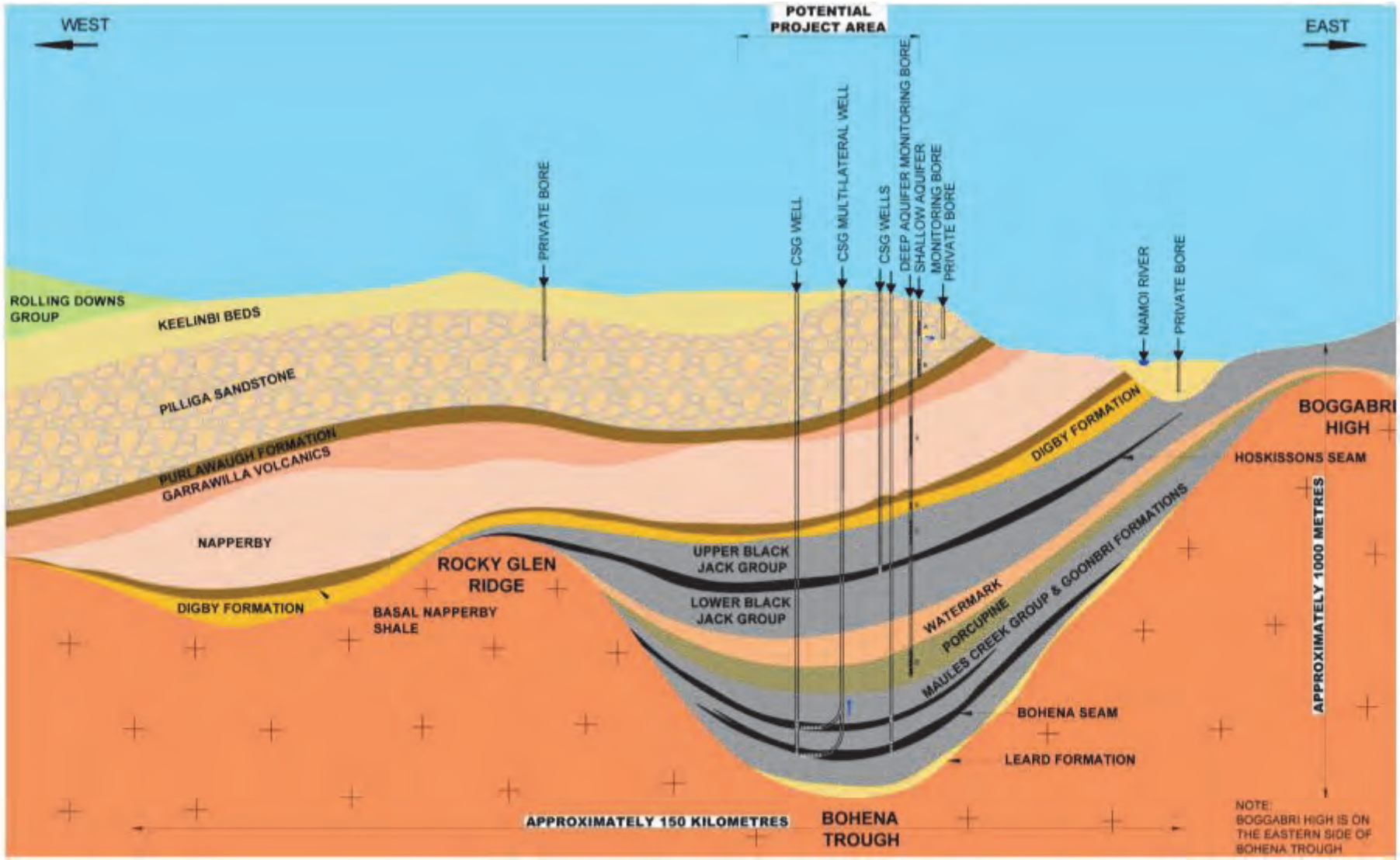


Figure 9-1 Schematic cross section through the Bohena trough (not to scale)

Source: Narrabri Groundwater Flow Model report (CH2MHill, 2013)

9.1.2 Groundwater use

Groundwater in the Namoi River catchment supports the irrigation industry and also provides the water supply for many towns and intensive industries. As the Upper Namoi and Lower Namoi Alluvium form the principal aquifers of the Namoi River Catchment they are heavily used for irrigation (Schlumberger Water Services, 2012). The Namoi catchment is licensed to provide over 343,000 megalitres of groundwater entitlement per year.

Groundwater use in close proximity to the two pilot sites is limited, due to both land use constraints arising from the sites being located within the Pilliga scrub and lower yields associated with the consolidated rock units. The Maules Creek Formation (including the target Bohena, Namoi and Rutley seams) is not currently used for water supply due to depth, water quality and availability of good quality groundwater near the surface.

According to the Pinneena database (NOW, 2010), there are 11 licensed groundwater bores within five kilometres of the Dewhurst 13-18H Pilot, while there are none within five kilometres of the Dewhurst 26-31 Pilot. Table 9-1 provides details of the registered groundwater bores in the vicinity of Dewhurst 13-18H.

Table 9-1 Registered groundwater bores within five kilometres of Dewhurst 13-18H Pilot

Bore ID	Easting	Northing	Max Depth (m)	GWMA	Authorised purpose	Water Bearing Zone (m)	Yield	Salinity
GW000336	762,229	6,620,096	66.4	GAB	Domestic/ stock	48.7-48.7	1.43	Good
GW000546	764,524	6,619,054	75.7	-	-	47.2-47.2	0.76	Good
GW002169	764,614	6,616,185	54.8	-	Domestic/ stock	54.8-54.8	0.76	Good
GW002191	761,730	6,616,040	56.4	-	-	50.9-50.9	0.63	Fresh
GW003052	767,261	6,620,743	72.2	-	-	62.4-70.9	1.01	Good
GW003587	764,421	6,614,834	72.5	-	-	69.1-69.1	0.45	Good
GW038774	763,882	6,614,601	76.2	GAB	Domestic/ stock	61.5-66.6	-	Good
						71.0-71.3	-	Good
						74.6-76.1	-	Good
GW045257	760,512	6,617,487	67.1	-	Domestic/ stock	46.3-47.5	0.15	Good
						48.5-65.6	0.38	Good
GW055085	763,296	6,615,694	65.0	-	Domestic/ stock	55.5-56.7	0.39	-
						61.7-65.0	0.69	-
GW059958	763,118	6,613,880	66.0	-	Domestic/ stock	52.0-65.0	0.50	Good
GW969324	764,015	6,615,005	71.0	GAB	Domestic/ stock	60.0-71.0	0.76	-

Source: Pinneena database (NOW, 2010)

9.1.3 Groundwater dependant ecosystems

There are three high priority groundwater dependent ecosystems (GDEs) listed within the NOW GDE database. These are Eather Spring, Hardy's Spring and Mayfield Spring, located approximately 10 and 20 kilometres to the east of Dewhurst 13-18H and Dewhurst 26-31, respectively. They are located on or close to the junction of the Pilliga Sandstone and Purlawaugh Formation at outcrop.

These springs are considered to represent recharge springs, sustained by rejection of rainfall recharge that doesn't enter the main GAB groundwater source. Recharge rejection occurs within the GAB intake beds

when the rate of recharge to the shallow groundwater sources exceeds the capacity for deep drainage into the GAB intake beds, principally due to low hydraulic conductivity of Purlawaugh Formation acting as a regional seal.

9.1.4 Water quality

A water quality assessment has been undertaken that included 317 samples from 126 sources; 178 samples collected from production/exploration wells in the Gunnedah and Narrabri region and 139 samples from the Regional Bore Inventory for the Gunnedah area (Golder, 2012). Groundwater samples were extracted from a number of formations including the Maules Creek (93 samples) and alluvial (11 samples).

Overall, groundwater pH values in the E&A Program area ranged from 6.81 to 11.2. Coal seam water in the Maules Creek Formation is slightly alkaline, with a range of 7 to 9. Based on TDS concentrations (measured at approximately 600 to 18,520 milligrams per litre), water from the coal seams can be classed as 'brackish to saline'. Alluvium and consolidated rock sources can be classed as 'fresh to brackish', with measured TDS between approximately 300 and 6000 milligrams per litre.

9.2 Assessment approach

A numerical groundwater flow model has been developed to simulate the potential cumulative impact on surface water and groundwater resources, and GDEs from the operation of the six pilot sites within the E&A Program. Initial model development included:

- data collation, literature review and gap analysis
- characterisation of the groundwater environment, including identification of environmental values associated with groundwater resources
- development of the hydrogeological conceptual model
- development of a groundwater flow model to facilitate the assessment of the potential impacts of CSG water extraction on water resources.

The numerical groundwater model was constructed using MODFLOW-2005 and the graphical user interface Groundwater Vistas interface V6.07 Build 18.

The model extends:

- eastward beyond the Boggabri Ridge to the eastern side of the Namoi River
- southward beyond the Walla Walla Ridge into the Bando Trough
- westward to the Rocky Glen Ridge
- northward beyond the Narrabri High and the Namoi River to the inferred location of the groundwater divide within the GAB (in accordance with groundwater level information presented in GABFLOW2000 (Welsh, 2000).

The modelling assumed that the operation of each of the six pilots will occur for a three year period. The estimated volumes of groundwater extracted from the target seams which were applied within the modelled operation scenario are provided in Table 9-2. Further details of the model and modelling process are provided in Appendix 3.

Table 9-2 Estimated extraction rates for pilots within the E&A Program

Pilot	Total Extraction (m^3)	Max Extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13-18 Pilot	331,121	397	302
Dewhurst 22-25 Pilot	285,140	273	260
Dewhurst 26-31 Pilot	413,801	448	378
Bibblewindi Multi-lateral Pilot	285,110	581	260
Bibblewindi West Pilot	92,940	209	85
Tintsfield 2-7 Pilot	25,162	43	23

There are no plans to use the process of hydraulic stimulation (also known as hydraulic fracturing or fracking) within the E&A Program.

9.3 Potential impacts

9.3.1 Construction

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

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

- creation of 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 if these are lost in the formation
- groundwater discharge to the surface, which may cause flooding or impact on surface water quality depending on the discharge and receiving water qualities.

Human consumptive uses and aquatic ecosystems may be impacted from these potential risks. These risks are rated as minor and are considered unlikely to occur as wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012b).

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

9.3.2 Operation

The assessment of potential groundwater impacts during operation was completed based on a cumulative approach, as outlined in Section 9.2. The outcome of this cumulative impact modelling is summarised in Section 9.4 below. The impacts of the proposed activity in isolation, while not modelled, would be much less than those predicted from the cumulative modelling.

9.4 Cumulative impacts

A detailed discussion of potential cumulative groundwater impacts, including relevant hydrographs and drawdown plots, is provided in the *Groundwater Impact Technical Report* (Appendix 3). A summary of the key outcomes, in regards to the Aquifer Interference Policy (AIP) is provided below. Impacts will be predominantly confined to the NSW MDB Porous Rock Groundwater Source WSP where the target seam is located. Water quality extracted from the target seam is highly brackish and unsuitable for drinking or irrigation without treatment.

9.4.1 Predicted impacts on the NSW Upper and Lower Namoi Groundwater Source WSP during operation of the pilot wells

The alluvial groundwater sources of the Upper and Lower Namoi alluvium (NSW Upper and Lower Namoi Groundwater Source WSP) are considered to be highly productive in the context of the AIP. The groundwater model predicts that there will be no significant decline in the water table or change in flux within these alluvial aquifers as a result of the operation of the E&A Program. This is due to the aquitard layers, including the Purlawaugh Formation, that separate the target coal seam from the alluvium.

9.4.2 Predicted impacts on the NSW GAB Groundwater Source WSP during operation of the pilot wells

The porous rock groundwater source of the GAB Surat Pilliga Sandstone (NSW GAB Groundwater Source WSP) is also considered to be a highly productive porous rock groundwater source in the context of the AIP. Groundwater modelling results indicate that there is no significant decline in groundwater level or change in flux within this aquifer during operation of the E&A Program. This is again due to the aquitard layers, including the Purlawaugh Formation, that separate the target coal seam from the GAB.

9.4.3 Predicted impacts on the NSW Murray-Darling Basin Porous Rock Groundwater Source WSP during operation of the pilot wells

The porous rock groundwater source of the Gunnedah-Oxley Basin MDB (NSW MDB Porous Rock Groundwater Source WSP) is considered a less productive porous rock groundwater source in the context of the AIP. This groundwater source comprises the Triassic strata of the Digby, Napperby and Deriah formations and the Permian strata of the Black Jack Group down to and including the Maules Creek Formation.

These different strata are represented in the groundwater model as separate layers, with the CSG water extraction occurring in the lowest layers. A decline in head of over two metres within the lowest strata is predicted by the model. Given that the targeted coal seams fall within the lower strata (Maules Creek Formation) of this water source, the impact on hydraulic (pressure) head within the combined group of the three strata and the fluxes developed within the groundwater source to meet the pilot CSG water demand are interpreted to comprise aquifer interference.

The zones of influence remain west of the outcrop of the Gunnedah Basin Permo-Triassic strata. Hence the registered bores which extract from the Gunnedah-Oxley Basin MDB groundwater source will not be impacted by the pilot CSG water extraction.

9.4.4 Predicted impacts on registered water supply bores

All of the registered bores within five kilometre of the proposed activity are understood to extract water from the Pilliga Sandstone. The Pilliga Sandstone of the Surat Basin is considered the lowest (and most easterly) intake beds of the GAB. As stated above, this aquifer will not be significantly impacted by the proposed activity during either construction or operation.

There is no known registered extraction from bores in formations deeper than the Pilliga Sandstone across the E&A Program area. From the modelling result, the predicted cumulative impact on registered water supply bores across this extent will not be significant.

9.4.5 Predicted impacts on high priority Groundwater Dependant Ecosystems and related vegetation

Hardy's, Eather and Mayfield Springs are hydrogeologically associated with the Pilliga Sandstone. As there is no significant impact to the Pilliga Sandstone, there is expected to be no significant impact on the GDEs

due to the proposed activity. Similarly, the model results indicate that there will be no significant impact on groundwater dependent terrestrial vegetation within the E&A Program area.

Discussion on the occurrence of stygofauna communities and potential impacts of the proposed activity on these communities are provided in Section 11.3.5.

9.5 Mitigation measures

9.5.1 Construction

- The wells will be designed and constructed in accordance with the *NSW Coal Seam Gas Code of Practice Well Integrity* (DTIRIS, 2012b).
- 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 the EIS.
- A driller that holds the relevant qualifications as defined by NOW will be on site during drilling of the top hole 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 surface and groundwater sources.
- Excessive drilling fluid 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 two kilometres of the two pilot sites 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 water quality observations in the field, and sampling for analysis by an accredited laboratory.

9.5.2 Operation

- The volume of water extracted from the pilot wells will be monitored.
- Pressure gauges will be fitted to the pilot wells, and monitored remotely through a SCADA system. Should pressure change due to a leak, the pilot wells will be shut down immediately and the affected area investigated.
- The groundwater monitoring program will be implemented.
- In line with monitoring during drilling, Santos will make reasonable endeavours to seek permission (from landowners) to continue monitoring of registered groundwater bores within two kilometres of the two pilot sites to determine if there are any impacts to aquifers.
- The wells will be decommissioned as soon as they are no longer required.

9.5.3 Proposed groundwater monitoring program

The monitoring of groundwater is required to confirm the absence or onset (and magnitude) of any impact associated with CSG activities at both the deep and shallow aquifer level. Registered bore users extract water from the shallow aquifers and while modelling has concluded that this will not be impacted, long-term monitoring over the duration of the CSG operations is proposed.

Santos is currently implementing a comprehensive groundwater monitoring program. This program was presented and discussed with NOW and was approved by the OCSG on 9 July 2013.

The groundwater monitoring program proposes to include installation of shallow aquifer monitoring bores (SAMBs) at eight locations and one deep aquifer monitoring bore (DAMB) over the next 12 months. The proposed location of these bores is provided in Figure 9-2, noting these are subject to change as required. A number of the monitoring locations already have relevant licences issued by NOW under the *Water Act 1912*.

Once installed, these monitoring bores will measure groundwater pressure and temperature within various strata and enable groundwater levels and flows to be monitored. Information will be transmitted via telemetry to a production database. The bores will not extract any groundwater beyond what is extracted during drilling and required for water quality sampling, where this occurs.

Baseline data gathered will include groundwater heads (pressures) within the hydraulically confined strata of the Gunnedah Basin and groundwater levels within these unconfined Permo-Triassic strata at or close to outcrop and subcrop. This will help to establish the baseline conditions prevailing before the commencement of any pilot trials within the wider region. The SAMBs will focus on:

- demonstrating the baseline groundwater levels and the background flow pattern within the Pilliga Sandstone
- confirming the groundwater pressure in the Purlawaugh Formation
- verifying the confining characteristics of the Orallo formation overlying the Pilliga Sandstone.

The DAMB will focus on:

- demonstrating the baseline groundwater pressures and the background flow patterns/existing hydraulic gradients within the hydrostratigraphic units of the Gunnedah Basin
- illustrating the absence or otherwise of vertical hydraulic continuity within the Gunnedah Basin strata
- enabling elaboration of the migration of groundwater depressurisation both laterally in the target seam and vertically above and below the target seam, following the commencement of CSG water extraction.

The proposed location of the monitoring network has been arranged to maximise the acquisition of beneficial data which can:

- inform the absence or otherwise of potential impact to the regional GAB aquifers
- act as sentinel monitoring locations between the E&A Progam area and groundwater abstractions in the Gunnedah Basin domain
- yield essential hydrogeological data comprising additional stratigraphic data, remote head and field testing data and cores for laboratory testing of hydraulic parameters.

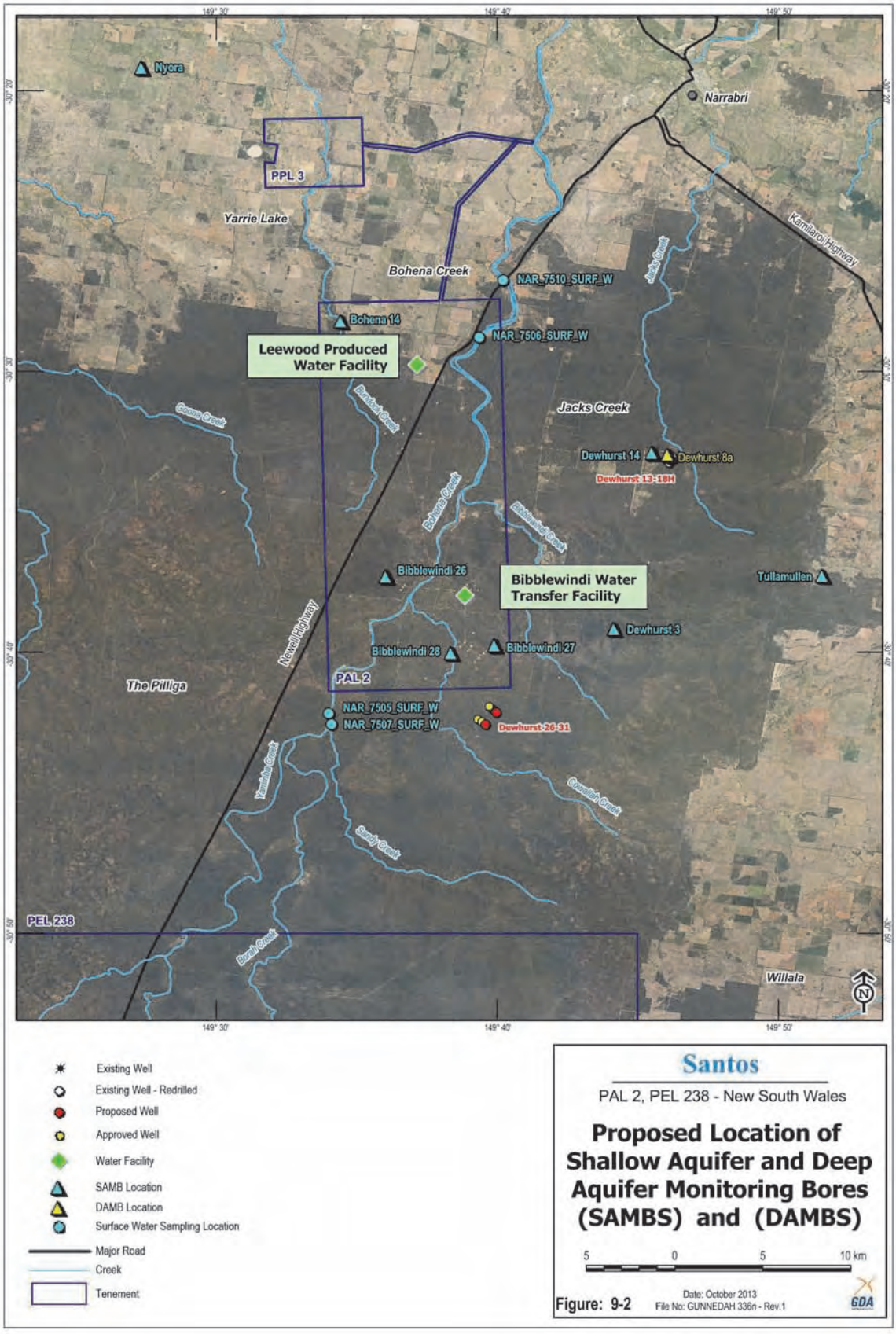


Figure 9-2 Proposed locations of shallow aquifer and deep aquifer monitoring bores

9.5.4 Licensing

Under section 60I of the WMA, a WAL is required to take water in the course of carrying out a mining activity. During their operation, the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot are expected to extract a maximum of approximately 331 and 414 megalitres of groundwater over three years from the Gunnedah-Oxley Basin MDB groundwater source under the NSW MDB Porous Rock Groundwater Source WSP, respectively. Santos has been granted a 'certificate of right to apply for an access licence' of 600 unit shares from within the Gunnedah-Oxley Basin MDB groundwater source by NOW. An application for a WAL of 600 megalitre per annum for this water source (one unit share is currently equal to one megalitre of water) has been made. Santos also currently holds a 20 unit share aquifer access licence entitlement for this same groundwater source.

10.0 Surface water

10.1 Existing environment

10.1.1 Surface water catchment

The two pilot sites are located within the Namoi River catchment which covers an area of approximately 42,000 square kilometres 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, 2013).

Given the dominant use of the land in the Namoi catchment as grazing and both dryland and irrigated cropping (refer Chapter 8.0); surface water quality within the catchment is likely to be influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2013).

Figure 10-1 shows the regional drainage within the vicinity of the proposed activity.

Dewhurst 13-18H is located within the Eulah Creek sub-catchment of the Namoi River catchment. The Eulah Creek sub-catchment covers an area of approximately 1581.4 square kilometres, which extends both north and south of the Namoi River. On the southern side of the river, the sub-catchment is drained by a number of creeks including Jacks, Kurrajong, Sandy, Pine and Tulla Mullen (Eco Logical, 2009).

The Eulah Creek sub-catchment forms the Eulah Creek Water Source under the *WSP for the Namoi Unregulated and Alluvial Water Sources* (NOW, 2012c). A search of NOW's website indicated that there are currently no records of any WAL under the WMA within this water source (NOW, 2013). This could be attributed to the ephemeral, and therefore unreliable, nature of the surface water that it is not used as a water resource.

Jacks Creek (the closest direct Namoi River tributary to the Dewhurst 13-18H pilot) and its tributaries are ephemeral, generally flowing for short periods following significant rainfall or prolonged wet periods. Baseflows in these creeks are insignificant. Jacks Creek remains dry for extended periods between runoff events, sometimes for periods in excess of 12 months and it contributes little inflow to the Namoi under normal conditions.

Dewhurst 26-31 is located within the Bohena sub-catchment of the Namoi River catchment. The 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, 2013). Issues within the sub-catchment include soil erosion, biodiversity conservation, water quality and riparian management.

The Bohena sub-catchment forms the Bohena Creek Water Source under the *WSP for the Namoi Unregulated and Alluvial Water Sources* (NOW, 2012c). A search of NOW's website indicated that there are currently no records of any WAL under the WMA within this water source (NOW, 2013). Again the ephemeral nature of the surface water means that it is not used as a water resource.

Bohena Creek and its tributaries are ephemeral watercourses that do not form significant topographical features within the landscape. They generally flow for short periods following significant rainfall or prolonged wet periods (WRM, 2006). Baseflows in these creeks are insignificant. Bohena Creek remains dry for extended periods between runoff events, sometimes for periods in excess of 12 months (WRM, 2006). It contributes little inflow to the Namoi under normal conditions; however during protracted wet conditions, significant flood inflows to the Namoi can be generated. Sedimentation in the catchment has resulted in extensive sand deposits in Bohena Creek and its tributaries. Due to the ephemeral nature of Bohena Creek, it can be inferred that the extensive sand deposits are caused by intense rainfall events that mobilise and rework sediment.

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 watercourses in this area. Details of the water quality measured at this sampling location on Bohena Creek are provided in Table 10-1.

Table 10-1 Water quality measured in Bohena Creek (station number 419905) from 2002–2007

Parameter	Minimum	25th percentile	Median	75th percentile	Maximum
EC (µS/cm)	148	184	185	192	327
Turbidity (NTU)	17	57	76	82	130
Total Phosphorus (mg/L)	0.061	0.063	0.073	0.099	0.107
Total Nitrogen (mg/L)	0.52	0.57	0.62	0.78	0.91

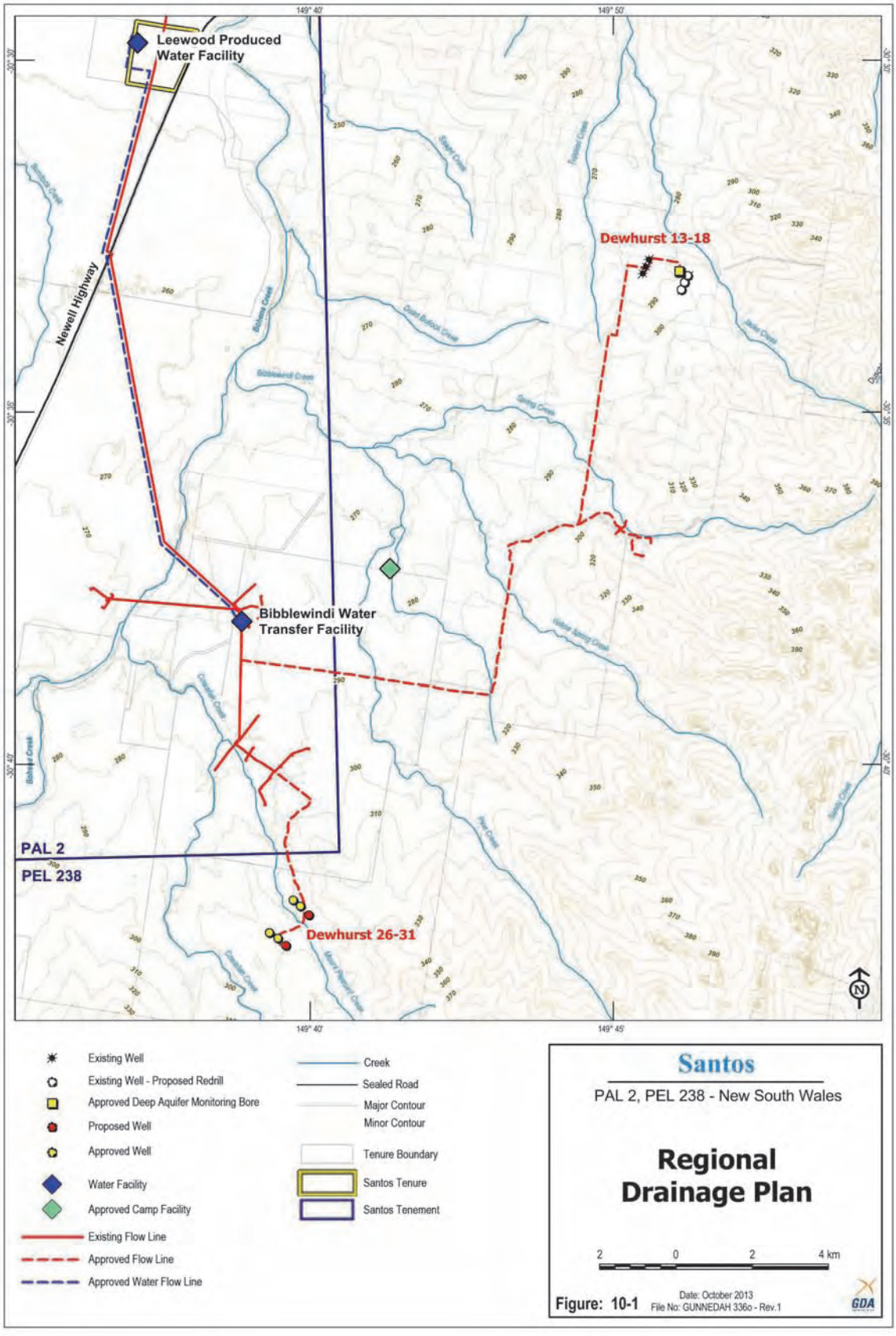


Figure 10-1 Regional drainage plan

10.1.2 Site drainage and local surface waters

The local drainage lines within the vicinity of Dewhurst 13-18H are shown in Figure 3-1. An unnamed tributary of Tuppiari Creek is mapped flowing from east to west across the site, crossing the gathering system between the Dewhurst 14 and 15, and Dewhurst 16H and 17H lease areas. Tuppiari Creek is a tributary of Jacks Creek, with its confluence approximately 5.5 kilometres north of the site. Jacks Creek itself is located approximately 0.5 kilometres north-east from the gathering system. Despite its presence on maps, no discernible indication of the unnamed drainage line was observed during the site inspection in January 2013.

According to a stream order classification assessment, Jacks Creek is considered to be a fourth order watercourse (as defined under the WMA, using the Strahler System). Tuppiari Creek is a second order watercourse, while the unnamed tributary of Tuppiari Creek is a first order watercourse (Table 10-2).

Table 10-2 Dewhurst 13-18H proximity to drainage lines and creeks

Water course	Stream order	Distance from Dewhurst 13 lease area (km)	Distance from Dewhurst 18H lease area (km)
Unnamed tributary of Tuppiari Creek	1st	0.2	1.2
Tuppiari Creek	2nd	1.2	2.5
Jacks Creek	4th	1.3	0.7

Three watercourses intersect Dewhurst 26-31, including Mount Pleasant Creek and two of its tributaries. These watercourses flow north-west to Cowallah Creek (refer Figure 3-2). At its closest point to the Dewhurst 26-31 footprint, Cowallah Creek is located approximately 1.6 kilometres east of Dewhurst 27. Cowallah Creek is a tributary of Bohena Creek.

According to a stream order classification assessment, Bohena Creek is considered to be a fifth order watercourse which exhibits generally good landscape condition. Cowallah Creek is a relatively undisturbed fourth order watercourse. Mount Pleasant Creek is a moderately eroded third order stream, while the unnamed tributaries of Mount Pleasant Creek are first order watercourses (Table 10-3). Stream Order was determined based on drainage lines captured from orthophotos at 1:50,000 and 1:25,000 scale.

Table 10-3 Dewhurst 26-31 proximity to drainage lines and creeks

Water course	Stream order	Distance from Dewhurst 26 lease area (km)	Distance from Dewhurst 31 lease area (km)
Unnamed tributary of Mount Pleasant Creek (western)	1st	0.4	0.2
Unnamed Tributary of Mount Pleasant Creek (eastern)	1st	0.5	0.7
Mount Pleasant Creek	3rd	0.2	0.5
Cowallah Creek	4th	2.8	2.4
Bohena Creek	5th	7.2	7.5

The more westerly unnamed tributary of Mount Pleasant Creek is mapped as crossing the southern section of the proposed Dewhurst 30 lease area (refer to Figure 3-2). Despite its presence on maps, no discernible indication of the unnamed drainage line was observed during site inspections in November 2012 and August 2013.

10.1.3 Geomorphology

Dewhurst 26-31 and Dewhurst 13-18H are located 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 watercourses 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), Bohena Creek is 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.

Lambert and Short (2004) summarise the geomorphic units of the low sinuosity, sand river style as a single, laterally unconfined and relatively active channel set within a slightly undulating, wide and continuous floodplain. The channel bed is a relatively featureless, mobile sand sheet with scattered gravels, while the banks are composed of fine sands with some silt and organic matter.

Mount Pleasant Creek is approximately three to four metres wide, with gentle banks characterised by sandy soils (Plate 10-1) that flow into Cowallah Creek. Deposition was not apparent and there was some evidence of bank erosion during a site visit in November 2012. Where observable, the tributaries of Mount Pleasant Creek are characterised by small tightly ephemeral channels (Plate 10-2). These tributaries are approximately one metre wide, with gentle banks. Active erosion was not evident during the site inspection in November 2013.

All watercourses of Dewhurst 26-31 and Dewhurst 13-18H appear to be 'losing' streams (where water is lost to the underlying groundwater), and therefore not groundwater influenced. Water levels in these ephemeral creeks are more likely to be affected by water backing-up the tributary, when water levels in Mount Pleasant Creek (Dewhurst 26-31) and Tuppiari Creek (Dewhurst 13-18H) are high, then by runoff flows within the tributary catchment. Only large catchment flows would activate erosion in this creek line and mobilise sediments.

There are a number of floodplains declared under the *Water Act 1912* located nearby but not onsite. The closest to Dewhurst 26-31 is the Namoi River: Carroll to Boggabri floodplain, located approximately 36 kilometres to the east, while the closest to Dewhurst 13-18H is the Namoi River: Narrabri to Wee Waa floodplain, located approximately 28 kilometres north.

Both Dewhurst 26-31 and Dewhurst 13-18H are not located within a drinking water catchment; however surface water would filter to groundwater which is potentially used for drinking water in the surrounding areas.



Plate 10-1 Mount Pleasant Creek



Plate 10-2 Mount Pleasant Creek tributary (offsite)

10.1.4 Values of receiving waters

Water Quality and River Flow Objectives have been defined for uncontrolled streams within the Namoi catchment (DECCW, 2006). The relevant objectives and how the proposed activity will achieve these objectives are outlined in Table 10-4. The key indicators and trigger values provided as guideline levels within the Water Quality Objectives for the Namoi catchment are adopted from the Australian and New Zealand Environment and Conservation Council (ANZECC) 2000 guidelines or *Australian Drinking Water Guidelines* (NHMRC and NRMMC 2011).

Table 10-4 Relevant water quality and river flow objectives for Dewhurst 26-31 and Dewhurst 13-18H.

Objective	Description of objective	How the proposed activity will meet objective
Water Quality Objectives		
Aquatic ecosystems	Maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term	The two pilot sites will be managed to ensure that no water used for drilling and operation is discharged to drainage lines and that existing salinity, turbidity and pH levels of surface waters are maintained.
Visual amenity	Aesthetic qualities of waters	The two pilot sites will be managed to ensure that no water, oil/fuel or debris is discharged to 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 watercourses.
Livestock water supply	Protecting water quality to maximise the production of healthy livestock	Due to its ephemeral nature, surface water in the vicinity of the two sites is not used to supply livestock, irrigation or homestead water. The *Groundwater Impact Technical Report* (Appendix 3) determined that the aquifers which may be used for livestock, irrigation or homestead water supply will not be significantly impacted upon by the proposed activity. The wells 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	
Homestead water supply	Protecting water quality for domestic use in homesteads, including drinking, cooking and bathing	
Drinking water – Disinfection only, or Drinking water – Clarification and Disinfection, or 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 potential drinking water from raw surface or groundwater sources.
River Flow Objectives		
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	
Protect important rises in water levels	Protect or restore a proportion of moderate flows ('freshes') and high flows	
Maintain wetland and floodplain inundation	Maintain or restore the natural inundation patterns and distribution of floodwaters supporting natural wetland and floodplain ecosystems	The proposed site footprint at Dewhurst 13-18H and Dewhurst 26-31 is approximately 5.37 ha and 3.52 ha, respectively. This extent of disturbance will not alter flooding patterns.

Objective	Description of objective	How the 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 Technical Report* (Appendix 3) determined that the aquifers which may feed GDEs and baseflows will not be significantly impacted upon by the proposed activity. The wells will be constructed in accordance with industry standards and will isolate aquifers.

10.1.5 Santos surface water monitoring program

Surface water monitoring is important in predicting and measuring the potential impact of CSG activities within the Namoi catchment. To enable this, the baseline water quality characteristics of the catchment must be understood, against which change can be measured and monitored.

URS has designed and implemented a baseline surface water sampling plan for Santos within the Narrabri Region. The sampling program commenced in February 2012, with approximately 30 locations considered to be 'regular' monitoring sites throughout the monitoring program period to date. Due to the ephemeral nature of tributaries within the Namoi catchment, including Bohena Creek, some locations can only be monitored periodically. The closest regular monitoring points to Dewhurst 13-18H and Dewhurst 26-31 are described in Table 10-5 and shown on Figure 9-2.

Table 10-5 Regular surface water monitoring locations

Monitoring ID	Site description	Easting	Northing	Number of samples (Feb 2012 – Jun 2013)	Distance from pilots (km)	
					Dewhurst 13-18H	Dewhurst 26-31
NAR_7505_SURF_W	Bohena Creek upstream of Bibblewindi site	745875	6600481	2	24	8
NAR_7506_SURF_W	Bohena Creek off Newell Hwy picnic area	755014	6625004	11	12	24
NAR_7507_SURF_W	Garlands Dam	746022	6599750	16	25	8
NAR_7510_SURF_W	Bohena Creek crossing, Newell Hwy	756470	6628742	11	14	28

Six locations were also monitored on an *ad hoc* basis. This monitoring is generally undertaken to quantify potential environmental impacts observed in the field, and/or to capture additional data during wet weather events. Most of the locations are situated on ephemeral tributaries which are known to flow only in prolonged wet periods, and are therefore not considered to be viable for long-term baseline monitoring on a regular basis. The closest additional monitoring points to Dewhurst 13-18H and Dewhurst 26-31 are described in Table 10-6.

Table 10-6 Additional surface water monitoring locations

Monitoring ID	Site description	Easting	Northing	Number of samples (Feb 2012 – Jun 2013)	Distance from pilots (km)	
					Dewhurst 13-18H	Dewhurst 26-31
NAR_7500_SURF_W	Tributary upstream of Bibblewindi WTF	754865	6604386	1	16	4
NAR_7501_SURF_W	Tributary downstream of Bibblewindi WTF	753042	6608471	1	14	8
NAR_7522_SURF_W	Bohena Creek downstream of confluence with Cowallah Creek	751182	6608728	1	16	9
NAR_7539_SURF_W	Bohena Creek upstream of confluence with Bibblewindi Creek	752086	6609903	1	14	10

Sampling is undertaken in accordance with the requirements of AS/NZS 566.6:1998, *Guidance on sampling of rivers and streams.*

In situ measurements for physico-chemical parameters are obtained at each monitoring location using a water quality meter. The following *in situ* parameters are recorded:

- pH
- Dissolved Oxygen (DO)
- electrical conductivity (EC)
- Total Dissolved Solids (TDS)
- water temperature.

Surface water samples are obtained using the grab sampling technique, a sample methodology set out in AS/NZS 5667.1:1998 and 5667.6.1998, and with consideration of ANZECC Guidelines and Water Quality Objectives in NSW. A suite of analysis is undertaken by a National Association of Testing Authorities (NATA) accredited laboratory.

Reporting is undertaken monthly following completion of the laboratory analysis and an annual characteristic report is currently being completed. As part of this report, the frequency and locality of the sampling is being reviewed based on the results to date. It is anticipated that surface water sampling will continue for the life of the CSG program to meet requirements of future regulation and environmental assessment.

Summaries of the data collected to date are provided in Table 10-7 and Table 10-8 for the regular and additional monitoring locations, respectively. Note that as only one sample event occurred for the additional monitoring locations, minimum, median and maximum values are not provided in Table 10-8.

Table 10-7 Regular surface water monitoring locations – data summary

Parameter	NAR_7505_SURF_W			NAR_7506_SURF_W			NAR_7507_SURF_W			NAR_7510_SURF_W		
	Min	Med	Max	Min	Median	Max	Min	Median	Max	Min	Median	Max
EC (µS/cm)	147	N/A	512	118	180.5	224	80	118	202	117	204.5	301
TDS (mg/L)	N/A	586	N/A	87	132.5	172	112	156	410	124	152	210
DO (mg/L)	7.58	N/A	9.38	4.29	7.5	9.47	4.76	6.94	12.79	5.7	7.16	8.4
Dissolved Organic Carbon (mg/L)	15	N/A	36	9	10.5	18	4	15	19	14	17	20
PAH (mg/L)	<0.0155	N/A	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155	<0.0155
pH	7.12	N/A	8.03	6.71	7.36	7.69	7.38	7.54	8.25	6.9	7.39	7.57
Total N (µg/L)	700	N/A	1300	400	600	1100	400	1000	2000	800	1000	1100
Total P (mg/L)	0.11	N/A	0.17	0.02	0.04	0.2	0.01	0.06	0.18	0.01	0.09	0.15
Sum of BTEX (µg/L)	<1	N/A	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Turbidity (ntu)	109	N/A	165	2.5	18.6	101	18.1	44.1	83.6	13.1	38.5	167

Table 10-8 Additional surface water monitoring locations – data summary

Parameter	NAR_7500_SURF_W	NAR_7501_SURF_W	NAR_7522_SURF_W	NAR_7539_SURF_W
EC (µS/cm)	124	272	448	435
TDS (mg/L)	-	177	290	284
DO (mg/L)	5.5	2.64	7.17	7
Dissolved Organic Carbon (mg/L)	21	79	9	8
Polycyclic Aromatic Hydrocarbons (mg/L)	<0.0155	<0.0155	<0.0155	<0.0155
pH	7.02	7.55	7.9	7.97
Total N (µg/L)	1100	5200	500	500
Total P (mg/L)	0.11	0.76	0.1	0.08
Sum of BTEX (µg/L)	<1	<1	<1	<1
Turbidity (ntu)	203	709	37.2	36.5

10.2 Potential impacts

Potential surface water impacts are greatest during construction and drilling. During operation, potential surface water impacts will be limited to those associated with leakages from the gathering system.

10.2.1 Surface water flow regimes

At the Dewhurst 13-18H pilot, the proposed activity will not result in any change to the existing approved disturbed areas during construction or operation. Some minor redirection of flow already occurs as a result of sediment controls and drainage bunding on the existing lease areas.

Similarly, sediment controls and drainage bunding to be installed at the proposed Dewhurst 30 and 31 lease areas will result in some minor redirection of flows.

Changes to the area, volume or flow of the surrounding surface watercourses, including Mount Pleasant Creek, Jacks Creek, Tuppiari Creek and Cowallah Creek are unlikely to occur particularly during drilling as activities will not be undertaken during prolonged wet periods.

10.2.2 Surface water quality

Potential impacts of the proposed activity on surface water quality include:

- sedimentation of waterways
- impacts to water quality from sediment laden runoff or chemical spills
- contamination to surface water from produced groundwater.

Bank erosion of tributaries, Mount Pleasant Creek, Cowallah Creek, Jack Creek and Tuppiari Creek is not anticipated. Creek banks are either indiscernible or gentle and are largely vegetated, and thus are not susceptible to erosion. Further, produced water will not be discharged into the local catchment or any drainage features and therefore increased erosion is not anticipated from the proposed activities.

Drilling fluids will be captured in tanks where it will be re-used or taken to the FTF. Some fluids could be spilt as a result of tank failure, during the drilling process, or during transit to and from site. This could result in pollution of drainage lines or watercourses with sediment and other contaminants, but this is considered unlikely given the level sensors fitted to tanks and the use of licensed waste transport operators. The proposed activity will only require small volumes of fluids to be transported to and from site with the potential for spills and/or leaks being minor and likely to remain localised. In the event of an incident, appropriate measures to contain and remediate areas of impact will be initiated.

There is potential for chemicals, fuels or oils used or stored onsite to leak or spill and enter drainage lines and degrade local water quality. Pollutants or wastewater could also be discharged to these watercourses during general site activities such as vehicle washing or dust suppression. Litter from personnel onsite may enter watercourses and degrade water quality. Surface runoff and gross pollutants 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, outlined in Section 10.3. An uncontrolled discharge to the environment could occur due a leak onsite at the lease areas or within the gathering system network. If this were to occur, there could be localised impacts to surface water. Due to the regular monitoring and inspection protocols that will be implemented, the extent of the impact will be minor, localised and short term.

Santos will operate the two pilot sites in accordance with the requirements of an EPL.

10.2.3 Local surface water resources and users

There are no existing permanent surface water features, and hence resources, in the vicinity of the two pilot sites. Water for the drilling and onsite requirements will be sourced from town water or a producing well, rather than a natural/local surface water body.

Due to the ephemeral nature of the creeks within the Bohena Creek and Eulah sub-catchments, there are currently no WALs issued within these water sources. Therefore there are no registered surface water users that will affected by the proposed activity.

10.2.4 Flooding

The proposed activity will not result in any significant change to the existing disturbed areas at Dewhurst 13-18H. However, 2.2 hectares of vegetation clearing will be required for the Dewhurst 30 and 31 lease areas and associated gathering systems. The impact to the extent, frequency or duration of flooding as a result of this clearance will be low.

In addition, the two sites are not located within a designated floodplain and the proposed activity is unlikely to significantly affect the distribution or flow of floodwaters.

For these reasons a detailed flood impact assessment was not considered necessary as part of this EIS. There is still potential that sediment, contaminants or gross pollutants may be released into watercourses as a result of localised flooding and inundation of the site during construction although given the scale of the activity, this is likely to be minor.

10.3 Cumulative impacts

Due to the staggered implementation of the construction phase across the E&A Program and the distances between sites, cumulative impacts to surface water are considered to be negligible.

During operation, the water management strategy proposed as part of the E&A Program includes a number of measures to reduce any impacts to surface water as a result of a spill or leak. This includes:

- remote monitoring, sensors and pressure gauges at all well heads and along key infrastructure nodes
- balance tanks to manage the volume and pressure of water
- the ability to remotely shut in wells at the well head if any leaks are detected
- a leak collection system at the Leewood Produced Water Facility
- double lining of ponds
- water level monitoring of ponds.

No produced water from either Dewhurst 13-18H and Dewhurst 26-31 will be transferred to the existing ponds at the Bibblewindi WTF.

Similar to construction, cumulative impacts to surface water during operation are considered to be negligible as any leakages that may occur will be localised and short term given the leakage detection and automated shutdown systems proposed.

10.4 Mitigation measures

The erosion and sediment control measures identified in Section 8.4 will minimise impacts to surface water and the two pilot sites will be rehabilitated in accordance with Section 4.5 of the EIS. The following additional measures will be implemented:

10.4.1 Construction

- Water will not be extracted from nearby watercourses, including Mount Pleasant Creek, Tuppiari Creek, Cowallah Creek or Jacks Creek.
- The existing diversion bund at Dewhurst 13-18H will be maintained on the up-slope side of the lease areas to divert clean water around the work area.
- Diversion bunds will be installed and maintained for the Dewhurst 30 and 31 lease areas.
- Drilling fluids will be contained in surface tanks which will be regularly inspected and maintained.
- Water that drains to the cellar pit will be circulated with the drilling fluid throughout the drilling process.
- Should any formation fluid rise through the well, it will be captured in the waste fluid tank and will be removed to a licensed waste facility that is able to accept liquid waste for disposal or treatment.
- Drilling fluids will be transported to and from site by an appropriately licensed contractor.
- Fuel and lubricants will be stored onsite only when necessary and maintained offsite whenever possible.
- Wastewater generated through general site activities will be removed by an appropriately licensed contractor for disposal at a licensed facility or treated to an appropriate quality prior to discharging.
- 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 or other relevant guidelines.
- Weather forecast 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.
- A minimum freeboard of 300 millimetres will be maintained for any tanks containing liquid waste.

10.4.2 Operation

- The surface infrastructure at the lease areas will be regularly inspected.
- The surface water monitoring program will be implemented.

10.4.3 Licensing

As no water is proposed to be extracted from any surface water within the Bohena Creek or Eulah Creek water sources during construction or operation, no WAL under the *WSP for the Namoi Unregulated and Alluvial Water Sources* (NOW, 2012c) is required.

11.0 Biodiversity

An *Ecological Assessment* has been completed by Eco Logical for the proposed activity (Appendix 4). The assessment included:

- database searches, including the EPBC Act Protected Matters Search Tool (DoE, 2013a) and Atlas of NSW Wildlife (OEH, 2013), for threatened species, populations and ecological communities within 50 kilometres of the two pilot sites
- review of relevant literature, photos and maps, including aerial photography and Namoi CMA vegetation mapping (Eco Logical, 2009) within the vicinity of the two pilot sites
- field surveys by qualified ecologists on 12 to the 16 November 2012 (RPS) and 25 to the 30 August 2013 (Eco Logical).

For the ecological assessment the site refers to the area directly impacted by the proposed activity and is defined as the vegetation to be removed for the Dewhurst 13-18H gathering system construction, and the disturbance footprints for the installation of the Dewhurst 30 and 31 pilot wells and associated service corridors. The ecological study area includes all areas of direct and indirect impacts including a 10 metre buffer around the two pilot sites.

11.1 Existing environment

11.1.1 Vegetation

Only one vegetation community occurs within the ecological study area, namely *Narrow-leaved Ironbark – White Cypress Pine – Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion* (Benson *et al.,* 2006). This vegetation community is commensurate with the BioMetric Vegetation Type *White Cypress Pine – Bulloak – ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion.*

Dominant canopy species include *Eucalyptus crebra* (Narrow-leaved Ironbark), *Allocasuarina luehmannii* (Bulloke) and *Callitris glaucophylla* (White Cypress Pine). The height of the canopy is variable between eight to 20 metres with 15 to 20 per cent projected foliage cover. The mid storey was sparse with scattered occurrences of *Acacia deanei* subsp. *deanei* (Deane's Wattle), *A. caroleae*, *Allocasuarina luehmannii* and *Callitris glaucophylla*. The height of the mid storey was between one to 10 metres with less than five per cent cover. The ground layer consists of *Panicum decompositum* (Native Millet), *Aristida jerichoensis* var. *jerichoensis* (Jericho Wiregrass), *Lomandra multiflora* (Many-flowered Mat-rush) and shrubs including *Pultenaea foliolosa* and *A. parviflora* (Coil-pod Wattle). The height of the ground layer was between 0.3 to one metre with less than 10 per cent cover.

Dewhurst 13-18 was observed to be dominated by *Allocasuarina luehmannii* regrowth, Dewhurst 30 is heavily disturbed by previous logging activities and Dewhurst 31 consists of a moderately dense shrub layer however the thin-leaved shrub species create an appearance of sparseness within the site.

11.1.2 Listed ecological communities

11.1.2.1 Threatened Ecological Communities under the EPBC Act

Seven TEC listed under the EPBC Act were identified as potentially occurring within 50 kilometres of the two pilot sites by the EPBC Protected Matters Search Tool. These are:

- 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 of the Brigalow Belt (North and South) and Nandewar Bioregions
- Weeping Myall Woodland
- White Box – Yellow Box – Blakely's Red Gum grassy woodland and derived native grassland

No TECs listed under the EPBC Act occur within the two pilot sites or the immediate surrounding area.

11.1.2.2 Endangered Ecological Communities under the TSC Act

Ten Endangered Ecological Communities (EEC) listed under the TSC Act were identified as potentially occurring within 50 kilometres of the two pilot sites, based on known or predicted communities occurring within the Namoi catchment (NSW Atlas of Wildlife Search). These are:

- 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 in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregion
- 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
- Marsh Club-rush sedgeland in the Darling Riverine Plains Bioregion
- 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
- White Box – Yellow Box – Blakely's Red Gum Woodland

No EECs listed under the TSC Act occur within the two pilot sites or the immediate surrounding area.

11.1.3 Flora

11.1.3.1 Threatened species

Threatened species database searches indicate 28 threatened flora species listed under the EPBC Act and/or TSC Act are identified as known or with potential to occur within the surrounding 50 kilometres of the two pilot sites. The likelihood of occurrence of these species was assessed, based on a number of factors including habitat preferences, recent field investigations, background data and local technical knowledge.

Table 11-1 outlines the threatened fauna species that have potential to occur, based on the likelihood assessment.

Table 11-1 Threatened flora species with potential to occur within the ecological study area

Species	Listing[1]		Identified during field survey	Likelihood to occur within the ecological study area
	TSC Act	EPBC Act		
Diuris tricolor (Painted Diuris)	V	-	No	Potential
Polygala linariifolia (Native Milkwort)	E	-	Yes	Known
Pterostylis cobarensis (Greenhood Orchid)	V	V	Yes	Known
Tylophora linearis	V	E	Yes	Known

Notes: 1. E = endangered, V = vulnerable

11.1.3.2 Species recorded at the two pilot sites

Over 70 flora species were identified during field surveys, three of which are EPBC and TSC Act-listed species (*Pterostylis cobarensis*, *Polygala linariifolia* and *Tylophora linearis*).

A list of the flora species recorded is provided in the Ecological Assessment.

11.1.3.3 Weeds

Weed incidence is low across the ecological study area. Occasionally recorded species during surveys included *Anagallis arvensis* (Pimpernel), *Opuntia stricta* (Prickly Pear), *Hypochaeris radicata* (Catsear) and *Sonchus oleraceus* (Common Sow-thistle).

Prickly pear (includes all *Opuncta* species other than *O. ficus-indica*) are a Class 4 weed under the *Noxious Weeds Act 1993* and a Weed of National Significance.

11.1.4 Fauna

Twenty-four threatened fauna species listed under the EPBC Act and 77 threatened species listed under the TSC Act are identified as known or with potential to occur within the surrounding 50 kilometres of the two pilot sites. The likelihood of occurrence of these species was assessed, based on broad habitat type within the surveyed area, as well as species distribution.

Table 11-2 outlines the threatened fauna species that have potential to occur within the ecological study area, based on the likelihood assessment. Depending on the species, the ecological study area may provide foraging, breeding, nesting and roosting habitat. No unique habitat occurs at the two pilot sites.

Table 11-2 Threatened fauna species with potential to occur within the ecological study area

Species	Listing[1]		Identified during field survey	Likelihood to occur within the ecological study area
	TSC Act	EPBC Act		
Anthochaera Phrygia (Regent Honeyeater)	CE	E	No	Potential
Burhinus grallarius (Bush Stone-curlew)	E	-	No	Potential
Calyptorhynchis lathami (Glossy Black Cockatoo)	V	-	Yes	Likely
Chthonicola sagittata (Speckled Warbler)	V	-	Yes	Known
Circus assimilis (Spotted Harrier)	V	-	No	Potential

Species	Listing[1]		Identified during field survey	Likelihood to occur within the ecological study area
Daphoenositta chrysoptera (Varied Sittella)	V	-	Yes	Known
Glossopsitta pusilla (Little Lorikeet)	V	-	No	Likely
Grantiella picta (Painted Honeyeater)	V	-	No	Likely
Hamirostra melanosternon (Black-breasted Buzzard)	V	-	No	Potential
Hieraaetus morphnoides (Little Eagle)	V	-	No	Potential
Lathamus discolour (Swift Parrot)	E	E	No	Potential
Lophoictinia isura (Square-tailed Kite)	V	-	No	Potential
Melanodryas cucullata (Hooded Robin)	V	-	Yes	Likely
Melithreptus gularis gularis (Black-chinned Honeyeater (eastern subspecies))	V	-	No	Likely
Neophema pulchella (Turquoise Parrot)	V	-	No	Likely
Ninox connivens (Barking Owl)	V	-	No	Potential
Pachycephala inornata (Gilbert's Whistler)	V	-	No	Potential
Petroica boodang (Scarlet Robin)	V	-	No	Potential
Pomatostomus temporalis temporalis (Grey-crowned Babbler)	V	-	Yes	Likely
Stagonopleura guttata (Diamond Firetail)	V	-	No	Likely
Tyto novaehollandiae (Masked Owl)	V	-	No	Likely
Aepyprymus rufescens (Rufous Bettong)	V	-	No	Potential
Chalinolobus dwyeri (Large-eared Pied Bat)	V	V	No	Potential
Chalinolobus picatus (Little Pied Bat)	V	-	Yes	Known
Dasyurus maculates (Spotted-tailed Quoll)	V	E	No	Potential
Macropus dorsalis (Black-striped Wallaby)	E	-	No	Likely
Miniopterus schreibersii oceanensis (Eastern Bentwing-bat)	V	-	Yes	Known
Nyctophilus corbeni (South-eastern Long-eared Bat)	V	V	No	Likely
Petaurus norfolcensis (Squirrel Glider)	V	-	No	Potential
Pseudomys pilligaensis (Pilliga Mouse)	V	V	No	Potential
Pteropus poliocephalus (Grey-headed Flying fox)	V	V	No	Potential
Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)	V	-	Yes	Known
Vespadelus troughtoni (Eastern Cave Bat)	V	-	No	Likely

Notes: 1. E = endangered, V = vulnerable

11.1.4.1 Species recorded during surveys

Over 110 fauna species were identified onsite or in the vicinity during field surveys. Eight of these are EPBC and TSC Act-listed species:

- *Calyptorhynchis lathami* (Glossy Black Cockatoo)
- *Chthonicola sagittata* (Speckled Warbler)
- *Daphoenositta chrysoptera* (Varied Sittella)
- *Melanodryas cucullata* (Hooded Robin)
- *Pomatostomus temporalis temporalis (Grey-crowned Babbler)*
- *Chalinolobus picatus (Little Pied Bat)*
- *Miniopterus schreibersii oceanensis (Eastern Bentwing-bat)*
- *Saccolaimus flaviventris (Yellow-bellied Sheathtail-bat)*.

A list of the fauna species recorded is provided in the Ecological Assessment.

11.1.4.2 Migratory species

The EPBC Protected Matters Search Tool indicated that 11 migratory species listed under the EPBC Act were identified as potentially occurring within a 50 kilometre radius of the two pilot sites. An assessment of likelihood of occurrence was completed for each species, based on habitat preference and known species distribution. The assessment confirmed that five species have the possibility of occurring:

- *Anthochaera Phrygia* (Regent Honeyeater)
- *Apus pacificus* (Fork-tailed Swift)
- *Haliaeetus leucogaster* (White-bellied Sea-eagle)
- *Hirundapus caudacutus* (White-throated Needletail)
- *Merops ornatus* (Rainbow Bee-eater)

Two migratory species were observed during field surveys (*Haliaeetus leucogaster* and *Hirundapus caudacutus*).

11.1.4.3 Introduced species

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

11.1.4.4 Habitat values

A range of fauna habitat features are present throughout the ecological study area. These features, and the fauna groups that may make use of them, are identified in Table 11-3.

Table 11-3 Key fauna habitat features present across the ecological study area

Habitat features	Species
Vegetated areas of open forest	Arboreal mammals, microchiropteran bats and owls
Hollow-bearing trees and stags	Birds, microchiropteran bats and arboreal mammals
Fallen timber	Reptiles, molluscs and birds
Leaf litter (sparse to moderate)	Foraging resources for birds and mammals
Winter flowering eucalypts	Migratory birds, arboreal mammals
Foraging resources	Mammals, birds

Twenty five hollow-bearing trees were recorded within the ecological study area at Dewhurst 30 and 31. Hollows range in size from 5 to 30 centimetres width, providing habitat for a variety of fauna species including microbats, birds, and arboreal mammals. No hollow-bearing trees were recorded at Dewhurst 13-18H.

11.1.5 Aquatic ecology

No aquatic habitat occurs in the ecological study area.

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

11.2 Assessment approach

The database searches undertaken as part of the Ecological Assessment identified threatened vegetation communities and flora and fauna species, as well as migratory fauna species, that have been recorded or that are considered likely to occur within 50 kilometres of the two pilot sites. The probability of individual threatened species and vegetation community occurring within the sites and surrounding 10 metre buffer was determined as being either unlikely, potential, likely or known, based on a range of criteria.

Once the likelihood to occur was determined, the likely level of impacts as a result of the proposed activity was considered for each species or community. They were assessed separately, based on their likelihood of occurrence, while recognising other parameters such as home range, habitat use, connectivity, as well as the scope of the proposed activity. Based on the outcome of the assessment, a decision was made as to whether further assessment was required.

11.3 Potential impacts

11.3.1 Vegetation clearing

Approximately 2.44 hectares of White Cypress Pine – Bulloak – ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion will be cleared due to the proposed activity. There is approximately 22,878 hectares of this vegetation type mapped in PEL 238 and PAL 2. Therefore the removal of approximately 2.44 hectares constitutes a less than 0.01 per cent reduction of this vegetation community in PEL 238 and PAL 2.

11.3.2 Terrestrial impacts

Minimal short-term impacts are associated with the proposed activity, during both construction and operational activities. Considerations of specific potential impacts are outlined in Table 11-4.

Table 11-4 Potential terrestrial impacts

Area of concern/impact	Overview
Impacts on threatened species and communities (under the TSC Act)	No EECs are present within the ecological study area. Section 5A of the EP&A Act lists seven factors (the 7-part test) 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 7-part test was applied to the 4 threatened flora and 33 threatened fauna species listed under the TSC Act that are considered to have the potential to occur within the ecological study area. The assessment is detailed in Appendix 4 and concluded that the proposed activity is unlikely to have a significant impact on these species. There is potential for indirect impacts during both the construction and operational phases of the proposed activity, in particular the removal of foraging, breeding or roosting/sheltering habitat. However, provided the mitigation measures in Section 11.5 are implemented, there will be no significant direct or indirect impacts upon threatened fauna species or their habitats as a result of the proposed activity. Threatened flora (*Tylophora lineris*, *Pterostylis cobarensis* and *Polygala linariifolia)* individuals will be cleared due to the proposed activity. Detailed targeted surveys within the broader Pilliga East State Forest have identified significant population of these threatened species, as outlined in Appendix 4. Assessments under the TSC Act concluded that, despite the clearance, the proposed activity is not likely to have a significant impact on these species. Therefore a Species Impact Statement (SIS) is not considered necessary for any of the threatened species, populations or ecological communities.
Impacts on threatened species and communities (under the EPBC Act)	No TECs are present within the ecological study area. The *EPBC Act Policy Statement 1.1 – Significant Impact Guidelines Matters of National Environmental Significance* (DEWHA, 2009) set out 'Significant Impact Criteria' that are to be used to assist in determining whether a proposed action is likely to have a significant impact on MNES. An Assessment of Significance was applied to the 2 flora, 7 fauna and 4 additional migratory species listed under the EPBC Act that are considered to have the potential to occur within the ecological study area. The assessments are detailed in Appendix 4 and concluded that the proposed activity is unlikely to have a significant impact on these species. There is potential for indirect impacts during both the construction and operational phases of the proposed activity, in particular the removal of foraging, breeding or roosting/sheltering habitat. However, provided the mitigation measures in Section 11.5 are implemented, there will be no significant direct or indirect impacts upon threatened fauna species or their habitats as a result of the proposed activity. Threatened flora (*Tylophora lineris* and *Pterostylis cobarensis)* individuals will be cleared due to the proposed activity. Detailed targeted surveys within the broader Pilliga East State Forest have identified significant population of this threatened species, as outlined in Appendix 4. Assessments under the EPBC Act concluded that, despite the clearance, the proposed activity is not likely to have a significant impact on these species.
Impacts on Pilliga East State Forest	The location of the Dewhurst 30 and 31 lease areas and associated service corridors have been sited to avoid key ecological values, including TECs and riparian zones. The proposed activity has been designed to minimise additional vegetation clearance. Provided the mitigation measures in Section 11.5 are adhered to, there will be no significant impact upon the Pilliga East State Forest. Furthermore, rehabilitation works will incorporate species native to the Forest.

Area of concern/impact	Overview
Loss of fauna habitat	For each threatened species likely to occur onsite, the total amount of potential foraging, breeding and roosting/sheltering habitat that would be cleared due to proposed activity was calculated. The extent of potential habitat loss in relation to the habitat availability within PEL 238 was also calculated. The maximum extent of foraging, breeding or roosting habitat that will be lost is approximately 2.44 ha, this equates to less than 0.03% of the habitat available across PEL 238 for any individual species. The location of hollow-bearing trees has been mapped so that the clearing can be undertaken to minimise the removal of as many hollow-bearing trees as possible. No 'potential' koala habitat, as defined by SEPP 44, will be removed as part of the proposed activity – nor does any occur within close proximity to the site and immediate surrounding area.
Habitat fragmentation	Habitat fragmentation is known to encourage the movement of feral animal predators through the landscape. Habitat fragmentation is considered to be minimal due to the linear construction of the proposed activity and the use of existing roads where possible to reduce fragmentation. No patches of habitat would be isolated as a result of the proposed activity.
Introduction and spread of weeds	The proposed activity has the potential to create favourable conditions for the introduction and spread of weed species onsite through the movement of traffic to site. However, provided the mitigation measures in Section 11.5 are adhered to, it is unlikely that this will occur as a result of the proposed activity.
Disruption of breeding cycle, roosting and sheltering behaviour	Given the minimal extent of habitat to be impacted, it is considered unlikely that the proposed activity will have a significant impact upon the breeding cycle, roosting, sheltering and foraging behaviour of fauna species.
Noise, dust and light	The proposed activity may result in short-term increased noise and dust pollution as well as an increase in light, which has the potential to temporarily disrupt foraging and roosting behaviour of some native fauna species. However, provided the mitigation measures in Section 11.5 are adhered to, it is unlikely that these impacts will be significant.

11.3.3 Aquatic impacts

No aquatic habitat occurs in the ecological study area and it is unlikely that any aquatic habitat will be directly or indirectly impacted by the proposed activity.

There are no proposed discharges to any watercourses during operation and therefore impact to water quality, flows or increases in bank and channel erosion are not anticipated for any watercourses in the immediate vicinity or downstream. As previously stated in Section 10.2, the potential exists for the leakage of produced water to occur during operation and enter waterways.

11.3.4 Key threatening processes

EPBC Act and TSC Act provide for the identification and listing of key threatening processes (KTPs). KTPs 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' (DoE, 2013b).

KTPs under the EPBC Act and TSC Act that are relevant to the proposed activity are discussed in Table 11-5.

Table 11-5 Summary of key threatening processes

Key threatening process	Relevance to proposed activity
EPBC Act/TSC Act	
Competition and land degradation by feral European Rabbits	Rabbits were observed onsite or in the immediate vicinity. However, it is not anticipated that the proposed activity will increase opportunities for increase to the Rabbit population.
Competition and land degradation by unmanaged goats	Goats were observed onsite or in the immediate vicinity. However, it is not anticipated that the proposed activity will increase opportunities for 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 2.44 ha of vegetation will be removed to facilitate the construction of a gathering system at Dewhurst 13-18H, and two wells and associated access tracks at Dewhurst 30 and 31.
Predation by European Red Fox	European Red Fox were observed onsite or in the immediate vicinity. It is considered unlikely that the proposed activity 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 observed onsite or in the immediate vicinity. If waste is not managed onsite, there is the potential for an increase in the feral cat population.
Predation, habitat degradation, competition and disease transmission by feral pigs	Feral pigs were observed onsite or in the immediate vicinity.. It is considered unlikely that the proposed activity will result in increased predation, habitat degradation, 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 are outlined in Chapter 17.
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 activity, but these habitat resources will be relocated elsewhere in the ecological study area.
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	No works are proposed to occur within any streams or wetlands. The proposed activity will not alter the natural regimes of any rivers, streams and their floodplains and wetlands.
Predation and hybridisation by feral dogs, (*Canis lupus familiaris*)	Feral dogs were not observed, but are considered likely to occur at the site. It is considered unlikely that the proposed activity 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.

11.3.5 Groundwater dependent ecosystems

Stygofauna communities (fauna that live in groundwater) may exist within aquifers and thus can also be classed as a GDE (Serov *et al.,* 2012). Slight changes in groundwater attributes (quality or quantity) may result in changes to the population assemblage.

Stygofauna are known to occur within the Namoi River alluvial aquifer. This aquifer does not underlie the two pilot sites, but is a potential source of colonisation for stygofauna. Thin sedimentary aquifers associated with Bohena, Cowallah and Bibblewindi Creeks extend south into the Pilliga and are potentially suitable habitat for stygofauna. It is possible that communities may be present in permanently saturated parts of these aquifers, especially if they have an occasional hydrological connection to the larger Namoi alluvium.

Stygofauna may also be present in the shallower GAB sandstone aquifers present onsite, such as the Pilliga Sandstone. For these to be suitable for stygofauna, they would have to be fractured or weathered enough to allow stygofauna movement and a sufficient flux of water and organic matter. The suitability of these rock aquifers as stygofauna habitat diminishes with depth from the surface.

The deeper target coal seam aquifers are unlikely to contain stygofauna as:

- the space available for movement is reduced significantly with increasing depth
- there is an overall decline in water quality.

The proposed activity potentially poses the following threats to stygofauna:

- penetrating suitable habitat during drilling and the subsequent draining of the aquifer or contamination through trans-boundary flow between aquifers
- depressurisation of underlying aquifers causing a change in the physical structure of stygofauna habitat that may result in drainage or contamination from more saline water.

Based on the groundwater modelling results summarised in Section 9.4 and provided drilling, operation and closure activities are undertaken in accordance with the relevant guidelines and legislation, the CSG drilling and extraction activities are unlikely to pose a significant threat to any known or likely stygofauna habitat.

In addition, as it is considered feasible that stygofauna populations may exist in the region, additional sampling will be undertaken to investigate presence or absence of stygofauna populations within PEL 238 and PAL 2 during the E&A Program.

11.3.6 Indirect impacts

The proposed activity has the potential to indirectly impact on flora and fauna including aquatic habitat. Potential indirect impacts include fauna strikes associated with increased vehicle movements, an increase in noise, dust and light impacts at the site and impacts to water resulting from spills or leaks and sediment laden runoff.

The potential for indirect impacts to flora and fauna as a result of the proposed activity are considered low given the existing environment and the minimal extent of vegetation clearance proposed. Provided mitigation measures for the proposed activity are adhered to, there will be no significant indirect impacts upon any TSC Act listed threatened species or their habitats as a result of the proposed activity during both construction and operation.

11.4 Cumulative impacts

Cumulative impacts of the E&A Program on biodiversity within PEL 238 and PAL 2 have been assessed under the TSC Act (Eco Logical, 2013a) and the EPBC Act (Eco Logical, 2013b). These studies address the removal of vegetation communities and habitat for threatened species at two different scales (refer to the Ecological Assessment for more details). For the purposes of this assessment, the cumulative impacts have been reported against the same study region as included in the TSC Act assessment (Eco Logical, 2013a).

To date, 78.1 hectares of White Cypress Pine – Bulloak – ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion has been removed for exploration activities within PEL 238 and PAL 2 since 2002. Of the vegetation that has been removed, 14.8 hectares is currently regenerating. A further 31.7 hectares of this vegetation type is proposed to be removed from 2013 onwards, including the 2.44 hectares impacted by the proposed activity. The total extent of clearance is small, considering that there is approximately 22,878 hectares of this vegetation type mapped in PEL 238.

The cumulative impact as a result of the E&A Program and existing exploration and appraisal activities to vegetation within the PEL 238 and PAL 2 equates to the loss of:

- 237.4 hectares which represents a loss of approximately 0.5 per cent of consolidated vegetation within the E&A Program area and 0.05 per cent of all vegetation within PEL 238 and PAL 2
- Between 26.3 and 237.1 hectares of potential foraging habitat (depending on species) for threatened fauna species which represents a loss of between 0.01 and 0.17 per cent of the available breeding habitat available within PEL 238 and PAL 2
- Between 12.3 and 159.9 hectares of potential breeding habitat (depending on species) for threatened fauna species which represents a loss of between 0.03 and 0.11 per cent of the available breeding habitat available within the PEL 238 and PAL 2.

Fragmentation of habitat as a result of the E&A Program and existing exploration and appraisal activities is considered unlikely to adversely affect any EPBC or TSC Act listed species, with only one of the 25 potential movement pathways for the Pilliga Mouse affected by long-term impacts. The remaining threatened and migratory fauna are highly mobile and can traverse large distances across modified and cleared landscapes. Fragmentation is unlikely to significantly affect any threatened flora species as the E&A Program and existing exploration and appraisal activities are unlikely to split contiguous habitat into two or more distinct patches with pollination and dispersal mechanisms able to continue largely unimpeded.

Given the relatively small extent of clearing as a proportion of available habitat (both within the ecological study area and the Namoi CMA region), minimisation of fragmentation impacts by locating linear infrastructure (flow lines) along existing tracks wherever possible, and measures proposed to avoid, minimise and mitigate impacts, the E&A Program and existing exploration and appraisal activities are not expected to significantly fragment or reduce the availability of habitat in a way which will adversely affect EPBC or TSC Act listed species.

Based on the above, the cumulative impact of the E&A Program combined with existing exploration and appraisal activities is considered unlikely to have a significant impact as there is unlikely to be a long term decrease in population sizes, significant fragmentation or adverse disturbance to breeding cycles or critical habitat.

11.5 Mitigation measures

The following measures will be implemented during both construction and operation:

- Micro-siting of lease areas and service corridors locations will be undertaken at Dewhurst 30 and 31 during detailed design and pre-clearance survey stage to minimise impacts on the ecological communities and species.
- Clearing of hollow-bearing trees will be avoided where possible.
- While clearing or disturbance to vegetation occurs, a fauna spotter/catcher will be onsite 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.
- The two pilot sites will be rehabilitated in accordance with Section 4.5 of the EIS.
- Construction and operational vehicles/plant will only travel on the designated access tracks. Site speed limits will be imposed to reduce the potential of fauna strike and to reduce dust generation.
- Prior to earthworks, noxious weeds present onsite will be removed or treated with herbicide to help prevent or reduce their spread.
- Weed management measures will be undertaken.
- Weed monitoring will occur throughout all phases of the proposed activity. Weed removal will be carried out as necessary.

12.0 Air Quality

Wilkinson Murray has completed an *Air Quality Impact Assessment* for the proposed activity. It is provided in Appendix 5 and summarised below.

12.1 Existing environment

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 other residential activities.

12.1.1 Local meteorology

Meteorological data for the two pilot sites and their immediate surrounds is not available. The meteorological component of The Air Pollution Model (TAPM) was used to generate representative local meteorological data. The TAPM process used, based on data from the Narrabri Airport BoM weather station, and the resulting windroses generated are provided in Appendix 5.

Annually, winds from the southeast and east-southeast are most frequent with a spread of winds from the other directions. The summer wind distribution pattern indicates the winds from the east-southeast are most predominant with a portion of winds from the southeast. Autumn shares a similar wind distribution to the annual windrose with winds from the southeast quadrant most common. In winter, winds tend to mainly occur from the southeast and range to the west-southwest. During spring, winds are varied and predominantly occur from east-southeast and north with a lesser portion of winds from the north-northeast and southeast.

Stability class distribution from the generated TAPM data suggest that relatively stable meteorological conditions (typically at night), are likely to occur for a fair portion of time.

12.1.2 Sensitive receivers

The nearest sensitive receiver during operation is a residential dwelling approximately 500 metres south of the Dewhurst 13 lease area; however it will not be occupied during construction. During construction, the nearest receiver will be a residence located approximately 1.8 kilometres south-west of Dewhurst 13 as shown in Figure 3-9. The nearest receivers to Dewhurst 26-31 are in excess of 10 kilometres from the site.

12.1.3 Air quality assessment criteria

Air quality criteria are targets set to protect the general health and amenity of the community in relation to air quality. The criteria that are relevant to the proposed activity are taken from the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005).

The air quality targets for the relevant criteria pollutants relate to the total pollutant burden in the air and not just the pollutants from the proposed activity. Therefore consideration of background pollutant levels is required when using these targets to assess potential impacts. Table 12-1 shows the impact criteria relevant to the proposed activity.

Table 12-1 NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
Total suspended particulates (TSP)	Annual	Total	90 µm/m^3
Particulate matter > 10 µm(PM_{10})	Annual	Total	30 µm/m^3
	24-hour	Incremental	50 µm/m^3
Deposited dust (DD)	Annual	Total	2 g/m^2/month
	Annual	Incremental	4 g/m^2/month
Nitrogen dioxide (NO_2)	1-hour	Total	246 µm/m^3
	Annual	Total	62 µm/m^3
Carbon monoxide (CO)	15-minute	Total	100 mg/m^3
	1-hour	Total	30 mg/m^3
	8-hour	Total	10 mg/m^3

12.1.4 Ambient air quality

Suitable monitoring data was not available to quantify the existing ambient levels of particulate matter (PM_{10}) and nitrogen dioxide (NO_2) at the two pilot sites. Therefore the nearest locations with available data (Tamworth and Muswellbrook EPA monitoring sites, approximately 132 and 215 kilometres from the proposed activity) were used to provide an approximation of air quality.

The measured and calculated estimates of PM_{10}, total suspended particulates (TSP), deposited dust (DD) and NO_2 used for the pilot sites are provided in Table 12-2. Due to the presence of human activity, including residential areas, traffic, major highways and industry, the data from the Tamworth and Muswellbrook monitoring locations are conservative as they are likely to overestimate the likely levels of air pollutants at these sites.

Table 12-2 Ambient air quality

Parameter	Averaging Period	NSW EPA Criterion	Ambient level
Particulate matter (PM_{10})	Annual	30 µm/m^3	15.9 µm/m^3 (1)
Total suspended particulates (TSP)	Annual	90 µm/m^3	39.7[2] µm/m^3 (2)
Deposited dust (DD)	Annual	2 g/m^2/month	1.8[2] g/m^2/month (2)
Nitrogen dioxide (NO_2)	1-hour	264 µm/m^3	86.48[3] µm/m^3 (3)

Notes: 1. Tamworth EPA monitoring site data
2. Calculated based on Tamworth EPA monitoring site PM_{10} data (refer to Appendix 5)
3. Muswellbrook EPA monitoring site data

The EPA monitoring sites at Tamworth and Muswellbrook do not record ambient concentrations of carbon monoxide (CO). Combustion activities are the cause of CO emissions and spatially there is very little such activity in the vicinity of the two sites apart from power generation, motor vehicles and wood heaters. Therefore, ambient concentrations of CO are expected to be low.

EPA air quality targets for CO are set at higher concentration levels than the NO_2 targets. Based on the NO_2 monitoring data which are low compared to the targets, and consideration of the typical mix of ambient pollutant levels, it can be assumed that ambient levels of CO will similarly also be well below the air quality targets.

12.2 Assessment methodology

12.2.1 Emission estimation

12.2.1.1 Construction

Dust emission estimates from construction works have been made using emission factors developed both locally and by the US EPA.

Table 12-3 presents the estimated TSP emissions for the construction works associated with the proposed activity. Further details regarding the emissions estimation techniques applied to estimate the TSP emissions are provided in Appendix 5.

Table 12-3 Estimated emissions for construction works

Activity	TSP emissions (kg/year)	
	Dewhurst 13-18H	Dewhurst 30/31
Travel to site	4,827	5,043
Travel between Dewhurst 13-18H and Dewhurst 30/31	588	-
Travel between Dewhurst 30 and Dewhurst 31	-	470
Excavating material	3	2
Drilling	5	4
Wind erosion of exposed areas	7,604	12,334
Total	**13,027**	**17,854**

12.2.1.2 Operation of the flares

During operation, the majority of the produced gas will be flared onsite at either the Dewhurst 14 or Dewhurst 28 lease area. Modelling of air emissions associated with the operation of these flares has been undertaken based on the flare exhaust flow rate and estimated stack concentrations (Table 12-4). Assessment of the flare operation is based on the capacity of the flares (peak gas flow rate), and therefore may be greater than the expected flow rate during actual operation.

Table 12-4 Stack parameters and estimated emissions for the Dewhurst 14 and 28 flares

Parameter	Units	Dewhurst 14	Dewhurst 28
Stack height	m	4.5	4.0
Stack diameter	m	0.3	0.3
Exit velocity	m/s	21.93	13.16
Exit temperature	°C	750	750
Peak gas flow rate	Am^3/s	5.81	3.48
Peak gas flow rate	Nm^3/s	1.55	0.93
NO_2 emission rate	g/s	0.008	0.0048
CO emission rate	g/s	0.19	0.12

12.2.1.3 NO_X to NO_2 conversions

The nitrogen oxides (NO_X) to NO_2 conversion was estimated using a method outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) and developed by Janssen *et al.* (1988).

It was determined that the predicted maximum NO_2 impacts were recorded approximately 0.26 kilometres from the source during summer. Based on this distance, the ratio of NO_2 to NO_x at nearby receptors due to the flare operations was calculated to be two per cent.

12.2.2 Modelling methodology

The AUSPLUME dispersion model in conjunction with The Air Pollution Model (TAPM) generated meteorological data file provided predictions of the ground level concentrations of pollutants based on the emission estimates provided in Section 12.2.1.

Air pollution sources for the construction scenario were modelled as volume sources, while sources for the operation scenario were modelled as point sources.

Modelling has been undertaken for a full year to account for seasonality variables.

12.3 Potential impacts

12.3.1 Construction

Dust created during construction will have the greatest impact on air quality. Other emissions will occur from the exhaust of plant equipment required for drilling. These emissions are generally considered to be too low to generate any significant pollutant concentrations in the vicinity of the two pilot sites and have not been assessed further.

Table 12-5 presents the predicted incremental and total impacts at each of sensitive receiver locations within five kilometres of the proposed activity (shown in Figure 3-9) for PM_{10} as an indicator of dust levels.

Table 12-5 Predicted incremental and total concentrations at sensitive receptors – construction for PM_{10}

Resident ID	Distance from nearest lease area (km)	24-hr Average ($\mu g/m^3$)	Annual average proposed activity ($\mu g/m^3$)	Total impact ($\mu g/m^3$)[1]
NSW EPA Criteria		**50**	**-**	**30**
RR1	3.6	0.15	0.01	15.91
RR2	3.4	0.15	0.02	15.92
RR3	2.5	0.23	0.02	15.92
RR4	0.5	N/A[2]	N/A[2]	N/A[2]
RR5	3.0	0.25	0.04	15.94
RR6	3.5	0.25	0.04	15.94
RR7	3.5	0.25	0.05	15.95
RR8	4.2	0.21	0.04	15.94
RR9	1.8	0.32	0.05	15.95

Notes: 1. Based on 2012 data measured at the Tamworth NSW EPA monitoring site
2. RR4 is not assessed during construction as it will remain vacant until December 2015.

At all sensitive receptors PM_{10} is well below acceptable levels (50 microgram per cubic metre for incremental 24-hour average and 30 microgram per cubic metre for total annual impact). When combined with estimated background data (noting that these are conservative as they are measured within a residential area in Tamworth) the predicted levels are also well below annual average criteria. Further, the impact on the nearby sensitive receptors is likely to be lower than predicted due to the vegetation between the two sites and receptors. Studies have shown that significant vegetation barriers can reduce dust emissions by up to 30 per cent (Warren, 1973). The modelling completed for this assessment has not taken into account any mitigation from the vegetation buffer.

When averaged across a year, in accordance with the criteria, PM_{10}, TSP and dust deposition at any sensitive receptor is also well below accepted criteria and in most cases will be negligible.

12.3.2 Operation

Emissions of CO and NO_2 can be expected from the combustion and flaring of intermittent gas during operation. In addition to CO and NO_2 formation, a small amount of PM_{10} may be generated from the combustion operation however this is considered to be negligible and has not been assessed further.

Table 12-6 presents the predicted incremental NO_2 and CO impacts at the sensitive receiver locations within five kilometres of either the Dewhurst 14 or 28 flare during operation. At all sensitive receptors this is well below acceptable levels (1-hour average – 246 and 30 microgram per cubic metre for NO_2 and CO, respectively).

Table 12-6 Predicted incremental concentrations at sensitive receptors – operation

Resident ID	Distance from the nearest flare (km)	NO_2 (µg/m^3)		CO (µg/m^3)	
		1-hr Average	15-min Average	1-hr Average	8-hr Average
NSW EPA Criteria		246	100	30	10
RR1	3.6	0.0987	0.00309	0.00234	0.00155
RR2	3.4	0.1015	0.00318	0.00241	0.00159
RR3	2.5	0.1408	0.00441	0.00334	0.00221
RR4	0.5	0.2426	0.00760	0.00576	0.00380
RR5	3.0	0.0884	0.00277	0.00210	0.00138
RR6	3.5	0.0776	0.00243	0.00184	0.00122
RR7	3.5	0.0846	0.00265	0.00201	0.00133
RR8	4.2	0.1051	0.00329	0.00250	0.00165
RR9	1.8	0.1553	0.00487	0.00369	0.00243

With the addition of the maximum 1-hour background NO_2 levels measured at Muswellbrook during November 2011 to July 2013 (86.48 micrograms per cubic metre), the total predicted impact still does not exceed the EPA criteria, even at the nearest sensitive receiver (RR4), located within one kilometre of the nearest flare.

Site specific CO monitoring was not undertaken as part of this assessment. However, comparison of the predicted incremental CO concentrations with the EPA criteria for CO shows that the contribution of the proposed activity will be significantly below the criteria. It is considered highly unlikely that existing background levels of CO will be approaching the criteria levels. Therefore the maximum CO impacts due to the proposed Dewhurst 14 and 28 flare operation should not exceed the EPA criteria in the vicinity of the site.

12.4 Cumulative impacts

In the vicinity of the proposed activity there are potentially other sources of NO_2 and CO emissions originating from onsite plant equipment, site vehicles, small generators and other flaring operations. These sources are unlikely to generate significant amounts of NO_2 and CO and will be located away from the nearby sensitive receptors to allow sufficient dilution.

Other flares associated with the E&A Program will similarly generate low levels of NO_2 and CO concentrations, and combined with the large spacing between the flares any cumulative impact will be negligible.

12.5 Mitigation measures

The following mitigation measures will be implemented throughout the duration of proposed activity:

- Dust will be suppressed as required by spraying water along the access tracks and lease areas.
- Site speed limits will be imposed to minimise dust generated by vehicle movements.
- Loose, dust generating materials will be covered when transported to and from site.
- 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.
- Rehabilitation works, including landform establishment, will occur within six months of abandonment.

13.0 Greenhouse Gases

13.1 Existing environment

Greenhouse gases (GHGs) are gases that absorb infrared radiation (heat) in the atmosphere. They occur naturally and are critical to maintaining the Earth's surface at liveable temperatures. When anthropogenic activities increase the concentrations of these gases this effect is accelerated, leading to the 'enhanced greenhouse effect'. It is the results of this enhanced greenhouse effect that are identified as 'climate change'.

Based on the current scientific consensus from the *Intergovernmental Panel on Climate Change Fifth Assessment Report: Climate Change 2013*, there is a high degree of confidence that our current climate is changing due to human activities, with this rate of change likely to intensify into the future.

It is therefore important to consider, on balance, the GHG contributions and benefits of significant projects.

13.2 Assessment methodology

In accordance with the *GHG Protocol Corporate Standard* (GHG Protocol) (WBCSD and WRI, 2004), Scope 1 GHG emissions have been defined as direct emissions of GHGs (expressed as CO_2 equivalent) which are owned and/or controlled by Santos in relation to the proposed activity. Relevant inclusions are:

- removal of vegetation for site preparation
- extracted gas consumed in flares
- extracted gas vented (both fugitively and directly)
- fuel use onsite for power generation
- fuel use onsite for plant and equipment (including civil works and drill rigs)
- fuel use for transport of personnel and materials where this transport is under Santos operational control.

Scope 2 emissions cover those GHGs resulting from the purchase of energy (electricity or steam) originating from outside the proposed activity boundary. No scope 2 emissions are relevant to the proposed activity as no energy will be purchased to undertake the proposed activity.

Scope 3 emissions have been defined as those indirect emissions which are a consequence of the proposed activity but are not under the control, influence or authority of Santos. These sources will form the Scope 1 emissions of other organisations, so are considered separately and with discretion to avoid 'double counting' of the emissions profile.

The potential inclusions for Scope 3 emissions are extensive and often beyond quantification. For the EIS the inclusions have been limited with respect to the scale of the proposed activity and the available information, as consistent with the GHG Protocol methodology. Specific inclusions include:

- the lifecycle emissions of materials and fuels, where this information is consistent and readily in the public domain (such as the Infrastructure Sustainability Council of Australia (ISCA) materials calculator)
- the processing of purchased diesel for civil works and other dedicated transport.

Emissions have been profiled over the construction and operation phases of the proposed activity, presented as both phase and annual totals as appropriate. Emissions intensity (relative to production) is also included.

13.2.1 Calculation methodology

The GHG Protocol outlines that a GHG inventory should be completed with regard to the following principles:

- relevance
- completeness
- consistency
- transparency
- accuracy.

In the absence of relevant local data, emission factors for calculation have been sourced from the National Greenhouse Accounts Factors (NGA Factors) (DCCEE, 2012), with some supplementary inputs taken from the *American Petroleum Institute Compendium of Greenhouse Gas Emissions Methodologies for the Oil and Natural Gas Industry* (the API Compendium) (URS, 2009). The relevant emission factors applied in estimates are provided in Table 13-1.

Table 13-1 Relevant greenhouse gas emission factors

Emission source	Energy content		CO_2	CH_4	N_2O	Total	NGA Factors Reference
Emission factor (kg CO_2^e/GJ)							
CSG combustion	0.0377	GJ/m^3	51.1	0.2	0.03	51.33	Table 2; Page 13
Diesel combustion – Stationary Energy	38.6	GJ/kL	69.2	0.1	0.2	69.5	Table 3; Page 15
Diesel combustion – Transport	38.6	GJ/kL	69.2	0.2	0.5	69.9	Table 4; Page 17
Diesel combustion –Scope 3	38.6	GJ/kL	-	-	-	5.3	Table 39; Page 70
Emission factor (t CO_2^e /t gas flared)							
CSG flaring (exploration)			2.8	0.7	0.03	3.53	Table 8; Page 13
Emission factor (t CO_2^e /gas throughput)							
CSG leakage (production)			-	1.2×10^{-3}	-	0.0012	S 2.4.2.6; Page 29
Emission factor (t CO_2^e /km pipeline)							
CSG leakage (transmission)			0.02	8.7	-	8.72	Table 15; Page 30
Emission factor (t CO_2^e /drilling day)							
Water-based drilling fluid degassing			-	5.47	-	5.47	Converted from Table 5-17 API Compendium (@ 83.85% CH4)

GHG estimates for vegetation clearing and loss of carbon sink have been generated using the FullCAM (V 3.40) model. Information for vegetative cover has been based on the Department of Climate Change and Energy Efficiency (Cth) database for the proposed activity's location. An existing regime of 'Eucalyptus Woodland' has been assumed for the entirety of the area proposed to be cleared. This assumption is consistent with the ecological surveys completed for the two pilot sites.

13.3 Potential impacts

13.3.1 Scope 1 emission quantification

The bulk of Scope 1 emissions from the project are expected to be derived from flaring of gas during the operation phase. Some additional emissions are expected from the use of diesel fuel for drilling and construction operations, and the use of captured gas for minor onsite power generation.

During the operation phase, the bulk of the gas collected will be flared. Flaring is preferred to venting and will be undertaken whenever it is possible and safe to do so.

The drilling of new horizontal wells at Dewhurst 16H, 17H and 18H will utilise existing surface infrastructure, so minimal site preparation works will be required. Gas captured from the Dewhurst 13-18H Pilot will be flared at the Dewhurst 14 lease area while gas captured at Dewhurst 30 and 31 will be collected and transported via new pipe work to the Dewhurst 28 lease area where it will be flared.

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 (as methane is recognised as having 21 times the global warming potential (GWP) of CO_2). Consistent with Santos' Climate Change Policy, venting will only be employed where there is no feasible alternative. Such situations may include:

- disposing of air and any produced gas (when air drilling)
- production testing the well
- drill stem testing
- in an emergency well control situation.

Minor amounts of gas will also be lost to the atmosphere as fugitive emissions during well development and operation, as well as from the gas gathering pipeline network and associated equipment. To assist in quantifying the extent of fugitive emissions across the E&A Program, a monitoring program, including baseline monitoring, will be implemented. The monitoring program will be conducted in the general area of the E&A Program to monitor any changes in methane levels as an indicator of fugitive emissions during operation.

Venting and flaring rates, durations and volumes can vary significantly and depend on drilling technology, the number of gas zones and the distance between the zones. Santos intends to drill the wells using water based drilling fluids to minimise venting and flaring requirements during this phase. These emissions are therefore expected to be incidental however have been included in the estimate for completeness.

Forecasting suggests approximately 10 per cent of the captured gas will be used for electricity generation at the drill sites, avoiding the need to use more emissions intensive fuels (such as diesel) for this purpose.

Exhaust emissions from site-based vehicle movements, plant and machinery are based on initial traffic model inputs and information for the drill rigs. For the purpose of this assessment delivery of dedicated plant and equipment between pilot well sites has been assumed to be a Scope 1 contribution.

The establishment of the Dewhurst 30 and 31 lease areas and access tracks will include clearing of approximately 2.44 hectares and stockpiling of the existing woody vegetation.

Table 13-2 provides a summary of quantified Scope 1 emissions.

Table 13-2 Scope 1 greenhouse gas emissions profile

Component	Tonnes/CO_2^e	Tonnes/CO_2^e/year	
	Construction Phase	Operation Phase (Dewhurst 13-18H)	Operation Phase (Dewhurst 26-31)
Estimated total	1,905	41,139	90,050

Based on the above operational emissions, the GHG intensity of the produced gas is estimated to be in the region of 70 kT CO_2^e/PJ.

Partial rehabilitation of the lease areas following completion of drilling activities (to approximately 30 by 30 metres) will result in some minor additional emissions which have not been included in the above. This replanting of approximately 1.9 hectares will result in some capture of carbon by the regrowth. FullCAM estimates this capture to be in the region of 55 T CO_2^e at the end of the three year exploration program, increasing logarithmically to approach the original carbon density of 77 tonnes carbon per hectare.

13.3.2 Scope 2 emission quantification

Scope 2 (indirect GHG) emissions will not occur as there will be no purchases of electricity from the grid. Electricity used onsite will be generated from captured gas, and as such, has already been accounted for in the Scope 1 inventory.

13.3.3 Scope 3 emission quantification

The Scope 3 profile in Table 13-3 below excludes any Scope 3 components which cannot be reliably or predicably forecast, in line with the GHG Protocol.

Lifecycle emissions associated with the purchase of concrete, aggregate, steel and HDPE pipe have been calculated using the ISCA materials calculator.

The emissions associated with the production of diesel for the drill rig and other onsite equipment has also been considered. These emission factors are sourced from the NGA Factors.

Table 13-3 Scope 3 greenhouse gas emissions profile

Component	Tonnes/CO_2^e	Tonnes/CO_2^e/year	
	Construction Phase	Operation Phase[1] (Dewhurst 13-18H)	Operation Phase[1] (Dewhurst 26-31)
Estimated total	328	0.3	0.25

13.3.4 Potential risks associated with greenhouse gas emissions

The primary risk associated with GHG emissions is their potential contribution to NSW and Australian GHG profiles.

Australia's GHG Inventory for 2011 (the most current data available at the time of writing) is provided in Table 13-4. The table shows the maximum expected emissions for the Scope 1 GHG emissions during operation phase of the proposed activity over a 12 month period. The potential GHG contribution of the proposed activity to Australia's existing GHG profile is very minor, being in the region of 0.02 per cent and 0.08 per cent of the National and State emissions profiles respectively. This is equivalent to about two hours of the existing NSW emissions profile.

Table 13-4 Australian and NSW emission profiles

	GHG Emissions (Tonnes CO_2^e)
Australian Emissions (2011)	563,140,390
NSW Emissions (2011)	158,991,280
Maximum Estimated Proposed Activity Emissions (operations phase)	131,189

Based on these results the risk of the proposed activity to the local and national climate is considered very minor. The magnitude of emissions is not of a scale to indicate any directly attributable and measurable impacts on climate.

13.4 Cumulative impacts

Emission estimates for the operation of the E&A Program place the Scope 1 GHG profile at between 170 and 190 kilotonnes of CO_2^e annually. This includes flaring and onsite power generation at Dewhurst 13-18H, Dewhurst 22-25, Dewhurst 26-31 and Tintsfield 2-7, and is exclusive of the Scope 3 Wilga Park Power Station emissions which add approximately 85 kilotonnes of CO_2^e to this profile each year. The proposed activity contributes in the region of 70 per cent of the Scope 1 GHG total.

CSG from the Bibblewindi Multi-Lateral Pilot and Bibblewindi West Pilot is intended for (primarily) consumption at WPPS. Cumulatively, the use of CSG by the WPPS can potentially offset in the region of 100 to 110 kilotonnes of CO_2^e annually if displacing similar generation from coal.

13.5 Mitigation measures

13.5.1 Construction

- Retain timber and woody debris cleared during site preparation (excluding merchantable timber identified by NSW Forestry Corporation) for use in rehabilitation to assist in re-establishing carbon sink.
- Energy efficient equipment and processes will be used where possible.
- Water based drilling fluids will be used.
- Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform National Greenhouse and Energy Reporting Scheme (NGERS) calculations).

13.5.2 Operation

- Regular monitoring and maintenance of equipment and pipes will occur to identify any leaks to minimise fugitive emissions.
- A fugitive emissions monitoring program will be implemented in the E&A Program area.
- Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform NGERS calculations).

13.5.3 Climate change policy

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 its 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.

13.5.3.1 Emissions reporting

Santos has publicly reported its 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). 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
- other audits of compliance with internal policies and procedures related to GHG reduction through the internal audit program.

14.0 Noise

An assessment of the potential noise impacts was prepared to consider the construction and operational noise associated with the proposed activity. This chapter provides a summary of the *Noise Assessment*, prepared by Noise Measurement Services and provided in Appendix 6.

14.1 Existing environment

The nearest residences to the two pilot sites are shown in Figure 3-9. The nearest residence (RR4) is a residential dwelling located approximately 500 metres south of the Dewhurst 13 lease area; however the dwelling is being leased by Santos until December 2015, and will remain vacant until that time. The next closest sensitive receiver to Dewhurst 13-18H is a residence situated approximately 1.8 kilometres south-west of the Dewhurst 13 lease area. The nearest residences to Dewhurst 26-31 are located over 10 kilometres to the north.

Long-term unattended noise monitoring was conducted at two locations, as shown in Figure 3-9, to establish the existing noise environment:

- adjacent to a residential dwelling (ML1) between 14 November 2012 and 26 November 2012
- within the forest (ML2) between 14 November 2012 and 15 November 2012.

Results of the noise monitoring, in terms of Rating Background Levels (RBLs) are provided in Table 14-1.

Table 14-1 Background noise levels for day, evening and night time periods at ML1 and ML2

Location	Rating Background Levels – LA_{90} (dB(A))		
	Day[1]	Evening[2]	Night[3]
ML1	32	33	35
ML2	28	33	16

Notes: 1. 7am to 6pm
2. 6pm to 10pm
3. 10pm to 7am

Under the NSW Industrial Noise Policy (INP), where the recorded RBL is found to be less than 30 dB(A), the RBL is set to 30 dB(A). Therefore, the RBL adopted for the assessment of the proposed activity is 30 dBA.

14.2 Assessment approach

The Noise Assessment was undertaken with reference to the relevant guidance documents:

- NSW Industrial Noise Policy (INP) (EPA, 1999)
- Interim Construction Noise Guideline (ICNG) (DECC, 2009)
- NSW Road Noise Policy (RNP) (DECCW, 2011).

Noise modelling has been undertaken 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 3744:2010 *Acoustics-Determination of sound power levels and sound energy 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 one kilometre. The sound levels calculated in this report are cross-checked with

measured levels at 50 metres and with a variation of approximately one dB(A) this allows confidence in the prediction methodology and assumptions.

14.2.1 Noise assessment criteria

For the purpose of the noise assessment, the proposed activity has been considered a mining activity. In accordance with the ICNG, the construction activities for mining projects are to be assessed under the INP.

The INP assessment procedure for industrial noise sources has two components, which are:

- controlling intrusive noise impacts in the short term for residences
- protecting noise amenity for particular land uses and for residences.

These two components are discussed below.

14.2.1.1 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 level of noise from the source, measured over a 15 minute period, does not exceed the RBL, measured in the absence of the source, by more than five dB(A). This is termed the 'intrusiveness criterion'. For the proposed activity, this is LA_{eq} 35 dB(A).

14.2.1.2 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'. Table 14-2 identifies recommended amenity criteria noise levels for land uses applicable to this assessment, namely 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 will be applied before the recommended upper limit noise levels are referenced.

Table 14-2 Recommended LA_{eq} noise levels from industrial noise sources

Type of Receptor	Indicative noise amenity area	Time of day	Recommended LA_{eq} noise level dB(A)	
			Acceptable	Recommended upper limit
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55

14.2.1.3 Sleep disturbance criteria

The INP recommends an amenity criterion of 40 dB(A) LA_{eq} for night-time (10.00 pm to 7.00 am) at a residence in a rural area. The INP application notes recommend that the LA_1(one minute) noise level outside a bedroom window should not exceed the LA_{90} background noise level by more than 15 dB(A) during the night-time period.

14.2.1.4 Construction noise criteria

Under the ICNG, the noise management level for construction works during the recommended standard hours is background plus an additional 10 dB(A). Above this noise level the proponent needs to implement all feasible and reasonable work practices, as defined in the ING, to minimise noise impacts. For the proposed activity, this is LA_{eq} 40 dB(A).

For works outside the recommended standard hours, the noise management level is background plus an additional five dB(A). For the proposed activity, this is LA_{eq} 35 dB(A).

14.2.1.5 Road traffic noise criteria

The RNP provides criteria to be used in assessing the impact of road traffic noise from new traffic generating developments, based on protecting amenity and wellbeing. It is not mandatory to achieve the noise assessment criteria set out in the RNP, however justification would need to be provided if they are unlikely to be met.

For principal haulage routes along public roads which are considered local roads, the RNP recommends an noise assessment criteria of 55 and 50 dB(A) $LA_{eq(1hr)}$ for day-time (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am), respectively.

In addition, any increase in noise levels for sensitive uses of more than 12 dB(A) for the day/evening or night-time periods will require consideration of mitigation. This is known as the ‘relative increase criteria’.

14.3 Potential impacts

14.3.1 Modelling results

Noise modelling was undertaken for different weather scenarios during both construction and operation.

14.3.1.1 Construction

Drilling activities at Dewhurst 16H was used to model the ‘worst case’ Dewhurst 13-18H construction impacts, as it is the closest lease area to the sensitive receivers at which drilling will be undertaken. Table 14-3 shows the results of this modelling under calm and ‘enhanced’ (windy) conditions.

Table 14-3 Noise modelling results during construction at Dewhurst 16H (LA_{eq})

Resident ID	Distance from site (km)	Predicted noise levels dB(A)	
Scenario		Calm weather	3 m/s winds towards receptor (enhanced conditions)
RR1	3.6	22	32
RR2	3.5	22	31
RR3	2.5	29	39
RR4	0.5	N/A[1]	N/A[1]
RR5	3.1	20	30

Resident ID	Distance from site (km)	Predicted noise levels dB(A)	
RR6	3.7	17	26
RR7	3.7	17	26
RR8	2.6	22	32
RR9	1.8	30	40

Notes: 1. RR4 is not assessed during construction as it will remain vacant until December 2015.

In general, noise levels will be below guideline levels for intrusive noise (35 dB(A)), noise amenity (40-50dB(A)), sleep disturbance (40 dB(A)) and construction noise (35-40 dB(A)). Under enhanced conditions (three metres per second breeze blowing towards the residence), the predicted noise levels at RR3 and RR9 are above the criteria for intrusive noise and night-time construction noise. The predicted noise levels at RR9 are also equal to the criteria for sleep disturbance and day-time construction noise.

Soft ground conditions (trees, grass) were not incorporated into the modelling. These conditions can significantly reduce sound transmission from drilling and construction activities.

Under all weather scenarios, noise levels from construction at Dewhurst 30 and 31 are predicted to be equal to or less than 15 dB(A) at the nearest sensitive receivers (further than 10 kilometres from the drill rig). These levels comply with the noise assessment criteria stated above.

14.3.1.2 Operation

Predicted noise levels modelled for the receivers in the vicinity of the Dewhurst 13-18H Pilot under calm and 'enhanced' (windy) conditions are summarised in Table 14-4.

Table 14-4 Noise modelling results for receivers in the vicinity of Dewhurst 13-18H during operation (LA_{eq})

Resident ID	Distance from site (km)	Predicted noise levels dB(A)	
Scenario		Calm weather	3 m/s winds towards receptor (enhanced conditions)
RR1	3.6	20	27
RR2	3.5	20	27
RR3	2.5	24	30
RR4	0.5	37	41
RR5	3.1	20	28
RR6	3.7	19	27
RR7	3.7	19	27
RR8	2.6	22	30
RR9	1.8	26	33

In general, noise levels will be below guideline levels for intrusive noise (35 dB(A)), noise amenity (40-50dB(A)) and sleep disturbance (40 dB(A)). However, at RR4 the predicted noise levels are just above the criteria for intrusive noise in both climatic scenarios, as well as sleep disturbance during windy conditions.

Again soft ground conditions were not incorporated into the modelling. These conditions can significantly reduce sound transmission from operation of the pilot wells.

During operation, noise levels are predicted to be equal to or less than 15 dB(A) at the nearest sensitive receivers (greater than 10 kilometres from the pilot) to Dewhurst 26-31 Pilot under both climatic conditions. These levels comply with the noise assessment criteria stated above.

Temperature inversions (where 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 and can assist the propagation of noise. Temperature inversion scenarios were modelled as part of the noise assessment and the predicted noise levels were determined to be lower than the enhanced conditions model results. The results are provided in Appendix 6.

14.3.2 Traffic noise

Noise levels associated with the increase in traffic on the Newell Highway due to the proposed activity will be minimal with all construction vehicles and equipment to be delivered during the beginning of the construction works and collected upon completion. Between these times, equipment will generally remain onsite. Road impacts are considered negligible during construction (at or less than 0.1 dB(A) at receivers in the vicinity of the Highway) and will meet the RNP criteria.

Noise levels from construction vehicle movements on the local road network have been calculated on the basis of a maximum pass-by noise level, corrected to $LA_{eq(1hr)}$. The noise levels will be measurable, but will not exceed the RNP criteria (55 dB(A)) under calm conditions, as outlined in Table 14-5.

Table 14-5 Modelled nominal truck noise levels at sensitive receivers (LA_{eq})

Resident ID	Distance from noise source (km)	Predicted noise levels dB(A)	
Scenario		Single pass-by	Two passes-by
RR1	1.75	18	21
RR2	1.65	18	21
RR3	1.10	23	26
RR4	0.28	N/A[1]	N/A[1]
RR5	0.81	22	25
RR6	2.90	14	17
RR7	2.66	14	17
RR8	0.47	31	34
RR9	0.14	42	45
RR10	6.15	13	16
RR11	7.00	20	23
RR12	6.98	33	36
RR13	5.62	19	22
RR15	4.85	19	22

Note: 1. RR4 is N/A during construction as it will remain vacant until December 2015.

During operation, traffic volumes on both the Newell Highway and local roads will be less, and will still be considered negligible.

14.4 Cumulative impacts

Noise impacts dissipate with distance. Other pilots within the E&A Program that will operate concurrently are all located at distances that will not create a cumulative impact, as the closest two pilots are in excess of 2.5 kilometres from each other within vegetated land (refer to Figure 7-1).

During drilling, a maximum of two drilling rigs will be in operation, including a smaller workover rig. The E&A Program ensures that the two drill rigs will operate at sufficient distances to eliminate any cumulative noise impacts.

It is also possible that construction of the northern and southern flow lines will occur at the same time as the proposed activity. The flow lines will involve construction using a ploughing technique parallel to the access track to Dewhurst 14, Killara Road, Rockdale Road, Beehive Road, Tighes Gully Road and other roads within the Pilliga forest. The nearest sensitive receiver is 1.8 kilometres from the proposed pilot sites and any cumulative impacts will be negligible.

14.5 Mitigation measures

The following measures will be carried out prior to and during construction and operation to minimise the potential noise impacts on receivers:

- Forestry NSW, the private landowner at Dewhurst 13-18H and the next two nearest sensitive receivers will be notified prior to the proposed activity commencing.
- During construction, feasible and reasonable work practices will be implemented with the aim to achieve LAeq 40 dB(A) noise levels during recommended standard construction hours and LAeq 35 dB(A) outside of these times.
- During operation, in the event that the residence located 500 metres south of the Dewhurst 13-18H Pilot (RR4) is to be re-occupied, monitoring will be undertaken to confirm operational noise levels at this location. If noise monitoring determines that levels are above noise criteria, an agreement will be negotiated with the landowner, or further feasible and reasonable mitigation measures will be implemented to reduce noise levels.

15.0 Traffic and transport

An assessment of the potential traffic and transport impacts was prepared by GTA. This chapter provides a summary of the *Traffic and Transport Assessment*, with the report provided at Appendix 7.

15.1 Existing environment

15.1.1 Road network

Haulage and access routes to the lease areas will be via existing roads as shown in Figure 15-1. The existing road networks that will service the two pilots include:

- Newell Highway (State road) – both pilots
- X-Line Road (unsealed forestry road) – both pilots
- Garlands Road (unsealed forestry road) – Dewhurst 13-18H pilot
- Westport Road (unsealed forestry road) – Dewhurst 13-18H pilot
- Killara Road (unsealed forestry road) – Dewhurst 13-18H pilot
- Unnamed road (Crown land) – Dewhurst 13-18H pilot
- McFarlanes Road (unsealed forestry road) – Dewhurst 13-18H pilot
- existing unsealed access tracks located at the Dewhurst 13-18H pilot
- Tighes Gully Road (unsealed forestry road) – Dewhurst 26-31 pilot
- Beehive Road (unsealed forestry road) – Dewhurst 26-31 pilot
- Middle Road (unsealed forestry road) – Dewhurst 26-31 pilot
- Bibblewindi Creek Road (unsealed forestry road) – Dewhurst 26-31 pilot.

Travel between the two pilot sites, Narrabri and the drillers camp on Westport Road will occur during the proposed activity.

15.1.1.1 Westport drillers camp

Access to and from the drillers camp will be via Westport Road which intersects the Newell Highway (approximately 25 kilometres) north of X-Line Road. Alternate routes are via McFarlanes Road, Garlands Road, Boundary Road, Nickel Road, Bibblewindi Creek Road, Tighes Gully Road and X-Line Road to the south.

15.1.1.2 Narrabri Operations Centre

During the drilling of Dewhurst 16H, 17H, 18H, 30 and 31 drilling fluid will be tankered to and from the NOC, located in Narrabri. The NOC is accessed via one driveway from Yarrie Lake Road. Yarrie Lake Road is identified as a local road and is aligned in a north southwest direction. The nearest State controlled road is the Newell Highway, located approximately 2.6 kilometres to the south east of the NOC.

Vehicle access between the NOC and the two pilot sites will be via the Newell Highway.

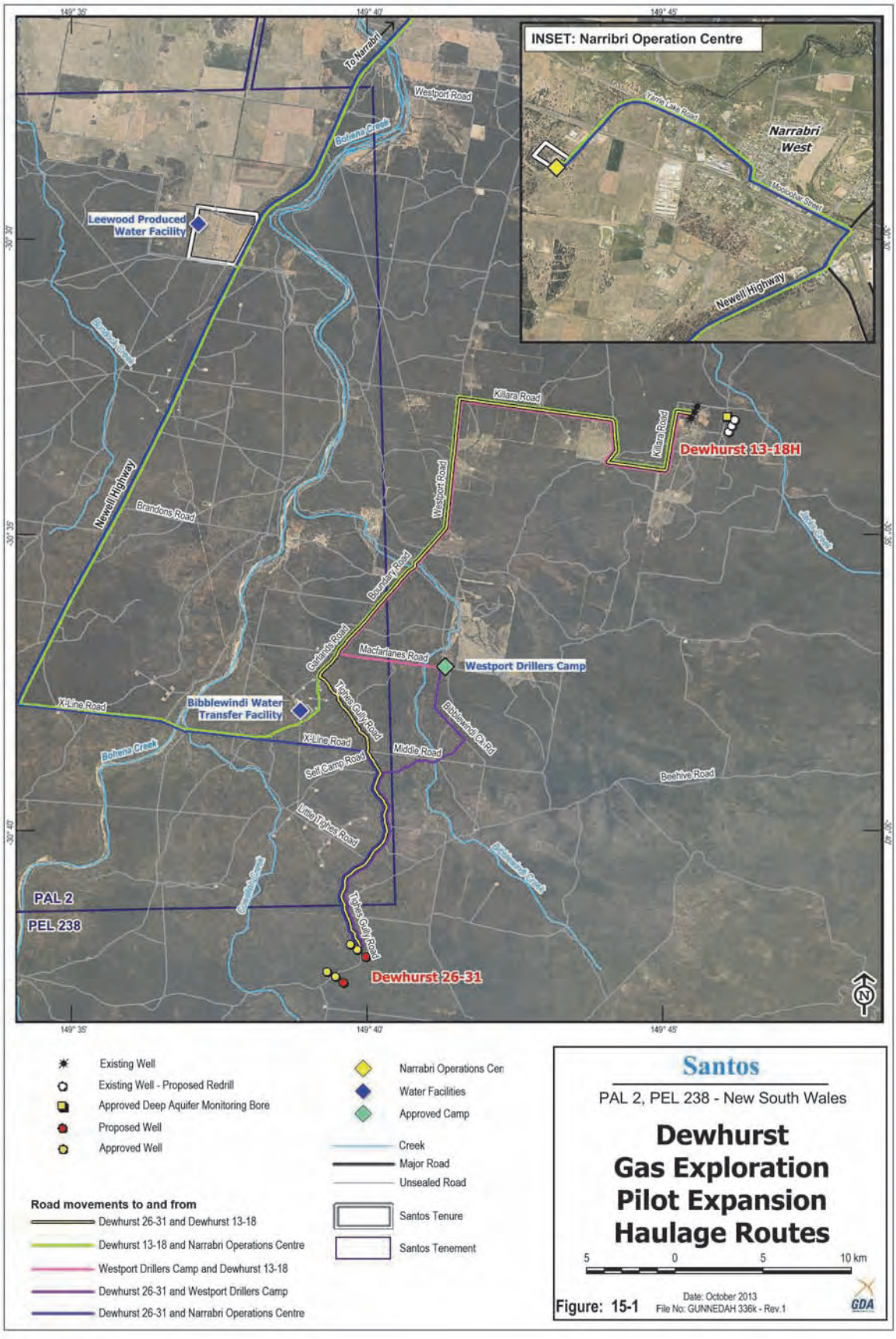


Figure 15-1 Dewhurst Gas Exploration Pilot Expansion haulage routes

15.1.2 Traffic volumes

Recent traffic volumes collected for the Newell Highway approximately 20 kilometres south of Narrabri and 20 kilometres north of X-Line Road are shown in Table 15-1. Traffic flows are relatively consistent across the day time period of 8 am to 4 pm and are in the order of 140 vehicles per hour. Full survey data is provided in Appendix 7.

Table 15-1 Traffic volumes for the Newell Highway

Detail	Volume[1]
Average daily traffic	1,860 vehicles
Proportion heavy vehicles	742 vehicles (40 %)
7 day average peak hour	134 vehicles
Highest average peak hour	156 vehicles

Note: 1. Tube count data collected between September 2011 and November 2011 (Source: Narrabri Shire Council)

Site observations indicate that vehicle activity within the local road network is low, with a maximum of 10 vehicle movements in any peak hour, and less than five vehicle movements in a typical hour. The forestry roads typically carry even less vehicles.

15.2 Assessment methodology

A conservative approach was adopted to identify the potential impacts of the proposed activity. Traffic generation was calculated using estimated traffic volumes based on truck and worker vehicle generation and the construction works schedule. Both peak and typical periods have been established, with consideration for the temporary nature of most construction vehicle volumes.

The traffic volumes and types of trips were broken down based on duration of specific activities during the construction phase. The activities which will produce the greatest number of trips per days are summarised in Table 15-2, while the full breakdown is provided in Appendix 7.

Table 15-2 Estimated maximum construction traffic volumes for the two pilot sites

Construction Activity	Approximate duration (days)	Construction vehicles	Worker vehicles	Total vehicles	Total trips per day
Dewhurst 13-18H					
Site preparation	0	0	0	0	0
Drilling (removal of equipment)	3	18	8[1]	26	52
Gathering system (delivery of equipment)	1	8	3	11	22
Surface facilities (delivery of equipment)	1	3	3	6	12
Dewhurst 30-31					
Site preparation	7	3	1	4	8
Drilling (delivery of equipment)	3	19	8[1]	27	54
Gathering system (delivery of equipment)	1	3	3	6	12
Surface facilities (delivery of equipment)	1	3	3	6	12

Note: 1. Vehicles associated with transportation of workers by bus and delivery of meals to workers at the works site.

Table 15-2 indicates that the peak vehicle activity for each pilot occurs when drilling equipment is delivered to or removed from site. Approximately 46 to 54 daily vehicle trips are likely over a maximum of three days per well.

Based on the current staging schedule for the two pilots, there will be a peak of approximately 66 vehicles trips. This will occur where drilling activities at Dewhurst 13-18H overlap with surface facility works at Dewhurst 30-31. This peak vehicle activity is likely to be over a maximum duration of three days and largely infrequent.

No new river crossings or upgrades to existing crossings (as shown in Figure 15-1) are proposed as all movements will be confined to existing Forest roads. Vehicle types will typically be heavy vehicles with the largest vehicle equivalent to a 19 metre rigid truck. During operation, vehicle types will generally by 4WD or passenger size vehicles.

15.3 Potential impacts

15.3.1 Construction

All construction vehicles and equipment will be delivered during the beginning of the construction works and collected upon completion. At these times delivery and collection of equipment will have an impact on the external road network. Between these times, equipment will remain onsite.

Access to the Dewhurst 13-18H pilot will be from the Newell Highway and a number of unsealed forestry roads including X-Line Road, Garlands Road, Westport Road and Killara Road. Access to the Dewhurst 26-31 Pilot will also be from the Newell Highway and a number of unsealed forestry roads including X-Line Road, Tighes Gully Road and Beehive Road, as shown in Figure 15-1.

The proposed route between Dewhurst 13-18H and Dewhurst 26-31 includes Killara Road, Westport Road, Garlands Road, Tighes Gully Road and Beehive Road, as shown in Figure 15-1. This route will be required for the transportation of heavy machinery between pilot sites and is anticipated to have minimal impact on the internal road network.

The majority of these roads have been used for the construction and operation of existing pilot wells, including Dewhurst 13-18H and the Bibblewindi Multi-Lateral Pilot. These routes will adequately accommodate all vehicles throughout construction and operation, and avoid sensitive receivers where possible.

15.3.2 Capacity

Capacity constraints generally occur at intersections where there are opposing traffic movements. As construction vehicles will enter the Forest via X-Line Road, this intersection with the Newell Highway will be impacted. However given the low volumes of traffic, and capacity of Newell Highway to accommodate additional vehicles, it is expected that the existing road network will accommodate the increase in traffic with minimal disruption.

The *Guide to Traffic Management Part 2: Traffic Theory* (Austroads, 2009) provides further guidance when assessing the impacts associated with increased traffic volumes, which has been referenced in assessing the anticipated increase in truck volumes at the intersection of the Newell Highway with X-Line Road. During a weekday peak period, a vehicle will pass X-Line Road along the Newell Highway every 20 to 30 seconds. A single vehicle exiting right from X-Line Road would require a gap of around seven to eight seconds to enter the Newell Highway traffic stream. On this basis the intersection will be capable of safely accommodating the anticipated increase in vehicles associated with the construction works.

15.3.3 Efficiency

Efficiency is a measure of the ease of travel between an origin and destination, primarily relating to travel times, delays and vehicle kilometres travelled. No changes to the operation of the local roads used (such as detours or realignment) are proposed. Construction traffic is proposed to use the most direct route(s) capable of accommodating the proposed activity. In combination with the existing low volumes of traffic on the unsealed forestry roads and the low volumes of traffic generated during construction, road network efficiency will not be reduced.

The Newell Highway will continue to operate at or near Level of Service (LOS) B, with an increase in daily vehicle movements of one to three per cent. LOS is a performance standard which describes the efficiency of traffic travelling along a stretch of road or at an intersection. LOS B consists of stable flow, where drivers have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream, as detailed in the *Guide to Traffic Generating Developments* (RTA, 2002).

15.3.4 Functionality

Functionality relates to the geometry and surface of roads and intersections to accommodate heavy vehicles.

The existing intersection configuration at the Newell Highway and X-line Road is capable of accommodating vehicle sizes up to 19 metres. As such, the access to the two pilot sites via X-line Road will be adequate to accommodate the proposed construction vehicles.

15.3.5 Safety

Additional traffic using forest roads could increase the occurrence of crashes. Santos will continually monitor road conditions. A 30 metre section of X-Line Road has recently been sealed at its intersection with the Newell Highway, to assist heavy vehicles and allow for safe operation.

15.3.6 Operation

The two pilots are anticipated to operate for up to three years, with a similar number of staff to current operations once drilling of the wells is complete. Typically one to two staff members will visit the pilot sites daily during operation for monitoring and maintenance activities.

Planned operational and maintenance activities will be primarily between the hours of 7 am to 5 pm, seven days a week with the workforce located in the local Narrabri area.

Given the very low volumes, the existing road network will easily accommodate the additional traffic without any additional mitigation.

15.4 Cumulative impacts

The *Traffic and Transport Assessment* includes a cumulative assessment undertaken to identify the peak construction traffic impact where an overlap of works occurs within the E&A Program. It is estimated that approximately 88 vehicle trips could potentially occur on any peak day. This includes 62 construction vehicle trips and 26 worker vehicle trips.

The specific site accesses and corresponding access routes will reduce impacts associated with the cumulative traffic volumes.

The cumulative impacts of the construction works result in less than a four per cent increase in existing Newell Highway traffic. The Highway has considerable spare capacity and will be capable of accommodating the peak traffic volumes generated by the E&A Program. The relevant intersections will also be capable of accommodating the peak vehicle generations associated with the cumulative vehicle generation.

Cumulative operational traffic volumes will have a negligible impact on the Newell Highway and its relevant intersections, with negligible long term impacts on the local road network.

15.5 Mitigation measures

15.5.1 Construction

- Vehicles will not travel at speeds greater than 80 kilometres per hour along unsealed roads (including within the forest) unless otherwise signed.
- Heavy vehicle activity passing through residential areas will be confined to standard construction hours (7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm Saturday).
- All site staff and delivery drivers will receive the appropriate induction (consistent with Santos policies), which will include driver protocols and identification of any local hazards.
- An in-vehicle monitoring system (IVMS) will be fitted to all Santos vehicles.
- Construction vehicle movements will be restricted to designated routes to/from site via the Newell Highway.
- Construction vehicle activity will be managed and controlled in the vicinity of the two pilot sites.
- Any damage to roads caused by construction activities will be repaired at Santos cost in accordance with the Permit to Occupy or land access agreement.

15.5.2 Operation

No site-specific mitigation measures are proposed or required.

16.0 Waste

16.1 Existing environment

The *NSW Waste Avoidance and Resource Recovery Strategy 2007* (DECC, 2007) (Waste Strategy) sets out principles promoting the adoption of measures which avoid unnecessary resource consumption and encourage resource recovery, including reuse, reprocessing, recycling and energy recovery. Four key areas are identified where outcomes must be achieved in order to avoid and manage waste. These are:

- preventing and avoiding waste
- increasing use of recovery and use of secondary materials
- reducing toxicity in products and materials
- reducing litter and illegal dumping.

Waste management measures implemented for the proposed activity will encourage efficient resource use alternatives, re-use and recycling. Waste that cannot be re-used or recycled will be disposed of in an appropriate manner.

The EPA's *Waste Classification Guidelines* (DECCW, 2009) describe a number of waste streams and provide specific direction on the classification of wastes, based on chemical composition and associated environmental impacts. Waste streams require different management, transportation and disposal depending on their classification. The six waste stream categories are:

- special waste (e.g. clinical and related, asbestos and tyres)
- liquid waste
- hazardous waste (e.g. waste with pH less than two, coal tar, lead paint waste)
- restricted solid waste
- general solid waste (putrescibles) (e.g. household wastes, manure, food wastes)
- general solid waste (non-putrescible) (e.g. glass, plastic, rubber, garden waste).

16.2 Potential impacts

The proposed activity will generate a number of waste streams. Waste will predominantly be generated during the construction phase including:

- drilling activities
- site clean up
- general waste from contractors and personnel onsite.

16.2.1 Construction

The main waste types and estimated volumes generated by the proposed activity during construction are identified and classified according to the *Waste Classification Guidelines* in Table 16-1. 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. These are described in detail in Sections 4.3.7.5 and 4.3.7.6.

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 illegal dumping 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.

Table 16-1 Classification of potential waste generated from the proposed activity during construction

Classification	Type	Estimated Volume		Disposal Option
		Dewhurst 13-18H	Dewhurst 30-31H	
Liquid waste	Drilling fluid	450 m^3	375 m^3	Transported by a licensed contractor to a Santos operated fluids treatment facility at Narrabri or an appropriately-licensed disposal facility.
	Drilling fluid-contaminated cement slurry	115 m^3	45 m^3	Transported by a licensed contractor to an appropriately-licensed disposal facility.
	Produced water	300 m^3	150 m^3	Transported by a licensed contractor to the Leewood Produced Water Facility or an appropriately-licensed facility.
	Fuels, engine coolant and hydrocarbon residuals	< 100 L	< 100 L	Transported by a licensed contractor to an appropriately-licensed disposal facility.
	Human waste including pump out waste and sewage[1]	<30 m^3	<30 m^3	Transported by a licensed contractor to an appropriately-licensed disposal facility.
General solid waste (putrescible)	General waste including food waste from personnel and non-recyclables	< 20 m^3	< 20 m^3	Transported to the Narrabri Waste Management Facility.
General solid waste (non-putrescible)	Drill cuttings[2]	150 m^3	200 m^3	Re-use onsite (under Naturally Excavated Material (NEM) exemption) or transported by a licensed contractor to an appropriately-licensed disposal facility.
	Drained oil filters, empty oil containers and oil absorbent materials that do not contain free liquids, plastics (e.g. packaging, pipe caps), concrete wastes, cured resins, paints, glues, etc.	< 40 m^3	< 40 m^3	Transported by a licensed contractor to an appropriately-licensed disposal facility.
	Recyclables including glass, PET bottles, aluminium, scrap metal (e.g. pipe cuttings), rope spacers, paper and cardboard	< 20 m^3	< 20 m^3	Transported to the Narrabri Waste Management Facility for sorting and recycling.

Note: 1. Sewage waste from toilet facilities provided for workers during their shift. Camp facilities will not be located onsite.
2. It is expected that drill cuttings will consist of NEM and can be used in site rehabilitation under the NEM exemption issued by the EPA on 19 October 2012. If required, drill cuttings will be tested using the bulk sampling technique for NEM, and if found to exceed the limits set by the NEM exemption, will be classified and treated as general solid waste (putrescible).

16.2.2 Operation

Waste generated during operation of the Dewhurst 13-18H Pilot and the Dewhurst 26-31 Pilot will consist predominantly of produced water. The estimated maximum rate of produced water from the Dewhurst 13-18H and Dewhurst 26-31 pilots is 397 and 448 cubic metres per day, respectively. This peak water production occurs at the start of operation, and will taper off relatively quickly. The estimated average rate from these pilots is 302 and 378 cubic metres per day, respectively.

Potential risks associated with the generation and disposal of produced water relate to the capacity of the infrastructure to handle this volume of water, and the possibility of infrastructure failure and resultant potential impact of the produced water on groundwater, soils or surface water.

Some waste will be generated through the undertaking of maintenance works, including potential workovers of the wells as per standard industry practice. It is considered that the volumes of waste generated from these activities will be minimal. As an estimate, during a workover it is likely that 75 to 125 cubic metres of water will be produced per well. This will be trucked (approximately three to five trailer loads) to the Leewood Produced Water Facility or a suitably licensed facility.

16.3 Cumulative impacts

16.3.1 Construction

The main waste types and estimated volumes generated across the E&A Program during construction are identified in Table 16-2.

Potential cumulative impacts associated with the generation and disposal of these wastes mainly relate to addition to landfill and capacity of management, disposal or recycling facilities to cope with the volumes produced.

Table 16-2 Estimated cumulative waste volumes during construction

Waste Type	Estimated Volume[1]				
	Dewhurst 13–18	Dewhurst 22–25	Dewhurst 26–31	Bibblewindi Multi-Lateral	Total
Drilling fluid (m^3)	450	450	775	400	2,075
Drilling fluid-contaminated cement slurry (m^3)	115	115	160	45	435
Produced water (m^3)	300	300	450	300	1,350
Fuels, engine coolant and hydrocarbon residuals (L)	< 100	< 100	< 100	< 100	<400
Human waste including pump out waste and sewage (m^3)[2]	<30	<30	<30	<30	<120
General waste including food waste from personnel and non-recyclables (m^3)	<20	<20	<20	<20	<80
Drill cuttings (m^3)[3]	150	780	880	195	2,005
Drained oil filters, empty oil containers and oil absorbent materials that do not contain free liquids, plastics (e.g. packaging, pipe caps), concrete wastes, cured resins, paints, glues, etc. (m^3)	<40	<40	<40	<40	<160
Recyclables including glass, PET bottles, aluminium, scrap metal (e.g. pipe cuttings), rope spacers, paper and cardboard (m^3)	<20	<20	<20	<20	<80

Note: 1. Bibblewindi West and Tintsfield 2-7 pilots are not included as they do not involve any additional drilling or significant construction works.
2. Sewage waste from toilet facilities provided for workers during their shift. Camp facilities will not be located onsite.
3. It is expected that drill cuttings will consist of NEM and can be used in site rehabilitation under the NEM exemption issued by the EPA on 19 October 2012. If required, drill cuttings will be tested using the bulk sampling technique for NEM, and if found to exceed the limits set by the NEM exemption, will be classified and treated as general solid waste (putrescible).

16.3.2 Operation

As stated previously, produced water will form the main waste component during operation. The estimated volumes of produced water for the entire E&A Program are provided in Table 16-3.

Potential cumulative impacts associated with this produced water relate to treatment and transportation capability, and the possibility of infrastructure failure and resultant leakages of the produced water to groundwater, soils or surface water.

Table 16-3 Estimated cumulative pilot extraction rates

Pilot	Maximum Extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13–18	397	302
Dewhurst 22–25	273	260
Dewhurst 26–31	448	378
Bibblewindi Multi-Lateral	581	260
Bibblewindi West	209	85
Tintsfield 2–7	43	23
Total	**1,951**	**1,308**

16.4 Mitigation measures

16.4.1 Construction

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.

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

16.4.1.1 General waste management

In addition, the following measures will be carried out to minimise waste and potential impacts associated with waste generation and disposal:

- Management of drilling fluids and drill cuttings in accordance with principles outlined in Sections 4.3.7.5 and 4.3.7.6.
- Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation.
- The Waste Management Plan will be implemented, that will be based on the waste reduction hierarchy of avoid, reduce, reuse, recycle, recover, treat and dispose.

- General site waste will be segregated according to their classifications under the *Waste Classification Guidelines* (DECCW, 2009) and stored in bins or skips within a designated waste transfer point within the lease area prior to transportation for disposal.
- Regulated waste will be collected by licensed contractors for offsite disposal. General and recyclable waste will be transported to local council landfill and recycling facilities.
- 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.
- Sewage waste will be removed from site by a licensed contractor for treatment and disposal, as required.
- The type and volume of all waste removed from site will be recorded.
- 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 SDS or manufacturers' directions to avoid potential impacts to the environment or human health.

16.4.2 Operation

The main waste stream during operation will be associated with water produced from the wells. The produced water extracted from the aquifer will be captured at the wellhead and transferred through the water gathering system to Dewhurst 14 or Dewhurst 28. As outlined in Section 4.4.2, the water will then be stored in a transfer tank and transferred by the existing pipeline to the Bibblewindi WTF, and then on to the Leewood Produced Water Facility.

Waste generated during maintenance works, including potential workovers is considered to be minimal and will be managed and disposed of using the same relevant methods as to those used during construction.

17.0 Hazards

17.1 Existing environment

17.1.1 Bushfire

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 of the Pilliga scrub, while an extremely dry winter and spring in 2006 saw a number of large fires develop. In January 2013, large fires threatened the Pilliga scrub.

17.1.2 Hazardous and offensive development

The *State Environmental Planning Policy No 33 – Hazardous and Offensive Development* (SEPP 33) presents a systematic approach to planning and assessing proposed activities for 'potentially hazardous' and 'potentially offensive' development for the purpose of industry or storage. The Hazardous and Offensive Development Application Guidelines – Applying SEPP 33 (SEPP 33 Guideline) (DP&I, 2011) provide guidelines to assist consent authorities and proponents to establish whether an activity would fit into such definitions and hence, come under the provisions of SEPP 33.

17.2 Assessment approach

17.2.1 Potentially hazardous industry

For an activity to be classified as a 'potentially hazardous industry' the policy establishes a comprehensive test by way of a preliminary hazard analysis (PHA) to determine the risk to people, property and the environment at the proposed location and in the presence of controls. Should such risk exceed the criteria of acceptability, the development is classified as 'hazardous industry' and may not be permissible, depending on the local zoning.

In order to determine whether the proposed activity is a potentially hazardous industry, the risk screening method outlined in the SEPP 33 Guidelines was applied. The risk screening method is based on the potential for, and consequences of an explosion, fire, or release of toxic substances. It takes the following factors into account:

- the properties of the substances being handled or stored
- the conditions of storage or use
- the quantity involved
- the location with respect to the site boundary
- the surrounding land use.

The SEPP 33 Guideline provides a three-step risk screening method to assist consent authorities in determining whether a proposed development is potentially hazardous as outlined below.

(1) Identify hazardous materials and the type of hazard

(2) Group hazardous materials and total by class, activity and location

(3) Compare with screening threshold.

Through the application of this risk screening method, it was identified that a small quantity of a hazardous material (diesel) will be transported to and stored onsite (refer to Table 17-1). None of the chemicals that may be used in the drilling process or held onsite during the drilling process are listed in the Australian Dangerous Goods Code (NTC, 2011) and therefore, for the purposes of the risk screening method, are not considered to be hazardous.

Table 17-1 List, volume, packaging and transport details of hazardous materials to be stored onsite

Material	Australian Dangerous Goods Code (ADGC)	Packaging Group I, II or III (according to ADGC)	Volume transported to site	Mode of storage
Diesel	3	III	<25 tonnes	Tank

Based upon a separation distance of 50 metres, the proposed activity will only be within the 'potentially hazardous region' if the quantity of diesel transported to site was around 1,100 tonnes. Therefore the proposed activity does not comprise a potentially hazardous industry and a PHA is not considered to be necessary.

17.2.2 Potentially offensive industry

The SEPP 33 Guidelines state that if a proposed activity requires a licence under any pollution control legislation the proposed activity should be considered to be potentially offensive. As discussed at Section 6.2.4, the proposed activity will require an EPL to be issued by EPA in accordance with the POEO Act. The key consideration in the assessment of a potentially offensive industry is that the consent authority is satisfied that there are adequate safeguards to ensure emissions can be controlled to a level at which they are not significant. If the consent authority is not satisfied, the proposed activity may be an offensive industry. The minimum test for such developments is meeting the requirements for licensing by EPA.

Santos is in the process of preparing the necessary applications for licensing under the POEO Act. The proposed activity will operate in accordance with the requirements of these EPLs. As such the proposed activity will not constitute an offensive industry and no further consideration of potentially offensive industry under SEPP 33 is required.

17.3 Potential impacts

17.3.1 Bushfire risk

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.

In the event of a bushfire a review and risk assessment will be conducted on drilling activities that have the potential to be exposed to the bushfire, with identified controls implemented to manage activity exposure. Santos has developed a bushfire management plan and an emergency response plan that details the broad responsibilities and duties of personnel during an emergency event such as a bushfire.

The bushfire management plan provides guidance onsite responsibilities, actions, reporting requirements and resources required to ensure effective and timely preparedness is undertaken in the prevention of any bushfire incident or emergency at operations sites. The plan is relevant to both State forest and private land, and addresses the requirements of the Permit to Occupy which includes:

- implementation of all reasonable precautions to minimise the risk of fire on the Permit to Occupy Area and in particular in any facilities, building or structure on the Permit to Occupy Area
- a cleared flare exclusion zone will be established around the proposed flare stack to ensure all personnel movements and revegetation activities occur outside the maximum radiation zone, and to minimise the likelihood of accidental ignition

- a fire tanker with capacity of not less than 400L on standby at all times together with adequate devices and appliances to prevent or retard the spread of fire
- any cleared vegetation other than merchantable logs or woody material reserved for rehabilitation is, with the prior approval of Forestry NSW removed from the Permit to Occupy area and destroyed as directed by Forestry NSW
- no burning of timber, grass, cleared vegetation or other combustible matter is undertaken without the prior consent of Forestry NSW.

17.3.2 Public safety and chemical use

The proposed activity will introduce potential hazards to the two pilot sites, such as moving vehicles, plant and machinery, and chemicals, fuels and oils. This could have safety implications for private landowners, Forestry NSW employees and recreational users, and Santos employees.

The proposed activity will require the use of chemicals, fuels and oils, particularly during drilling activities, as described in Section 4.3.7. While these substances are nontoxic, 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, or pollution of land, water or air. Moving vehicles, plant and machinery may also introduce a potential hazard to the two sites, which may have safety implications due to the accidental ignition by vehicles or machinery.

The risk to the environment is considered to be low as chemicals will be stored onsite in small quantities, and will be elevated in a trailer. The proposed activity will be short term and all chemicals will be used and disposed of in accordance with the relevant SDS.

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.

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

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

The impacts associated with spills and associated mitigation measures are covered in the discussion on soil quality (Sections 8.2 and 8.4) and surface water quality (Sections 10.2 and 10.4).

No radiation impacts are expected from the proposed activity.

As discussed at Chapter 16.0, a waste management plan will be prepared prior to construction to minimise potential from waste. Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation.

17.4 Cumulative impacts

Diesel will be used in plant during construction of the proposed activity and other activities as part of the E&A Program, and for maintenance activities during operation. There is potential for diesel to be spilled or leaked during transport, storage or use. However, these substances are stored and used in relatively small volumes and any spills or leaks are likely to remain localised. Therefore the potential for cumulative impacts as a result of hazardous substances is low.

There is potential for fire during the construction and operation phases of the exploration activities, particularly given the flammability of gas which could fuel a fire should there be any gas leaks near ignition sources. Provided bushfire prevention and mitigation measures (e.g. adequate asset protection zones) are

implemented, it is unlikely that the exploration activities will alter current fire regimes across the E&A Program area.

17.5 Mitigation measures

17.5.1 Construction

- Site safety protocols, incident management and emergency procedures will be implemented during the construction and drilling works.
- The two pilot sites will be kept in a clean and tidy manner during site preparation, drilling activities and operation of the pilot wells.
- 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*.
- Chemical, fuel and oil containers will be managed according to the SDS or manufacturers' directions to avoid potential impacts to the environment or human health.

17.5.2 Operation

- The flare at Dewhurst 14 will be designed to limit the risk of ignition. Acceptable radiation limits for various locations at the flare site will be determined based on the *American Petroleum Institute (API) 521 Standard* (API, 2007) and *AS 60079.10.1 – Classification of Areas – Explosive Gas Atmospheres*.
- Within the sterile zone, a HDPE liner will be laid, covered with approximately 300 millimetres of compacted soil and blue metal aggregate.
- Where feasible best practice bushfire risk management will be implemented.
- All statutory obligations for bushfire management will be met.
- An education program for staff and contractors regarding the risks from bushfires in consultation and collaboration with relevant stakeholders will be implemented.

18.0 Social and economic

18.1 Existing environment

18.1.1 Social and demographic overview

Social and demographic data based on the 2011 Australian Bureau of Statistics (ABS) Census was reviewed to identify any specific characteristics for the Narrabri LGA compared to NSW averages.

Based on 2012 ABS Estimated Resident Population (ERP) the population of the Narrabri Shire is approximately 13,564 people. This is an increase of approximately 89 people from the 2011 ERP figure.

The age distribution in the Narrabri LGA is indicative of a mix of young families with children as well as an ageing population. There is a lower proportion of residents aged 25 to 54 (which make up the majority of the working population) compared to the NSW average, 38.2 per cent and 41.4 per cent respectively (2011 Australian ABS Census). This is reflective of the possible lack of job/career opportunities for this age bracket within the LGA.

The growth in new industries such as mining, and the local services required to support this growth, will help to not only diversify the economic base which is largely reliant on the agriculture sector of the region, but will also increase local skills in line with new employment opportunities. In order to attract younger working families to the region, provision of closer employment opportunities as well as a range of opportunities is necessary. Investment in the mining industry and the resulting employment, both directly and indirectly, will provide additional job and career opportunities for the local population.

Based on the March 2013 small area labour data the Narrabri Shire had an unemployment rate of 4.9 per cent (DEEWR, 2013). This is lower than the average NSW unemployment rate of 5.4 per cent. The addition of further employment opportunities for local residents associated with the proposed activity will have a positive impact on the current unemployment levels, helping to maintain low levels of unemployment in the shire.

The *Narrabri Shire Economic Development Strategy* (AEC Group, 2011) outlined future opportunities for the Narrabri Shire to help diversify its economy. This included the opportunity to leverage the mining sector to create further investment in the area as well as expand value adding uses such as mining services businesses locating in industrial land in the Shire.

18.1.2 Santos' role in the local community

18.1.2.1 Regional community benefit fund

As part of its commitment to the Narrabri community, Santos takes part in a local sponsorship program that benefits the local community. Approximately $300,000 is contributed annually by Santos. This money goes towards a mix of community wellbeing and health, education and youth, indigenous engagement and industry and environment programs. This program aims to enhance a range of local community networks and facilities. Figure 18-1 provides an indication of how the sponsorship is distributed.

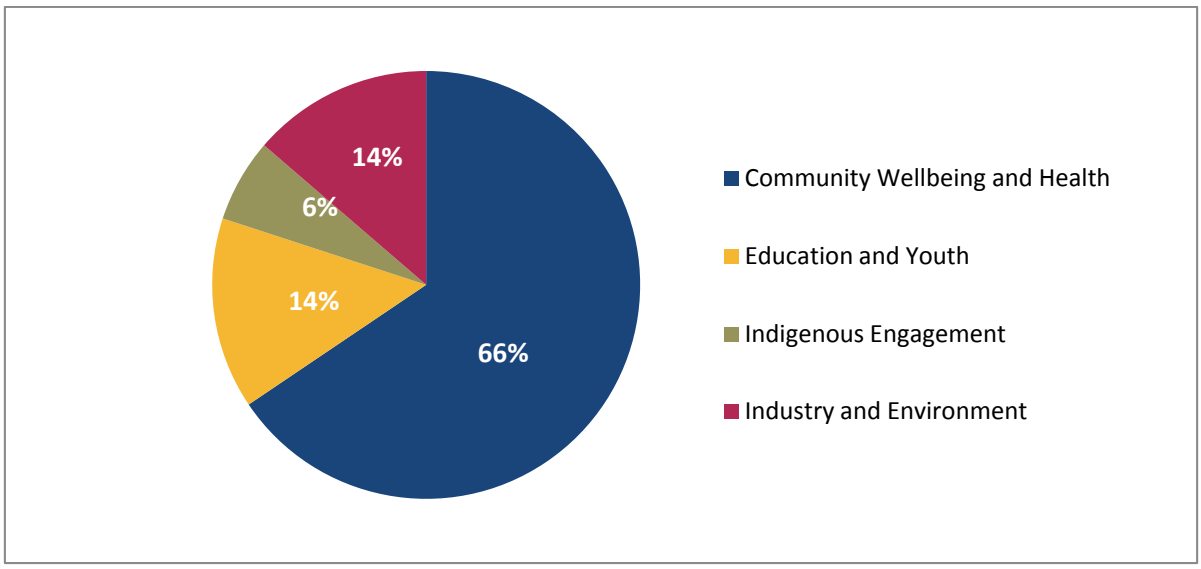


Figure 18-1 Santos sponsorship program

Moving forward, Santos has committed to contributing to the regional community benefit fund the equivalent of 5 per cent of the royalty payment made to the NSW Government within the future production licence area. This amount will then be matched by the government. It is estimated that the fund could reach $300 million over the next two decades.

18.1.2.2 Employment

Santos employs 31 Equivalent Full Time (EFT) people within its current operations in Narrabri and Gunnedah. All these staff are locally based. The local team are supported by employees within Sydney and Brisbane as part of Santos' Eastern Australia operations. On average an additional 12 employees visit the region per week.

18.1.2.3 Social Infrastructure provision

Any additional population drawn to the area as a result of employment from the proposed activity is likely to be minimal, and catered for by the existing residential communities. Santos currently has four residences in the local area. These properties are rented to the local workforce.

The increased number of employees during drilling activities will be accommodated in the Westport Drillers Camp (refer Section 3.2.1.4). This is located approximately 10 kilometres north of the Dewhurst 26-31 pilot and will have capacity to accommodate 24 to 64 drillers at the camp site. The provision of this accommodation will help to mitigate any risks such as housing stress which could arise if the entry of these workers to the housing market started to limit housing supply and thus increasing rents.

18.1.2.4 Buy local program

Santos is implementing a buy local program that seeks to promote local contractors, services, equipment and products. Contractor forums have been held (refer Section 5.3.5) to provide information of upcoming activities and to identify opportunities for local businesses.

Santos estimates that approximately $0.8 million has already been spent in the last financial year on vehicle maintenance and leases, fuel and locally based contractors. This continued expenditure is likely to contribute both to the Narrabri economy and the wider northwest NSW region.

18.1.2.5 Land access and compensation

Santos has an established land access and compensation agreement protocol and a series of initiatives to support working with landowners, including the landowner of Lot 32 DP 757104. These incorporate the following aspects:

- the agreement is entered into voluntarily
- the agreement runs only for the period that exploration and appraisal activities will be undertaken on the landowner's property
- if required, a separate agreement will be prepared to allow for access and compensation payments during the production phase
- Santos recommends that landowners receive independent legal advice prior to entering into an agreement, whereby Santos pays the associated legal fees
- Where possible, Santos negotiates with the landowner to find mutually agreeable CSG infrastructure locations on their property.

18.2 Assessment approach

In order to determine the direct and indirect benefits of the proposed activity an Input-Output model calculating economic and employment multipliers for different industries has been developed. The multipliers have been calculated in line with the methodology prescribed in *Information Paper Australian National Accounts Introduction to Input-Output Multipliers* (Cat No 5246.0) (ABS, 1995). The calculations use data from *Australian National Accounts: Input-Output Tables – Electronic Publication, 2007/08 Final* (Cat No. 5209.0.55.001) (ABS, 2007), namely Tables 5 and 20.

18.3 Potential impacts

18.3.1 Direct employment

The proposed activity will see approximately 11.2 EFT direct jobs created during the construction and drilling phase of the project. This workforce is considered to comprise a mix of fly in-fly out (FIFO) workers (8.3 EFT) as well as local residents (2.9 EFT) for the project. Once the proposed activity is operational an additional two EFT jobs for local residents may be created by the proposed activity. This workforce breakdown will see a much higher number of EFT jobs offered in the construction phases of the proposed activity compared to the operations stage of the proposed activity.

Any local based employees are anticipated to be sourced from Narrabri as well as nearby Gunnedah and Tamworth depending on the skills required for the job. Additional employment in the mining industry is in line with desired outcomes of the Narrabri Shire Economic Development Strategy and will provide employment opportunities for the growing local population.

18.3.2 Indirect employment

Based on capital investment of approximately $15.2 million the proposed activity is estimated to generate $8.1 million in output multiplier effect (i.e. additional demand). This effect will lead to the creation of up to an additional indirect 24 jobs in the local and wider economy as part of this multiplier effect. It should be noted that these are preliminary projections and provide an indication of the potential additional economic and employment benefits the proposed activity may have based on current inputs.

The proposed activity relies on a number of FIFO workers during drilling however this will still benefit the local and regional economy in a number of ways. The Westport Drillers camp will be serviced by local people and provisions, including food and fresh produce which are sourced locally. FIFO workers are also estimated to generate a local expenditure of approximately $25 per person per day on local businesses such as restaurants, cafes, cinema, hotels, etc. This expenditure on local goods and services ensures that the benefits of the FIFO workforce of the proposed activity are passed along to local businesses and are not confined to the mining services sector.

18.3.3 Other economic and social impacts

The potential effects of the proposed on the economic and social fabric of Narrabri and its surrounding communities are summarised in Table 18-1 below. A '+' indicates a positive effect, a '0' a neutral or uncertain and a '-' a negative effect.

18.4 Cumulative impacts

The E&A Program will further increase local expenditure and employment opportunities. Approximately 29 EFT jobs for local residents in Narrabri and Gunnedah, and four EFT FIFO jobs will be created due to the E&A Program. This will stimulate the local and regional economies through employment and investment in the region and contribute to diversifying the local economy. Santos is committed to working with local governments to ensure that these benefits are realised.

The proposed activity as part of the E&A Program will lead to a net benefit for the local and regional community and possibly NSW as part of a growing CSG industry.

18.5 Mitigation measures

- Consultation activities will occur in accordance with Chapter 5.0 of the EIS.
- Continued contribution to the local sponsorship program.
- Implementation of a buy local program.

Table 18-1 Proposed activity impact on economic and social indicators

Criteria			Impact	Comment
1	Economic Impacts	Increases or decreases retail and other services within the local area	0	No change to current situation.
		Increases or decreases facilities within the local area	0	No change to current situation.
		Better uses or makes redundant existing infrastructure	+	Makes use of existing infrastructure where feasible.
		Increases or decreases demand for local goods and services	+	Additional local jobs as part of the construction phase will increase household expenditure levels creating flow on economic benefits for local businesses and services.
		Impact on existing economic land uses (commercial, tourism, etc)	0	No change to current situation.
		Impact on existing energy supply	+	Proposed activity will contribute to future domestic gas supply.
2	Employment	Improves or reduces access to employment	+	Provision of more local employment during each phase of project.
		Increases or decreases long term jobs (temporary or permanent)	+	Predominately short term employment opportunities during proposed activity however E&A Program may result in an increase in long term employment opportunities during production.
		Impact on skills / education	+	Provision of local employment will assist in up-skilling, where education and qualifications are provided on-the-job.
		Safeguards or threatens existing jobs	+	Additional jobs will ensure existing mining related and supply services in Narrabri as well as the wider region have the opportunity to continue to employ people.
4	Community Networks	Provides or reduces facilities or opportunities for social interaction	0	No change to current situation.
		Improves or reduces community identity and cohesion	0	No change to current situation.
		Improves or reduces existing residential amenity	0	No change to current situation.
		Creates or removes physical barriers between homes and community facilities	0	No change to current situation.
		Impacts on disadvantaged social groups	+	Santos sponsorship program includes education and youth, and indigenous engagement.
		Benefits or displaces disadvantaged groups	+	Sponsorship program benefits local youth and indigenous population through engagement and education.

Criteria			Impact	Comment
		Consolidates or dislocates existing social or cultural networks	+	The sponsorship program will aim to engage and consolidate community and cultural networks through funding a variety of different categories.
5	Public Realm	Safeguards or threatens heritage sites or buildings, or archaeological sites	0	No change to current situation – no heritage sites, relics or places of non-Indigenous cultural heritage value, or vegetation with natural heritage values, were recorded at the two pilot sites during the archaeological survey undertaken by RPS.
		Makes available / enhances or detrimental to public places / open space	0	No change to current situation.
		Provides or displaces public facilities	0	No change to current situation.
		Avoids or exhibits overdevelopment / large scale buildings	+	The proposed activity makes use of existing infrastructure and is entirely within the footprint of existing lease areas.
6	Infrastructure	Increases or decreases housing stock	0	Drillers will be accommodated within the Westport drillers camp. Other FIFO workers will stay at local hotel/motel accommodation. As such no effect on local housing stock.
		Increases or decreases stock of low income housing, or its affordability	0	No change to current situation.
		Increases or decreases housing rental averages	0	No change to current situation.
		Increases or decreases choice in housing	0	No change to current situation.
		Increases or decreases provision of special needs housing	0	No change to current situation.
		Increases or decreases the social mix of residents in the area	0	No change to current situation.
7	Access	Decreases or increases distance from homes to local community facilities and services	0	No change to current situation.
		Improves or reduces public transport services or access to such services	0	No change to current situation.
		Improves or reduces access to local facilities for pedestrians, cyclists or the disabled	0	The proposed activity will have a small scale disturbance footprint however; this is not anticipated to adversely affect recreational tourism opportunities in the Pilliga Forest such as hiking, camping and bird watching. The proposed activity will not change any other existing or future travel patterns for local residents.

19.0 Other issues

While not identified as a key risk for the proposed activity, cultural heritage was considered as part of the impact assessment.

19.1 Aboriginal cultural heritage

19.1.1 Existing environment

A search of the Aboriginal Heritage Information Management System (AHIMS) register indicated that there are no previously recorded Aboriginal cultural heritage objects or previously declared Aboriginal places within 10 kilometres of either pilot site. A review of previous literature indicates the presence of a number of places containing Aboriginal cultural heritage objects within the broader Narrabri region, but none were located in close proximity to the sites.

No Aboriginal objects, sites, places of significance or culturally modified trees were identified during the archaeological field survey at the proposed Dewhurst 13-18H Pilot gathering system (31 January 2013) or the Dewhurst 30 and 31 lease areas (14 November 2012). The Dewhurst 13-18H Pilot is on disturbed land (as defined in the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales 2010*) from previous and current agricultural and CSG-related activities. It is therefore reasonable to conclude that there is a low probability of unknown Aboriginal cultural heritage objects being present at this site. At Dewhurst 30 and 31, past land uses such as vegetation clearance, track grading and forestry may have damaged and/or destroyed any remnant evidence of any potential transient occupation. The archaeological potential for this site is therefore assessed as low to nil.

Additionally, no sensitive landscape features (such as water features, sand dune systems, ridge lines, cliff faces, caves or rock shelters) were identified within the vicinity of either pilot site during the field survey.

19.1.2 Potential impacts

Given previous land disturbance and the absence of more permanent water sources and any Aboriginal objects or sites identified during site investigations, there is very low potential for any previously unidentified Aboriginal sites or objects to be impacted.

19.1.3 Cumulative impacts

Where possible, activities associated with the E&A Program are located on previously disturbed land. The sites have undergone due diligence assessments, with no evidence of heritage items observed to date. As such, negligible cumulative impacts to Aboriginal cultural heritage are predicted.

19.1.4 Mitigation measures

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

- Project staff and contractors will be made aware of their statutory obligations to protect Aboriginal cultural heritage objects under the NPW Act, through the site induction and toolbox talks.
- All works will be undertaken to comply with Part 6 of the NPW Act.
- If any previously unidentified Aboriginal cultural heritage objects are identified during works, then such 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 accordance with relevant legislative and policy requirements.

- 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 will be contacted. Should the NSW Police determine that the material is not recent, 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.

19.2 Non-Aboriginal cultural heritage

19.2.1 Assessment approach

Database searches of the World Heritage List register, Australian Heritage Database and the NSW State Heritage Inventory indicated that there are no listed items of National, State or Local heritage significance within either pilot site or their surrounds. No heritage sites, relics or places of non-Aboriginal cultural heritage value, or vegetation with natural heritage values, were recorded at either pilot site during the archaeological survey undertaken by RPS on 14 November 2012 and 24 January 2013.

19.2.2 Potential impacts

The project will not impact on any listed non-Aboriginal cultural or natural heritage. There is limited potential for previously unidentified non-Aboriginal cultural heritage items or relics to be impacted during the works.

19.2.3 Cumulative impacts

Where possible, activities associated with the E&A Program are located on previously disturbed land. The sites have undergone archaeological surveys, with only two unlisted heritage items identified at the Leewood property to date. As such, negligible cumulative impacts to non-Aboriginal cultural heritage are predicted.

19.2.4 Mitigation measures

If any previously unidentified potential non-Aboriginal 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.

PART C

20.0 Statement of Commitments

Table 20-1 provides a draft Statement of Commitments for the proposed activity.

Table 20-1 Draft Statement of Commitments

Item	Commitment
Activity type	The Dewhurst Gas Exploration Pilot Expansion (proposed activity) includes the expansion of operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operation of both pilots for up to three years. Works at Dewhurst 13-18H involve re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells. Works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas to expand the pilot from four to six wells.
Location	The proposed activity is within PEL 238, on private and Crown land (Dewhurst 13-18H) and within the Pilliga East State Forest (Dewhurst 26-31).
Hours of operation	Hours of operation will be up to 24 hours a day, seven days a week.
Activity duration	Approximately 5-6 months construction/drilling and up to 3 years for operation of the wells.
Proposed commencement date	Works are scheduled to commence in Q2 2014.
Maximum area of disturbance	8.89 ha (Dewhurst 13-18H – 5.37 ha; Dewhurst 30/31 – 3.52 ha)
Rehabilitation commitments and timeframes	Pilot well decommissioning and rehabilitation of the well lease areas and access tracks will occur within 6 months of abandonment where practical. Pilot wells and ancillary infrastructure will be decommissioned and lease areas rehabilitated as outlined in Section 4.5 of the EIS.
Community consultation	▪ Community consultation will be undertaken in accordance with Chapter 5 of the EIS. ▪ Advice will be provided to relevant landowners that may be impacted by the activity 14 days prior to the proposed activity commencing. ▪ Narrabri Shire Council will be consulted on a monthly basis where appropriate. ▪ Updates on the proposed activity will be provided to the Narrabri Community Consultation Committee. ▪ Advertisements will be placed in the local media of the up-coming exploration and drilling activities. ▪ 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.

Item	Commitment
Land resources	**Construction** ▪ Excess topsoil and subsoil generated during site preparation activities will be stockpiled onsite and used as backfill following completion of drilling. ▪ 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'). ▪ Erosion and sediment controls will be implemented where necessary during construction activities, in accordance with best management practices (such as the Blue Book). These controls will be maintained until disturbed areas of the site are stabilised. ▪ The quantity of chemicals, fuels and oils stored onsite will be minimised, where practicable. ▪ All additives, chemicals, fuels and oils stored onsite will be kept in an appropriately secured, bunded storage shed in accordance with the relevant SDS. ▪ Where there is a risk of contamination pits will be lined or material will be stored in surface tanks or metal bins. ▪ An SDS register of all chemicals used or stored onsite will be maintained. ▪ Maintenance of vehicles, plant and equipment will occur offsite at an appropriately licensed facility unless deemed necessary and appropriate to conduct such maintenance onsite. ▪ 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 placed in a bag 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 onsite will occur, including water transfer area and well heads. ▪ The gathering system water pressure will be monitored. Should line failure occur between the wells to the transfer tanks at Dewhurst 14 and Dewhurst 28, operation of the well will be suspended until the problem is rectified. ▪ The two pilot sites will be rehabilitated in accordance with Section 4.5 of the EIS.

Item	Commitment
Groundwater	**Construction** ▪ The wells will be designed and constructed in accordance with the NSW Coal Seam Gas Code of Practice Well Integrity (DTIRIS, 2012b). ▪ 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 the EIS. ▪ A driller that holds the relevant qualifications as defined by NOW will be onsite during drilling of the top hole 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 surface and groundwater sources. ▪ Excessive drilling fluid 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 2 km of the two pilot sites 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 water quality observations in the field, and sampling for analysis by an accredited laboratory. **Operation** ▪ The volume of water extracted from the pilot wells will be monitored. ▪ Pressure gauges will be fitted to the pilot wells, and monitored remotely through a SCADA system. Should pressure change due to a leak, the pilot wells will be shut down immediately and the affected area investigated. ▪ The groundwater monitoring program will be implemented. ▪ In line with monitoring during drilling, Santos will make reasonable endeavours to seek permission (from landowners) to continue monitoring of registered groundwater bores within 2 km of the two pilot sites to determine if there are any impacts to aquifers. ▪ The wells will be decommissioned as soon as they are no longer required.

Item	Commitment
Surface water	**Construction** ▪ Water will not be extracted from nearby watercourses, including Mount Pleasant Creek, Tuppiari Creek, Cowallah Creek or Jacks Creek. ▪ The existing diversion bund at Dewhurst 13-18H will be maintained on the up-slope side of the lease areas to divert clean water around the work area. ▪ Diversion bunds will be installed and maintained for the Dewhurst 30 and 31 lease areas. ▪ Drilling fluids will be contained in surface tanks which will be regularly inspected and maintained. ▪ Water that drains to the cellar pit will be circulated with the drilling fluid throughout the drilling process. ▪ Should any formation fluid rise through the well, it will be captured in the waste fluid tank and will be removed to a licensed waste facility that is able to accept liquid waste for disposal or treatment. ▪ Drilling fluids will be transported to and from site by an appropriately licensed contractor. ▪ Fuel and lubricants will be stored onsite only when necessary and maintained offsite whenever possible. ▪ Wastewater generated through general site activities will be removed by an appropriately licensed contractor for disposal at a licensed facility or treated to an appropriate quality prior to discharging. ▪ 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 or other relevant guidelines. ▪ Weather forecast 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. ▪ A minimum freeboard of 300 mm will be maintained for any tanks containing liquid waste. **Operation** ▪ The surface infrastructure at the lease areas will be regularly inspected. ▪ The surface water monitoring program will be implemented.
Biodiversity	▪ Micro-siting of lease areas and service corridors locations will be undertaken at Dewhurst 30 and 31 during detailed design and pre-clearance survey stage to minimise impacts on the ecological communities and species. ▪ Clearing of hollow-bearing trees will be avoided where possible. ▪ While clearing or disturbance to vegetation occurs, a fauna spotter/catcher will be onsite 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. ▪ The two pilot sites will be rehabilitated in accordance with Section 4.5 of the EIS. ▪ Construction and operational vehicles/plant will only travel on the designated access tracks. Site speed limits will be imposed to reduce the potential of fauna strike and to reduce dust generation. ▪ Prior to earthworks, noxious weeds present onsite will be removed or treated with herbicide to help prevent or reduce their spread. ▪ Weed management measures will be undertaken. ▪ Weed monitoring will occur throughout all phases of the proposed activity. Weed removal will be carried out as necessary.

Item	Commitment
Air quality	▪ Dust will be suppressed as required by spraying water along the access tracks and lease areas. ▪ Site speed limits will be imposed to minimise dust generated by vehicle movements. ▪ Loose, dust generating materials will be covered when transported to and from site. ▪ 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. ▪ Rehabilitation works, including landform establishment, will occur within six months of abandonment.
Greenhouse Gases	**Construction** ▪ Retain timber and woody debris cleared during site preparation (excluding merchantable timber identified by NSW Forestry Corporation) for use in rehabilitation to assist in re-establishing carbon sink. ▪ Energy efficient equipment and processes will be used where possible. ▪ Water based drilling fluids will be used. ▪ Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform National Greenhouse and Energy Reporting Scheme (NGERS) calculations). **Operation** ▪ Regular monitoring and maintenance of equipment and pipes will occur to identify any leaks to minimise fugitive emissions. ▪ A fugitive emissions monitoring program will be implemented in the E&A Program area. ▪ Appropriate monitoring of emissions and consumables will be undertaken for legislative reporting requirements (such as to inform NGERS calculations).
Noise	▪ Forestry NSW, the private landowner at Dewhurst 13-18H and the next two nearest sensitive receivers will be notified prior to the proposed activity commencing. ▪ During construction, feasible and reasonable work practices will be implemented with the aim to achieve LA_{eq} 40 dB(A) noise levels during recommended standard construction hours and LA*eq* 35 dB(A) outside of these times. ▪ During operation, in the event that the residence located 500 m south of the Dewhurst 13-18H Pilot (RR4) is to be re-occupied, monitoring will be undertaken to confirm operational noise levels at this location. If noise monitoring determines that levels are above noise criteria, an agreement will be negotiated with the landowner, or further feasible and reasonable mitigation measures will be implemented to reduce noise levels.
Traffic and Transport	▪ Vehicles will not travel at speeds greater than 80 km per hour along unsealed roads (including within the forest) unless otherwise signed. ▪ Heavy vehicle activity passing through residential areas will be confined to standard construction hours (7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm Saturday). ▪ All site staff and delivery drivers will receive the appropriate induction (consistent with Santos policies), which will include driver protocols and identification of any local hazards. ▪ An in-vehicle monitoring system (IVMS) will be fitted to all Santos vehicles. ▪ Construction vehicle movements will be restricted to designated routes to/ from site via the Newell Highway. ▪ Construction vehicle activity will be managed and controlled in the vicinity of the two pilot sites. ▪ Any damage to roads caused by construction activities will be repaired at Santos cost in accordance with the Permit to Occupy or land access agreement.

Item	Commitment
Waste	▪ Management of drilling fluids and drill cuttings in accordance with principles outlined in Sections 4.3.7.5 and 4.3.7.6. ▪ Management of waste, including its transport, will comply with the POEO Act and POEO (Waste) Regulation. ▪ The Waste Management Plan will be implemented, that will be based on the waste reduction hierarchy of avoid, reduce, reuse, recycle, recover, treat and dispose. ▪ General site waste will be segregated according to their classifications under the *Waste Classification Guidelines* (DECCW, 2009) and stored in bins or skips within 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. ▪ 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. ▪ Sewage waste will be removed from site by a licensed contractor for treatment and disposal, as required. ▪ The type and volume of all waste removed from site will be recorded. ▪ 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 SDS or manufacturers' directions to avoid potential impacts to the environment or human health.
Hazards	**Construction** ▪ Site safety protocols, incident management and emergency procedures will be implemented during the construction and drilling works. ▪ The two pilot sites will be kept in a clean and tidy manner during site preparation, drilling activities and operation of the pilot wells. ▪ 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*. ▪ Chemical, fuel and oil containers will be managed according to the SDS or manufacturers' directions to avoid potential impacts to the environment or human health. **Operation** ▪ The flare at Dewhurst 14 will be designed to limit the risk of ignition. Acceptable radiation limits for various locations at the flare site will be determined based on the *American Petroleum Institute (API) 521 Standard* (API, 2007) and *AS 60079.10.1 – Classification of Areas – Explosive Gas Atmospheres*. ▪ Within the sterile zone, a HDPE liner will be laid, covered with approximately 300 mm of compacted soil and blue metal aggregate. ▪ Where feasible best practice bushfire risk management will be implemented. ▪ All statutory obligations for bushfire management will be met. ▪ An education program for staff and contractors regarding the risks from bushfires in consultation and collaboration with relevant stakeholders will be implemented.

Item	Commitment
Social and Economic	▪ Consultation activities will occur in accordance with Chapter 5 of the EIS. ▪ Continued contribution to the local sponsorship program. ▪ Implementation of a buy local program.
Other	▪ Project staff and contractors will be made aware of their statutory obligations to protect Aboriginal cultural heritage objects under the NPW Act, through the site induction and toolbox talks. ▪ All works will be undertaken to comply with Part 6 of the NPW Act. ▪ If any previously unidentified Aboriginal cultural heritage objects are identified during works, then such 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 accordance with relevant legislative and policy requirements. ▪ 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 will be contacted. Should the NSW Police determine that the material is not recent, 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. ▪ If any previously unidentified potential non-Aboriginal 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.

21.0 Summary and Conclusion

This EIS has assessed the environmental impacts of the proposed activity to re-enter three existing single horizontal wells to convert into triple-stacked horizontal wells at Dewhurst 13-18H, construct and drill two additional wells as part of the Dewhurst 26-31 Pilot, install new ancillary surface and subsurface infrastructure, and the management of the water and gas produced during operation of the twelve wells for up to three years.

21.1 Environmental considerations

Table 21-1 summarises the environmental impacts of the proposed activity.

Table 21-1 Environmental considerations of the proposed activity

Aspect	Potential impacts	Potential impact category (with mitigation measures)
Land resources	▪ The two pilot sites are not located on Biophysical Strategic Agricultural Land and/or a Critical Industry Cluster. ▪ Increased erosion potential due to land disturbance and vegetation clearance.	Negligible impact
Groundwater	▪ Groundwater contamination due to mixing of aquifers, loss of drilling mud into the formation or inappropriate management of spills. ▪ Total water extracted over 3 years, approximately 744,922 m^3. ▪ No significant change in flux or drawdown in the upper productive layers, no significant impact to registered bore users or groundwater dependant ecosystems.	Minimal impact
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 two pilot sites.	Minimal impact
Flooding	▪ Area not within flood prone land.	Negligible impact
Biodiversity	▪ removal of approximately 2.44 ha of White Cypress Pine – Bulloak – ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion vegetation. ▪ Removal of hollow-bearing trees and threatened flora species individuals. ▪ temporary disruption to breeding cycle, roosting, sheltering and foraging behaviour of fauna species.	Minimal impact
Air quality	▪ Generation of dust and other particulates, particularly during construction. ▪ Generation of CO and NO_2, particularly during flare operation.	Negligible to minimal impact
Greenhouse gases	▪ Total Scope 1 GHG emissions resulting from operation of the proposed activity are estimated to be approximately 131,189 t CO_2^e per year. This represents approximately 0.08% of the total GHG emissions from NSW in 2011 (158,991,280 t CO_2^e). ▪ The beneficial aspects of the proposed activity provides significant GHG mitigation potential through the supply of CSG for power generation, which represents a 50% emissions saving (per GJ) over more traditional large-	Minimal impact

Aspect	Potential impacts	Potential impact category (with mitigation measures)
	scale energy sources such as coal. ▪ Likely GHG emissions from the proposed activity are not considered to have significant impact on increasing GHG emissions.	
Noise	▪ In general, noise levels will be below the *NSW Industrial Noise Policy* (EPA, 1999b) during construction. ▪ Operational noise impacts related to the activity are unlikely to result in any audible impacts at nearby residences, with the potential exception of the residence 500 m from the Dewhurst 13-18H Pilot.	Minimal to moderate impact
Traffic and transport	▪ Based on existing traffic volumes on the Newell Highway and local road network, and the distribution of vehicles over the day, the anticipated traffic generation for the proposed activity (typical and maximum) both during construction and operation will have a minimal impact on the Newell Highway and the surrounding road network.	Minimal impact
Waste	▪ The proposed activity is likely to result in the generation of wastes, in particular during the construction phase. Waste management procedures will be developed as part of the waste management plan for the activity which will ensure waste is handled and stored appropriately and ultimately reused, recycled or disposed of in accordance with legislative requirements and best practice. ▪ Reusable other materials will be managed and reused onsite or recycled where appropriate, including treated water. Waste requiring offsite disposal will consequently be minimised and residual waste will be disposed of in an appropriate manner. As such significant, residual impacts in relation to waste are not anticipated.	Minimal impact
Hazards	▪ Increase risk of bushfire due to accidental ignition during construction or flare operation. ▪ Land, water or air pollution, or fire, from improper use of hazardous substances or chemicals.	Minimal impact
Social and economic	▪ The proposed activity will result in a number of positive economic impacts for the local, regional and State economies. This includes a mix of both local and fly in fly out jobs over the course of the proposed activity (11.2 Equivalent Full Time jobs at peak), a $8.1 million economic multiplier effect from capital expenditure, increase in local expenditure on goods and services as well as the potential to increase the NSW domestic gas supply. The development of the proposed activity is in line with the goals and outcomes of both the *Narrabri Economic Development Strategy* (DTIRIS, 2011) and the *Strategic Regional Land Use Plan* (SRLUP) for New England and the North West.	Minimal impact
Cumulative impact	▪ The proposed activity has been assessed in conjunction with other E&A Program activities. All impacts have been assessed from a cumulative aspect with a particular focus on biodiversity and groundwater. ▪ The E&A Program is expected to have a negligible to minimal impact on the environment.	Minimal impact

21.2 Conclusion

Santos has a long term commitment to the development of new gas supplies to the growing NSW market. The proposed activity and the E&A Program have been developed taking into account environmental, economic and social considerations. The EIS has identified the potential environmental impacts together with measures mitigate those potential impacts.

The proposed activity is 'State Significant Development' to which Division 4.1 of Part 4 of the *EP&A Act* applies in accordance with the *State Environmental Planning Policy (State and Regional Development) 2011*.

The EIS assesses the potential environmental impacts of the activity in accordance with clauses 6 and 7 in Schedule 2 of the *NSW Environmental Planning and Assessment Regulation 2000* and the DGRs which were issued on 20 May 2013.

The proposed activity is temporary and minor in scale. The two sites for the proposed activity have been selected to avoid significant environmental and heritage constraints, and reduce impacts to the surrounding community.

In considering the likely environmental significance of the impacts from the proposed activity it has been predicted that:

- potential impacts are considered to be localised and temporary in nature
- the proposed activity is unlikely to have a significant effect on highly productive groundwater sources, registered groundwater users or groundwater dependent ecosystems
- the proposed activity is unlikely to have a significant effect on the environment or the community
- the proposed activity is unlikely to have a significant effect on threatened species, populations, ecological communities or their habitats
- the proposed activity is not on land that is, or part of, critical habitat.

Based on the assessments undertaken within the EIS the impact of the activity will be kept to a minimum provided that the mitigation measures identified in the EIS are employed.

22.0 References

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23.0 Terms and abbreviations

Enter any acronyms or units throughout the document in the table below:

Abandonment	Decommissioning the well. A process which involves shutting down the well and rehabilitating the site.
ABS	Australian Bureau of Statistics
ADGC	Australian Dangerous Goods Code
AEMO	Australian Energy Market Operator
AGE	Australasian Groundwater and Environmental Consultants
AHD	Australian Height Datum
AHIMS	Aboriginal Heritage Information Management System
AIP	Aquifer Interference Policy
AIS	Agricultural Impact Statement
Annulus	The space between the wellbore and surrounding pipe
ANZECC	Australian and New Zealand Environment and Conservation Council
API	American Petroleum Institute
APPEA	Australian Petroleum Production and Exploration Association
Aquiclude	Compacted geological formations through which no groundwater flows.
Aquitard	Low permeability formation which restricts the flow of groundwater.
ASC	Australian Soils Classification
BNCCA Act	*Brigalow and Nandewar Community Conservation Area Act* 2005 (NSW)
BoM	Bureau of Meteorology
BOP	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.
BSAL	Biophysical Strategic Agricultural Land
BTEX	Benzene, toluene, ethylbenzene, and xylenes
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.
CCC	Community Consultation Committee
Cementing	The application of a liquid slurry of cement and water to various points inside and outside the casing.
Cement plug	Portion of cement placed at some point in the wellbore.
CH_4	Methane
CIC	Critical Industry Cluster
CL Act	*Crown Lands Act* 1989 (NSW)
CO	Carbon monoxide
CO_2	Carbon dioxide
CONCAWE	Model which predicts noise levels at a distance based on the weather conditions and a knowledge of the source spectrum in octave bands
CSG	Coal seam gas
DA	Development application
DAMB	Deep aquifer monitoring bore
dB(A)	A-weighted decibels – an expression of the relative loudness of sounds in air as perceived by the human ear

DCCEE	Commonwealth Department of Climate Change and Energy Efficiency
DD	Deposited dust
DEC	NSW Department of Environment and Conservation
DECC	NSW Department of Environment and Climate Change
DECCW	NSW Department of Environment, Climate Change and Water
DEEWR	Commonwealth Department of Education, Employment and Workplace Relations
DEWHA	Commonwealth Department of Environment, Water, Heritage and the Arts
DGRs	Director-General's Requirements
DLWC	NSW Department of Land and Water Conservation.
DO	Dissolved oxygen
DoE	Commonwealth Department of the Environment
DP&I	NSW Department of Planning and Infrastructure
DPC	NSW Department of Premier and Cabinet
DPI	NSW Department of Primary Industries
DRE	Division of Resources and Energy
DRET	Commonwealth Department of Resources, Energy and Tourism
Drilling fluid	Circulating fluid that can lift cuttings from the wellbore to the surface and to cool down the drill bit.
DSITIA	Queensland Department of Science, Information Technology, Innovation and the Arts.
DST	Drill Stem Test
DTIRIS	NSW Department of Trade and Investment, Regional Infrastructure and Services
DWE	NSW Department of Water and Energy
E&A Program	Energy NSW CSG Exploration and Appraisal Program
EC	Electrical conductivity
EEC	Endangered Ecological Communities
EHSMS	Environmental, Health and Safety Management System
EIS	Environmental Impact Statement
EFT	Equivalent Full Time
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act* 1979 (NSW)
EP&A Regulation	*Environmental Planning and Assessment Regulation* 2000 (NSW)
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999 (Cth)
EPL	Environment Protection Licence
ERP	Estimated Resident Population
ESD	Ecologically Sustainable Development
ESG	Eastern Star Gas
ESP	Electrical submersible pump
FIFO	Fly in-fly out
flux	rate of volume flow across a unit area ($m^3/s/m^2$)
Forestry NSW	Forestry Corporation of New South Wales
Freeboard	Height of a tank above the fluid level.
FTF	Fluids treatment facility
GAB	Great Artesian Basin
GABCC	Great Artesian Basin Consultative Council

GCL	Geosynthetic clay liner
GDE	Groundwater Dependent Ecosystem
GHG	Greenhouse gas
GHG Protocol	*GHG Protocol Corporate Standard (*WBCSD & WRI, 2004)
GJ	Gigajoule
GPS	Global Positioning System
GWP	Global warming potential
HDPE	High-density polyethylene
ICNG	*Interim Construction Noise Guideline* (DECC, 2009)
INP	*NSW Industrial Noise Policy* (EPA, 1999)
ISCA	Infrastructure Sustainability Council of Australia
IVMS	In vehicle monitoring system
K_2S0_4	Potassium sulfate
kill the well	Flushing the well with a higher density liquid
KTPs	Key threatening processes
LA_{eq}	Logarithmic average noise level from all sources
LA_{90}	Also called L90 or background. An indicator of the quietest time of day and is calculated as the noise level equalled or exceeded for 90% of the measurement time.
LALC	Local Aboriginal Land Council
LCM	Lost circulation material
LEPs	Local Environmental Plans
LGA	Local government area
LOS	Level of Service
LSC	Land and soil capability class
m MD	metres Measured Depth
m TVD	metres True Vertical Depth
MDB	Murray-Darling Basin
Mining SEPP	*State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries)* 2007
ML	Megalitres/monitoring location
MMSCF	Million standard cubic feet
MNES	Matter of National Environmental Significance
NATA	National Association of Testing Authorities
Native Title Act	*Native Title Act* 1993 (Cth)
NCMA	Namoi Catchment Management Authority
NEM	Naturally Excavated Material
NGA Factors	*National Greenhouse Accounts Factors* (DCCEE, 2012)
NGERS	National Greenhouse Energy Reporting Scheme
NHMRC	National Health and Medical Research Council
NOC	Narrabri Operations Centre
NOW	NSW Office of Water
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
NPW Act	*National Parks and Wildlife Act* 1974 (NSW)

NPWS	National Parks and Wildlife Services
NRMMC	National Resource Management Ministerial Council
NSW	New South Wales
NSW State Plan 2021	*NSW 2021: A Plan to Make NSW Number One*
NTC	National Transport Commission Australia
NV Act	*Native Vegetation Act* 2003 (NSW)
OCSG	Office of Coal Seam Gas
OEH	NSW Office of Environment and Heritage
PAL	Petroleum Assessment Lease
PAWC	Plant Available Water Capacity
PCP	Progressive cavity pump
PEL	Petroleum Exploration Licence
PET	Polyethylene terephthalate
Petroleum Act	*Petroleum (Onshore) Act* 1991 (NSW)
PHA	Preliminary hazard analysis
PM_{10}	PM_{10} is a measure of particles in the atmosphere with a diameter of less than 10 or equal to a nominal 10 micrometres.
POEA Act	*Protection of the Environment Administration Act* 1991 (NSW)
POEO Act	*Protection of the Environment Operations Act* 1997 (NSW)
POEO (Waste) Regulation	*Protection of the Environment Operations (Waste) Regulation* 2005 (NSW)
PPL	Petroleum Production Lease
RAMSAR	RAMSAR convention is an intergovernmental treaty to conserve wetlands of international importance
RBL	Rating Background Level
REF	Review of Environmental Factors
RMS	NSW Roads and Maritime Services
RNP	*NSW Road Noise Policy* (DECCW, 2011)
RPS	RPS Australia East Pty Ltd
RTA	NSW Roads and Transport Authority
RTU	Remote Telemetry Unit
SAL	Strategic Agricultural Land
SAMB	Shallow aquifer monitoring bore
Santos	Santos NSW (Eastern) Pty Ltd
SCADA	Supervisory control and data acquisition
SDS	Safety Data Sheet
SEPP	State Environmental Planning Policy
SEPP 33	*State Environmental Planning Policy 33 – Hazardous and Offensive Development* 1992
SIS	Species Impact Statement
SRD SEPP	*State Environmental Planning Policy (State and Regional Development*) 2011
SRLUP	Strategic Regional Land Use Policy
SSD	State Significant Development
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.
TAPM	The Air Pollution Model
TDS	Total dissolved solids
TEC	Threatened Ecological Community
TSC Act	*Threatened Species Conservation Act* 1995 (NSW)
TSP	Total suspended particles
TSR	Travelling stock routes
WAL	Water access licence
Wall cake	Low permeability 'skin' around the wall of the hole.
Waste Strategy	*NSW Waste Avoidance and Resource Recovery Strategy 2007*
Water Act	*Water Act* 1912 (NSW)
WBCSD	World Business Council for Sustainable Development
Wellhead	The system of spools, valves and associated adapters that provide pressure control for production.
WMA	*Water Management Act 2000* (NSW)
WM Regulation	*Water Management (General) Regulation* 2011 (NSW)
WPPS	Wilga Park Power Station
WRI	World Resources Institute
WSP	Water Sharing Plan
WTF	Water Transfer Facility

Appendix 1

Director-General's Requirements

Director-General's requirements	EIS Reference
General requirements	
▪ detailed description of the development, including	Chapter 4
- need for the proposed development	Sections 2.1 and 2.2
- justification for the proposed plan, including efficiency of resource recovery, safety and environmental protection	Section 2.3
- likely staging of the development – including construction, operational stage/s and rehabilitation	Section 4.1, including Table 4-1
- likely interactions between the development and existing, approved and proposed gas exploration and production activities in the vicinity of the site	Section 3.2.1
- plans of any proposed building works	No permanent building structures proposed onsite.
▪ consideration of all relevant environmental planning instruments, including identification and justification of any inconsistencies with these instruments	Chapter 6
▪ risk assessment of the potential environmental impacts of the development, identifying key issues for further assessment	Section 7.2, including Tables 7-1 and 7-2
▪ detailed assessment of the key issues specified below, and any other significant issues identified in the risk assessment, which includes;	Chapters 8 to 19
- a description of the existing environment, using sufficient baseline data	Section x.1 of chapters 8 to 19
- an assessment of potential impacts of all stages of the development, including any cumulative taking into consideration relevant guidelines, policies, plans and statutes	Sections 8.2, 8.3, 9.3, 9.4, 10.2, 10.3, 11.3, 11.4, 12.3, 12.4, 13.3, 13.4, 14.3, 14.4, 15.3, 15.4, 16.2, 16.3, 17.3, 17.4, 18.3, 18.4, 19.1, 19.2
- a description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the development, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment	Sections 8.4, 9.5, 10.4, 11.5, 12.5, 13.5, 14.5, 15.5, 16.4, 17.5, 18.5, 19.1, 19.2
▪ consolidated summary of all the proposed environmental management and monitoring measures, highlighting commitments included in the EIS	Table 20-1
▪ a detailed calculation of the capital investment value (as defined in clause 3 of the *Environmental Planning and Assessment Regulation 2000*) of the proposal, including details of all the assumptions and components from which the CIV calculation is derived	Attached
▪ a close estimate of the jobs that will be created by the development during the construction and operational phases of the development	Sections 18.3.1 and 18.3.2
▪ certification that the information provided is accurate at the date of preparation	Attached
Key Issues	
Land Resources	**Specialist reports in Appendix 2, summarised in Chapter 8.**
▪ an assessment of the potential impacts on	
- soils and land capability (including contamination)	Section 8.2.2
- soil erosion, sediment transport and regional salinity	Section 8.2.2
- agricultural land, including a Site Verification Certificate and Agricultural Impact Statement	Section 8.2.1 and Appendix 2
- land use, including forestry, conservation and recreational use, with particular reference to the Pilliga East State Forest and the Jacks Creek State Forest	Section 8.2.1

Director-General's requirements	EIS Reference
Water Resources	**Specialist reports in Appendix 3, summarised in Chapters 9 and 10.**
▪ adequate baseline monitoring for all surface water and groundwater sources and dependent ecosystems within and adjacent to the development	Sections 9.1.4, 9.5.3 and 10.1.5
▪ demonstrated compliance with the *NSW Aquifer Interference Policy* (2012)	Section 9.4 and Appendix 3
▪ detailed assessment of potential impacts on the quality and quantity of existing surface water and groundwater resources, including	Sections 9.3, 9.4 and 10.2
- detailed modelling of potential groundwater impacts including identification of any highly productive groundwater (as defined by the *Aquifer Interference Policy*) or groundwater dependent ecosystems, with particular reference to the Gunnedah-Oxley and Lachlan Fold Murray-Darling Basin buried groundwater sources and the southern recharge groundwater sources of the NSW Great Artesian Basin	Sections 9.3 and 9.4, and Appendix 3
- a description of any proposed hydraulic fracturing	No hydraulic fracturing is proposed
- impacts on riparian, ecological, geomorphological and hydrological values of watercourses or swamps, including environmental flows, with particular reference to Cowallah Creek, Mount Pleasant Creek, Tuppiari Creek and Jacks Creek and associated tributaries	Section 10.2
- cumulative impacts associated with existing developments as well as any currently approved developments or proposed future developments	Sections 9.4 and 10.3
- the quantity and quality of regional water supplies	Sections 9.1.2, 9.1.4, 9.4, 10.1.1 and 10.2
- details of critical thresholds for negligible impacts to surface water and groundwater sources and dependent ecosystems	Section 10.1.4 and Appendix 3
- affected licensed water users and basic landholder rights (including downstream water users)	Sections 9.1.2, 9.4.4 and 10.2.3
▪ a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures	Section 4.4.2
▪ a detailed description of the management of water at both the Bibblewindi Water Management Facility and the Leewood Produced Water and Brine Management Facility	Sections 3.2.1.1 and 4.4.2
▪ identification of any licensing requirements, including existing or future Environment Protection Licences (EPLs) or Pollution Reduction Programs (PRPs), and approvals under the *Water Act 1912* and/or *Water Management Act 2000*	Sections 6.2.3, 6.2.4 and 6.4
▪ a description of the casing of wells that ensures the protection of the integrity of all underground aquifers, prevents gas escape and maintains groundwater quality, in accordance with the *Code of Practice for Coal Seam Gas Well Integrity*	Section 4.3.9
▪ demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plans (WSP) or water source embargo	Sections 4.3.14, 4.4.2, 9.5.4 and 10.4.3
▪ a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP	Section 9.5 and 10.4
▪ a description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts, including the use of above ground tanks to contain drilling fluids, adequate spill control measures, contingency planning and produced water management	Sections 4.4.2, 9.5, 10.1.5 and 10.4
▪ an assessment of local flood risks, including appropriate mitigation measures	Sections 10.2.4 and 10.4

Director-General's requirements	EIS Reference
Biodiversity	**Specialist report in Appendix 4, summarised in Chapter 11.**
▪ Accurate estimates of any proposed vegetation clearing	Section 11.3.1
▪ an assessment of potential impacts of the development on any	
- terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems	Sections 11.3.2, 11.3.3, 11.3.5. No EECs listed under the TSC or EPBC Acts occur at either pilot sites or within the immediate surrounds.
- regionally significant remnant vegetation, or vegetation/wildlife corridors	Sections 11.3.1 and 11.3.2
▪ impacts on the Pilliga State Forest, including impacts on conservation and recreational values	Section 11.3.2
▪ measures taken to avoid, reduce or mitigate impacts on biodiversity	Section 11.5
Air Quality	**Specialist report in Appendix 5, summarised in Chapter 12.**
▪ a quantitative assessment of potential	
- construction and operational impacts, with a particular focus on dust emissions including PM_{10} emissions and the dust generation from transport	Section 12.3
- risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal, including risk of environmental harm and risk to human health and amenity	Sections 12.3 and 13.3.1
- cumulative impacts associated with existing emission sources as well as any currently approved developments or proposed future developments	Section 12.4
- flaring and/or venting	Section 12.3.2
- monitoring and management measures, including real-time air quality monitoring	Section 12.5
Greenhouse Gases	**Chapter 13**
▪ a quantitative assessment of potential Scope 1, 2 and 3 greenhouse gas emissions	Section 13.3 (there are no Scope 2 emissions as there is no purchase of energy from the grid).
▪ a qualitative assessment of the potential impacts of these emissions on the environment	Section 13.3.4
▪ an assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency, including consideration of alternative power sources	Section 13.5
Noise	**Specialist report in Appendix 6, summarised in Chapter 14.**
▪ an assessment of potential	
- construction, operational and transport noise impacts	Section 14.3
- offsite road noise impacts	Section 14.3.2
- reasonable and feasible mitigation measures, including evidence that there are no such measures available other than those proposed	Section 14.5
- monitoring and management measures	Section 14.5

Director-General's requirements	EIS Reference
Traffic and Transport	**Specialist report in Appendix 7, summarised in Chapter 15.**
▪ an assessment of the project on the capacity, functionality, efficiency and safety of the local road network	Section 15.3
▪ details of road transport volumes and types broken down into origin and destination, travel routes and peak hours for the construction, operation and decommissioning of the project	Section 15.2, Table 15-2 and Figure 15-1
▪ a description of the measures that would be implemented to maintain and/or improve the capacity, functionality, efficiency and safety of the road networks in the surrounding area over the life of the project	Section 15.5
▪ details of the location of all waterways crossings, including any new access tracks or existing waterway crossing upgrades	Section 15.2 and Figure 15-1 (there are no new waterway crossings, or proposed waterway crossing upgrades)
▪ a description of the transfer of gas via pipeline and flowline to the Bibblewindi Water Management Facility and Wilga Park Power Station	Section 4.4.3 (gas will not be transferred offsite, but instead be flared onsite at the pilots)
Waste	**Chapter 16**
▪ estimates of the quantity and nature of the potential waste streams of the development, including well cuttings, drilling fluids and produced water	Section 16.2, including Table 16.1
▪ identification, characterisation and classification of all waste that is proposed to be disposed of to an offsite location, including proposed quantities and disposal locations	Section 16.2, including Table 16.1
▪ a description of measures that would be implemented to minimise production of other waste, and ensure that the waste is appropriately managed	Section 16.4
▪ outline contingency plans for any event that affects operations at the site that may result in environmental harm	Sections 8.4, 16.4 and 17.5
Hazards	**Chapter 17**
▪ attention to public safety, chemical use and including bushfires	Section 17.3
Social and Economic	**Chapter 18.**
▪ an assessment of the	
- potential direct and indirect economic benefits of the project for local and regional communities and the State	Sections 18.1.2 and 18.3
- an assessment of the costs and benefits of the development as a whole, and whether it would result in a net benefit for the NSW community	Section 18.4, and Table 18-1
Rehabilitation	
▪ proposed rehabilitation strategy for the site, having regard to the key principles in the *Code of Practice for Coal Seam Gas Well Integrity*, including:	Section 4.5
- rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria	Section 4.5.2
- nominated final land use, having regard to any relevant strategic land use planning or resource management plans or policies	Section 4.5.2.1
- timeframes for exploration activities and subsequent rehabilitation	Table 4-1 and Table 4-12
- justification of criteria regarding completion of any rehabilitation program	Section 4.5.2.3
- the potential for integrating this strategy with any other rehabilitation strategies in the region	Section 4.5.2
Plans and Documents	
▪ The EIS must include all relevant plans, architectural drawings, diagrams and relevant documentation required under Schedule 1 of the *Environmental*	Throughout EIS document

Director-General's requirements	EIS Reference
Planning and Assessment Regulation 2000. These documents should be included as part of the EIS rather than as separate documents	
Consultation	
▪ During the preparation of the EIS, you must consult with relevant local, State and Commonwealth Government authorities, service providers, community groups and affected landowners In particular you must consult with the:	Chapter 5, in particular Tables 5-2 and 5-3
- Commonwealth Department of the Environment (formerly Department of Sustainability, Environment, Water, Population and Communities)	
- Office of Coal Seam Gas and Division of Resources and Energy within the Department of Trade and Investment, Regional Infrastructure and Services	
- Department of Primary Industries (including the NSW Office of Water, Forestry Corporation, NSW Agriculture and NSW Fisheries, and Catchments and Lands (Crown Lands Division))	
- Environment Protection Authority	
- NSW Health	
- Office of Environment and Heritage (including the Heritage Branch)	
- Namoi Catchment Management Authority	
- Transport for NSW (including the Centre for Transport Planning and Roads and Maritime Services)	
- Narrabri Shire Council	
- Rural Fire Services	
▪ The EIS must	
- describe the consultation process used and demonstrate that effective consultation has occurred	Sections 5.2 and 5.3
- describe the issues raised by public authorities, service providers, community groups and landowners	Tables 5-2 and 5-3
- identify where the design of the development has been amended in response to issues raised	Tables 5-2 and 5-3
- otherwise demonstrate that issues raised have been appropriately addressed in the assessment	Tables 5-2 and 5-3

Appendix 2

Agricultural Impact Statement

Dewhurst Gas Exploration Pilot Expansion PEL 238, Gunnedah Basin, NSW

Agricultural Impact Statement

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Signature	Date
	30/10/2013

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1.0 Summary

An agricultural impact statement (AIS) has been prepared for the proposed Dewhurst Gas Exploration Pilot Expansion. The AIS determines if any agricultural resources or associated agricultural infrastructure would be impacted by the proposed works.

In the context of the total area of the proposed activity and the wider agricultural uses of the region, the short-term activities are considered to have low risk on agricultural resources and industries. Further, the proposed mitigation, management and monitoring systems in place suggest that the likelihood of impacts occurring would be unlikely or rare.

The proposed activity will not impact on any Biophysical Strategic Agricultural Land (BSAL) or any Critical Industry Clusters (CIC). Further, there will be no pressure on agricultural support infrastructure including:

- Water supply or services;
- Railways;
- Travelling stock routes (TSR); and
- Processing facilities.

The proposed works will result in minor increases in traffic along the Newell Highway, X Line Road, Tighes Gully Road and Beehive Road (Dewhurst 26-31), and Westport Road, L-Line Road, Garlands Road and Killara Road (Dewhurst 13-18H) throughout the duration of the proposed activity. This level of traffic could easily be accommodated by the existing road network. Further, there will be negligible disruption to agricultural rail networks or TSRs, as the proposed pilots are not located adjacent to any such infrastructure.

2.0 Introduction

The Strategic Regional Land Use Plan New England North West (SRLUP) (Department of Planning and Infrastructure (DP&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 (CSG) projects in regional NSW.

As a result of this policy, an agricultural impact statement (AIS) is required for exploration activities subject to approval for any State Significant Development (SSD). The AIS is to form part of the Environmental Impact Statement (EIS) for assessment.

Santos NSW (Eastern) Pty Limited (the proponent) proposes to expand operations at two petroleum pilots, referred to as Dewhurst 13-18H and Dewhurst 26-31. Works at Dewhurst 13-18H involve redrilling three existing single horizontal wells into triple stacked horizontal wells, removal of the existing water gathering system connecting Dewhurst 13, 14 and 15, installation of a gas flare and water balance tank at Dewhurst 14, construction or a new gas and water gathering system connecting all wells to Dewhurst 14 and operating the Dewhurst 13-18H Pilot. Works at Dewhurst 26-31 involve establishing lease areas and drilling two new wells (Dewhurst 30 and 31), the construction of service corridors and access roads from Beehive Road to the new wells, construction of a flare at Dewhurst 28, extension of the existing water and gas gathering system to Dewhurst 30 and 31 and operating the Dewhurst 26-31 Pilot well set. The proposed activity is within a large tract of bushland referred to as the Pilliga Scrub located south of Narrabri, NSW. The purpose of the proposed activity is to investigate the potential CSG resource of the Gunnedah Basin within Petroleum Exploration Lease (PEL) 238.

The purpose of the AIS is to assess the potential impacts of proposed works 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 impact statements’* (DP&I, 2012b) and *‘Guidelines for agricultural impacts statements at the exploration stage’* (DP&I, 2012c).

This document is an appendix of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a) and should be read in conjunction with the EIS.

2.0 Introduction

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This document is an appendix of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a) and should be read in conjunction with the EIS.

3.0 Existing Environment

3.1 Location

Dewhurst 13-18H

Dewhurst 13-18H is located in the eastern section of PEL 238 (**Figure 3.1**). 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 within the Narrabri LGA.

Dewhurst 13-18H is located approximately 25 kilometres south of Narrabri and approximately 32 kilometres north-west of Boggabri. The site is located on private free hold and Crown land, adjacent to Jacks Creek State Forest. Jacks Creek State Forest forms part of the Pilliga Scrub.

Dewhurst 26-31

The site is located in the south-eastern section of PEL 238 (**Figure 3.1**) in the Narrabri LGA. The site is located approximately 37 kilometres west of Boggabri and 44 kilometres south of Narrabri. The site is within the Pilliga East State Forest.

3.2 Site Description

Dewhurst 13-18H

Lease areas for the existing pilot wells (Dewhurst 13-18H) are already cleared. The majority of the proposed gas and water gathering system is located along existing access tracks and a road, while some sections are located within areas of disturbed vegetation. There are a number of roads and access tracks surrounding the existing CSG infrastructure to the west of Dewhurst 13-18H (**Figure 3.2**). The site will be visible from Jacks Creek Road and Chromite Road. The nearest dwelling is located approximately 0.5 kilometres south of site, but is currently vacant as it is leased by Santos until December 2015. This property is still used for low intensity non-commercial grazing.

Dewhurst 26-31

As Dewhurst 26-31 is located within State forest the site is well vegetated. A large proportion of the water and gas gathering system is located along Beehive road, which intersects the site, while the proposed expansion to incorporate Dewhurst 30 and 31 occurs within vegetated areas (**Figure 3.3**), with the remaining leases also occurring within dense vegetation.

3.3 Proposed Activities

The proposed activity involves the expansion of operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operation of both pilots for up to three years. Works at Dewhurst 13-18H involve re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells. Works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas to expand the proposed pilot from four to six wells.

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The NSW Department of Primary Industries (DPI) approved construction, drilling and operation of Dewhurst 13, 14, 15, 16H, 17H and 18H on 21 July 2009 following an REF assessment under Part 5 of the EP&A Act. The wells operated for a short period in 2011.

Dewhurst 26-29 is a proposed four well pilot which was approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) on 16 August 2013 following a REF assessment under Part 5 of the EP&A Act. Dewhurst 26-29 is scheduled to be drilled in Q3 2013.

More specifically, the proposed activity includes:

Site preparation

- Establishing two 10 metre wide service corridors between Beehive Road and the Dewhurst 30 and 31 lease areas (including clearing of approximately 0.2 hectares of vegetation);
- Constructing access roads within the two service corridors at Dewhurst 30 and 31;
- Establishing the Dewhurst 30 and Dewhurst 31 lease areas each up to approximately one hectare in size (including approximately two hectares of vegetation clearing);
- Removing the existing water gathering system and electrical cable connecting Dewhurst 13, 14 and Dewhurst 15 wells; and
- Preparing the sites and establishing necessary equipment, temporary structures and facilities on the existing well leases Dewhurst 16H, 17H and 18H and on the new lease areas Dewhurst 30 and 31 to enable drilling.

Drilling

- Drilling an additional two horizontals from existing casing within Dewhurst 16H, 17H and 18H to convert each well from a single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley coal seams; and
- Drilling one vertical (Dewhurst 30) and one triple-stacked horizontal (Dewhurst 31) well to target coal seams within the Maules Creek Formation.

Surface and subsurface facility construction

- Preparing the site on the existing well lease Dewhurst 14 to enable installation of a gas flare and water balance tank;
- Constructing a new gas and water gathering system connecting all the wells within the Dewhurst 13-18H Pilot to the existing Dewhurst 14 well lease area (including clearing of approximately 0.24 hectares of disturbed vegetation);
- Extending the existing water and gas gathering system for Dewhurst 26-29 within the service corridors to Dewhurst 30 and 31;
- Installing surface and sub-surface infrastructure within the lease areas to connect the wells to the Dewhurst 13-18H and Dewhurst 26-31 gas and water gathering system; and
- Installing a gas flare and water balance tank at the existing Dewhurst 14 lease area and a gas flare at the Dewhurst 28 lease area.

Operation

- Operating the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot for up to three years from the commencement of operations at each pilot respectively;
- Managing the water and gas produced during operation; and
- Undertaking occasional maintenance of the pilots.

Post operation

- On completion of operations, suspending the wells and ancillary infrastructure or decommissioning them

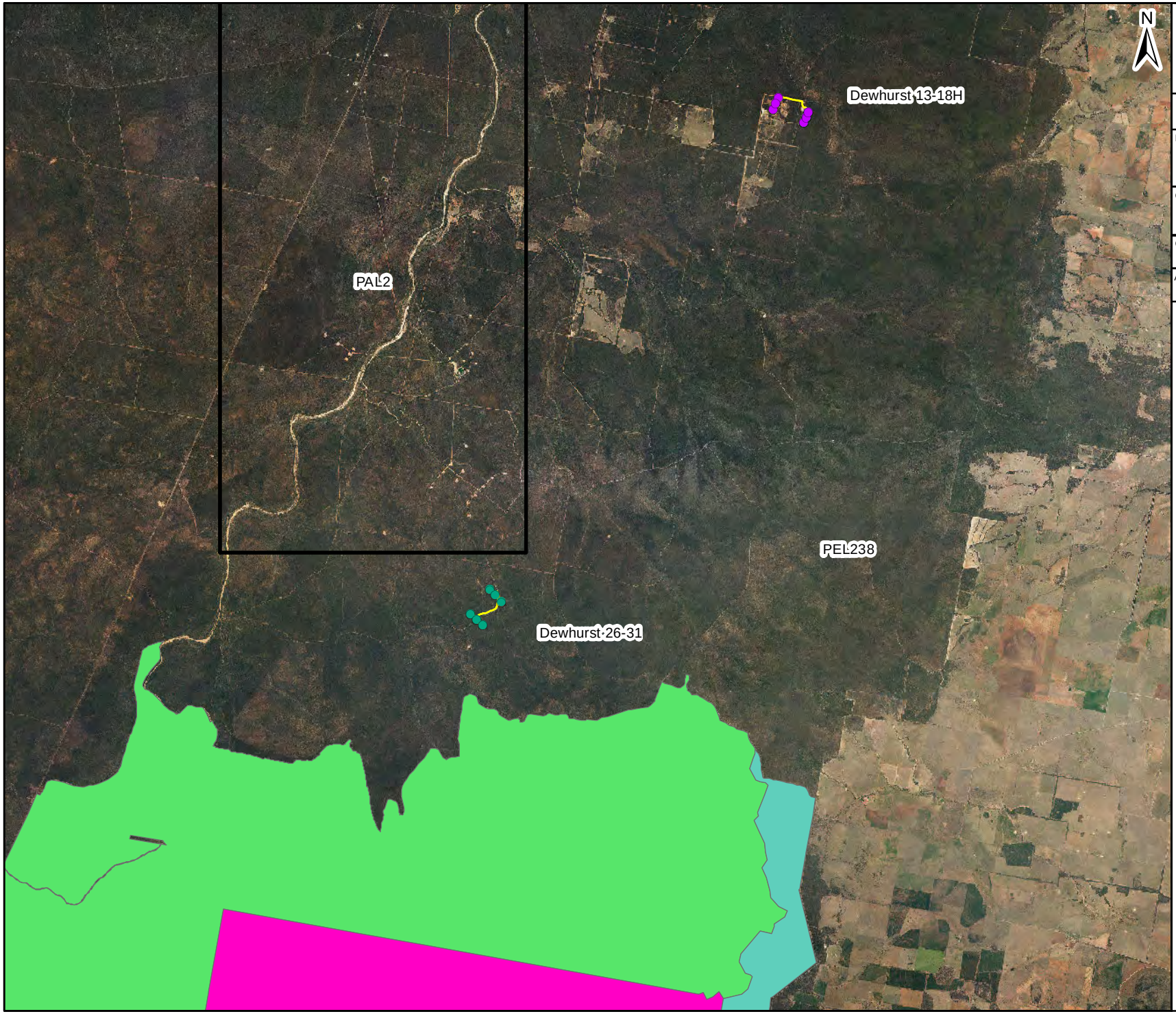
and rehabilitating the well leases.

Table 3.1: Dewhurst 13-18H project timeframes

Activity	Approximate duration	Estimated timing
Construction		
Site preparation	30 days	Q2 2014
Drilling and completion	65 days	Q2/3 2014
Surface facilities	65 days	Q3/4 2014
Operation		
Operation of the pilot	up to 3 years	2014 to 2017
Post operation and Rehabilitation		
Post operation/rehabilitation	approximately six months after well abandonment where practicable and considering external factors such as weather	on completion of activities

Table 3.2: Dewhurst 30-31 project timeframes

Activity	Approximate duration	Estimated timing
Construction		
Site preparation	20 days	Q2 2014
Drilling and completion	60 days	Q2/3 2014
Surface facilities	60 days	Q3 2014
Operation		
Operation of the pilot	up to 3 years	2014 to 2017
Post operation and Rehabilitation		
Post operation/rehabilitation	approximately six months after well abandonment where practicable and considering external factors such as weather	on completion of activities



NSW Estates and Petroleum Titles

Figure 3.1

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: BH	Date: 05/08/2013
Approved by: JC	Date: 05/08/2013

Legend

- Wells
- Drilling opportunities
- Proposed pipelines
- Petroleum Titles

NSW Estates

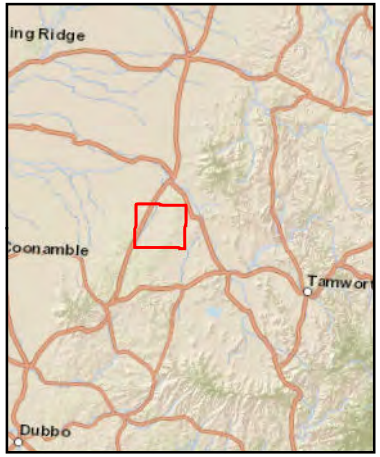
- ABORIGINAL AREA
- CCA ZONE 1 NATIONAL PARK
- CCA ZONE 2 ABORIGINAL AREA
- CCA ZONE 3 STATE CONSERVATION AREA
- NATIONAL PARK
- NATURE RESERVE
- STATE CONSERVATION AREA

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 1.25 2.5 5 km

Datum: GDA94
Scale 1:175,000 @ A4

RPS





Dewhurst 13-18H Site Layout

Figure 3.2

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: BH	Date: 05/08/2013
Approved by: JC	Date: 05/08/2013

Legend

- Wells
- Drilling opportunities
- Flowline buffers
- Proposed pipelines
- Watercourses
- Roads

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS





Dewhurst 26-31 Site Layout

Figure 3.3

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: BH	Date: 05/08/2013
Approved by: JC	Date: 05/08/2013

Legend

- Drilling opportunities
- Roads
- Proposed pipelines
- Proposed drilling leases
- Flowline buffers
- Watercourses

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS



4.0 Project Design Review / Alternatives

The justification for the proposed activity and analysis of alternatives are discussed in **Sections 2.3** and **2.4** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a), respectively.

5.0 Agricultural Enterprise and Resources

The proposed activity is located on private free hold and Crown land (Dewhurst 13-18H) and within the Pilliga East State Forest (Dewhurst 26-31). Both the site and surrounds have minimal agricultural land uses. Since the site does not currently support any intensive agricultural industries, the following section identifies the agricultural enterprises that exist within the surrounding Narrabri LGA.

5.1 Agricultural Enterprise

In the Northern Plains, grain and cotton are the most significant crops, while beef and sheep grazing are also important. Moree and Narrabri LGAs produce 66% of NSW cotton from 4% of the state's area. These same LGAs also produce 5% of the gross value of NSW beef cattle. The area known as the Golden Triangle (350,000 hectares between Bellata, North Star and Yallaroi), produces consistently high yields of prime hard (high protein) wheat (DP&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 (NSC, 2007).

The dominant land use in the Namoi catchment is sheep and cattle grazing which accounts for 51% 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. Extensive areas of land for conservation and forestry occur in the middle of the catchment to the south of Narrabri. Together with other natural vegetation landscapes, these land uses account for over 24% of the catchment. Much of this area comprises the Pilliga Scrub, a significant area of remnant dry sclerophyll forest. Timber harvesting / forestry within the Pilliga Scrub has been reduced largely due to conservation efforts; therefore such forestry enterprises are not considered significant in the Narrabri LGA.

Table 5.1: Land use statistics for the Namoi catchment (source: NSW Department of Environment and Climate Change, 2011).

Land Use	Extent (ha)	Proportion of Catchment (%)
Wetland	2153	<0.1
River/drainage	61100	1
Transport/corridor	27032	1
Urban	35726	1
Cropping	848769	20
Irrigation (cotton, fodder crop, pastures)	80188	2
Grazing	2132230	51
Horticulture	1217	<0.1
Intensive Animal Production	1422	<0.1
Conservation Area	628999	15
Tree and Shrub Cover	369950	9
Mining/Quarrying	1923	<0.1
Power Generation	99	<0.1
Farm Infrastructure	2917	<0.1
Native Landscapes (cliffs / rock outcrop, crown reserve)	4637	0.1

Dewhurst 26-31 is located within the Bohena sub-catchment, and Dewhurst 13-18H is located in the Eulah sub-catchment. Dewhurst 13-18H Pilot is located within private free hold land and Crown land road reserve. The land has previously been used for low intensity stock grazing activities; however no commercial farming activity currently takes place on this property, with some grazing of domestic stock still occurring. The Dewhurst 26-31 Pilot is located within the Pilliga East State Forest, with much of the surrounding area comprised of similar landscapes. Both the site and its surrounds are not used for intensive agricultural purposes.

There are approximately 3,195 registered beekeepers in the state of NSW. Amateur beekeepers account for 77% of registrations in NSW. The 148 beekeepers that own over 500 hives may be termed professional beekeepers and constitute 4.6% of total apiary registrations in NSW (RIRDC, 2007). Current estimates with the Narrabri and Gunnedah LGAs indicate that a total of 7 people are employed as beekeepers (ABS, 2010). The Pilliga East State Forest provides areas for beekeepers to carry out apiary activities. No artificial nesting hives were identified at defined Santos project sites in the Pilliga Scrub, including the Dewhurst pilots earmarked for expansion.

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 (DP&I, 2012a).

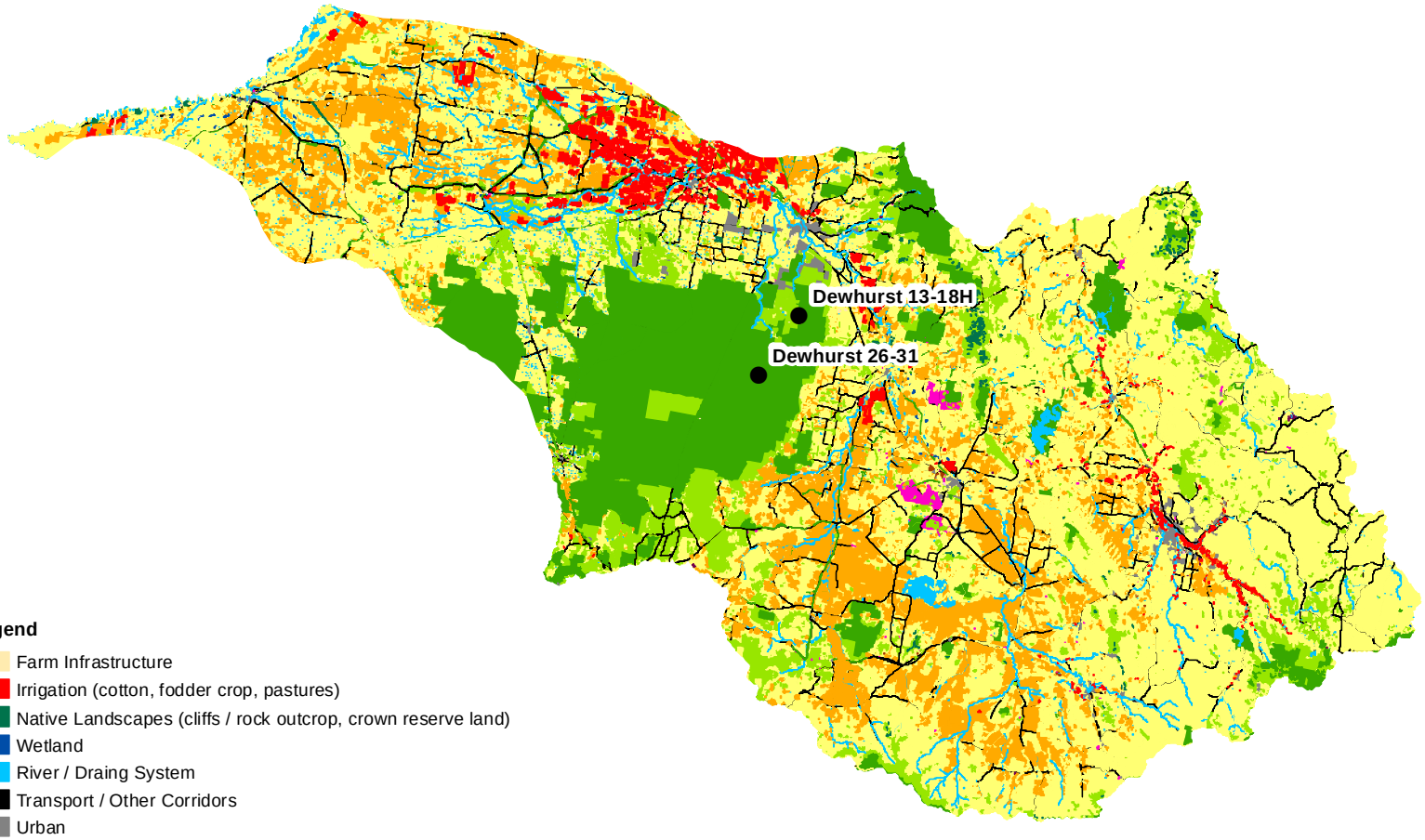
In 2009 / 2010 the Narrabri Shire recorded a Gross Regional Product (GRP) of $730 million, with agriculture, forestry and fishing contributing $115.3 million (15.8%) of total GRP (AEC, 2011). This sector is the second largest contributor to GRP in Narrabri Shire, behind the mining sector.

In 2006, gross value of agricultural production in Narrabri Shire was $260.50 million, with crop value contributing $215.10 million (82.5%) to total production value. Livestock slaughtering and livestock products contributed $41.40 million (15.9%) and $4.0 million (1.5%) to total production value, respectively.

5.1.2 Employment

The Narrabri Shire area sustains expansive cropping activities, with the two largest crops produced in the region being cotton and wheat. Other crops grown in the region include sorghum, sunflowers, cereal grains, oilseeds and legumes. Grazing of beef cattle, sheep and pigs is also a significant contributor to the agricultural productivity within the region (AEC, 2011).

Agricultural employment data recorded in 2009 / 2010 has been reproduced below to represent the diversity of agricultural enterprise across the Narrabri Shire (**Figure 5.2**). The data demonstrates that the largest agricultural enterprises in the region are cotton and grain industries, which employ approximately 47% of the agricultural workforce.



Namoi Catchment Land Use

Figure 5.1

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: JC	Date: 08/07/2013
Approved by: DF	Date: 08/07/2013

Source: Imagery from Bing Maps 2012
Infrastructure from Santos 2013
other data from OEH2012 and DECC 2011

0 20 40 80 km

Datum: GDA94

RPS



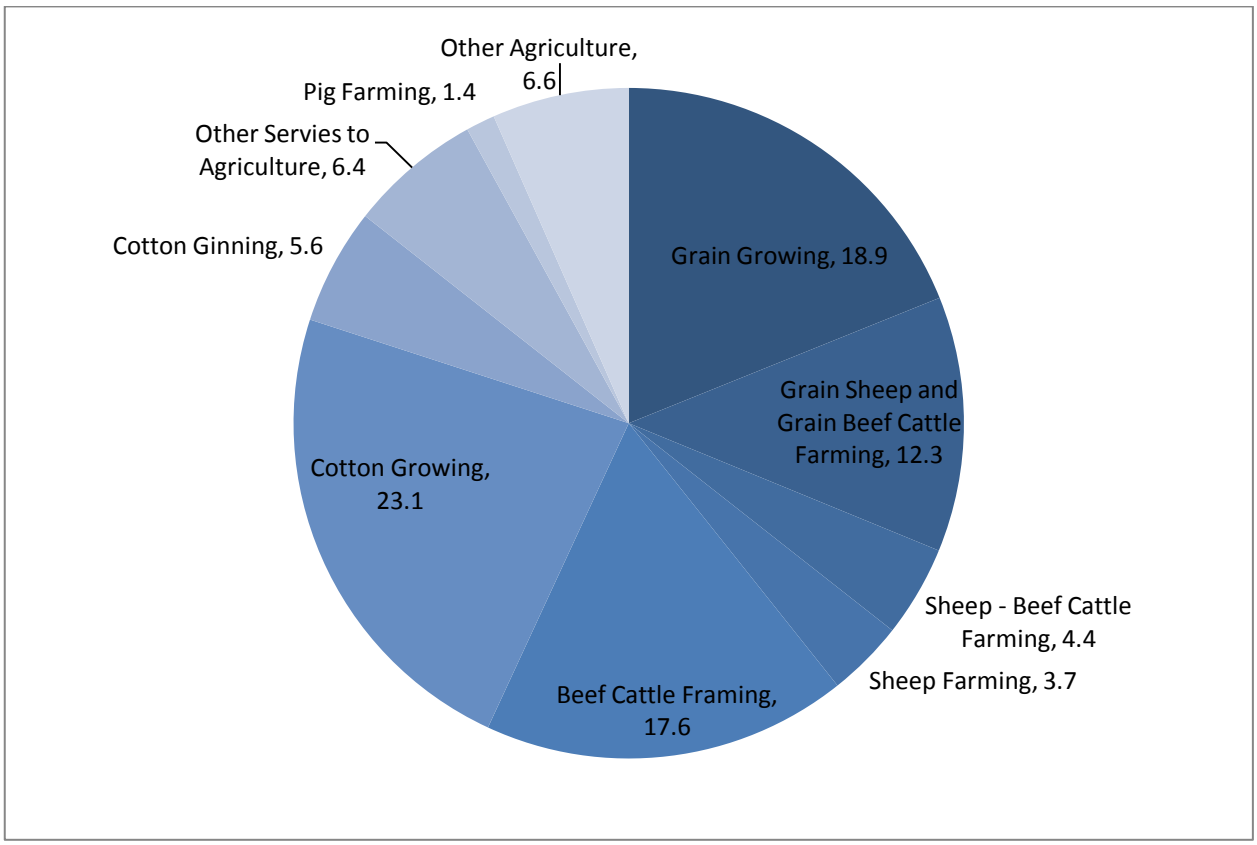


Figure 5.2: Agricultural Employment by Place of Work (Reproduced from AEC, 2011)

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 been established in the Narrabri Shire (DP&I, 2012a), including:

- Livestock selling centre;
- Farm management services;
- Grain and cotton processing centres;
- Grain and field bean merchant wholesalers;
- Agricultural research facilities; 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 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.

The Kimilaroi and Newell Highways run through Narrabri and provide access between the coast and inland NSW. The Newell Highway is part of the National Land Transport Network and forms a major linkage between regional centres in North West NSW to Brisbane and Melbourne (DP&I, 2012a). Existing traffic

volumes along the Newell Highway are typically in the order of 1,860 vehicles per day with a 40% proportion of heavy vehicles (GTA 2013). The Walgett railway services part of north-western New South Wales. Opened in 1908, it branches from the Main North line at Narrabri and passes through the towns of Wee Waa and Burren before terminating at Walgett. The line is used mainly for wheat haulage and runs adjacent to Culgoora Road.

There is no agricultural rail infrastructure near the site or in the surrounds of the proposed activity. The nearest railway line is located approximately 33 kilometres east of the proposal. Further, the proposal is not located on or in the vicinity of any travelling stock routes (TSR). According to the Livestock Health and Pest Authority (LHPA 2010), the nearest TSR is located approximately 11.5 kilometres north-west of Dewhurst 13-18H and 20.5 kilometres north of Dewhurst 26-31.

5.3 Tourism

Tourism in the Narrabri shire is led by its natural attractions. The Pilliga forest and Mount 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 region's tourism attractions. The impact assessment has not identified any tourism opportunities within the site or surrounding areas on which agricultural enterprises are reliant.

5.4 Agricultural Resources

5.4.1 Climate

The closest running weather station is located north east of both the pilot and proposed flare sites (Narrabri West - station 53030). Climate in this area is regarded as semi-arid, due to hot summers and mild winters. Average (1900 - 2013) monthly maximum temperatures range from 18°C (July) to 35°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 May.

Average annual rainfall at Narrabri West is 650 mm. Pan evaporation exceeds rainfall throughout the year (**Figure 5.3**), indicating the regions reliance on irrigation and soil water storage during fallows.

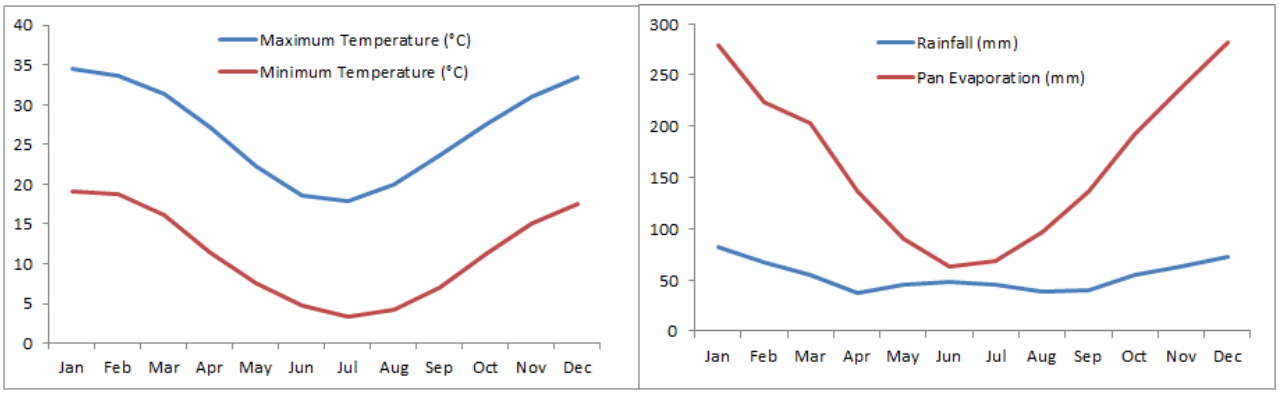


Figure 5.3: Mean maximum and minimum temperature (°C) and rainfall (mm) and pan evaporation (mm) of Narrabri West (station no: 53030) (1900 to May 2013) (SILO 2013)

Table 5.2: Climate statistics Narrabri West for years 1900 to 2013, weather station 53030 (SILO 2013).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum Temperature (°C)	35	34	31	27	22	19	18	20	24	28	31	34
Minimum Temperature (°C)	19	19	16	11	8	5	3	4	7	11	15	18
Rainfall (mm)	82	68	55	37	46	48	45	39	40	55	63	73
Pan Evaporation (mm)	279	224	203	137	91	64	68	97	136	192	237	282

5.4.2 Geology

Detailed surface geology mapping indicated that the location of sites is underlain by two geological formations (Qrxs1/JKlk and Qavl1) .The lithological description is provided in **Table 5.3**.

Table 5.3 : Geological Formations (source: Geosciences Australia 2011).

Site	Formation Name	Map Symbol	Age	Dominant Lithology	Lithological Description
Dewhurst 26-31	Unnamed	Qavl1	Cainozoic–Quaternary	clay	Interpreted clay, silt, sand, gravel.
Dewhurst 13-18H and Dewhurst 26-31	Orallo Formation	Qrxs1/JKlk	Mesozoic - Cretaceous	sandstone	Colluvial polymictic gravel, sand, silt and clay; may include some eluvial in situ regolith deposits overlies off-white, fine to coarse grained, poorly to well sorted, quartzose sandstone, pebbly sandstone and conglomerate interbedded with minor shale

5.4.3 Topography

Dewhurst 13-18H

The topography of Dewhurst 13-18H is flat to undulating and the land rises generally to the south east, with elevations ranging from approximately 286 to 294 metres Australian Height Datum (AHD). There is a single unnamed drainage line mapped as flowing across the site from east to west, crossing over the proposed gathering system between Dewhurst 16H and 17H. This drainage feature was not observed during onsite ground-truthing. Jacks Creek is also located approximately 0.5 kilometres north of the nearest gathering system point. An unnamed tributary of Tuppiari Creek flows in a north-west direction approximately 240 metres south of Dewhurst 13.

Dewhurst 26-31

The topography of the study area is gently undulating, with no significant topographic features. Individual topographic characteristics of the proposed lease areas are as follows:

- Dewhurst 30 – generally slopes in a south-west direction, with elevations ranging between approximately 304.3 and 306.6 metres AHD
- Dewhurst 31 – generally slopes to the north, with elevations ranging between approximately 308.8 and 310.4 metres AHD.

Three watercourses intersect the pilot, including Mount Pleasant Creek and two of its tributaries. The nearest dwelling is located approximately 11 kilometres north of the site.

5.4.4 Soils

5.4.4.1 Australian Soils Classification

Australian Soil Classification (ASC) soil order mapping (1:100,000) prepared by the OEH (2012c) shows that the Project area and the surrounding landscape is dominated by Sodosols with a sub-dominant occurrence of Rudosols/Tenosols (**Figure 5.4**). These soil orders are briefly described in **Table 5.4.**

Table 5.4: Australian Soils Classification

ASC Soil Order	Description
Rudosols and Tenosols	These soils have weak (Tenosol) to negligible (Rudosol) pedological organisation.
Sodosols	Soils with a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon is sodic and not strongly acid.

5.4.4.2 Eastern Star Gas Pipeline Soil Survey

Eastern Star Gas commissioned a soil survey of proposed gas pipeline alignment from the Bibblewindi State Forest in the south to the Wilga Park Power Station in the north (GCNRC, 2008). A total of 33 soil profiles were sampled, approximately 12 kilometres west of Dewhirst 13-18H and eight kilometres north of Dewhurst 26-31. The survey identified that the soils along the alignment in the Pilliga East and Bibblewindi State Forests were dominated by deep texture contrast soils with a sub-dominant occurrence of deep sandy soils.

The subsoil of the deep texture contrast soils was described as having a high to very high dispersion potential which is characteristic of Sodosol soils. The deep sandy soils observed in the Bibblewindi State Forest were light textured (Sand to Sandy Loam) throughout the solum and are best classified as Rudosol/Tenosol soils.

The findings of this survey were consistent with those made by RPS in a previous soil survey in a similar area of the Pilliga East and Bibblewindi State Forests and support the conclusion that soils of the project area are likely dominated by Sodosols, with the potential occurrence of deep sandy, light textured Rudosol/Tenosols.

5.4.4.3 Previous RPS Soil Surveys in Local Area

An ecological survey (Eco Logical, 2013) at Dewhurst 13-18H and Dewhurst 26-31 confirmed that existing vegetation is consistent with *Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion*.

The vegetation types identified during the ecological survey were consistent with those observed by RPS during a previous soil survey in the Pilliga East State Forest. RPS noted that the vegetation was dominated by eucalypt (*E. Crebra*) overstorey, Casuarina and Cypress understorey with shrubs, sedges and native grass species. Cypress and sedges are common to deep sandy and texture contrast soils. The vegetation at the Project area was consistent with the vegetation types previously observed by RPS associated with Sodosols and Tenosols in the Bibblewindi and Pilliga East State Forests.

An example of the upper 600 millimetres of a Sodosol soil profile at a site in the Bibblewindi State Forest from a previous RPS soil survey is provided in the Dewhurst Gas Exploration Pilot Expansion BSAL Site Verification report (RPS 2013b). These soils typically include a shallow sandy A11 horizon overlying a lighter coloured A12 horizon. These upper horizons typically exhibit a singular or weak pedal structure. A conspicuously bleached A2 horizon is present in the profile due to the poor subsoil drainage caused by the heavier textured, hard-set and strongly sodic B horizon (Exchangeable Sodium Percentage (ESP) ranging

from 14 to 42 per cent). Soils at a survey check point approximately one kilometre north of the Dewhurst 26-31 Pilot area were previously identified by RPS as Sodosols.

An example of the upper 700 millimetres of a brown orthic Tenosol soil profile at a site in the Pilliga East State Forest from a previous RPS survey is provided in the Dewhurst Exploration and Appraisal Program BSAL Site Verification report (RPS, 2013b). The Tenosols had weakly developed horizons and were lightly textured throughout the profile, ranging from Sand to Sandy Loam (i.e. less than 15 per cent clay content). These deep sandy, light textured soils were observed to extend to a depth of at least two metres at some exposed soil profile sites near Bohena Creek in the Bibblewindi State Forest.

The consistency in vegetation associations and broadscale mapping and field survey data supports the conclusion that soils of the Project area are likely dominated by Sodosols with the potential occurrence of deep sandy, light textured Tenosol soils.

5.4.5 Soil Fertility

According to the *Draft Inherent Soil Fertility Mapping, Upper Hunter and New England North West Strategic Regional Landuse Areas* (OEH, 2012a), the inherent soil fertility of the proposed activity site and their surrounds is moderately low to low (**Figure 5.6** and **Figure 5.7**).

5.4.6 Soil Erosion and Sediment Transport

5.4.6.1 Sodicity

Land Management Units in the Namoi Catchment (NCMA, 2009a) was a project commissioned by the Namoi Catchment Management Authority (CMA) and involved soil and land capability mapping (scale: 1:100,000) of the Namoi Catchment. Derivative maps were also created and included sodicity maps.

The sodicity mapping indicates that the location of both Dewhurst 13-18H and Dewhurst 26-31 are characterised by low surface sodicity and widespread subsurface sodicity.

5.4.6.2 Dispersion

The Eastern Star Gas survey (GCNRC 2008) also analysed dispersion. The nearest dispersion test site to Dewhurst 13-18H was Profile 18, located 13.5 kilometres to the west. Profile 18 was also identified as a Sodosols. The dispersion percentages identified that surface dispersions (0 – 0.23 m) was only slight (dispersion % = 6 – 30), while subsoils (>0.23 m) dispersion was slight to moderate (dispersions % = 6 - 50).

The nearest dispersion test site for a Sodosol to Dewhurst 26-31 is Profile 6, located 10 kilometres north. The dispersion percentages identified that surface dispersions (0 – 0.14 m) was slight (dispersion % = 6 – 30), while subsoils (>0.14 m) dispersion was either high to very high (dispersions % = >65).

The nearest dispersions site for a Rudosols/Tenosols to Dewhurst 26-31 was Profile 21, located 22 kilometres to the north. The dispersion percentages identified that surface dispersions (0 – 0.19 m) was slight (>0.19 m), while subsoil dispersion (0.33 – 1.44) was high (dispersion % = 6 – 30).

5.4.7 Soil Limitations

Soil characteristics of the sites indicate moderate to severe limitations, as the features listed in **Table 5.5** limit agricultural productions.

Table 5.5: Soil limitations of the proposed activity.

ASC	PAWC*	Stoniness	Soil Depth	Nutrients	Sodicity
Sodosol	✓	-	-	✓	✓
Rudosols/Tenosols	✓	-	-	✓	✓

*PAWC – Plant available water capacity



Dewhurst 13-18H Australian Soil Classification

Figure 5.4

Project: Dewhurst Gas Exploration Pilot Expansion

Client: Santos

Compiled by:	BH	Date:	06/08/2013
Approved by:	JC	Date:	06/08/2013

Legend

- Wells
- Proposed pipelines
- Flowline buffers

Australian Soils Classification

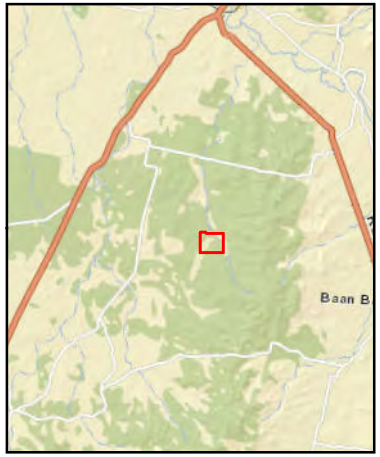
- Rudosols and Tenosols
- Sodosols

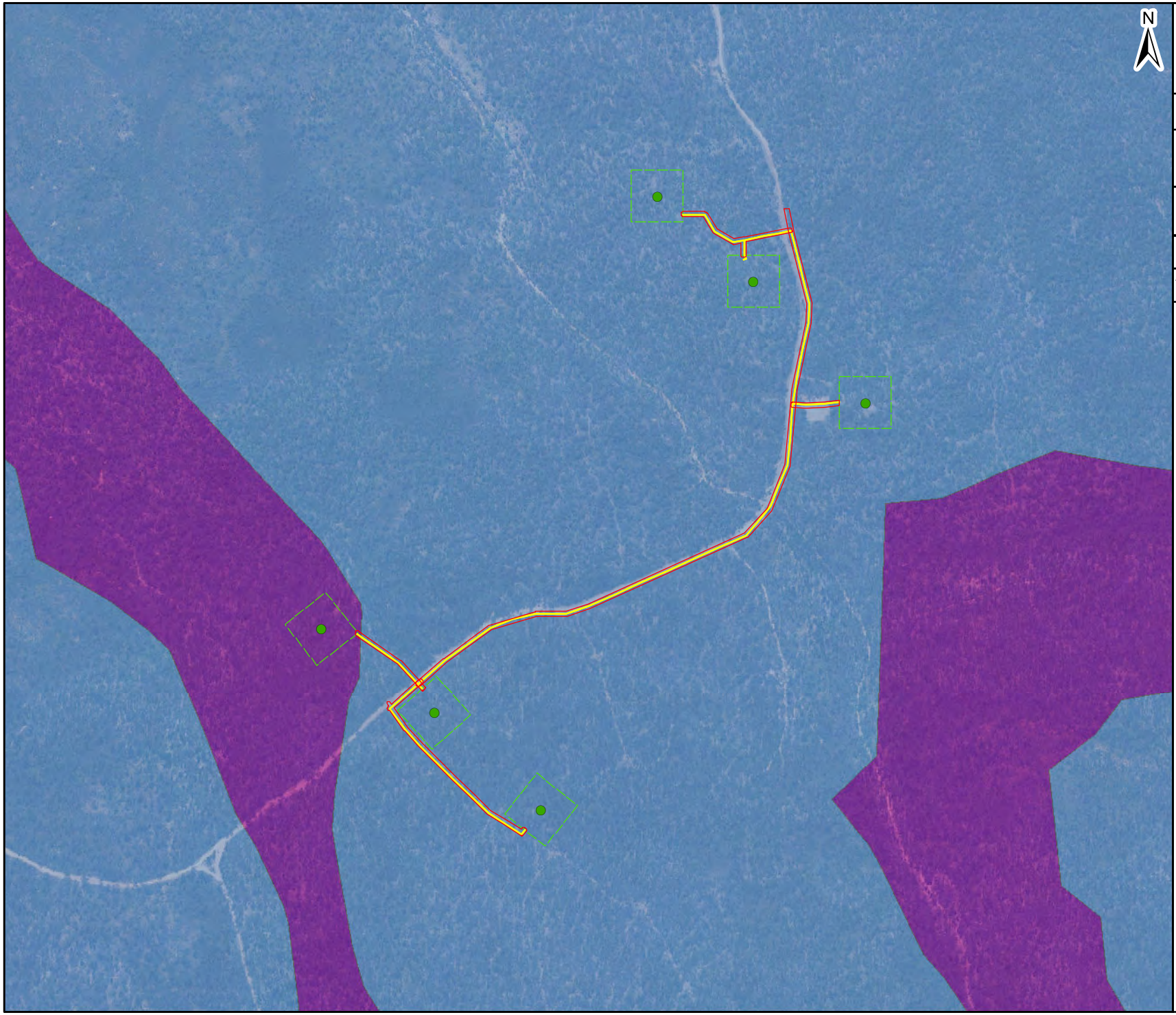
Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from Geosciences Australia 2011

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS





Dewhurst 26-31 Australian Soil Classification

Figure 5.5

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos

Compiled by:	BH	Date:	06/08/2013
Approved by:	JC	Date:	06/08/2013

Legend

- Drilling opportunities
- Proposed pipelines
- Flowline buffers
- leases drilling proposed

Australian Soils Classification

- Rudosols and Tenosols
- Sodosols

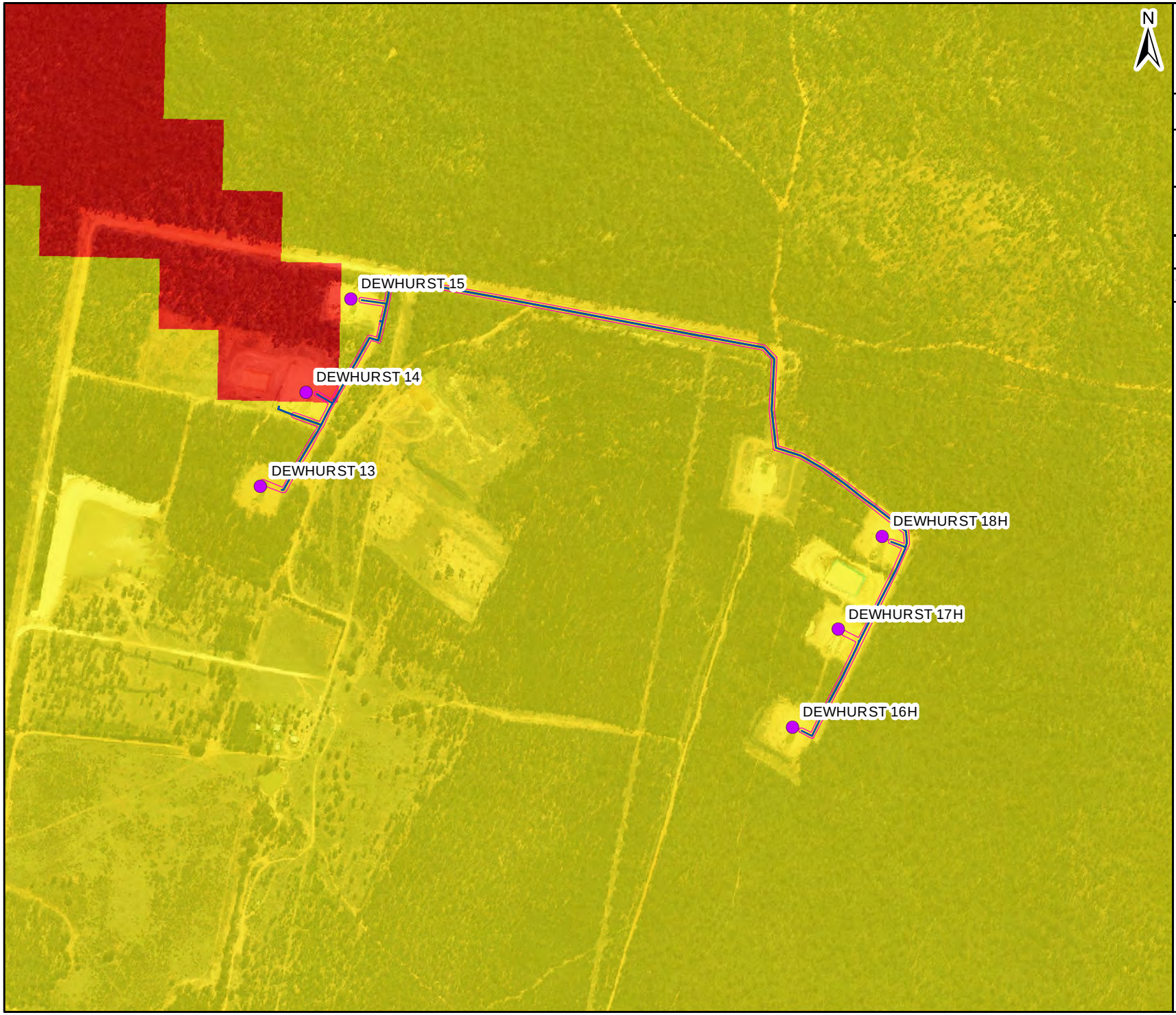
Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from Geosciences Australia 2011

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS





Dewhurst 13-18H Soil Fertility

Figure 5.6

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: BH	Date: 05/08/2013
Approved by: JC	Date: 05/08/2013

Legend

- Wells
- Proposed pipelines
- Flowline buffers

Soil Fertility

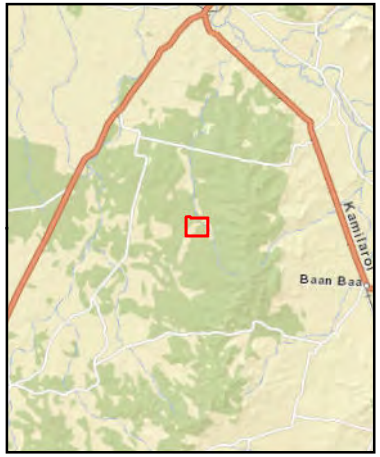
- High
- Moderately High
- Moderate
- Moderately Low
- Low

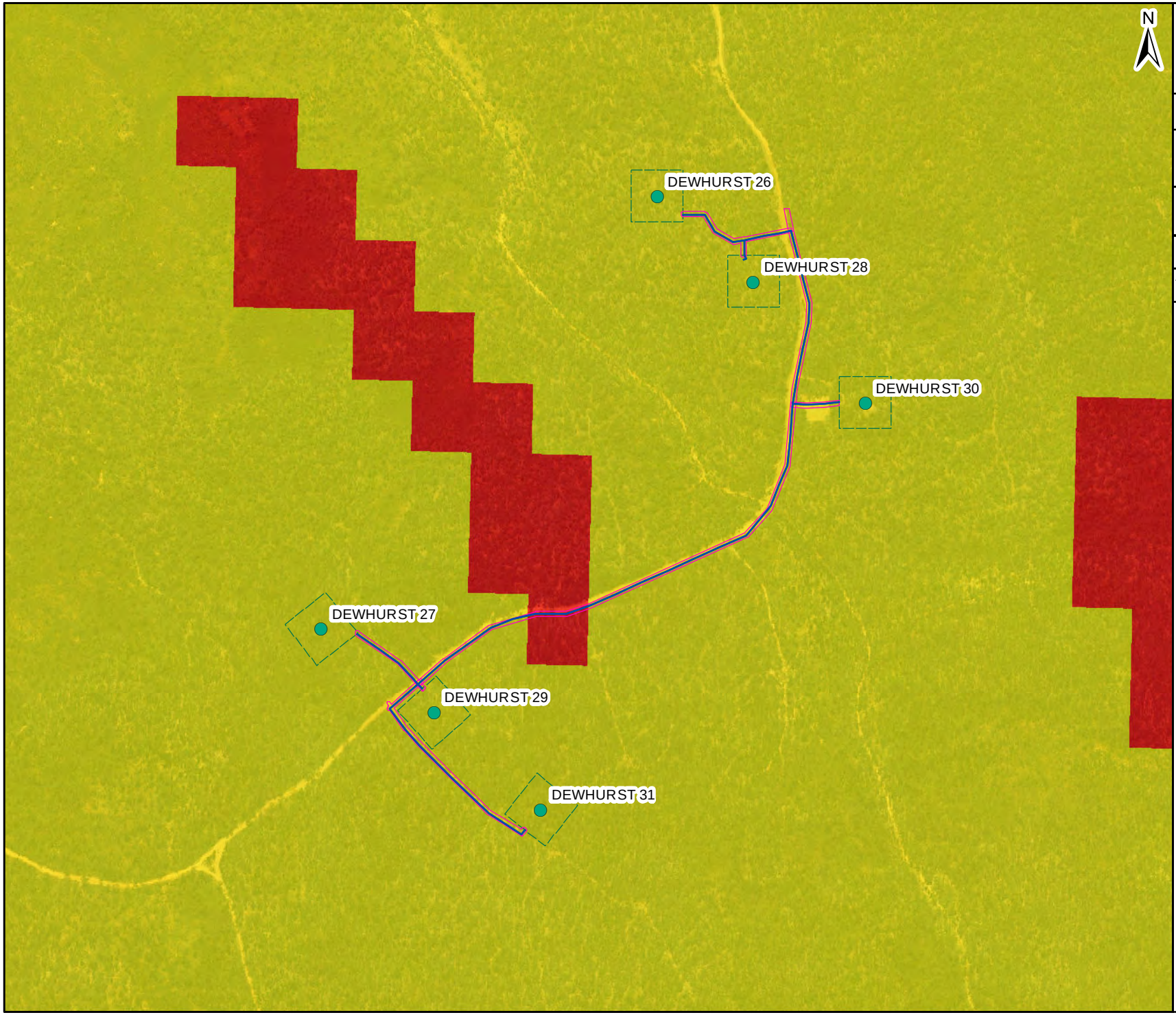
Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS





Dewhurst 26-31 Soil Fertility

Figure 5.7

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos
Compiled by: BH	Date: 05/08/2013
Approved by: JC	Date: 05/08/2013

Legend

- Drilling opportunities
- Proposed pipelines
- Flowline buffers
- Proposed drilling leases

Soil Fertility

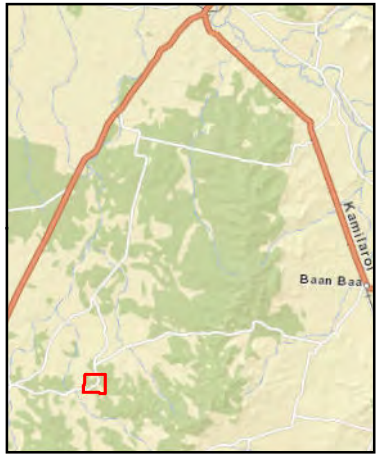
- High
- Moderately High
- Moderate
- Moderately Low
- Low

Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS



5.4.8 Land Capability and Agricultural Land Use Suitability

5.4.8.1 BSAL and CIC

Strategic Agricultural Land (SAL) is highly productive land that has both unique natural resource characteristics as well as socio-economic value (DP&I, 2012a). Based on this definition there are two (2) categories of SAL: Critical industry Clusters (CICs) and Biophysical Strategic Agricultural Land (BSAL).

BSAL is land with the best quality landforms, soil and water resources which are naturally capable of sustaining high levels of productivity with minimal management practices (DP&I, 2012a). 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 (DP&I, 2012a).

According to the Strategic Agricultural Land mapping (DP&I, 2012a), the site and surrounds are not located on BSAL of the New England - North West region. The nearest BSAL polygon is located approximately 10 kilometres east of Dewhurst 13-18H and 13 kilometres east of Dewhurst 26-31 as shown in **Figure 5.8**. No CICs have been identified in the New England North West Region (DP&I, 2012a).

5.4.8.2 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 site and surrounds have been mapped as LSC Class 4 and 5 (**Figure 5.9** and **Figure 5.10**). Lands in LSC Class 4 are described as having moderate to severe limitations and are generally not capable of sustaining high impact land uses unless using specialised land 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). Lands in LSC Class 5 are described as having severe limitations and are not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (e.g. high value crops). Lower impact land uses (e.g. grazing) can be managed by readily available practices.

5.4.8.3 Land Capability as Mapped by SCS

The Soil Conservation Service (SCS) of NSW (Land and Water Conservation) uses 1:100,000 scale maps for evaluating rural land (Emery 1986). Mapping is based on an assessment of the biophysical characteristics of the land, the extent that these will limit a particular land use and also includes assessments of soil erosion hazards. The Soil Conservation Service of NSW study classed the proposed site as a State forest and did not assign a land capability classification.

For a full review, please refer to:

- Emery, K.A. (1986) 'Rural Land Capability Mapping' Soil Conservation Service of NSW available on www.environment.nsw.gov.au/soils/publications.htm, in 4 parts.

5.4.8.4 Agricultural Land Use Suitability

Similar to the SCS mapping land capability mapping (Emery 1986), the NSW Department of Primary Industries land use assessment has not assigned the Project area a land use suitability class.



Strategic Agricultural Land

Figure 5.8

Project:	Dewhurst Gas Exploration Pilot Expansion
Client:	Santos

Compiled by:	BH	Date:	06/08/2013
Approved by:	JC	Date:	06/08/2013

Legend

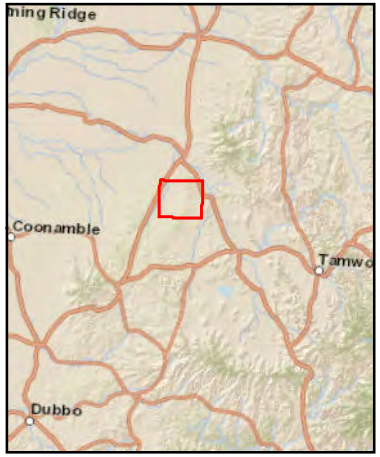
- Wells
- Drilling opportunities
- Proposed pipelines
- BSAL

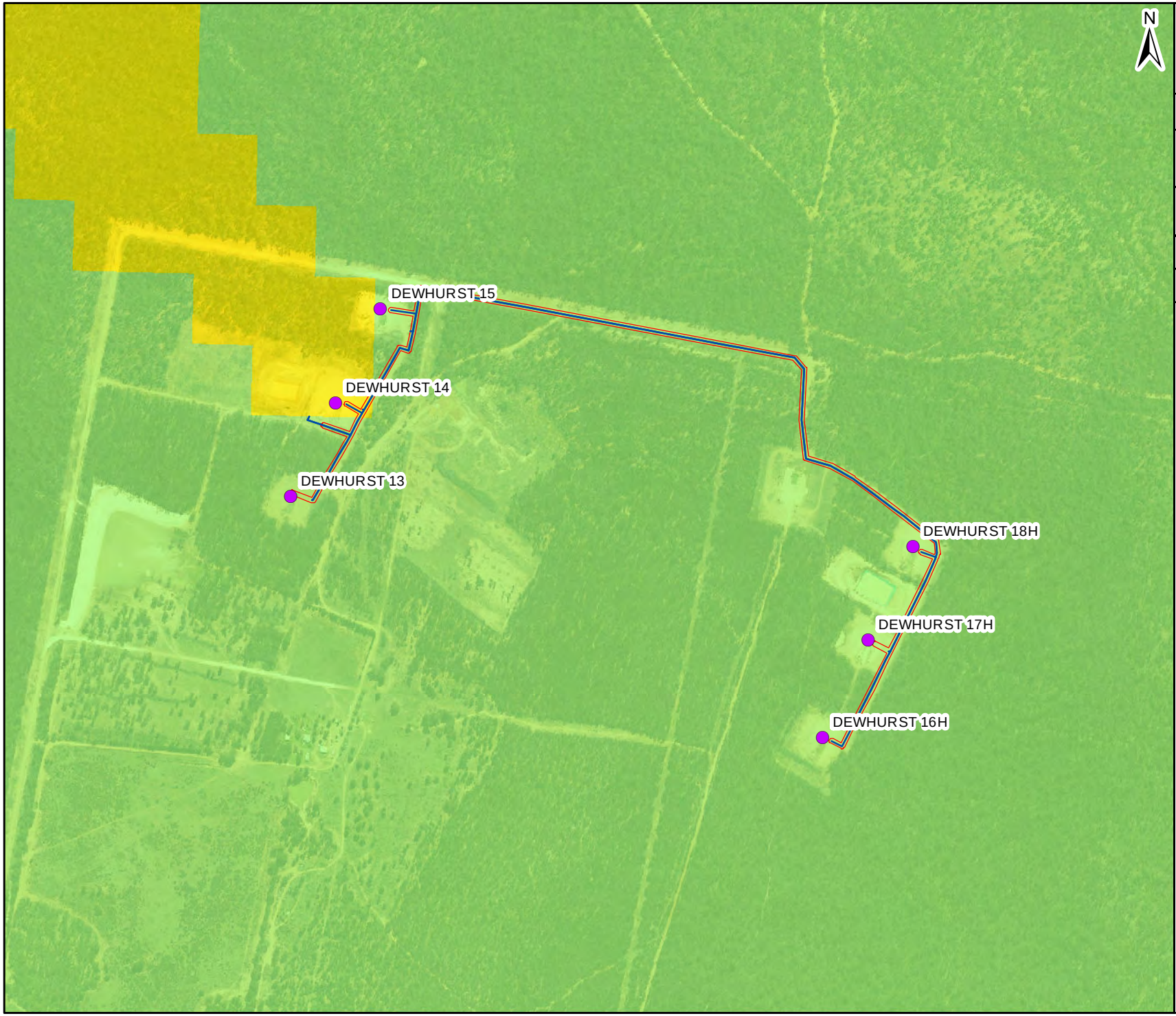
Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 1.25 2.5 5 km

Datum: GDA94
Scale 1:150,000 @ A4

RPS





Dewhurst 13-18H Land and Soil Capability

Figure 5.9

Project: Dewhurst Gas Exploration Pilot Expansion

Client: Santos

Compiled by:	BH	Date:	06/08/2013
Approved by:	JC	Date:	06/08/2013

Legend

- Wells
- Proposed pipelines
- Flowline buffers

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*

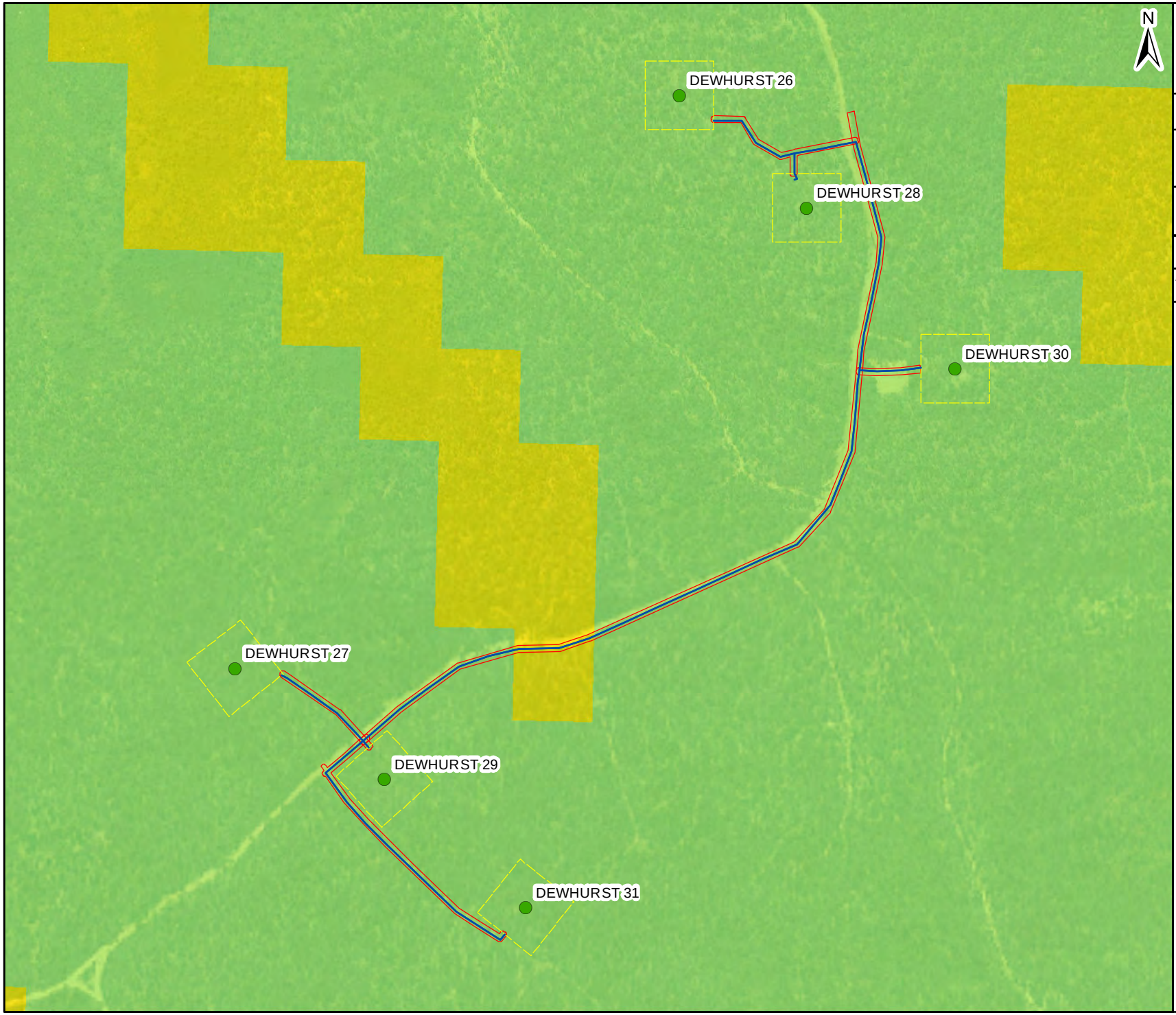
Source: Imagery from Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 75 150 300 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS





Dewhurst 26-31 Land and Soil Capability

Figure 5.10

Project: Dewhurst Gas Exploration Pilot Expansion

Client: Santos

Compiled by:	BH	Date:	06/08/2013
Approved by:	JC	Date:	06/08/2013

Legend

- Drilling opportunities
- Proposed pipelines
- Flowline buffers
- leases drilling proposed

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 Santos 2012
Infrastructure from Santos 2013
Other dats supplied from OEH 2012

0 55 110 220 Meters

Datum: GDA94
Scale 1:10,000 @ A4

RPS



5.4.9 Water Resources

5.4.9.1 Surface water

The site is located within the Namoi River catchment which covers an area of approximately 42,000 square kilometres 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).

Overall trends indicate a decline in surface water quantity and quality in the Namoi catchment. The Namoi River basin has one of the largest irrigated areas in the northern Murray Darling Basin (MDB), accounting for 15% of the total irrigated area in 2000-01 (MDBC, 2008 cited in CMA, 2009b). Average surface water availability in the Namoi Region is 965 GL/year, with 37% (357 Gigalitres) of this water being used. The high demand on surface water resources is attributed to surface water diversions (260 Gigalitres/year) and stream flow losses induced by groundwater use (99 Gigalitres/year) (NCMA, 2009b). Surface water quality within the catchment is influenced by agricultural runoff, spray drift, and vapour transport (NCMA, 2012). The water quality parameters which are of greatest concern for the Namoi catchment includes nutrients, salinity and turbidity.

Dewhurst 13-18H is located within the Eulah Creek sub-catchment of the Namoi River catchment. The Eulah Creek sub-catchment covers an area of approximately 1581.4 square kilometres, which extends both north and south of the Namoi River. On the southern side of the river, the sub-catchment is drained by a number of creeks including Jacks, Kurrajong, Sandy, Pine and Tulla Mullen (Eco Logical, 2009).

Jacks Creek (the closest direct Namoi River tributary to the Dewhurst 13-18H site) and its tributaries are ephemeral, generally flowing for short periods following significant rainfall or prolonged wet periods. Baseflow in these creeks are insignificant. Jacks Creek remains dry for extended periods between runoff events, sometimes for periods in excess of 12 months and it contributes little inflow to the Namoi under normal conditions.

An unnamed tributary of Tuppiari Creek is mapped flowing from east to west across the site, crossing the gathering system between the Dewhurst 16H and 17H lease areas. Tuppiari Creek is a tributary of Jacks Creek, with its confluence approximately 5.5 kilometres north of the site. Jacks Creek itself is located approximately 0.5 kilometres north-east from the gathering system. Despite its presence on maps, no discernible indication of the unnamed drainage line was observed during the site inspection in January 2013.

Dewhurst 26-31 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.

Three watercourses intersect the site, including Mount Pleasant Creek and two of its tributaries. These watercourses flow north-west to Cowallah Creek. Cowallah Creek is located approximately 1.6 kilometres east of Dewhurst 27. Cowallah Creek is a tributary of Bohena Creek, which is located approximately 8.1 kilometres north-west of the closest lease pad (Dewhurst 26).

5.4.9.2 Groundwater

Groundwater is a significant resource in the Namoi catchment and has been extensively developed for irrigation, stock and domestic uses, with the catchment having the highest rate of groundwater use in NSW. Within the catchment there are alluvial, fractured rock and porous rock groundwater management areas. The highest yielding and most actively used bores being located in unconsolidated alluvial sediment aquifers associated with the Namoi River and its tributaries (upper and Lower Namoi Alluvium).

The porous rock groundwater sources of the Great Artesian Basin (GAB) Surat Pilliga Sandstone underlie the Upper and Lower Namoi groundwater sources. Waters associated with this formation are more saline than the Lower and Upper Namoi and are generally used for stock purposes rather than irrigation. The Dewhurst 13-18H and Dewhurst 26-31 pilots will not extract water from these two sources. The proposed pilots will extract water from the Maules Creek Formation, which is a less productive porous rock groundwater source.

As with surface water, over-allocation beyond sustainable extraction limits is a key concern for groundwater in the Namoi catchment. With over 700 licence holders, the Namoi region has the highest level of groundwater development in NSW and one of the highest levels of groundwater extraction in the MDB (NCMA, 2012). Groundwater use is approximately 261 gigalitres, which comprises about 15% of the MDB total (DWE, 2008 and CSIRO, 2007 cited in Namoi CMA, 2009b). Approximately 39% of this extraction is from the Upper Namoi Alluvium groundwater management unit (GWMU) and about 35% is from the Lower Namoi Alluvium GWMU (CSIRO, 2007 cited in NCMA, 2009b).

According to the Pinneena database (NOW, 2010), there are 11 licensed groundwater bores within five kilometres of the Dewhurst 13-18H Pilot, while there are none within five kilometres of the Dewhurst 26-31 Pilot. Registered groundwater bore details within the vicinity of the Project area are provided in **Section 9.1.2** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).

5.4.9.3 Licensed Water Use

The Water Sharing Plans that apply to the proposed activities are detailed in **Section 6.2.3.1** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).

6.0 Agricultural Impact Risk Assessment

The Project is required to support CSG exploration activities; therefore the potential agricultural impacts were evaluated in accordance with the *Guidelines for Agricultural Impact Statements at the Exploration Stage* (DP&I, 2012b). 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. However, the *Guidelines for Agricultural Impact Statements at the Exploration Stage* (DP&I, 2012b) later states 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. Other high or moderate risk activities identified by the DP&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 CSG pilot testing.

Table 6.1: Agricultural Impact Risk Ranking Matrix (DP&I 2012c)

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

Where:

	= low risk
	= medium risk
	= high risk

Table 6.2: Agricultural Impact Risk Ranking – probability descriptors (DP&I 2012c)

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 (DP&I 2012c)

Level: 1	Description	Example of Implications
Severe Consequences	▪ Severe and/or permanent damage to agricultural resources, or industries ▪ Irreversible ▪ Severe impact on the community.	▪ Long term (e.g. 20 years) damage to soil or water resources ▪ Long term impacts (e.g. 20 years) on a cluster of agricultural industries or important agricultural lands.
Level: 2	**Description**	**Example of Implications**
Major Consequences	▪ 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 (e.g. 20 years) ▪ Long term (e.g. 20 years) displacement / serious impacts on agricultural industries.
Level: 3	**Description**	**Example of Implications**
Moderate Consequences	▪ 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 (e.g. 1 – 5 years) ▪ Management could include significant change of management needed to agricultural enterprises to continue.
Level: 4	**Description**	**Example of Implications**
Minor Consequences	▪ 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 resources 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	**Description**	**Example of Implications**
Negligible Consequences	▪ 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 resources on industry.

6.1 Dewhurst Gas Exploration Pilot Expansion Related Impacts

Table 6.4 details the nature of risk, likelihood and consequence of potential impacts on agricultural resources and industries. **Table 6.4** also details the mitigation measures for the identified potential impacts. Based on the Agricultural Impact Risk Ranking System, the proposed activity has been classified as a low risk exploration activity due to the following:

- The proposed activity is not located on or near BSAL or CIC;
- No intensive agricultural activities are currently undertaken at the proposed pilots;
- The proposed activity is located on land with low potential for commercial agricultural land use;
- As Dewhurst 13-18H Pilot wells are located on existing lease areas there will be no further surface disturbances associated to lease pad development. Therefore, surface disturbances associated to Dewhurst 13-18H are largely associated to the flowline construction;
- All surface disturbance areas will be fully rehabilitated to the pre-existing land condition or that agreed upon with the landowner (including the Forestry Corporation of NSW). There will be no permanent land capability reduction of agricultural resources;
- There will be no anticipated impacts on surface waters; and
- There will be no expected lifting or decline in head of agricultural groundwater resources (CH2MHill, 2013).

The proposed mitigation, management and monitoring systems will reduce the likelihood of any impacts to agricultural resources or industries. The Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a) describes in full the mitigation, management and monitoring systems in place that will reduce the likelihood of potential impacts to agricultural resources and supporting infrastructure.

Table 6.4: Agricultural Impact Risk Ranking of the Proposed Activities

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
Socio-Economic Impacts					
Agricultural Support Infrastructure	▪ Pressure on regional water supplies. ▪ Pressure on transport infrastructure. ▪ Impact on agricultural support industries (e.g. processing facilities).	E (Rare)	4 (Minor)	E4 (Low)	▪ Negligible consequence as the proposed works will not source or utilise agricultural support infrastructure. ▪ The proposed activity is not located on or within the surrounding area of any mapped CICs. ▪ The minor increase of traffic along Beehive Road, X line Road, Tighes Gully Road, Westport Road, Killara Road and the Newell Highway can easily be accommodated by the existing road network. Further, a traffic management plan will be installed to mitigate any pressures on the local road network. ▪ Minor traffic delays may occur during the construction phase from vehicles utilising the Newell Highway, however this will only be a short term impact as construction will only take up to 6 months.
Employment and Economic Development	▪ Reduction of current or future agricultural employment opportunities. ▪ Adverse impact to local tourism industry. ▪ Competition for labour resources.	E (Rare)	5 (Negligible)	E5 (Low)	▪ No impacts to agricultural employment opportunities are anticipated as no intensive agricultural activities are being undertaken on or adjacent to the Project area. Also, the site is located on land with low potential for commercial agricultural use. ▪ Negligible impacts on labour resources within the local area as specialised skills are required to complete the proposed activity. As such, trained / skilled professionals will be brought in to work on the project. ▪ No mitigation measures required.
Tourism	▪ Reduction of agricultural related tourism (wineries, bed and breakfast, etc.)	Rare (E)	5 (Negligible)	E5 (Low)	▪ Negligible consequence as there are no agricultural-related tourism (e.g. wineries, farm stays etc.) in the Project area and surrounds. ▪ No mitigation measures required.
Agricultural Resources					
Loss of land from agricultural use.	▪ Alienation of land for agricultural uses.	E (Rare)	5 (Negligible)	E5 (Low)	▪ The proposed activity is located on land with low potential for commercial agricultural use, therefore future agricultural production is very limited.

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
					▪ Negligible consequences as the proposed activity is not located on or near any intensive agricultural activities. ▪ The proposed activity is located at least 10 kilometres from the nearest mapped BSAL. ▪ The Dewhurst 13-18H is predominantly located on existing lease areas (previously cleared) and hence do not harbour target honey trees. Furthermore, the areas requiring vegetation clearing are minimal, approximately 2.5 ha of predominately Narrow-leaved ironbark (potential honey tree). Therefore, the proposed activity is anticipated to have negligible impact on the apiary industry. ▪ The disturbed area will be fully rehabilitated once the works are completed.
Soil	▪ Soil erosion. ▪ Contamination due to groundwater discharge ▪ Contamination due to fuel/oil spill during construction. ▪ Soil compaction.	D (Unlikely)	4 (Minor)	D4 (Low)	▪ Very minor damage or impact to agricultural resources or industries as mitigation and management measures outlined in **Section 8.4** within Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a) will minimise the likelihood of potential impacts. ▪ Due to the likely presence of sodic subsoils, it will be necessary to maintain an adequate groundcover on the existing landscape and on the reformed landscapes after rehabilitation works are carried out, if erosion is to be prevented and rehabilitation to be successful. ▪ Mitigation measures for the potential contamination for land resources are detailed in **Section 8.4** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).
Surface water	▪ Sedimentation of waterways. ▪ Impacts to water quality from sediment laden runoff or chemical spills. ▪ Contamination due to groundwater discharge. ▪ Removal from agricultural related uses	D (Unlikely)	2 (Major)	D2 (medium)	▪ Erosion and sediment controls will be implemented during site preparation activities 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. ▪ No surface waters will be lifted for either the construction, operational or rehabilitation phases of the proposed activities. ▪ Drilling activities will require approximately 0.25 megalitres of water at Dewhurst 16H, 17H and 18H respectively and 0.2 megalitres at each of Dewhurst 30 and 31. In addition,

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
					▪ approximately 0.02 megalitres per day of potable water will be required for facilities during construction. This will be sourced from Narrabri's town water supply or local industrial licensed water bores and trucked to the site. Alternatively, produced water from pilot wells will be used when available for the preparation of drilling fluid. Therefore, required water will not be sourced from agricultural supplies. ▪ Further potential impacts will be mitigated and managed as outlined in **Section 10.4** and **16.4** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a), which will minimise the likelihood of potential impacts.
Groundwater	▪ Cross contamination of aquifers. ▪ Contamination by drilling fluids or mud. ▪ Contamination due to spills, fuels or chemicals. ▪ Removal from agricultural related uses	D (Unlikely)	2 (Major)	D2 (medium)	▪ Wells will be designed, constructed and abandoned in accordance with the *NSW Code of Practice for Coal Seam Gas Well Integrity* (DTIRIS, 2012), therefore minimising the likelihood of potential impacts. For further details on well design, construction and rehabilitation refer to **Section 4.0** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a) ▪ Groundwater modelling has indicated that there will be no impact on registered bore users linked to agriculture. An ongoing groundwater monitoring program will be implemented. ▪ The groundwater that will be lifted is not suitable for agricultural use. Water quality of the Maules Creek Formation is too saline (e.g. total dissolved solids (TDS) range is 8,960 mg/L to 23,040 mg/L) for agricultural uses such as irrigation and livestock use. ▪ The potential impacts will be readily managed and mitigated through standard construction site environmental and engineering controls outlined in **Section 9.5** Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).
Air and Noise	▪ Reduced productivity of cropping areas due to dust generation and settlement ▪ Unfavourable conditions	C (Possible)	4 (Minor)	C4 (Low)	▪ Minor or short term impact on grazing stock near Dewhurst 13-18H given the short duration of the construction phase (primary air and noise polluting period) (approximately 6 months). ▪ Impacts would be mitigated by the measures outlined in

Potential Impact	Nature of Risk	Likelihood	Consequence level	Impact Risk Ranking	Potential Consequence / Mitigation Measures
	for livestock due to the following: 1. Exhaust emissions from, vehicle movements and plant and machinery operations; and 2. Noise generation above agricultural background level of 30 dB(A). 3. Venting or flaring of methane (CH_4) and carbon dioxide (CO_2) during drilling				**Section 12.5** and **14.5** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).
Weeds	▪ Introduction of weeds to area ▪ Land degradation ▪ Reduced agricultural productivity	D (Unlikely)	4 (Minor)	D4 (Low)	▪ No intensive agricultural activities are being undertaken on or adjacent to the proposed activity. ▪ These potential impacts would be readily managed and mitigated through standard construction site weed hygiene measures as outlined in **Section 11.5** of the Dewhurst Gas Exploration Pilot expansion EIS (RPS, 2013a).
Biosecurity	▪ Spread of *Phytophthora cinnamomi*	E (Rare)	5 (Negligible)	E5 (Low)	▪ Vehicles and plant from any known *P. cinnamomi* risk areas shall be washed down prior to entry to site. ▪ The proposed activity is located on land with low potential for commercial agricultural use.

7.0 Cumulative Impacts

Santos plans to continue exploration, appraisal and evaluation of the CSG hydrocarbon potential in PEL 238 and PAL 2 and has developed the Energy NSW CSG Exploration and Appraisal Program (the program). The program will assist in gaining further knowledge of coal fines, gas composition, flow rates and deliverability, well design, drilling and completion technologies. The program will be conducted over the next two to three years and will include:

- Operation of the existing Dewhurst 13-18H Pilot and the construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H, 17H and 18H (the proposed activity, subject of the EIS);
- Construction, drilling and operation of the Dewhurst 26-31 Pilot (incorporates the proposed activity, partially subject of the EIS);
- Construction, drilling and operation of the Dewhurst 22-25 Pilot;
- Operation of the existing Bibblewindi Multi-Lateral Pilot, and the construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32) from existing well leases within the pilot;
- Operation of the existing Bibblewindi West Pilot;
- Operation of the existing Tintsfield CSG Pilot;
- Construction of the Dewhurst Northern Water and Gas Flow Lines and operation the Dewhurst Northern Water Flow Line;
- Construction of the Dewhurst Southern Water and Gas Flow Lines and operation of the Dewhurst Southern Water Flow Line;
- Construction and operation of the Leewood Produced Water Facility and ancillary infrastructure; and
- Gas and water management during operation of the program.

These activities are subject to separate environmental assessment and approval processes.

The proposed activity forms part of the larger program, however cumulative impacts to agricultural resources and industries are expected to be minimal as discussed below.

7.1 Agricultural Land Use Disturbance

Approximately 90 existing exploration wells are located within PEL 238 and PAL 2. The majority of these have either been plugged and abandoned and rehabilitated, or suspended for future use.

The area of land that will be quarantined for exploration activities within PEL 238 and PAL 2 is approximately 107 hectares, which includes 28 hectares of existing infrastructure and well sites to be retained and 79 hectares of proposed infrastructure and well sites. This is approximately 0.013% of land within PEL 238 and PAL 2.

The current extent of agricultural land use within PEL 238 and PAL 2 is approximately 791,478 hectares. At this stage defined CSG projects within PEL 238 and PEL 2 are not located on any agricultural land (in terms of major agricultural industries identified in PEL 238 and PAL 2 e.g. cropping, grazing, horticulture and plantations). Although production forestry is mapped within PEL 238 and PAL 2, there is little evidence of exotic plantations; rather these areas include State forest used for timber harvesting and nature reserves (accounting for an additional 190,462 ha). Timber harvesting within the Pilliga Scrub has been reduced largely due to conservation efforts; therefore such enterprises are not considered significant.

Defined projects are anticipated to have a negligible impact on agricultural land as the disturbance footprint is not located on any intensive agricultural enterprises. Further, the majority of land disturbances would be fully rehabilitated following the completion of activities.

Based on the nominated gross margins (GM) and potential agricultural land use (LSC classes identified by the DP&I, 2012a for the New England - North West region), the PEL 238 and PAL 2 existing (2002-2012) and proposed (post 2012) exploration program has the capacity to generate an estimated gross margin of approximately $15,413 and $22,419 per annum, respectively. However, as there are no current agricultural enterprises on the well sites within PEL 238 and PAL 2, this amount is not applicable for both retained and proposed sites (**Table 7.1**). The amounts are based on the DTIRIS agricultural productivity data for agricultural enterprises suitable for each of the LSC classes that have been identified for the disturbance areas. For this assessment, the most productive agricultural enterprises have been selected to provide a "best case" scenario for impacted LSC classes, rather than the more likely land use outcome (forestry).

Table 7.1: Agricultural productivity of the Santos PEL 238 and PAL 2 exploration project.

LSC Class	$/ha	Area Quarantined (ha)	GM based on the potential agricultural land use ($)	GM based on site with a current agricultural enterprise ($)
Existing infrastructure and well sites to be retained within each LSC Class				
2	712	-	-	-
3		9.0	6,480	-
4	450	3.29	1,481	-
5		16.56	7,452	-
Total		**27.85**	**15,413**	**-**
Proposed disturbance within each LSC Class				
2	712	-	-	-
3		-	-	-
4	450	37.02	16,659	-
5		12.23	5,504	-
Total		**49.25**	**22,163**	**-**

*LSC Classes 2 and 3 agricultural enterprises include: winter crop of short fallow no till wheat and summer crop of no till sorghum. While it is conceivable to produce two crops annually, a general agricultural enterprise in the north-west region of NSW is more likely to have a single successful crop (R. Freebairn personal comm 07/03/2013).

*LSC Classes 4 and 5 agricultural enterprises include: sheep Merino ewes (18 micron) referred to as rams by DTIRIS.

*The area quarantined in each LSC Class is based on knowledge and understanding at the time of writing (June 2013).

7.1.1 Apiary Industries

The most utilised beekeeping area is the temperate land stretching from southern Queensland to central Victoria. This area contains about 80% of the nation's hives and its beekeepers. Beekeepers in NSW depend on a combination of both public and private land. The Pilliga State forest provides areas for beekeepers to carry out apiary activities. No artificial nesting hives were identified at defined project sites in the Pilliga Scrub; however these sites contain Pilliga Box, Yellow Box and Narrow Leaved Ironbark species which may yield honey from time to time. Yellow Box and Pilliga Box do not provide adequate pollen on their own and require supporting pollens at honey sites or specific pollen management to correct protein inadequacies.

Narrow leaved Ironbark are considered dominant within the defined project sites in the Pilliga Scrub, while Yellow Box and Pilliga Box have smaller distributions (**Table 7.2**). Narrow-leaved Ironbark communities account for 198,219 hectares of the Pilliga Scrub. The program disturbance footprint for defined projects accounts for approximately 0.02% of Narrow-leaved Ironbark in the Pilliga Scrub. No such calculations could

be made for the Yellow Box and Pilliga Box species however disturbance footprints of these species are minimal and not considered significant within the Pilliga Scrub.

Due to the minimal disturbance of potential honey trees within the Pilliga Scrub a low to negligible impact is anticipated on the apiary industry.

Table 7.2: Impacted honey-yielding vegetation communities across the program

Species	Impact across all proposed activities
Narrow-leaved Ironbark	Dominant species across 25 - 30 ha
Pilliga Box	Potential to impact upon 4 - 6 trees
Yellow Box	Occurs at very low densities across less than 1 ha

7.2 Water Resources

7.2.1 Surface Water

No surface water will be lifted from local creeks and wetland for any of the program activities. Potential impacts posed by soil erosion and contamination will be managed and mitigated with the measures outlined in **Sections 10.4** and **16.4** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).

7.2.2 Groundwater

CH2MHill has undertaken a cumulative groundwater impact assessment assuming concurrent operation of all existing and proposed pilot well sets (CH2MHill, 2013).

The assessment has found that 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 cumulative CSG water extraction activities, therefore there will be no impact to registered groundwater users.

Further, the water quality of the groundwater extracted during the program in the Pilliga Scrub (Maules Creek Formations) and the Tintsfield Pilot (Hoskissons seam) is saline, as described below:

- Malues Creek Fomation target seams:
  - Bohena seam - mean TDS= 18,752 mg/L, maximum TDS= 21,980 mg/L and minimum TDS= 13,159 mg/L;
  - Namoi seam - mean TDS= 14,110 mg/L, maximum TDS= 15,740 mg/L and minimum TDS = 13,159 mg/L; and
  - Rutley seam - no data.
- Hoskissons seam - mean TDS = 12,880, maximum TDS= 14,000 and minimum TDS= 12,000.

These levels are outside the general TDS ranges for irrigation (650 – 5,200 mg/L) and livestock (2,000 – 10,000 mg/L) use.

7.3 Additional Risks to Agriculture

Additional risks to agricultural enterprises posed by the program include:

- Dust and noise;
- Weed management; and
- Pest animals / biosecurity.

The above additional cumulative risks will be managed similarly to mitigation measures outlined in **Sections 12.5** (Air) **14.5** (Noise) and **11.5** (Weed and Biosecurity Management) of the Dewhurst Gas Exploration Pilot Expansion (RPS, 2013a).

8.0 Trigger Response Plan and Water Monitoring Program

8.1 Trigger Response Plan

The primary trigger response plans are highlighted in **Table 8.1**. Due to the low impact nature and relative short duration of the proposed activity, no significant impact to agricultural resources or supporting infrastructure are anticipated.

Table 8.1: 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

8.2 Water Monitoring Program

The proposed groundwater monitoring program is discussed in **Section 9.5.3**, while the surface water monitoring program is discussed in **Section 10.1.5** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).

9.0 Consultation

Santos undertakes consultation activities with relevant stakeholders and the community in the areas within which they work. This includes consultation with landowners and adjacent landowners, Council, Local Aboriginal Land Councils and relevant State agencies. Santos has also established a Community Consultative Committee in Narrabri, which meets on a regular basis to discuss Santos' activities across the broader area.

A detailed overview of existing and proposed consultation for the proposed activity is provided in **Section 5.0** of the Dewhurst Gas Exploration Pilot Expansion EIS (RPS, 2013a).

10.0 Conclusion

Santos is proposing to construct two new wells (Dewhurst 30 and 31), redrill three existing single horizontal wells to convert them into triple-stacked horizontal wells (Dewhurst 16H, 17H and 18H), construct a gas flare and water balance tank (at Dewhurst 14) and construct associated gas and water gathering system, access roads and service corridors. The proposed activity is within the Pilliga Scrub, approximately 25 - 42 kilometres south of Narrabri.

- The proposed construction footprint for Dewhurst 13-18H is 5.37 hectares which includes the existing lease areas at Dewhurst 14, 16H, 17H and 18H and the proposed gathering system. Approximately 0.24 hectares of vegetation will be cleared from within the construction footprint at Dewhurst 13-18H.
- The proposed construction footprint for Dewhurst 26-31 is 3.52 hectares including the lease area at Dewhurst 28 (which will already have been established but which a flare is to be constructed on as part of the proposed activity), the proposed lease areas at Dewhurst 30 and 31 and the proposed service corridor for Dewhurst 30 and 31. Approximately 2.2 hectares of vegetation will be cleared from within the construction footprint at Dewhurst 26-31 as part of the proposed activity.
- The proposed activity is considered low risk and will not have an adverse impact on the current or future agricultural production capacity or resources in the Narrabri LGA due to the following considerations:
  - There are no intensive agricultural enterprises at the site or adjoining lands. Therefore, the proposed development does not have an unreasonable impact on agricultural production at the subject site.
  - The site area is characterised by Sodosols, Rudosol / Tenosols, which are not suited for intensive agricultural production;
  - The site is not located on or within two kilometres of BSAL and/or a CIC,
  - The proposed activity will not impact groundwater or surface waters that are linked or appropriate for agricultural use;
  - The proposed activity is considered to be short to medium term, and
  - 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 likelihood and impact, provided that mitigation measures are followed and applied according to best known methods.

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Appendix 3

Groundwater Impact Technical Report

Prepared for

Santos NSW (Eastern) Pty Ltd

Dewhurst Gas Exploration Pilot Expansion EIS - Groundwater Impact Technical Report

Energy NSW Coal Seam Gas Exploration and Appraisal Program





FINAL

August 2013

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REPORT DETAILS

Title:	**Dewhurst Gas Exploration Pilot Expansion EIS - Groundwater Impact Technical Report**
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Client Reference:	**Dewhurst Gas Exploration Pilot Expansion EIS, Dewhurst 13-18H and Dewhurst 26-31 Pilots Gunnedah Basin NSW**

Synopsis**:** This report presents an assessment of impacts to groundwater as a result of the operation of the Dewhurst Gas Exploration Pilot Expansion (which incorporates the Dewhurst 13-18H and Dewhurst 26-31 pilots) set within a cumulative impact assessment of six pilots within the Narrabri Program area, which are part of the Energy NSW Coal Seam Gas Exploration and Appraisal Program, Gunnedah Basin, NSW.

Executive Summary

Santos is undertaking an assessment of the environmental impacts of the *Dewhurst Gas Exploration Pilot Expansion.* The proposed activity includes the drilling of two horizontal wells from existing casing within Dewhurst 16H, 17H and 18H to convert each single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley Coal Seams; and the drilling of one new vertical well (Dewhurst 30) and one new triple-stacked horizontal well (Dewhurst 31) to target the same coal seams within the Maules Creek Formation. This groundwater technical report presents the findings of a cumulative groundwater impact assessment, based on numerical groundwater modelling undertaken for the concurrent operation of six pilots within the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program (the program).

Amendments to the original regional model included grid refinement in the area surrounding the pilots, assigning DRN/WEL cells and extraction rates to all six pilot locations and separation of extraction phases into three distinct transient models (historical, proposed and recovery).

Five pilots target the Maules Creek Formation coals (Layer 12), while the sixth pilot targets the Hoskissons Seam within the Black Jack Group (Layer 8). Water extraction rates were calculated from data provided by Santos and applied in proportion to the number of model DRN/WEL cells required to represent each simulated extraction well. Three transient model simulations were run to cover historical extraction, predictive (proposed) extraction (all proposed extractions run for a 3 year period) and long term recovery over 1,500 years.

The main outcomes of the combined model simulation were as follows:

1. The total volume of water to be abstracted from the Maules Creek Formation coals (five active pilots) is 1.41 GL. All six pilots extract groundwater for a total of three years with different proposed start dates. The total quantity of water to be abstracted from the Hoskissons Seam (one active pilot, Tintsfield 2-7 Pilot) is approximately 0.03 GL.
2. 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 six pilot CSG water extraction activities;
3. A decline in groundwater head of over 2 m is indicated for the lower part of the porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP). This impact on hydraulic (pressure) head combined with the fluxes developed within the lower part of the groundwater source required to meet the pilot CSG water demand are interpreted to comprise an aquifer interference within the combined groundwater source and thus will require licensing;
4. No impact to any identified high priority GDEs identified in the vicinity of the program area is predicted to occur as a consequence of the six pilot CSG extraction activities;
5. No impact on any registered water extraction bores identified in the vicinity of the program area is predicted to occur as a consequence of the six pilot CSG extraction activities; and
6. It is therefore considered unnecessary to instigate mitigation measures beyond standard operational environmental management controls in relation to the program.

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1 Introduction

1.1 Background

Santos NSW (Eastern) Pty Ltd (Santos) is proposing to undertake the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program in the Narrabri area within Petroleum Exploration Licence (PEL) 238 and Petroleum Assessment Lease (PAL) 2 (hereafter referred to as the program). The program will primarily target CSG reserves associated with the Early Permian coal seams of the Maules Creek Formation (MCF), located at depth in the northern portion of the Gunnedah Basin.

The production of CSG requires depressurisation of target coal seams to stimulate release of gas from the coal. Water extraction is required to achieve this depressurisation and this water extraction has the potential to impact on groundwater and surface water resources and groundwater dependant ecosystems (GDEs).

1.2 Study Objective

Santos has commissioned CH2M HILL to undertake an assessment of the potential cumulative impacts to groundwater resources from CSG exploration to support the Environmental Impact Statement (EIS) for the *Dewhurst Gas Exploration Pilot Expansion* (incorporating Dewhurst 13 to 18H and Dewhurst 26 to 31 pilots). This assessment considers the operation of the **Dewhurst 13 to 18H Pilot**, **Dewhurst 26 to 31 Pilot,** Dewhurst 22 to 25 Pilot, Bibblewindi Multi-lateral Pilot, Bibblewindi West Pilot, and the Tintsfield 2 to 7 Pilot, and utilises the existing numerical groundwater flow model for the Narrabri Program area which was modified and refined for this assessment.

1.3 Scope of Work

The scope of this assessment is summarised as follows:

- Modification of the existing numerical groundwater flow model for the Narrabri program area to simulate the predicted water extraction rates from the six pilots;
- Description of the existing baseline monitoring for all surface and groundwater sources and GDEs within and adjacent to the development, and a summary of proposed future monitoring;
- Identification of the potential requirements to comply with the NSW Aquifer Interference Policy; and
- Assessment of the potential impacts on the quality and quantity of existing surface water and groundwater resources; including:
    - The results of detailed modelling of potential groundwater impacts including identification of any highly productive groundwater (as defined in the Aquifer Interference Policy) or groundwater dependent ecosystem, with particular reference to the Gunnedah-Oxley Basin and Lachlan Fold Belt groundwater sources of the Murray-Darling Basin buried groundwater sources and the NSW Great Artesian Basin southern recharge groundwater source;
    - A description of impacts on riparian, ecological, geomorphological and hydrological values on watercourses or swamps, including environmental flows, with particular

reference to Cowallah Creek, Mount Pleasant Creek, Tuppiari Creek and Jacks Creek and associated tributaries;

- The representation of the cumulative impacts associated with existing developments as well as currently planned developments or proposed future developments (comprising six pilots consisting of **Dewhurst 13-18H**, **Dewhurst 26-31**, Dewhurst 22-25, Bibblewindi Multi-lateral, Bibblewindi West, and Tintsfield 2-7);
- Affected licensed water users and basic landholder rights (including downstream water users); and
- Identification of mitigation measures to reduce impacts to groundwater sources.

The findings of this report should be read in conjunction with the Narrabri Groundwater Flow Model Report (CH2M HILL, 2013) which presents the basis for the creation of the groundwater flow model. The general limitations of this study are presented below.

1.4 Assumptions and Limitations

CH2M HILL was contracted by Santos to undertake an assessment of the potential impacts associated with the pilot activities on groundwater resources. This report is based on the information that has been made available to CH2M HILL from the sources listed in the report. The conclusions drawn in the report are based on the data available at the time of writing and any subsequent additional information may allow refinement of the conclusions. It should be noted that:

- This report has been prepared under the express instructions by, and solely for the use of Santos.
- The findings of this report represent the professional opinion of experienced Hydrogeologists, Numerical Groundwater Modellers and Environmental Scientists.
- All work carried out in preparing this report has utilised, and is based upon, CH2M HILL's professional knowledge and understanding of current relevant Australian and New South Wales Government regulation and legislation.
- Changes in legislation and guidance may occur at any time in the future and cause any conclusions to become inappropriate or inaccurate. CH2M HILL does not accept responsibility for advising Santos or other interested parties of the facts or implications of any such changes.
- This report has been prepared using factual information contained in data, maps and documents prepared by others. No responsibility can be accepted by CH2M HILL for the accuracy of such information.

2 Proposed Action

2.1 Pilots

This report supports the Dewhurst Gas Exploration Pilot Expansion EIS. The proposed activity includes the drilling of two horizontal wells from existing casing within Dewhurst 16H, 17H and 18H to convert each single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley Coal Seams; and the drilling of one new vertical well (Dewhurst 30) and one new triple-stacked horizontal well (Dewhurst 31) to target the same coal seams within the Maules Creek Formation.

This assessment considers the cumulative impact caused by the program, which consists of the exploration activities associated with 42 wells at six pilots. These comprise:

- **Dewhurst 13-18H** (6 wells) – abbreviated for modelling purposes as DWH 13-18H;
- **Dewhurst 26-31** (6 wells) – abbreviated as DWH 26-31;
- Dewhurst 22-25 (5 wells) – abbreviated as DWH 22-25;
- Bibblewindi Multi-lateral Pilot, including Bibblewindi 12-21/27-29/31-32 (14 wells) – abbreviated as BBW 12-21;
- Bibblewindi West, includes Bibblewindi 22-26 (5 wells) – abbreviated as BBW 22-26; and
- Tintsfield 2-7 (6 wells) – abbreviated as TNT 2-7.

Table 2-1 details the pilot wells to be included within the cumulative assessment. The arrangement of the wells and location in relation to one another is presented in Figure 2-1. Figure 2-2 presents the pilot wells in relation to the proposed Shallow Aquifer Monitoring Bores (SAMB), proposed Deep Aquifer Monitoring Bore (DAMB), existing registered groundwater bores and current Water Sharing Plans (WSP).

Table 2-1: Pilot Wells to be included in the Proposed Action

Pilot ID	Pilot well	Easting	Northing	V / H	Pairing	Stacking	Target Seam
Dewhurst 13-18H Pilot	DWH13	764567	6616967	V			Maules Creek Formation (MCF)
	DWH14	765592	6616503	V			
	DWH15	764654	6617147	V			
	DWH16	765680	6616689	H	13 & 16	triple	
	DWH17	764741	6617327	H	14 & 17	triple	
	DWH18	765766	6616870	H	15 & 18	triple	
Dewhurst 26-31 Pilot	DWH26	754309	6599871	H	26 & 27	triple	
	DWH27	754943	6600649	V			
	DWH28	754525	6599701	H	28 & 29	triple	
	DWH29	755159	6600479	V			
	DWH30	755385	6600332	H	30 & 31	triple	
	DWH31	754760	6599547	V			
Dewhurst 22-25 Pilot	DWH6	764249	6610018	V			
	DWH22	763704	6610149	V			
	DWH23	764471	6609505	H	22 & 23	triple	
	DWH24	764025	6610531	V			

Pilot ID	Pilot well	Easting	Northing	V / H	Pairing	Stacking	Target Seam
	DWH25	764792	6609888	H	24 & 25	single	
Bibblewindi Multi-lateral Pilot	BBW12	753818	6604437	V			
	BBW13	754200	6603693	V			
	BBW14	754456	6603955	V			
	BBW15	754027	6604759	V			
	BBW16	754728	6604238	V			
	BBW17	755033	6604538	V			
	BBW18H	753388	6604718	H	18 & 14	single	
	BBW19H	753647	6604994	H	19 & 16	single	
	BBW21H	754168	6605608	H	21 & 27	single	
	BBW27	755478	6604689	V			
	BBW28H	752989	6604214	H	28 & 29	single	
	BBW29	754273	6603234	V			
	BBW31	753647	6604994	V			
	BBW32	754456	6603954	H	31 & 32	single	
Bibblewindi West Pilot	BBW22	749807	6609043	V			
	BBW23	750106	6608555	V	26 & 23		
	BBW24	750230	6608719	V	26 & 24		
	BBW25	750358	6608877	V	26 & 25		
	BBW26	749412	6609350	H x 3			
Tintsfield 2-7	TNT2	752539.4	6635898	H	2 & 5	single	Hoskissons Seam
	TNT3	752489.7	6635904	H	3 & 6	single	
	TNT4	752589	6635891	H	4 & 7	single	
	TNT5	751650	6635915	V			
	TNT6	751721.2	6636128	V			
	TNT7	751767	6636399	V			

2.2 Operation

2.2.1 General Operation

Future operation of each appraisal well will occur for a three year period commencing in 2014. Operation activities will include the extraction of water from the pilots of the estimated volumes in Table 3-3. Figure 2-3 shows periodised, monthly average extraction data including both historical and proposed rates, as used in the model.

Table 2-2: Proposed Extraction Rates for Pilots

Pilot ID	Total Extraction (m^3)	Max extraction (m^3/day)	Average Extraction (m^3/day)
Dewhurst 13-18H Pilot	331,121	397	302
Dewhurst 26-31 Pilot	413,801	448	378
Dewhurst 22-25 Pilot	285,140	273	260
Bibblewindi Multi-lateral Pilot	285,110	581	260
Bibblewindi West Pilot	92,940	209	85
Tintsfield 2-7 Pilot	25, 162	43	23

During operation of the six pilots, groundwater levels will be monitored by SAMBs and a DAMB, as presented on Figure 2-2.

2.2.2 Hydraulic Stimulation

There are no plans to use the process of hydraulic stimulation (also known as hydraulic fracturing or fracking) within the program.

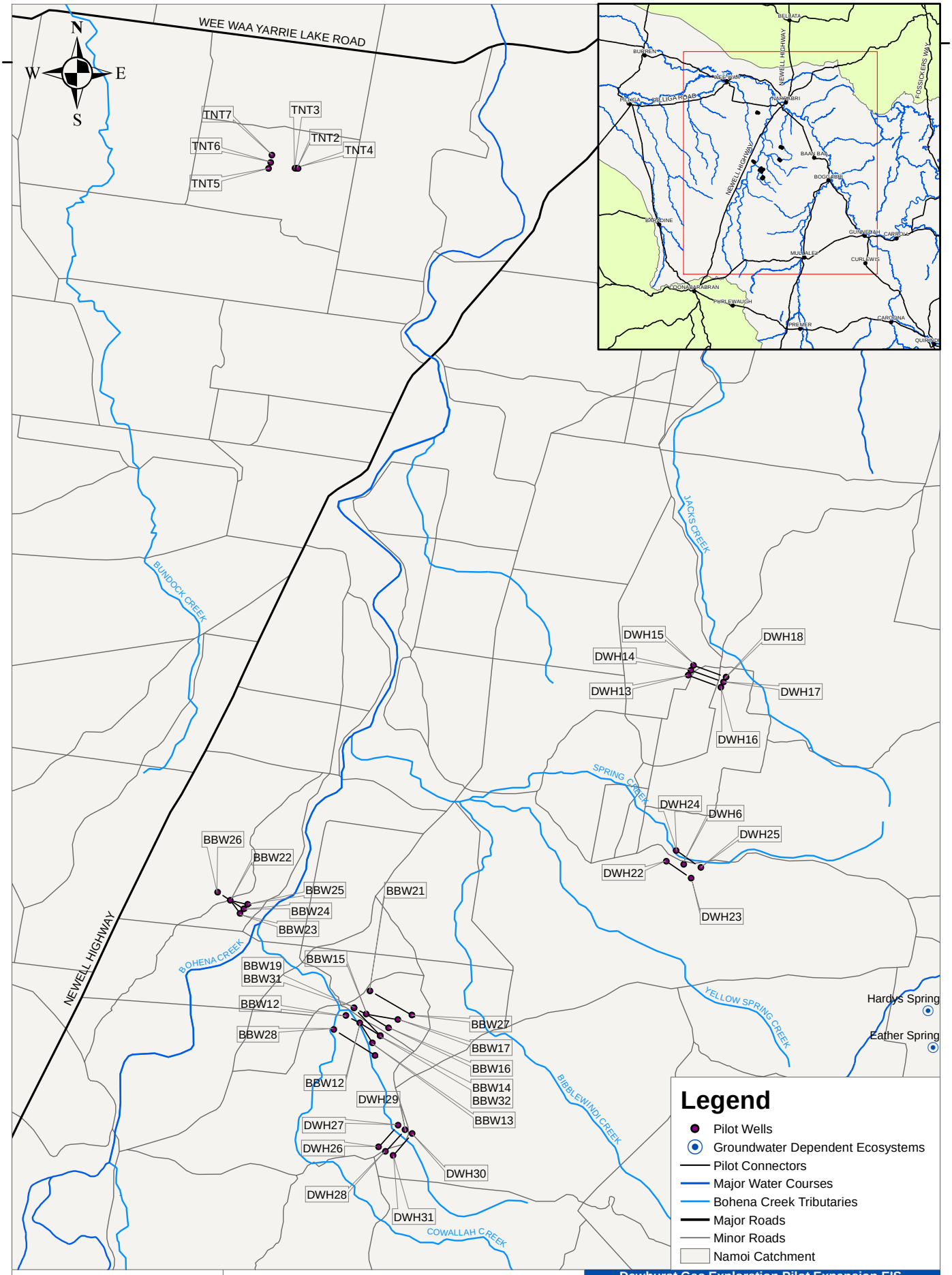
2.3 Historical Extraction

Historical water extraction has occurred at four of the pilots (Bibblewindi Multi-lateral, Bibblewindi West, Tintsfield 2-7 and Dewhurst 13-18H) between March 2009 and February 2012, as detailed in Table 2-3 and Figure 2-3. No historical abstraction has taken place at the Dewhurst 26-31 Pilot. Since February 2012, no extraction has been undertaken within the program area.

The historical extraction at Bibblewindi Multi-lateral, Bibblewindi West and Tintsfield 2-7 was simulated in the predictive model. The historical extraction at Dewhurst 13-18H (254 m^3) is considered insignificant, accounting for less than 0.1 % of total historic extraction, and therefore was not simulated in the predictive model.

Table 2-3 Historical extraction rates

Pilot ID	Historical extraction (m^3) (Between March 2009 and February 2012)
Bibblewindi Multi-lateral Pilot	177,172
Bibblewindi West Pilot	94,020
Tintsfield 2-7 Pilot	19,226
Dewhurst 13-18H*	254
** Operational between May and July 2011. Historical abstraction not simulated in model.*	



Legend

- Pilot Wells
- Groundwater Dependent Ecosystems
- Pilot Connectors
- Major Water Courses
- Bohena Creek Tributaries
- Major Roads
- Minor Roads
- Namoi Catchment

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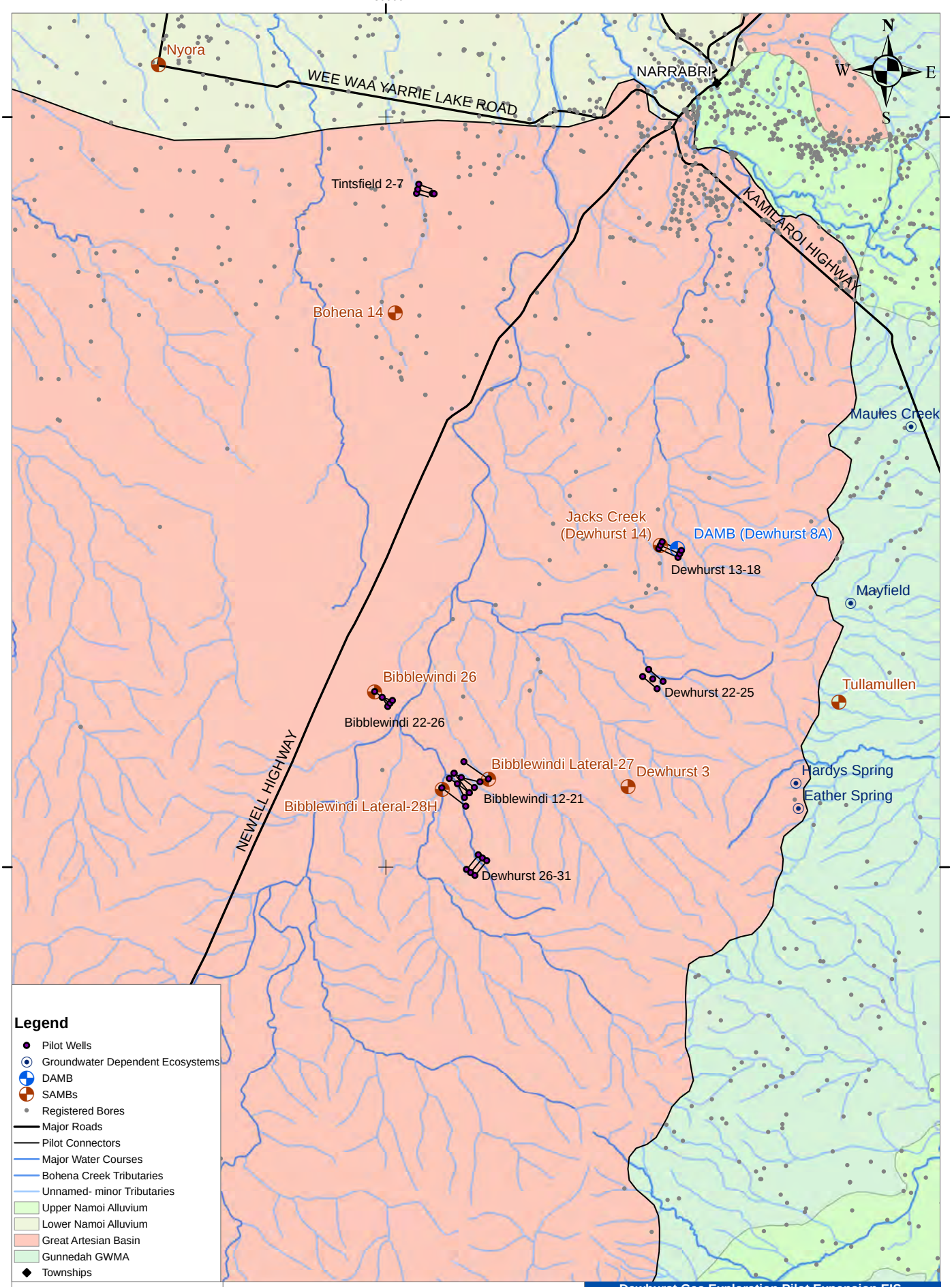
0 2.5 5 10 Km

Scale: 1:190,000 @A4
Projection: GDA94

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Figure 2-1
Location and Arrangement of Pilot Wells

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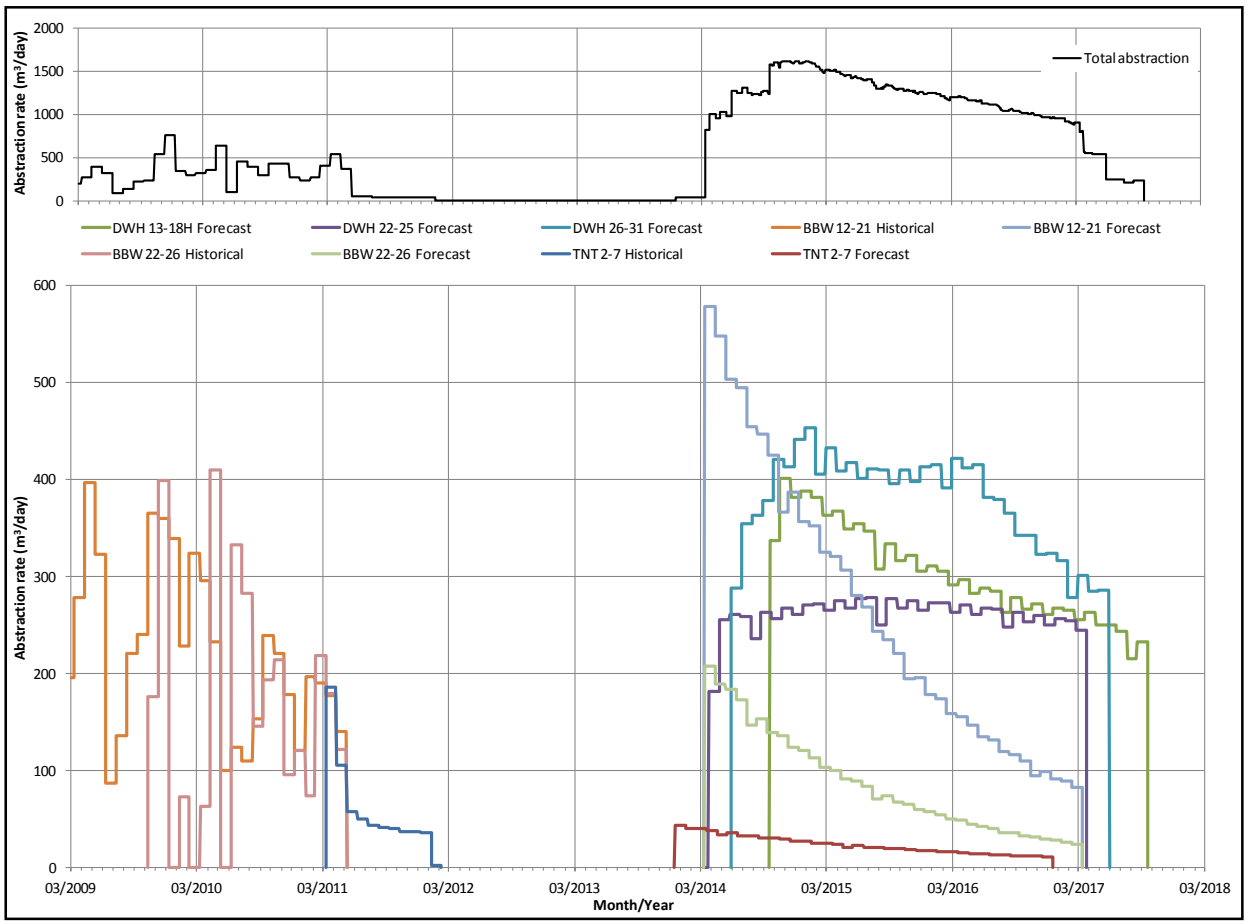
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Figure 2-2
Location of SAMBs and DAMB and WSP

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Figure 2-3 Simulated water extraction rates



3 Numerical Model

3.1 Narrabri Program Area Groundwater Flow Model

The numerical groundwater flow model of the Narrabri program area has been utilised to simulate the potential cumulative impact on surface water and groundwater resources, and GDEs from the operation of the six pilots. Initial model development included:

- Data collation, literature review and gap analysis, including review of:
  - geological data;
  - existing exploration program borehole data;
  - existing well test work and formation evaluation data;
  - existing regional coal mining exploration borehole data;
  - relevant water management records;
  - groundwater quality data; and
  - regional groundwater literature and relevant coal mining-related groundwater studies;
- Characterisation of the groundwater environment, including identification of environmental values associated with groundwater resources;
- Development of the hydrogeological conceptual model (HCM); and
- Development of a groundwater flow model to facilitate the assessment of the potential impacts of CSG water extraction on water resources.

3.1.1 Model Development

The numerical groundwater model was constructed using MODFLOW-2005 and the graphical user interface (GUI) Groundwater Vistas interface V6.07 Build 18. MODFLOW is a three-dimensional finite-difference multi-layered numerical model developed by USGS. Groundwater Vistas was used to undertake pre- and post- processing of the input and output from MODFLOW. Further model refinement and development was undertaken by Halcrow using Groundwater Vistas V6.22 Build 2.

A 3D geological model of the study area was synthesised from point data provided by Santos, including Department of Minerals and Energy (DME) and the Department of Mineral Resources (DMR) borehole logs. The base of the model was set within the Boggabri Volcanics/Werrie Basalts.

The model extends:

- Eastward beyond the Boggabri Ridge to the eastern side of the Namoi River;
- Southward beyond the Walla Walla Ridge into the Bando Trough;
- Westward to the Rocky Glen Ridge; and
- Northward beyond the Narrabri High and the Namoi River to the inferred location of the groundwater divide within the GAB (in accordance with groundwater level information presented in GABFLOW2000 (Welsh, 2000).

The model grid is aligned with grid north and the domain extends 123 km along a north-south axis and 107 km along an east-west axis. The south western corner of the grid is located near Yearinan at 711000 mE, 6547000 mN and the north eastern corner of the grid is located near Rocky Creek at 818000 mE, 6670000 mN, in the GDA94 (MGA94 Zone 55) coordinate system.

The model consists of 178 columns and 176 rows. The nominal model grid cell size is 1 km by 1 km (Table 3-2 provides actual minimum and maximum cell horizontal dimensions) with refinement of the cells in the vicinity of Rocky Glen Ridge, Narrabri High and Boggabri Ridge (refined to 0.5 km wide and/or 0.5 km long) to accommodate steep changes in basement topography. The model consists of 14 layers, defined in Table 3-1.

Table 3-1 Stratigraphy and model layering

Geological Period	Hydrostratigraphic unit	Hydrogeological Classification	Model layer
Quaternary	Alluvium	STU	1
Jurassic	Pilliga Sandstone	STU	2 and 3
	Purlawaugh Formation	NTU	4
	Garrawilla Volcanics	LSTU	
Triassic	Deriah Formation	PNTU	5 and 6
	Napperby Formation	PNTU-NTU	
	Digby Formation	NTU	
Permian	Black Jack Group	STU to PNTU	7, 8 and 9
	Millie Group (Porcupine Formation & Watermark Formation)	NTU	10
	Upper Maules Creek Formation	NTU	11
	Target coal seams (Rutley Namoi & Bohena)	STU	12
	Lower Maules Creek Formation	NTU	13
Pre-Permian	Basement	NTU	14

Notes:
STU – Significant transmissive unit
LSTU – Less significant transmissive unit
PNTU – Probable negligibly transmissive unit
NTU – Negligibly transmissive unit

3.2 Approach to Cumulative Impact Modelling

The numerical groundwater flow model of the Narrabri program area was adapted and refined to model the potential cumulative impact of the operation of the six pilots.

The modelling was undertaken utilising MODFLOW-SURFACT™ v4 to assess the cumulative impact assessment of pilot activities. MODFLOW SURFACT™ was selected over the standard MODFLOW2005 package on account of MODFLOW SURFACT's better ability to handle the re-wetting of dry cells within the model, enabling the model to recover following depressurisation. Groundwater Vistas v6.33 was utilised for pre- and post-processing of numerical outputs.

The basic model architecture has not been modified, preserving the existing vertical layer structure and parameterisation. Additional horizontal discretisation has been focused at the location of each pilot to provide clearer spatial resolution and to model appropriate curvature of the piezometric surface.

3.2.1 Grid refinement

The minimum cell spacing of the base Narrabri groundwater flow model was 500 by 500 m. To facilitate a more accurate representation of the curvature of the water table in the vicinity of the localised hydraulic stress imposed by the six pilots, further grid refinement was made to a minimum cell size of 100 by 100 m, as presented in Table 3-2 below.

Table 3-2 Details of grid refinement

Model	No. Rows	No. Columns	No. Layers	No. Active cells	Row spacing (m)		Column Spacing (m)	
					Min	Max	Min	Max
Narrabri program area model	176	178	14	395,612	500	1125	500	1476
Refined six pilot model	309	288	14	1,184,022	100	1125	100	1476

3.2.2 Pilot configurations

Individual pilots, comprising combinations of vertical and horizontal well arrays, have been modelled in greater detail with the in-seam horizontal component of individual wells in each array represented as multiple WEL or DRN boundaries at which the flux or head is manipulated respectively. Hence DWH 26-31, consisting of three vertical and three triple-stacked horizontal wells is simulated in this model as three lines of nine WEL/DRN boundary cells, 27 model cells in total. In the WEL simulation used to determine system fluxes, the proposed water extraction rate is divided equally between the 27 cells. In the DRN simulation used to determine head impacts, the depressurisation is applied equally at all 27 cells (See Table 3-3 for details of all simulated pilots).

Table 3-3 Pilot configuration

Pilot	No. Pilot Lines	No. Pilot wells per line	Total No. DRN/Well Cells
DWH 13-18H	3	10	30
DWH 26-31	3	9	27
DWH 22-25	2	8	16
Bibblewindi Multi-lateral	Mixed configuration	-	75
Bibblewindi West (BBW 22-26)	3	-	20
TNT 2-7	3	8	24

3.2.3 Extraction rates

Historical and predicted water rates were simulated within the model. Historical water extraction data were incorporated into the simulations due to the consequence of the magnitude of these historical extractions and the likely impacts on heads in the respective coal seam. Table 2-2 and Table 2-3 detail the proposed and historical water rates respectively. Figure 2-3 illustrates the simulated water extraction rates, periodised according to modelled timesteps.

Water extraction from WEL boundaries relating to each of the six pilots is assigned to the model layer associated with the respective target seam. The **Dewhurst 13-18H**, **Dewhurst 26-31,** Dewhurst 22-25, Bibblewindi Multi-lateral and Bibblewindi West Pilots target seams of the Maules Creek Formation coal (Layer 12). The Tintsfield 2-7 pilot targets the Hoskissons seam of the Black Jack Group (Layer 8).

3.2.4 Model Simulation Duration

The model simulated three separate transient models, as shown in Table 3-4, representing historical extraction, proposed extraction and a recovery period. Three transient models were required in this instance to maintain model stability and optimise computational resources.

Each pilot extracts water for a duration of 3 years with different start dates. To accommodate the varying start dates the proposed extraction model was run for a total duration of 4 years. Extraction at each of the six pilots was represented as active well nodes within the model simulation. Well nodes were activated at the relevant start date for each pilot and deactivated after a three year period. The hydraulic heads within the model domain were then allowed to recover for a period of 1,500 years.

The duration of recovery was designed to ensure that impacts arising due to releases from aquifer storage at later times, delayed yield, induced by greater-than-negligible drawdown due to water extraction, could be captured.

Table 3-4 Details of model simulation durations

Model Run	Duration	Start date	Stress Period (SP) Set-Up	Total No. Stress Periods (SP)	Time Steps (TS) per SP
Historical	55 months	March 2009	55 monthly SPs	55	5 TS/SP
Proposed extraction "predictive model"	4 years*	October 2013	48 monthly SPs	48	5 TS/SP
Recovery	1500 years	October 2017	1 x 10 year SP 1x 40 year SP 1x450 year SP 1x 1000 year SP	4	Adaptive time stepping used
*Each pilot is active for duration of 3 years. Proposed extraction model duration of 4 years accommodates the different start dates of proposed extraction.					

3.2.5 Initial Conditions

Initial values of groundwater head, or 'Initial Heads' (IH), are commonly derived from a precursor "*steady-state model*", calibrated using available data. These IH have been used as seed heads for the "*historical model*" for the simulation of the historical pilot water extraction (the first transient model). The historical model incorporates some water level/pressure recovery which will have occurred between the end of the historical water extraction and the commencement of the six pilots presented in this report. The historical model yields "historical heads" (HH) representing the groundwater condition at the time of the start of the "*predictive model*" (the second transient model).

3.2.6 Observation Wells

The 'specific' determination deploys theoretical observation wells sited at each pilot to capture the maximum drawdown created by the water extraction from that respective pilot array. The 'generalised' determination relies on monitoring positions located in accordance with the proposed SAMB and (DAMB arrays (see Figure 2-2).

3.3 Model Assumptions

There is inherent uncertainty associated with any numerical groundwater model. The uncertainty arises from the assumptions employed in the model, but also the adequacy of the input data to sufficiently calibrate a steady state model, and run transient models. Some of the assumptions include:

- The formations are assumed to be homogeneous and isotropic (with the exception of the coal seams) from the scale of each grid cell to the regional scale. In reality, the hydraulic properties of each formation will vary spatially both laterally and with depth.
- The groundwater level and extraction data from the Pineena database and from the New South Wales Office of Water are assumed to be adequate to represent the long term average. However, the period of measurement is only 16 years, whereas the period of modelling is likely to be at least 1500 years.

- A constant groundwater extraction rate (from private bores) and constant rainfall recharge are used in the transient (prediction) simulations. However, in reality the rates will change with season and from year to year. The inclusion of time-variable values may result in scatter of the predicted heads which is unrelated to the CSG extraction.
- Recharge to the Maules Creek and Black Jack Group is required to be able to model the observed high groundwater pressures. Recharge is likely to be via vertical infiltration through the Boggabri Volcanics at outcrop. Recharge in the model was implemented by adding a basement flux to the bottom layer of the model. Although this has allowed a more reasonable calibration to the deeper Drill Stem Test (DST) pressure measurements, it has also resulted in groundwater mounding where the Permo-Triassic strata of the Gunnedah Basin outcrop.

Some of the potential input data gaps include:

- Extraction returns or licensed rates are not available for all of the Namoi Alluvium/ Pilliga Sandstone extractions. Extractions for which returns/licensed rates are not available were not included into the model. This may have an effect on the extent of the calibration.
- A steady state model is designed implicitly to represent the long term conditions. However, the model was calibrated to spot groundwater level measurements within the Pilliga Sandstone, underlying formations from Santos DST pressure measurements and from work undertaken by Aquaterra at the Narrabri Coal Mine in 2009. This could potentially result in poor calibration with some of the deeper formations.
- In general, the spatial coverage of groundwater measurement is sparse and as there are no targets for calibration over large areas of the model it is not possible to calibrate these areas.

The calibration dataset is considered not of sufficient duration to undertake transient calibration.

4 Impact Assessment

4.1 Potential head impact

Simulation of multiple pilots, including the Dewhurst 13-18H and Dewhurst 26-31 Pilots, and their associated historical and proposed extractions results in groundwater head impacts which vary with time and location. Consequently two determinations of head impact have been made including specific (impacts manifested at individual pilots) and generalised (impacts manifested in the proposed SAMB and DAMB monitoring locations) as discussed in Section 3.2.6.

Thresholds of significance of water level or pressure head decline of 0.5 m and 2.0 m have been considered by which to determine the significance of impact on highly productive and less productive groundwater sources respectively.

4.1.1 Specific determination of impact

Figure 4-1 shows drawdown versus time for the period covering historical and proposed extraction and an initial 40 years of water level recovery for all theoretical observation bores located centrally within each pilot, including the Dewhurst 13-18H and Dewhurst 26-31 Pilots, in the Maules Creek Formation (MCF) coals (Layer 12). The graph shows the same trend observed in all bores after two stages of extraction and demonstrates the initial rapid recovery that occurs when extraction ceases.

Drawdown within all pilots achieves a maximum by the end of the proposed extraction period at each site (pilots have different start dates) and generally achieves over 80% recovery within 10 years following the cessation of water extraction. Maximum drawdown in the MCF coals is 995 m, observed in Dewhurst 13-18H at the end of the proposed extraction period at this pilot and 8.5 years after the onset of the historical model run in March 2009. Dewhurst 13-18H shows a 93% recovery of groundwater head within 10 years following the cessation of water extraction at that site. Similarly, the maximum drawdown in the MCF coals at Dewhurst 26-31 is 955 m, observed 8.3 years after the onset of the historical model run in March 2009. Groundwater head recovery of 81 % is observed at Dewhurst 26-31 within 10 years following the cessation of water extraction.

Figure 4-2 shows drawdown versus time data for all theoretical observational bores located centrally within each pilot in the MCF coals (Layer 12) for the recovery period between 50 years and 1500 years following the onset of historical extraction in March 2009. The graph in figure 4-2 shows a slower recovery rate than that observed in the initial 10 year period. Drawdown in layer 12 at all pilots recovers to less than 2 m within 600 years of the cessation of proposed pilot extraction.

Figure 4-3 shows the spatial extent of drawdown within the MCF coals (Layer 12) at 8 years from March 2009 when the majority of pilots exhibit maximum drawdown. Values of drawdown less than 0.5 m have not been illustrated.

Maximum drawdown in the layers overlying the MCF coals develops at later periods and recovers more slowly due to low vertical hydraulic conductivity of the overlying layers. The maximum drawdowns in the Porcupine and Watermark Formations (Layer 10) observed at Dewhurst 13-18H and Dewhurst 26-31 are 3.9 m and 9.5 m respectively, and occur around 34 years from March 2009. The overall maximum drawdown in the Porcupine and Watermark Formations (Layer 10) is 15 m, observed at the Bibblewindi Multi-lateral around 34 years

from March 2009. The other pilots within the cumulative assessment exhibit a lesser maximum drawdown at an earlier time.

Figure 4-4 shows the spatial extent of drawdown in the Porcupine and Watermark Formations at 28.5 years since March 2009 when the majority of pilot wells exhibit a maximum drawdown in model Layer 10. Values of drawdown less than 0.5 m have not been illustrated.

Figure 4-5 shows drawdown versus time for the same time period as Figure 4-1 but for the theoretical observation bore at the Tintsfield site at which extraction from the Hoskissons Seam (Layer 8) is simulated. Similar to the extraction observed in the MCF, the graph shows the rapid response to the commencement and cessation of extraction in the target Hoskissons seam. Maximum drawdown in the Hoskissons seam is 726 m occurring 8 years after the onset of historical extraction in March 2009. After the initial 50 years of recovery, drawdown in the Hoskissons Seam (Layer 8) at the Tintsfield pilot is reduced to less than 2 m.

Figure 4-6 shows the extent of drawdown down to 0.5 m in the Hoskissons seam at 8 years from March 2009. As with extraction from the MCF, drawdown in the strata overlying the Hoskissons seam experiences a lag due to low vertical hydraulic conductivity values of the overlying strata. Maximum drawdown in the Triassic strata (Deriah, Napperby and Digby Formations, Layer 6) occurs at the Tintsfield pilot, where it is predicted to be 6.5 m 12 years following the onset of historical extraction in March 2009. Impacts to the MCF at the Tintsfield Pilot are negligible. Figure 4-7 shows the extent of drawdown in the Triassic strata at 12 years from March 2009. Values of drawdown less than 0.5 m have not been illustrated.

There is no measurable drawdown in the overlying Pilliga Sandstone (Layer 3) or Namoi alluvium (Layer 1) at the location of either the Dewhurst 13-18H or Dewhurst 26-31 pilots.

4.1.2 Generalised determination of impact

Table 4-1 presents the maximum drawdown predicted at proposed SAMB/DAMB monitoring bore locations within key layers and at key time steps. It illustrates that there is negligible predicted impact (defined as less than 0.5 m) in the Namoi alluvium (Layer 1) and the Pilliga Sandstone (Layer 3).

Figure 4-8 and Figure 4-9 show drawdown versus time data for the Namoi alluvium (Layer 1), Pilliga Sandstone (Layer 3), Triassic strata (Layer 6), Hoskissons seam (Layer 8), and the Porcupine and Watermark Formations (Millie Group, Layer 10) in the location of Bibblewindi Lateral 28H SAMB (proximal to several pilots) and Jacks Creek (Dewhurst 14) SAMB (proximal to Dewhurst 13-18H pilot) respectively. SAMB locations are shown on Figure 2-2. Figure 4-8 and Figure 4-9 confirm that the drawdown at the Bibblewindi Lateral 28H SAMB and Jacks Creek (Dewhurst 14) SAMB locations emulates that predicted for the theoretical wells located centrally to the individual pilots and that there is no significant impact above the Triassic strata (no drawdown exceeding 0.5 m).

Figure 4-10 shows drawdown versus time data for the Namoi alluvium (Layer 1), Pilliga Sandstone (Layer 3), Triassic strata (Layer 6), Hoskissons seam (Layer 8), Porcupine and Watermark Formations (Millie Group, Layer 10) and MCF (Layer 12) at the Tullamullen SAMB (located between Hardy's and Mayfield springs, see Figure 2-2). The figure shows minimal impact of extraction outside of the Program area in all layers.

Table 4-1 Maximum drawdown in SAMB and DAMB locations

HSU	HSU No.	Model Layer	Maximum drawdown in layer (m)*					
			Oct 2013 (End of historical extraction)	Oct 2017 (End of predictive model run)	Oct 2027 (10 years of recovery)	Oct 2117 (100 yrs of recovery)	Oct 2517 (500 yrs of recovery)	Jan 3517 (1500 yrs of recovery)
Namoi alluvium	8	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pilliga Sandstone	10	3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Triassic Strata (Deriah, Napperby and Digby Formations)	3	6	<0.5	<0.5	<0.5	<0.5	0.7	<0.5
Hoskissons seam	3	8	<0.5	<0.5	1.1	2.9	1.6	<0.5
Porcupine and Watermark Formations	5	10	2.0	4.8	9.4	9.7	3.7	0.8
Maules Creek Formation seams	11	12	179.4	995.0	116.0	7.3	2.2	0.5

*Maximum drawdown based on generalised impact at proposed monitoring locations. Specific drawdown at theoretical observation bores located centrally within pilots may potentially be greater.

4.2 Predicted Fluxes

Mass balance data have been used to identify the factors supporting the modelled CSG water extraction from the MCF coals (Layer 12) and the Hoskissons Seam (Layer 8), in terms of flux between layers and change in layer storage. Previous analysis of DST data indicated a hydraulic gradient existing between deeper strata to shallower strata, creating a consistent upward flux in the system naturally with or without active CSG extractions. To exclude the impacts of the naturally occurring upward flux and to identify the impacts resulting from the proposed CSG extraction only, two transient simulations were conducted; one with and one without active CSG extraction. The nett difference between the two simulations is presented below.

Figure 4-11 shows the nett change in flux between layers and in layer storage for model layers 1-12 at 8 years from March 2009, or 36 months after the onset of proposed extraction when all six pilots are active. Figure 4-11 shows the extraction from Layer 12 (MCF coals) is accommodated by a nett increase in flux from Layer 13 (Qz bottom), a nett decrease in flux to Layer 11 (Qz top) and a nett decrease in storage in the target layer itself. The extraction from layer 8 (Hoskissons seam) is accommodated by a nett increase in flux from Layer 9 (Qz bottom) and a nett decrease in flux in to Layer 7 (Qz top). Figure 4-11 demonstrates that the fluxes originating from layers above Layer 6 (the Triassic Strata) are negligible at 36 months from the onset of the proposed pilot extraction, indicating the impacts of depressurisation of the MCF coals (Layer 12) and the Hoskissons Seam (Layer 8) are confined by the Black Jack Group (Layers 7-9) and the Triassic Strata (Layers 5 and 6).

Figure 4-12 shows the nett change in flux between layers and in layer storage for model Layers 1-12 at 28.5 years from March 2009, 20 years into the recovery phase and at the time of maximum impact observed in the Porcupine and Watermark Formations (Layer 10). Figure 4-12 demonstrates that the nett decrease in flux from underlying layers (Qz bottom), is

accommodated by a nett increase in flux from layer 9 (Qz top) and a nett decrease in storage in the Layer 10 itself. Figure 4-12 demonstrates that the fluxes originating from layers above Layer 9 (Black Jack Group) are negligible at 20 years into the recovery phase. Negligible fluxes above Layer 9 indicate that the impacts of depressurisation of the MCF coals are still confined by the Black Jack Group (Layers 7-9) and the impacts related to depressurisation of the Hoskissons Seam (Layer 8) are insignificant beyond 20 years of recovery.

Figure 4-13 illustrates the nett change in fluxes (flows) of groundwater into and out of model Layers 6 to 12 and into or from layer storage, at 8 years and 28.5 years from March 2009. The black arrows indicate the CSG produced water extraction from the respective layers. The fluxes / storage changes in each layer sum to zero, with gains or losses from overlying or underlying layers matched by extractions and changes in layer storage accordingly. The numbers have been rounded to the nearest whole number for simplicity.

A total of 1.43 GL of water is predicted to be extracted by the six pilots. A maximum induced flux of approximately 2.0 m^3/d is predicted to occur between the Gunnedah-Oxley Basin (GOB) and the NSW Great Artesian Basin (GAB) groundwater sources 500 years from commencement of the recovery phase. A maximum induced flux of approximately 0.5 m^3/d is predicted to occur between the GOB and Upper Namoi Alluvium groundwater sources at 1,100 years from the start of the recovery phase.

Predicted fluxes between groundwater sources are considered insignificant in terms of the aquifer interference policy.

4.3 Outcomes related to the Aquifer Interference Policy

The outcomes of the simulations have been considered in the context of the NSW Aquifer Interference Policy (AIP) 2012 minimal harm criteria. The target formations for the Dewhurst 13-18H and Dewhurst 26-31 pilots are classified as belonging to the Murray-Darling Basin Porous Rock groundwater WSP (incorporating the Gunnedah-Oxley Basin). This is overlain at the location of the Dewhurst 13-18H and Dewhurst 26-31 pilots by the NSW GAB groundwater sources WSP which comprises part of the Southern Recharge Beds of the GAB.

4.3.1 NSW Upper and Lower Namoi Groundwater Source WSP

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. The Upper and Lower Namoi alluvium are not considered to overlie the Dewhurst 13-18H and Dewhurst 26-31 pilots. Where they occur, these deposits are represented in the model as Layer 1. No significant decline in water table level or change in flux is indicated by model outcomes (Table 4-1). Hence no aquifer interference to this groundwater source is indicated by the modelling of the pilot CSG water extraction activities.

4.3.2 NSW GAB Groundwater Source WSP

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 on account of its lithological characteristics. No significant decline in water table level or change in flux in Layers 2, 3 or 4 is indicated by the model outcomes. Hence no

aquifer interference to this groundwater source is indicated by the modelling of the pilot CSG water extraction activities.

4.3.3 NSW Murray-Darling Basin Porous Rock Groundwater Source WSP

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 MCF (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 Layers 8 and 12. A decline in head of over 2 m within Layers 8 to 12 is indicated by the model outcomes. 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 aquifer interference and will require licensing and approval.

Figure 4-3 and Figure 4-4 illustrate the extent of cumulative drawdown in the target MCF seams (Layer 12) and the Porcupine and Watermark Formations (Layer 10) of all six pilots respectively. Figure 4-6 and Figure 4-7 illustrate the extent of drawdown in the target Hoskissons Seam (Layer 8) and the Triassic strata (Layer 6) of the Tintsfield pilot respectively. The zones of influence illustrated in these figures remain west of the outcrop of the Gunnedah Basin Permo-Triassic strata. Those registered bores illustrated in Figure 2-2 that also lie within the zones of influence shown in Figure 4-3, Figure 4-4, Figure 4-6 and Figure 4-7 are positioned on the outcrop of the Pilliga Sandstone and are highly likely to be completed within this groundwater source only and are therefore considered very unlikely to experience any impact. Impacts to registered bores are considered further in Section 4-6.

4.4 Potential impact on high priority GDEs

The three high priority GDEs identified in the vicinity of the Narrabri program area, Hardy's Spring, Mayfield Spring and Eather Spring, are understood to be hydrogeologically associated with the Pilliga Sandstone. They are located approximately 10 and 20 km to the east of the Dewhurst 13-18H and Dewhurst 26-31 respectively.

As stated above, the Pilliga Sandstone forms part of the NSW GAB Groundwater Source WSP. Modelling has indicated no significant decline in water table level or change in flux in the relevant model layers and hence no impact at any of these GDE springs is predicted to occur. It is considered that each of the GDEs can be characterised as a recharge-rejection ("water table") spring in the Pilliga Sandstone, caused by the underlying very low vertically conductive Purlewaugh Formation which effectively insulates the spring from any depressurisation occurring below.

4.5 Potential impact on GDE terrestrial vegetation

Given the findings set out in Section 4.2, the model results also indicate that there will be no significant impact on groundwater dependant terrestrial vegetation (including the Pilliga Scrub) identified within the program area.

4.6 Potential impact on registered water supply bores

The locations of registered water supply bores are shown on Figure 2-2. Based on the hydrogeological setting of the project area, and the accessibility of groundwater from the GAB Surat Pilliga Sandstone, it is considered unlikely that any registered groundwater extraction exists from bores in formations deeper than Layer 3 of the model (Pilliga Sandstone). As discussed in Section 4.2, the impacts on the GAB Surat Pilliga Sandstone and Upper and Lower Namoi alluvium groundwater sources are predicted to be insignificant, and thus the predicted impact on registered water supply bores as a result of the cumulative pilot activities is also predicted to be insignificant.

There are 11 registered bores within 5 km of the Dewhurst 13-18H pilot, and no registered bores within 5 km of the Dewhurst 26-31 pilot. All bores within 5 km are understood to draw water from the GAB Surat Pilliga Sandstone, and thus, the impact on these water supply bores is not predicted to be significant.

4.7 Mitigation

Given the outcomes reported in Sections 4.1 to 4.5 above, it is considered unnecessary to instigate mitigation measures beyond standard construction and operational environmental management controls. It is also considered unnecessary to instigate mitigation measures in relation to impacts to groundwater or groundwater dependent features as a result of the operation of the proposed six pilots.

4.8 Monitoring

Santos proposes to undertake the following aquifer monitoring bore installation and monitoring activities to demonstrate that pilot testing, or further development, activities are unlikely to cause harm to groundwater, surface water and GDEs:

- Design and implementation of a DAMB: one location has been identified as a proposed DAMB within the Triassic and Permian (GOB) strata;
- Design and implementation of a SAMB network: eightpotential SAMB locations have been identified for installation within the overlying substrates (including Pleistocene alluvial deposits and Cretaceous to Jurassic GAB strata).
- Baseline assessment of registered groundwater bores within the program area, which includes gathering information on the water quality, groundwater level and general condition of the bores; and
- Baseline assessment of surface water sites within the program area to provide baseline water quality conditions to enable the identification of any changes in water quality in the future.

Figure 4-1 Predicted drawdown in the MCF coals (Layer 12) at the pilot locations (up to 50 years)

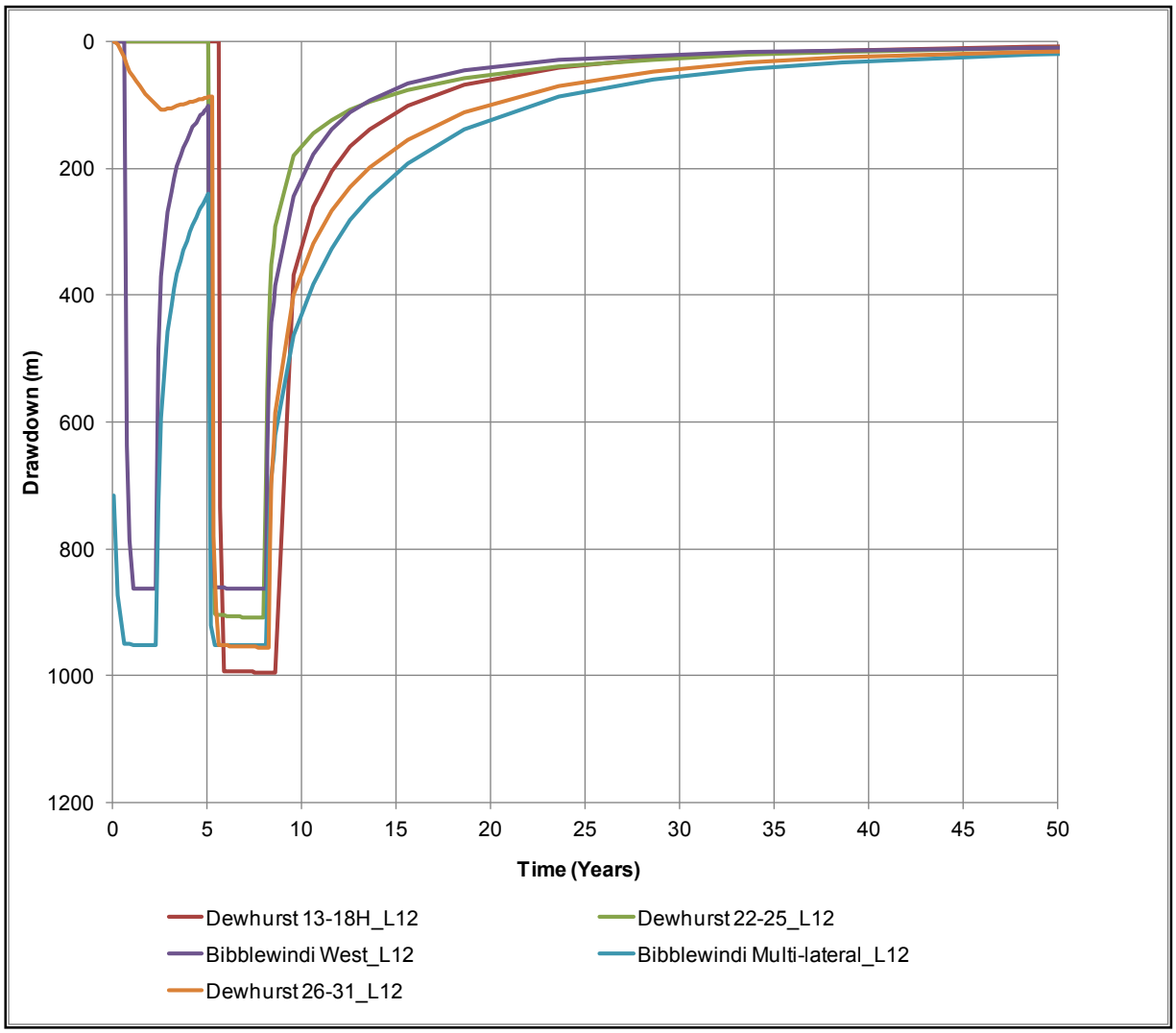
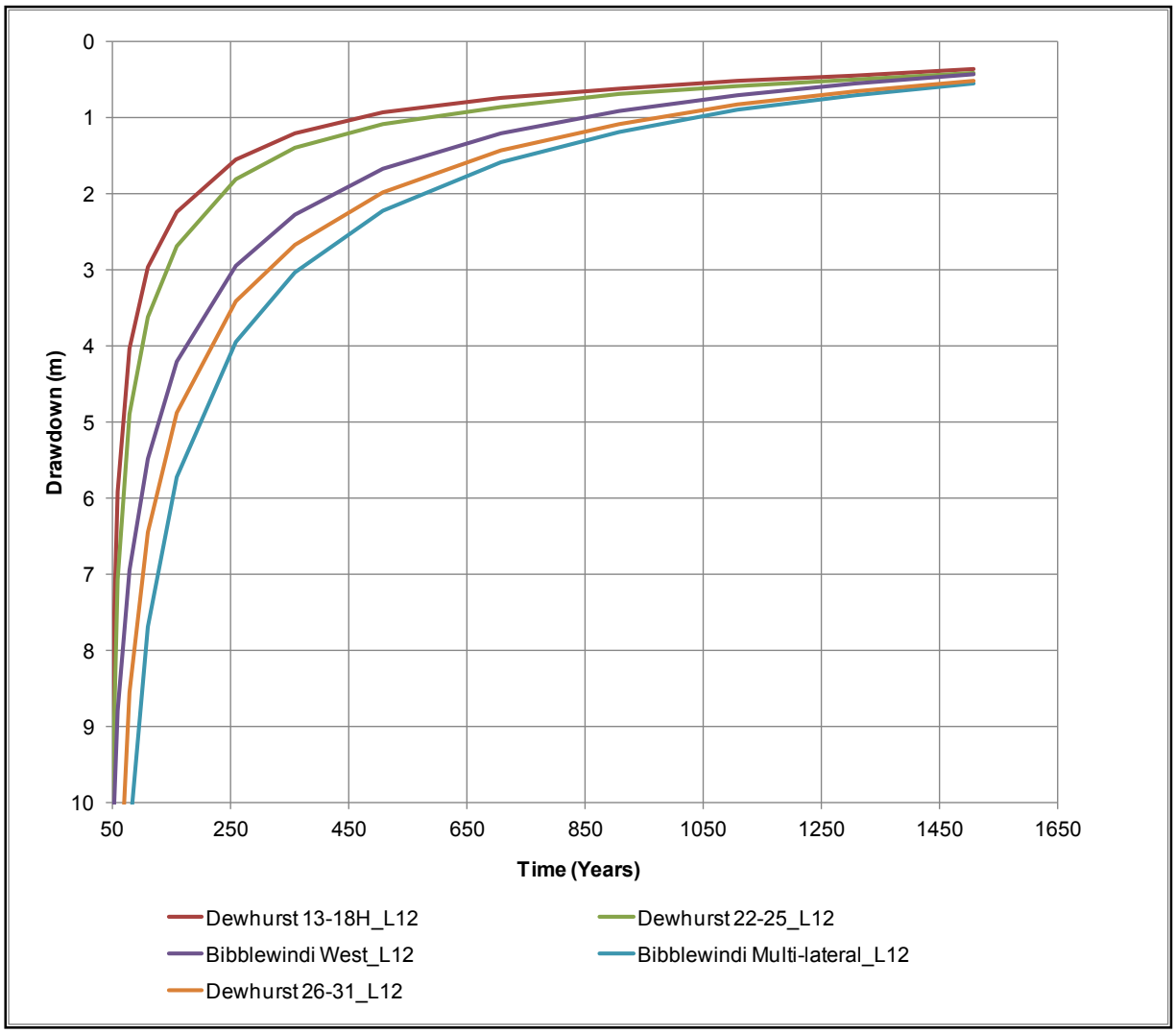
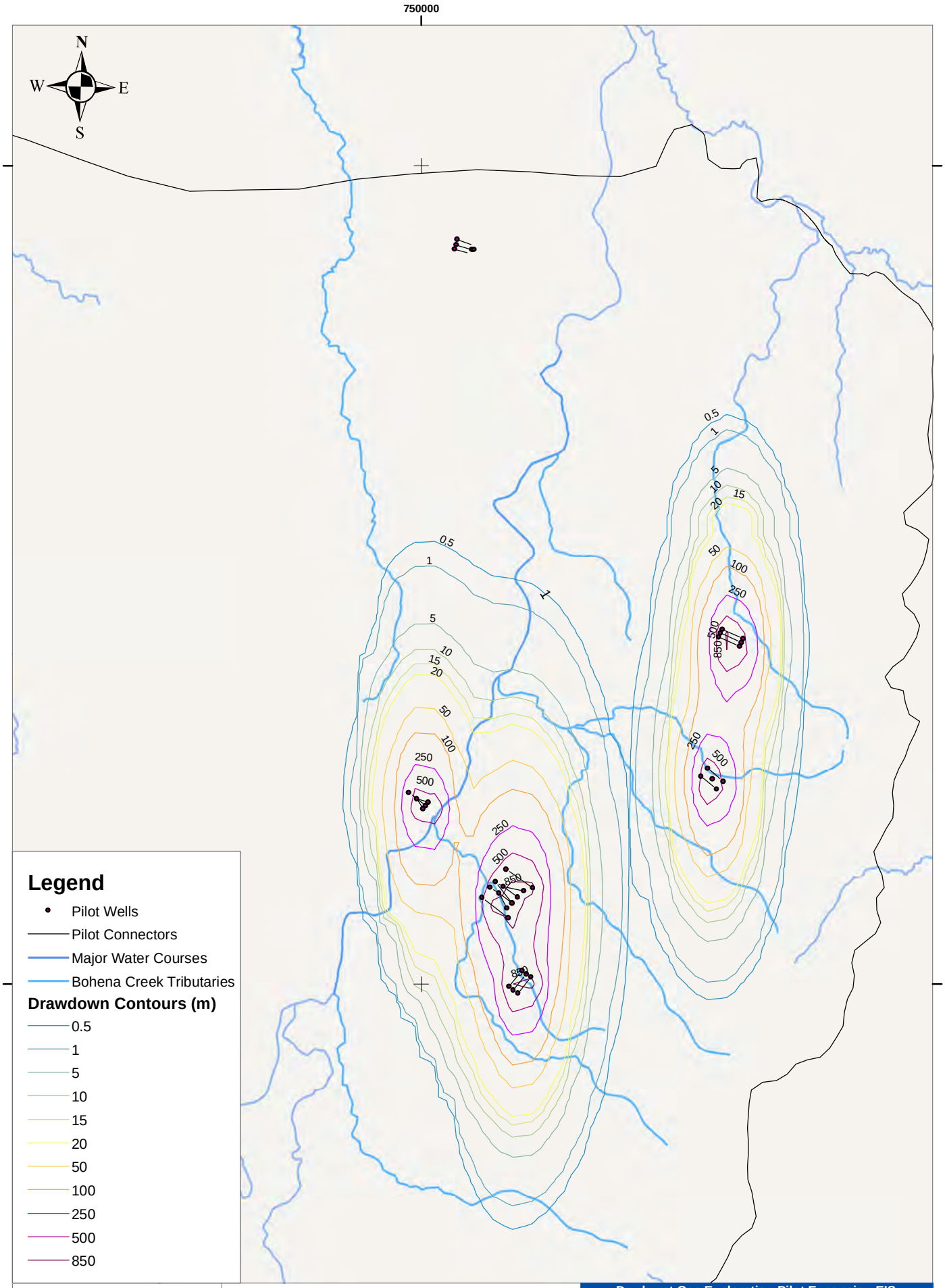


Figure 4-2 Predicted drawdown in the MCF coals (Layer 12) at the pilot locations (from 50 to 1500 years)





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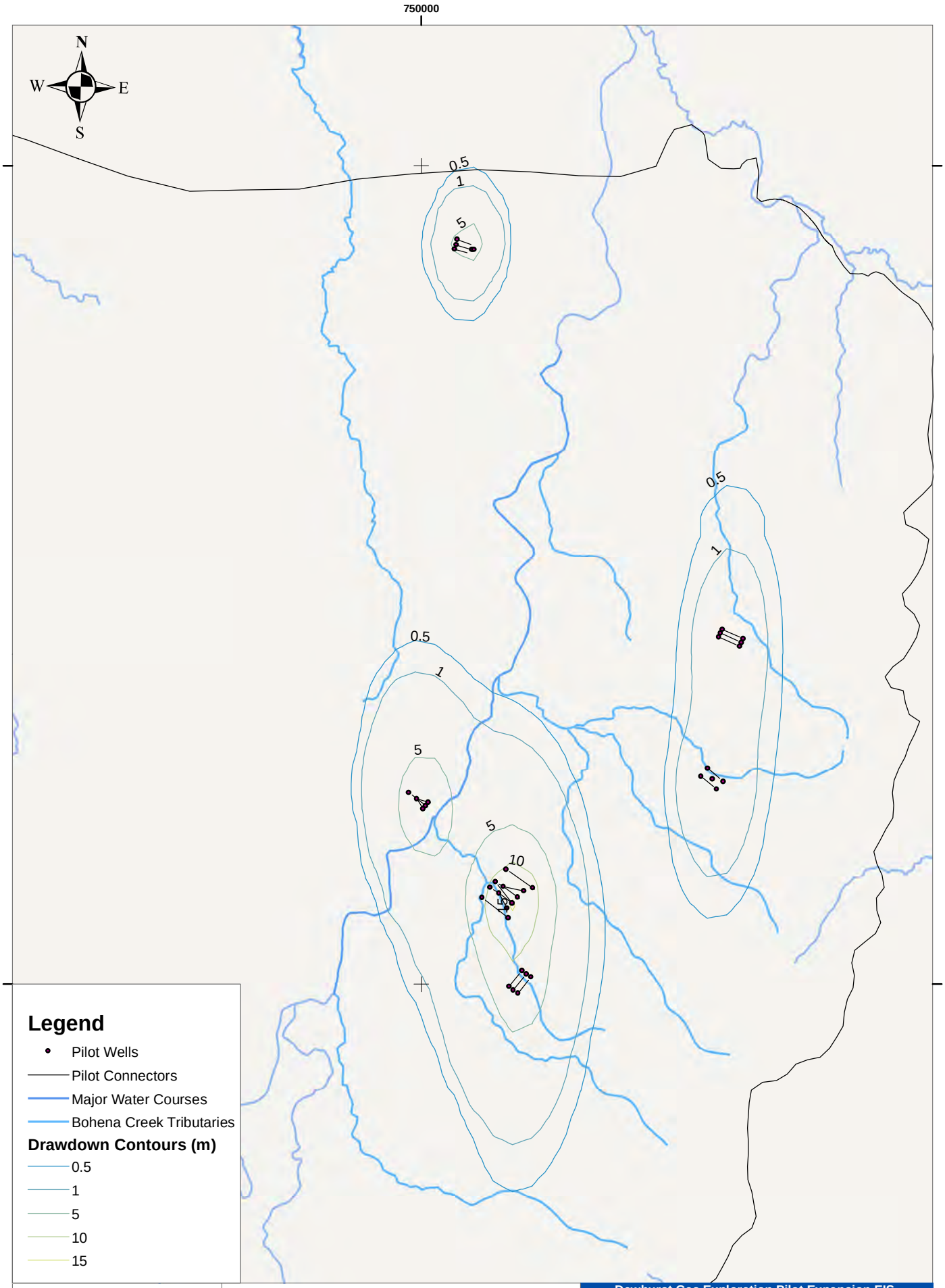
0 2.5 5 10 Km

Scale: 1:250,000 @A4
Projection: GDA94

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Figure 4-3
Predicted Drawdown Contours in HSU 11 (MCF Coals) 8 years from March 2009

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0 2.5 5 10 Km

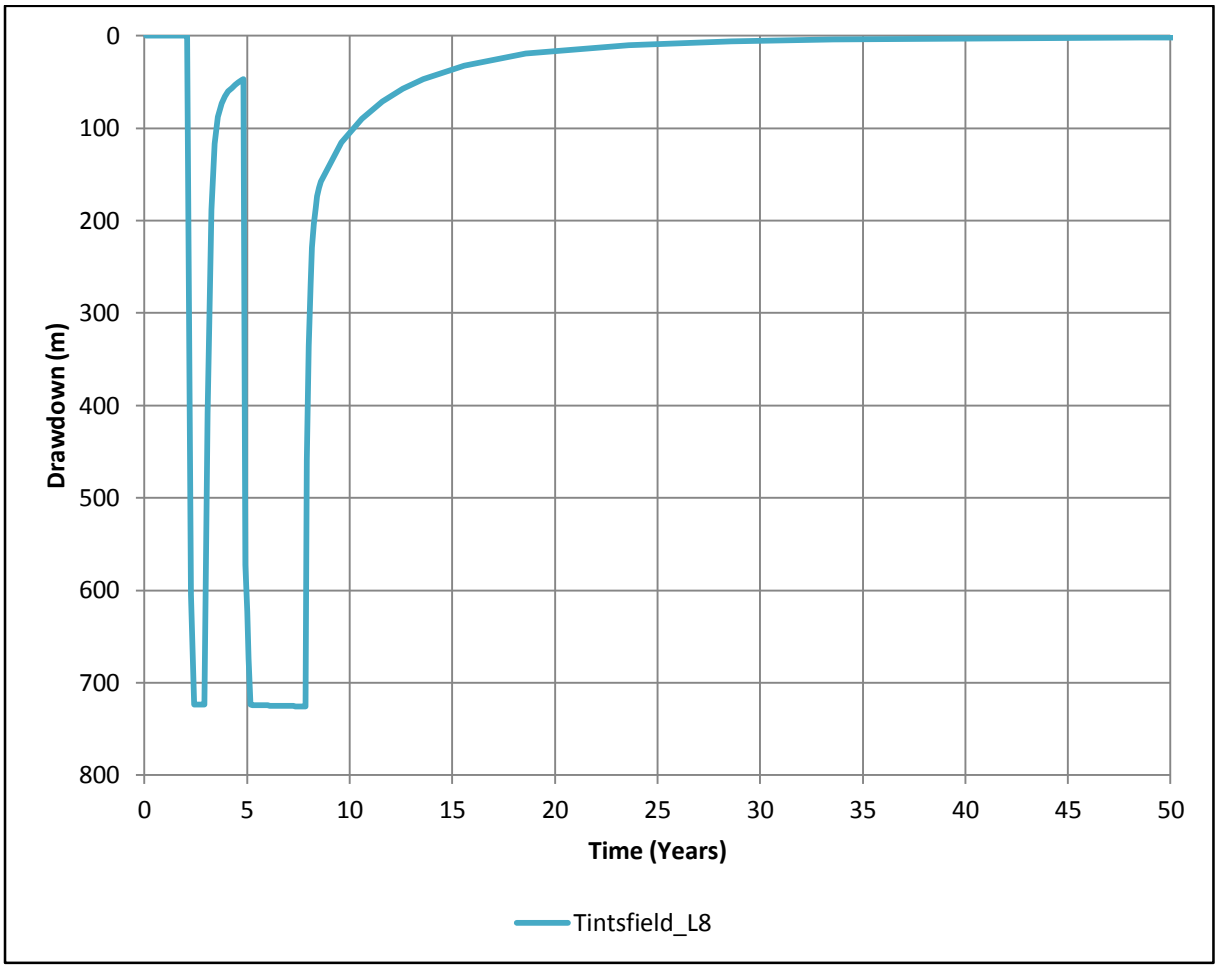
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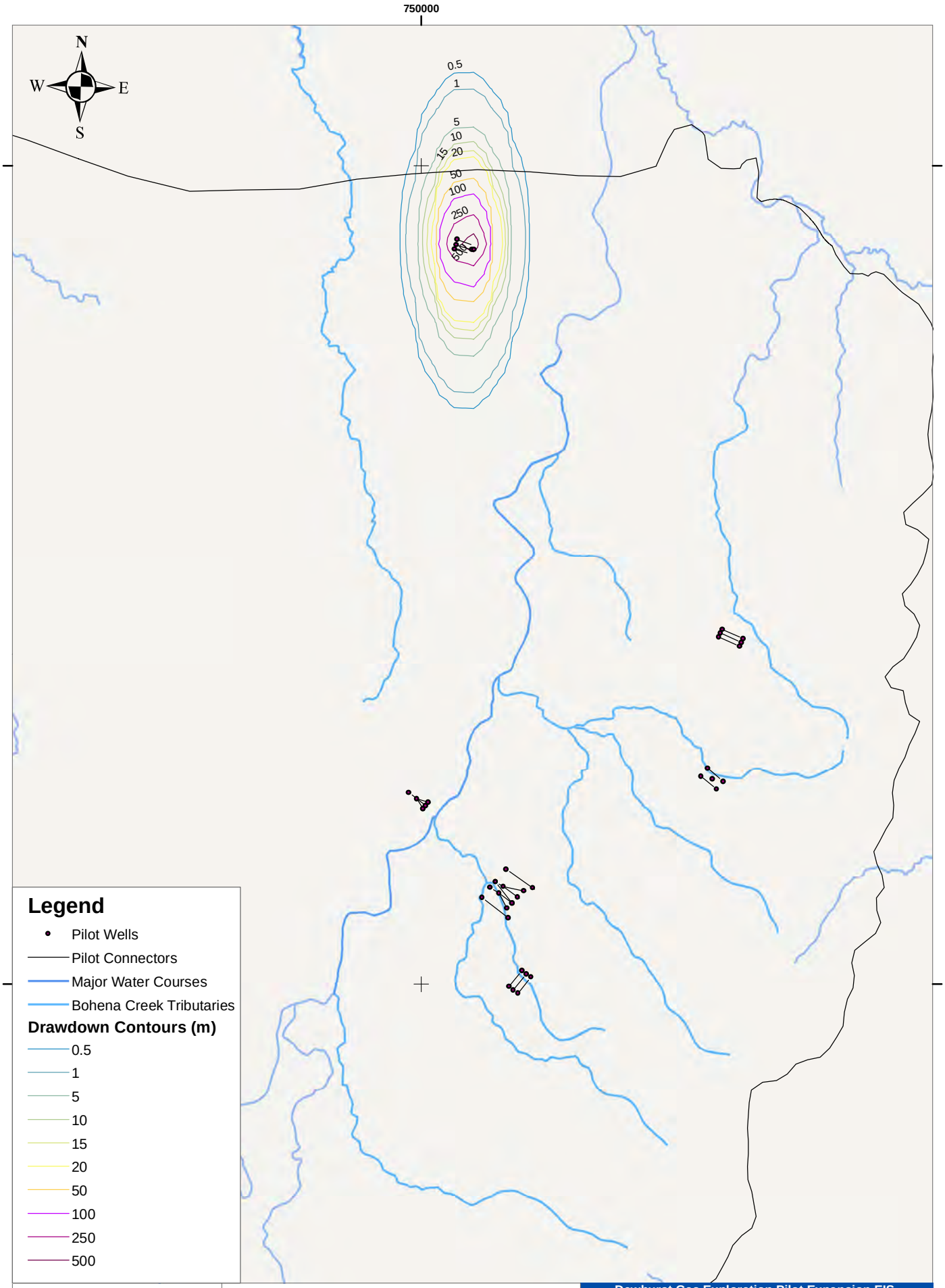
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Figure 4-4
Predicted Drawdown Contours in HSU 5 (Porcupine and Watermark Fms) 28.5 years from March 2009

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Figure 4-5 Predicted drawdown in the Hoskissons Seam (Layer 8) at the Tintsfield pilot location (up to 50 years)





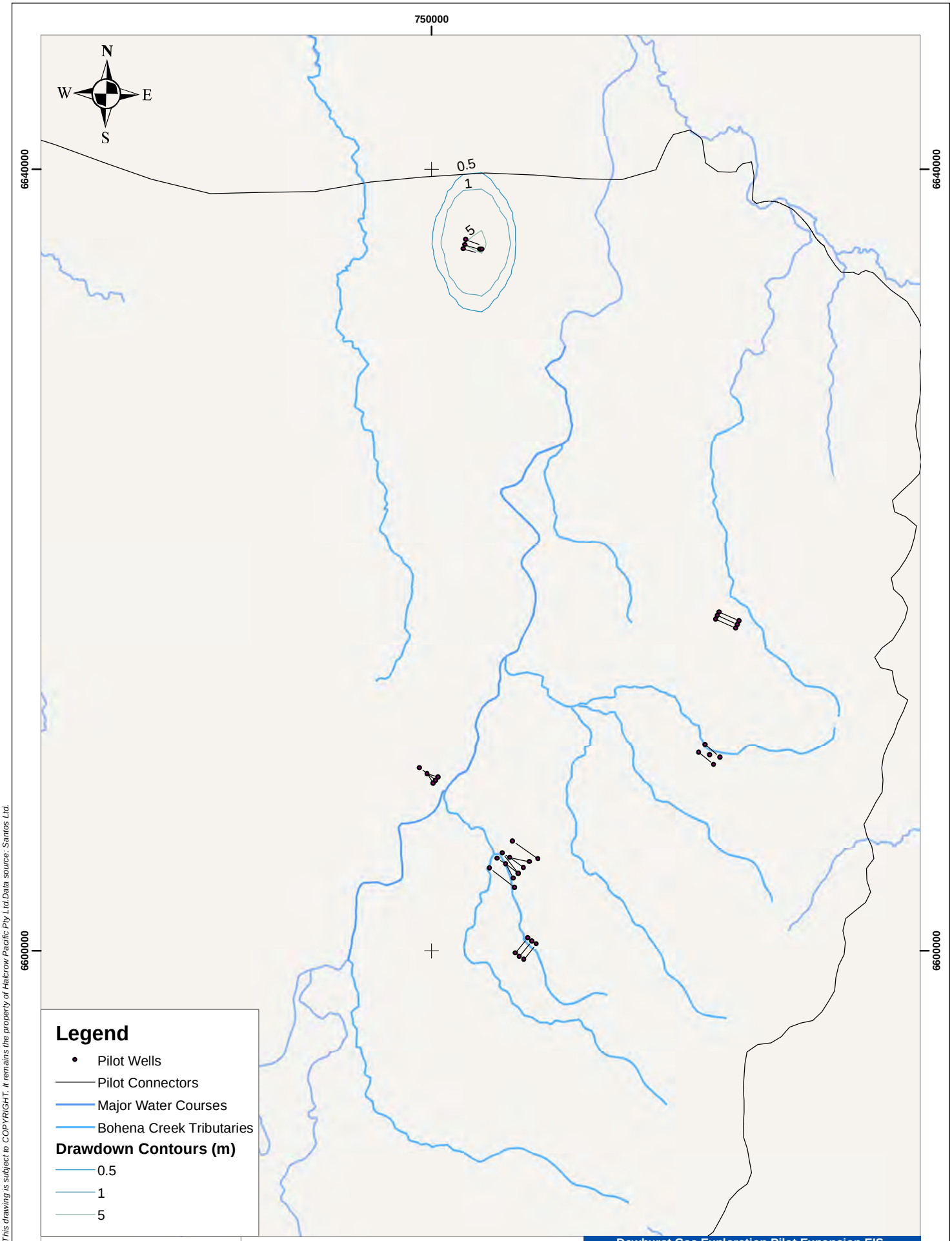
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Figure 4-6
Predicted Drawdown Contours in HSU 13 (Hoskissons Seam) 8 years from March 2009

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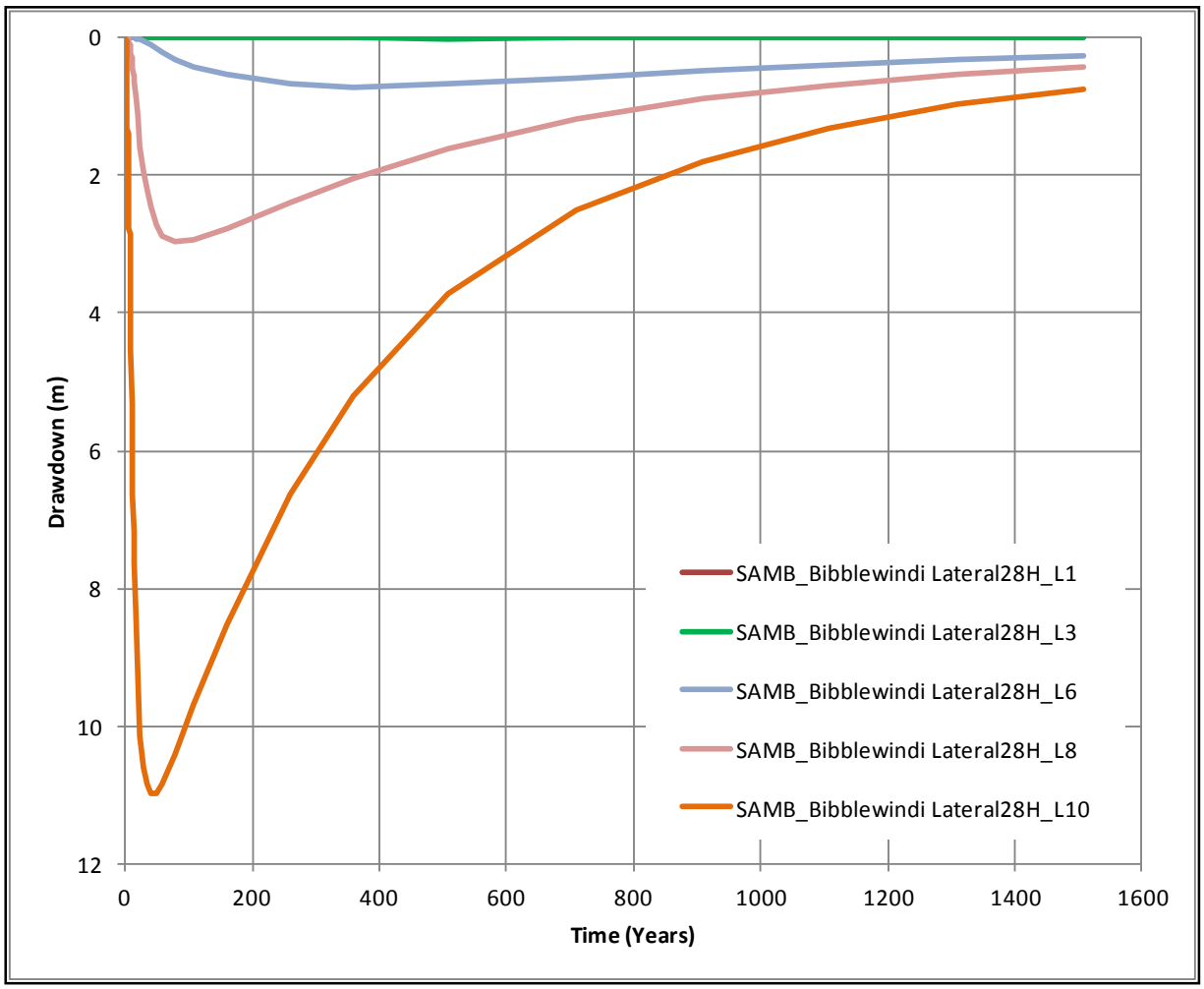
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Figure 4-7
Predicted Drawdown Contours in HSU 3 (Triassic Strata) 12 years from March 2009

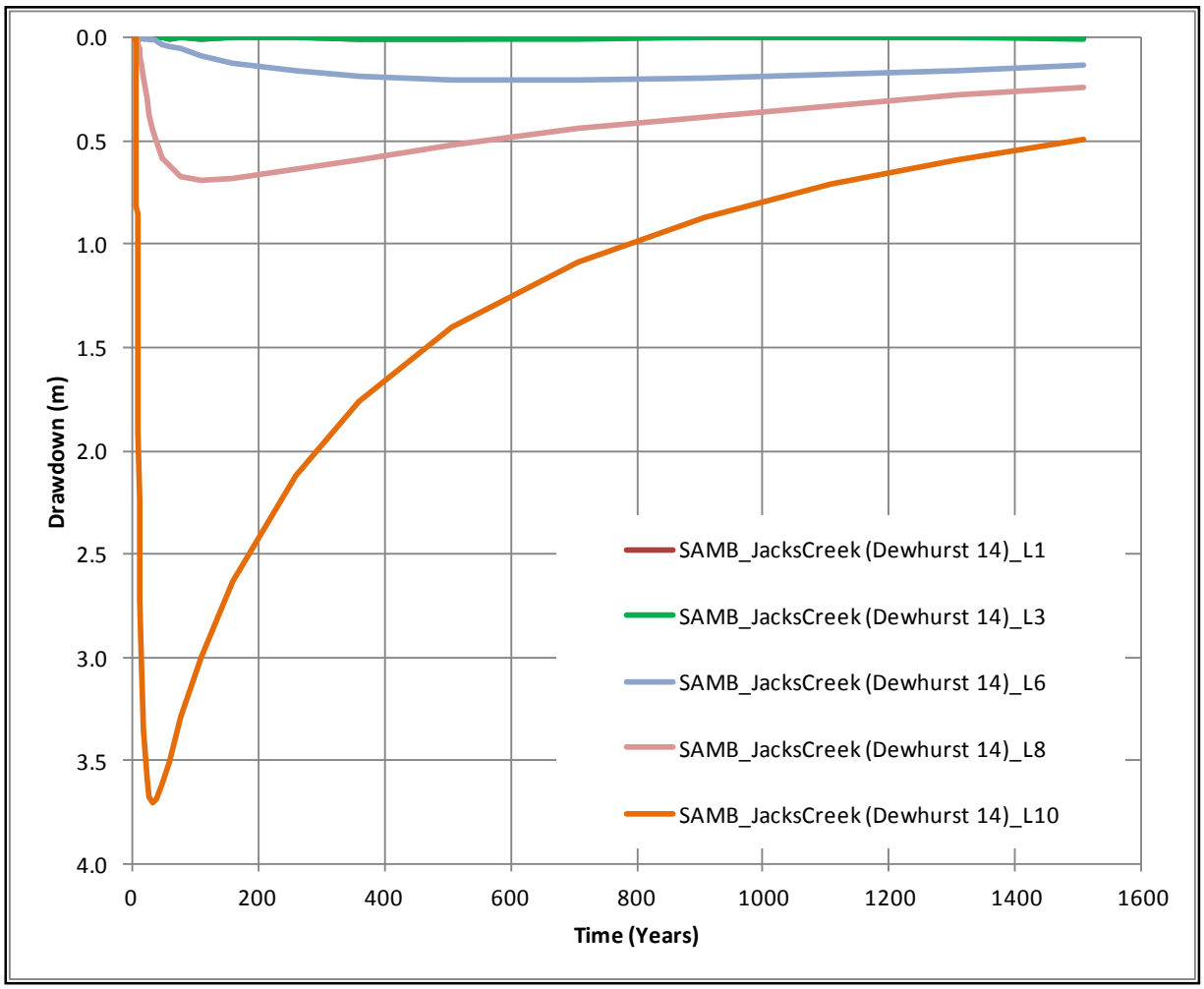
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Figure 4-8 Predicted drawdown at Bibblewindi Lateral-28H SAMB (Layers 1, 3, 6, 8 and 10)



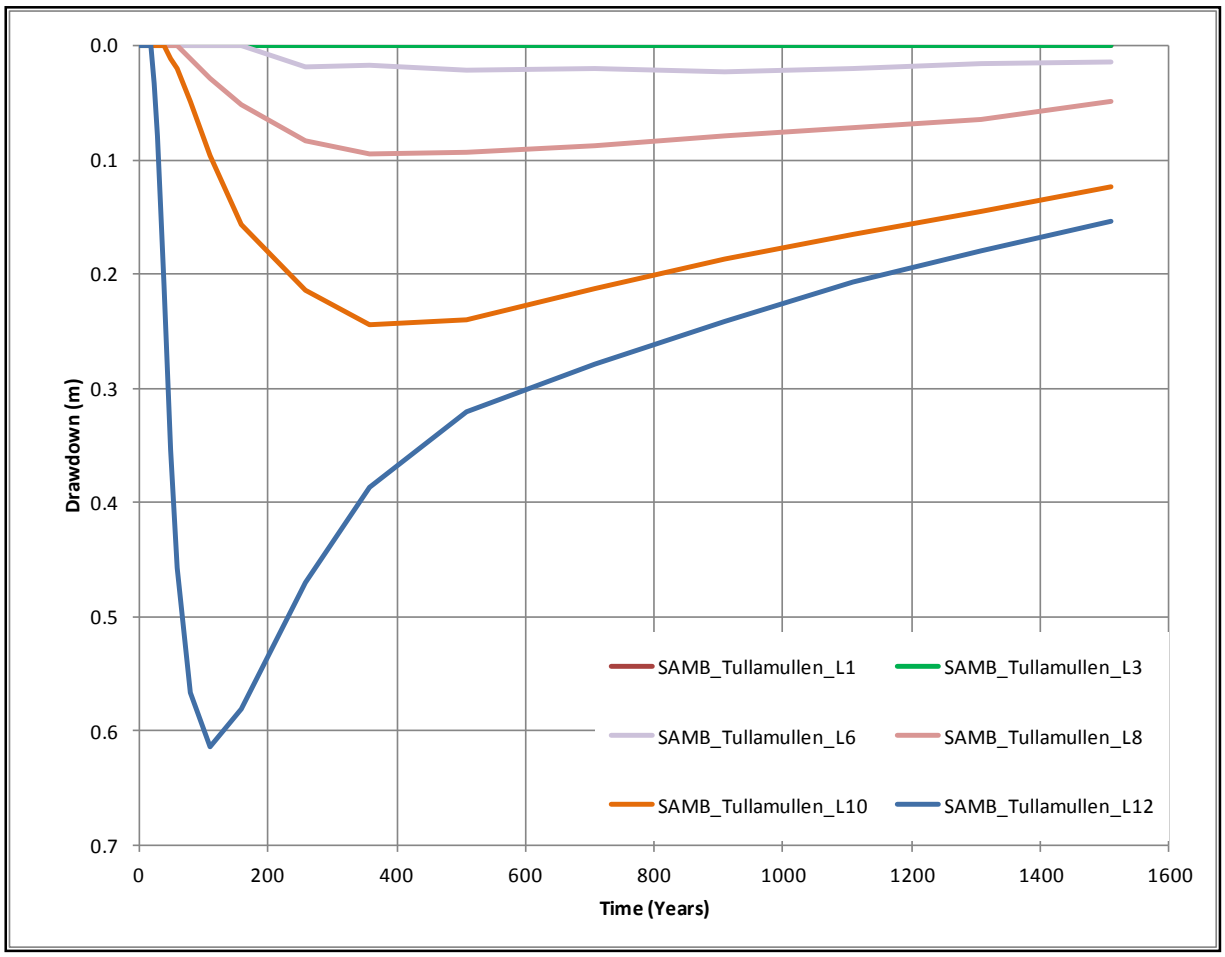
(Layer 1 is masked by Layer 3)

Figure 4-9 Predicted drawdown at Jacks Creek (Dewhurst 14) SAMB (Layers 1, 3, 6, 8 and 10)



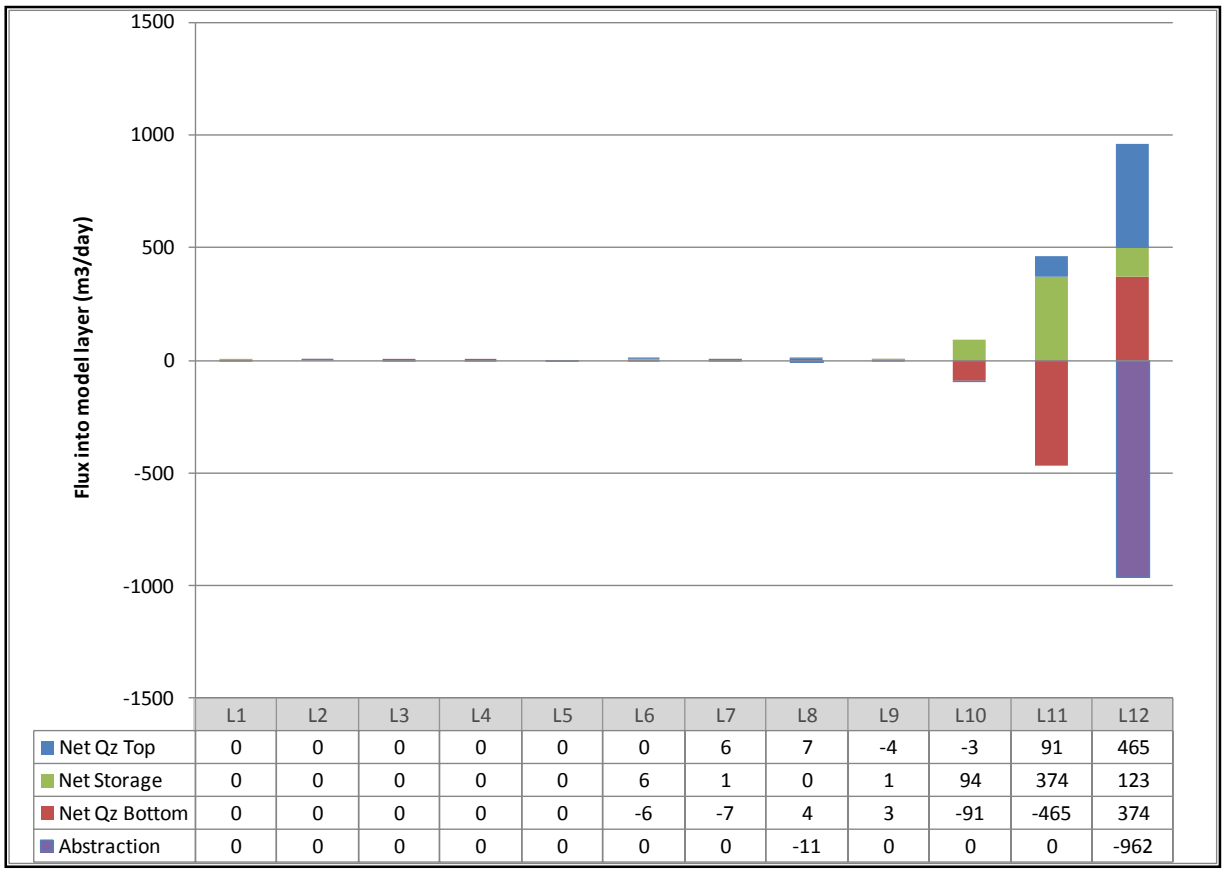
(Layer 1 is masked by Layer 3)

Figure 4-10 Predicted drawdown at Tullamullen SAMB (Layers 1, 3, 6, 8, 10 and 12)



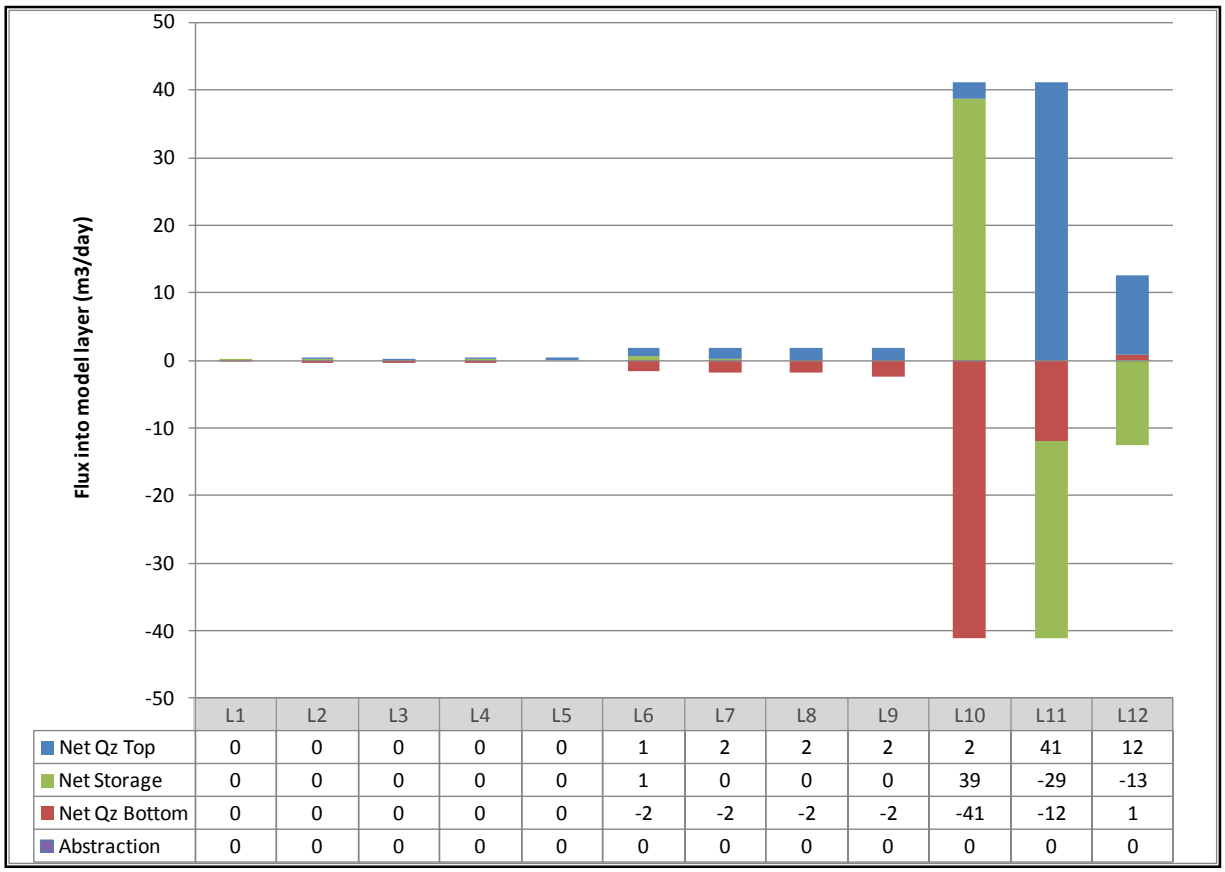
(Layer 1 is masked by Layer 3)

Figure 4-11 Mass balance summary by model layer, 8 years from March 2009 (36 months from onset of pilot extraction)



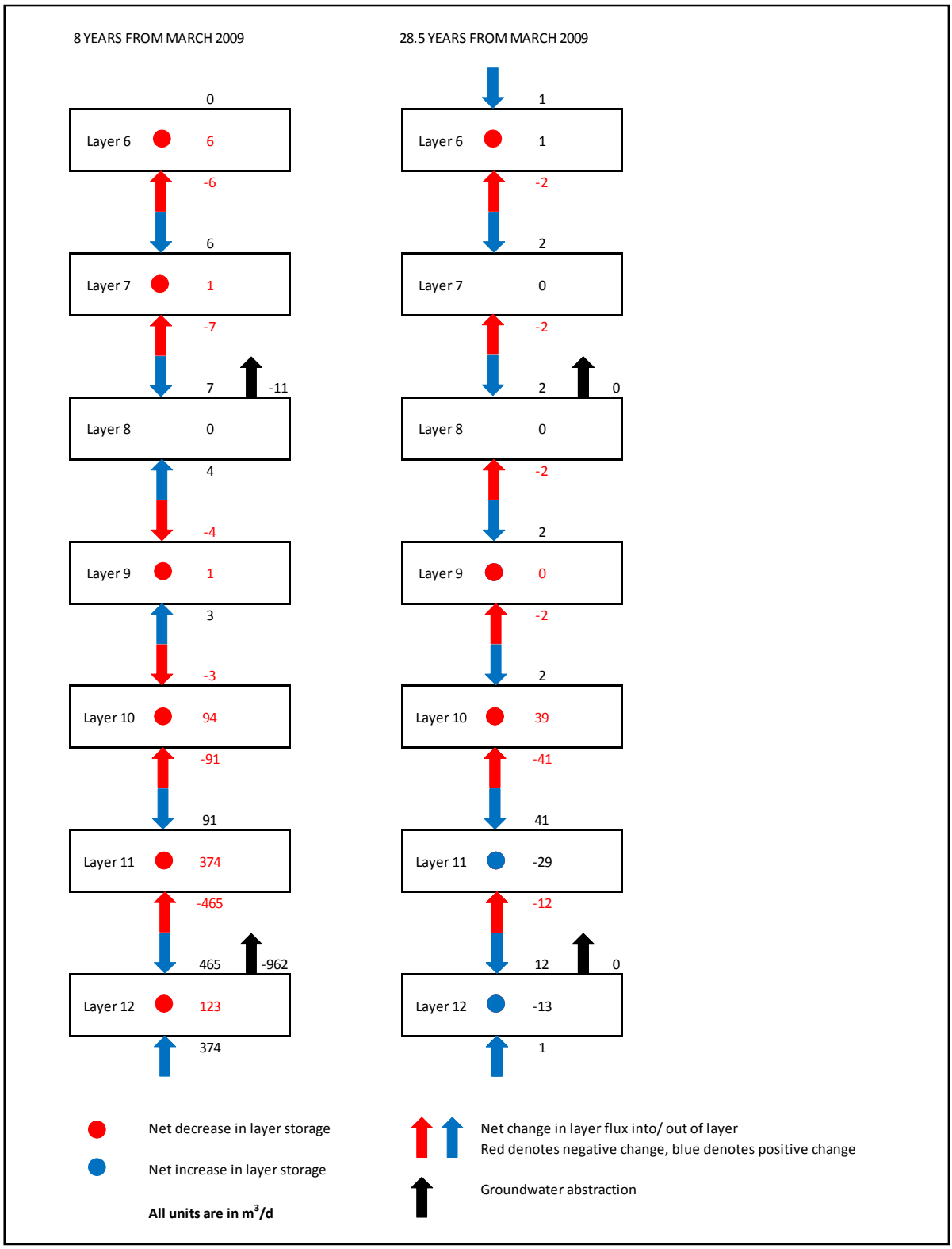
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Net Qz Top	0	0	0	0	0	0	6	7	-4	-3	91	465
Net Storage	0	0	0	0	0	6	1	0	1	94	374	123
Net Qz Bottom	0	0	0	0	0	-6	-7	4	3	-91	-465	374
Abstraction	0	0	0	0	0	0	0	-11	0	0	0	-962

Figure 4-12 Mass balance summary by model layer, 28.5 years from March 2009 (20 years from cessation of pilot extraction)



	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
Net Qz Top	0	0	0	0	0	1	2	2	2	2	41	12
Net Storage	0	0	0	0	0	1	0	0	0	39	-29	-13
Net Qz Bottom	0	0	0	0	0	-2	-2	-2	-2	-41	-12	1
Abstraction	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4-13 Mass balance comparison of model layers 6 to 12 at 8 and 28.5 years from March 2009 (units in m^3/d)



5 Summary and Conclusions

5.1 Summary

The following summarises this assessment of the potential impacts to groundwater and groundwater dependent resources as a result of the operation of the six concurrent CSG pilots, including the Dewhurst 13-18H and Dewhurst 26-31 pilots:

1. A cumulative impact assessment of 6 concurrent CSG extraction pilots operating within the Narrabri Gas program area has been undertaken using an amended version of the Narrabri groundwater flow numerical model run using MODFLOW SURFACT^{TM} v4.
2. Amendments to the original regional model included grid refinement in the vicinity of the pilots, assigning DRN/WEL cells and extraction rates to all six pilot locations and separation of extraction phases into three distinct transient models (historical, proposed and recovery).
3. Five pilots target the Maules Creek Formation coals (Layer 12), while the sixth pilot targets the Hoskissons Seam within the Black Jack Group (Layer 8). Applied extraction rates were calculated from data provided by Santos divided by the number of model DRN/WEL cells required to represent the pilot wells.
4. Three transient model simulations were run to cover *historical* extraction (4.5 years duration), *predictive* (proposed) extraction (4 years duration to accommodate different start dates of pilots, all proposed extractions were run for a 3 year period) and long term *recovery* (1,500 years duration). Simulation outcomes of each were then collated and considered together.
5. Groundwater head data were used to assess the maximum drawdown in the target seams and the overlying layers, particularly focussing on the Namoi alluvium (Layer 1), Pilliga Sandstone (Layer 3), Triassic strata (Layer 6) and the Porcupine and Watermark Formations (Layer 10).
6. Mass balance data were used to assess the interlayer fluxes and change in storage resulting from the CSG extraction.
7. There are no plans to implement hydraulic stimulation (also known as hydraulic fracturing or fracking) within the program.

Significant impacts on highly productive and less productive groundwater sources have been defined as reductions in groundwater level or pressure head of 0.5 m and 2.0 m respectively.

5.2 Conclusions

Based on the outcomes of the numerical groundwater modelling presented and interpreted in this report, the following conclusions have been drawn:

1. All six pilots are proposed to extract groundwater for a total of three years with different proposed start dates in 2014. The total volume of water to be abstracted from the Maules Creek Formation coals (five active pilots) is 1.41 GL. The total quantity of water to be abstracted from the Hoskissons Seam (one active pilot, Tintsfield 2-7) is 0.03 GL.
2. 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 combined six pilot CSG water extraction activities, and hence Dewhurst 13-18H and Dewhurst 26-31 in isolation;

3. A reduction in groundwater head of over 2 m is indicated for the lower part of the porous rock groundwater source of the Gunnedah Basin (GMA604) (NSW MDB Porous Rock groundwater source WSP). This impact on hydraulic (pressure) head combined with the fluxes developed within the lower part of the groundwater source required to achieve satisfactory coal seam depressurisation are interpreted to comprise an aquifer interference within the combined groundwater source and thus will require licensing
4. No impact to any identified high priority GDE identified in the vicinity of the Narrabri Gas program area is predicted to occur as a consequence of the cumulative six pilot CSG extraction activities, and hence Dewhurst 13-18H and Dewhurst 26-31 in isolation;
5. 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 cumulative six pilot CSG extraction activities, and hence Dewhurst 13-18H and Dewhurst 26-31 in isolation; and
6. It is therefore considered unnecessary to instigate mitigation measures in relation to the proposed Dewhurst 13-18H and Dewhurst 26-31 pilots alone or the combined six pilot CSG extraction activities beyond standard construction and operational environmental management controls.

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Abbreviations	
AIP	Aquifer Interference Policy
AMB	Aquifer Monitoring Bore
CSG	Coal Seam Gas
DAMB	Deep Aquifer Monitoring Bore
EPBC	Environmental Protection, Biodiversity and Conservation
GAB	Great Artesian Basin
GDE	Groundwater Dependent Ecosystem
GMA	Groundwater Management Area
GMZ	Groundwater Management Zone
HSU	Hydrostratigraphic Unit
MAR	Managed Aquifer Recharge
MCF	Maules Creek Formation
MDBA	Murray-Darling Basin Authority
MNES	Matters of National Environmental Significance
NGP	Narrabri Gas Project
NOW	New South Wales Office of Water
NSW	New South Wales
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration Licence
PIP	Pre-drilling project initiation package
SAMB	Shallow Aquifer Monitoring Bore
SDE	Surface Water Dependent Ecosystem
WSP	Water Sharing Plan

Glossary	
Aquiclude	A saturated geologic unit that is incapable of transmitting significant quantities of water under ordinary hydraulic gradients.
Aquifer	A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.
Aquitard	In relation to an aquifer, a geological unit exhibiting lower permeability. These units may be permeable enough to transmit water in quantities that are significant in the study of regional groundwater flow, but their permeability is not sufficient to allow the completion of production wells within them.
Confined aquifer	An aquifer that is confined between two aquitards or aquicludes and in which the water level may rise above the upper surface of the aquifer.
Ecosystem	The community of a plant, animal and other organisms existing within a defined area, and their interactions within the community and their non-living environment
Groundwater Dependent Ecosystem (GDE)	Ecosystems which have their species composition and their natural ecological processes determined by groundwater
Proposed action	A project, a development, an undertaking, an activity or series of activities

Appendix 4

Ecological Assessment

Dewhurst Gas Exploration Pilot Expansion

Ecological Assessment of the expansion of operations at Dewhurst 13 – 18H and Dewhurst 26 – 31 pilots

Prepared for
Santos NSW (Eastern) Pty Ltd

October 2013









DOCUMENT TRACKING

Item	Detail
Project Name	Dewhurst Gas Exploration Pilot Expansion. Ecological Assessment for the expansion of operations at Dewhurst 13 – 18H and Dewhurst 26 – 31 pilots
Project Number	13NEWECO-0046
Project Manager	Name: Andrea Sabella Phone: 02 4910 0125 Office address: PO Box 1056 Newcastle NSW 2300
Prepared by	Rebecca Dwyer, Andrea Sabella
Reviewed by	Martin Sullivan
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Cover photo	Clockwise from left: *Pterostylis mitchellii* (WI, 2012), Arboreal Elliott A trap with remote camera (AS, 2013), *Vespadelus vulturnus* (Little Forest Bat) (PK, 2013), Harp trap installed in flyway (PK 2013)

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Abbreviations

Abbreviation	Description
BBAM	BioBanking Assessment Methodology
CAP	Catchment Action Plan
CMA	Catchment Management Authority
CMA Act	Catchment Management Authorities Act 2003
DGRs	Director Generals Requirements
DoE	Australian Government Department of the Environment
DoP&I	NSW Department of Planning and Infrastructure
DPI	NSW Department of Primary Industries
DTIRIS	NSW Department of Trade and Investment, Regional Infrastructure and Services
EEC	Endangered Ecological Community
EIS	Environmental Impact Statement
ELA	Eco Logical Australia Pty Ltd
EP&A Act	Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FM Act	Fisheries Management Act 1994

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Abbreviation	Description
GPS	Global Positioning System
HBT	Hollow Bearing Tree
Km	Kilometres
LEPs	Local Environmental Plans
LGA	Local Government Area
m	Metres
mm	Millimetres
MNES	Matters of National Environmental Significance
NGDP	Narrabri Gas Development Project
NPWS	NSW National Parks and Wildlife Service (part of OEH)
NW Act	Noxious Weeds Act 1993
OEH	NSW Office of Environment and Heritage (formerly NSW Department of Environment, Climate Change and Water)
PAL	Petroleum Assessment Lease
PDA	Personal Digital Assistant
PEL	Petroleum Exploration Lease
PPL	Petroleum Production Lease
REF	Review of Environmental Factors
SEPPs	State Environmental Planning Policies
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now Australian Government Department of the Environment)
SRD	State and Regional Development
SSD	State Significant Development
TEC	Threatened Ecological Community
TSC Act	Threatened Species Conservation Act 1995

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Executive summary

Eco Logical Australia (ELA) was engaged by Santos NSW (Eastern) Pty Ltd (the proponent) to undertake an Ecological Assessment of the Dewhurst Gas Exploration Pilot Expansion which addresses the expansion of operations at Dewhurst 13 - 18H and Dewhurst 26 - 31 pilots (the proposed activity) within Petroleum Exploration Lease (PEL) 238. This Ecological Assessment will from part of the Environmental Impact Statement (EIS) for the proposed activity.

The study area is located approximately 25 to 44 kilometres (km) south of Narrabri NSW on freehold land and Crown Land (Dewhurst 13-18H) or within the Pilliga East State Forest (Dewhurst 30-31), which forms part of a large tract of remnant native vegetation referred to colloquially as the Pilliga Scrub.

This report details the ecological survey undertaken by RPS and ELA used to assess the potential impacts of the proposed activity on ecological values and the environment more broadly. Surveys were undertaken in 2012 by RPS with supplementary survey undertaken in 2013 by ELA.

The vegetation in the study area is consistent with the vegetation community *Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion*. This vegetation type provides habitat for a range of threatened flora, as well as foraging, breeding and roosting habitat for a range of threatened fauna species addressed in this impact assessment.

A total of four threatened flora and 33 threatened fauna including 21 birds and 12 mammals have been assessed as potentially, likely or known to occur in the study area and Assessments of Significance for these species under the *Threatened Species Conservation Act 1995* (TSC Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) have been undertaken where applicable.

The removal of 2.44 hectares (ha) of vegetation for the proposed activity is not considered likely to have a significant impact on ecological values listed under the TSC Act or EPBC Act or on the environment more broadly, provided the measures described in **Section 6** are adhered to.

Avoidance, minimisation and mitigation measures have been addressed in order to reduce the impact of the proposed activity on ecological values and the environment.

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1 Introduction

1.1 Project description

Eco Logical Australia (ELA) was engaged by Santos NSW (Eastern) Pty Ltd (the proponent) to undertake an Ecological Assessment of the Dewhurst Gas Exploration Pilot Expansion which addresses the expansion of operations at the Dewhurst 13 – 18H and Dewhurst 26 - 31 pilots (the proposed activity) within Petroleum Exploration Lease (PEL) 238 (hereafter referred to as the study region). This Ecological Assessment will from part of the Environmental Impact Statement (EIS) for the proposed activity.

The study area is located approximately 25 to 44 kilometres (km) south of Narrabri NSW on freehold land and Crown Land (Dewhurst 13-18H) or within the Pilliga East State Forest (Dewhurst 30-31), which forms part of a large tract of remnant native vegetation referred to colloquially as the Pilliga Scrub (**Figure 1**). The proposed location of works is shown in **Figure 2**.

The proposed activity involves the expansion of operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operation of both pilots for up to three years. Works at Dewhurst 13-18H involve re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells. Works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas to expand the proposed pilot from four to six wells.

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The NSW Department of Primary Industries (DPI) approved construction, drilling and operation of Dewhurst 13, 14, 15, 16H, 17H and 18H on 21 July 2009 following a Review of Environmental Factors (REF) assessment under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). The wells operated for a short period in 2011.

Dewhurst 26-29 is a proposed four well pilot which was approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) on 16 August 2013 following a REF assessment under Part 5 of the EP&A Act. Dewhurst 26-29 is scheduled to be drilled in Q3 2013.

More specifically, the proposed activity includes:

Site preparation

- Establishing two 10 metre wide service corridors between Beehive Road and the Dewhurst 30 and 31 lease areas (including clearing of approximately 0.2 hectares of vegetation).
- Constructing access roads within the two service corridors at Dewhurst 30 and 31.
- Establishing the Dewhurst 30 and Dewhurst 31 lease areas each up to approximately one hectare in size (including approximately two hectares of vegetation clearing).
- Removing the existing water gathering system and electrical cable connecting Dewhurst 13, 14 and Dewhurst 15 wells.
- Preparing the sites and establishing necessary equipment, temporary structures and facilities on the existing well leases Dewhurst 16H, 17H and 18H and on the new lease areas Dewhurst 30 and 31 to enable drilling.

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Drilling

- Drilling an additional two horizontals from existing casing within Dewhurst 16H, 17H and 18H to convert each well from a single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley coal seams.
- Drilling one vertical (Dewhurst 30) and one triple-stacked horizontal (Dewhurst 31) well to target coal seams within the Maules Creek Formation.

Surface and subsurface facility construction

- Preparing the site on the existing well lease Dewhurst 14 to enable installation of a gas flare and water balance tank.
- Constructing a new gas and water gathering system connecting all the wells within the Dewhurst 13-18H Pilot to the existing Dewhurst 14 well lease area (including clearing of approximately 0.24 hectares of disturbed vegetation).
- Extending the existing water and gas gathering system for Dewhurst 26-29 within the service corridors to Dewhurst 30 and 31.
- Installing surface and sub-surface infrastructure within the lease areas to connect the wells to the Dewhurst 13-18H and Dewhurst 26-31 gas and water gathering system.
- Installing a gas flare and water balance tank at the existing Dewhurst 14 lease area and a gas flare at the Dewhurst 28 lease area.

Operation

- Operating the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot for up to three years from the commencement of operations at each pilot respectively.
- Managing the water and gas produced during operation.
- Undertaking occasional maintenance of the pilots.

Post operation

- On completion of operations, suspending the wells and ancillary infrastructure or decommissioning them and rehabilitating the well leases.

1.2 Area addressed in this assessment

1.2.1 Subject site

The subject site is the area directly impacted by the proposed activity and is defined as the vegetation to be removed for the construction of the new Dewhurst 13 – 18H gathering system and the disturbance footprint for the construction of the Dewhurst 30 and 31 pilot wells and associated service corridors.

1.2.2 Study area

The study area includes all areas surveyed as part of this assessment, incorporating all areas of direct and indirect impacts including a 10 metre (m) buffer around the subject sites (**Figure 1** and **Figure 2**).

1.2.3 Study region

The study region is defined as the area within PEL 238 which includes Petroleum Assessment Lease (PAL) 2 and Petroleum Production Lease (PPL) 3 (**Figure 1**). This area is used to discuss the

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proposed activity within the context of the broader north-east Pilliga Forest and assess the cumulative impacts of all projects undertaken by the proponent in the Pilliga region.

1.3 Report structure

The report is structured in the following chapters:

1. **Introduction** – outlines the proposed activity and provides detail on all project components and their likely impact areas. Also outlines the legislative framework under which the proposed activity is to be assessed including Commonwealth and NSW legislation and the Director General's Requirements (DGRs).
2. **Existing environment** – provides context for the landscape in which the study region is located.
3. **Methods** – outlines the methods used for database and literature review and field survey.
4. **Results** – outlines the findings of the database and literature review and field survey.
5. **Impact assessment** – assesses the likely direct, indirect and cumulative impacts from the proposed activity (residual impacts after avoidance).
6. **Mitigation measures** - outlines the proposed measures to mitigate impacts from the proposed activity.
7. **Conclusion** - summarises the key findings of this assessment and provides recommendations.

1.4 Objectives

The key objectives of the Ecological Assessment are to:

- Identify and describe any threatened flora and fauna species, populations, ecological communities, as well as migratory species and their habitats that may occur within the study area.
- Evaluate the conservation significance of the proposed subject sites.
- Assess the impact of the proposed activity on threatened flora and fauna species, populations and ecological communities, and migratory species, likely to occur in the study area through significance assessments in accordance with the EP&A Act and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Recommend measures to minimise and mitigate the impacts of the proposed activity on native flora and fauna and their habitats.

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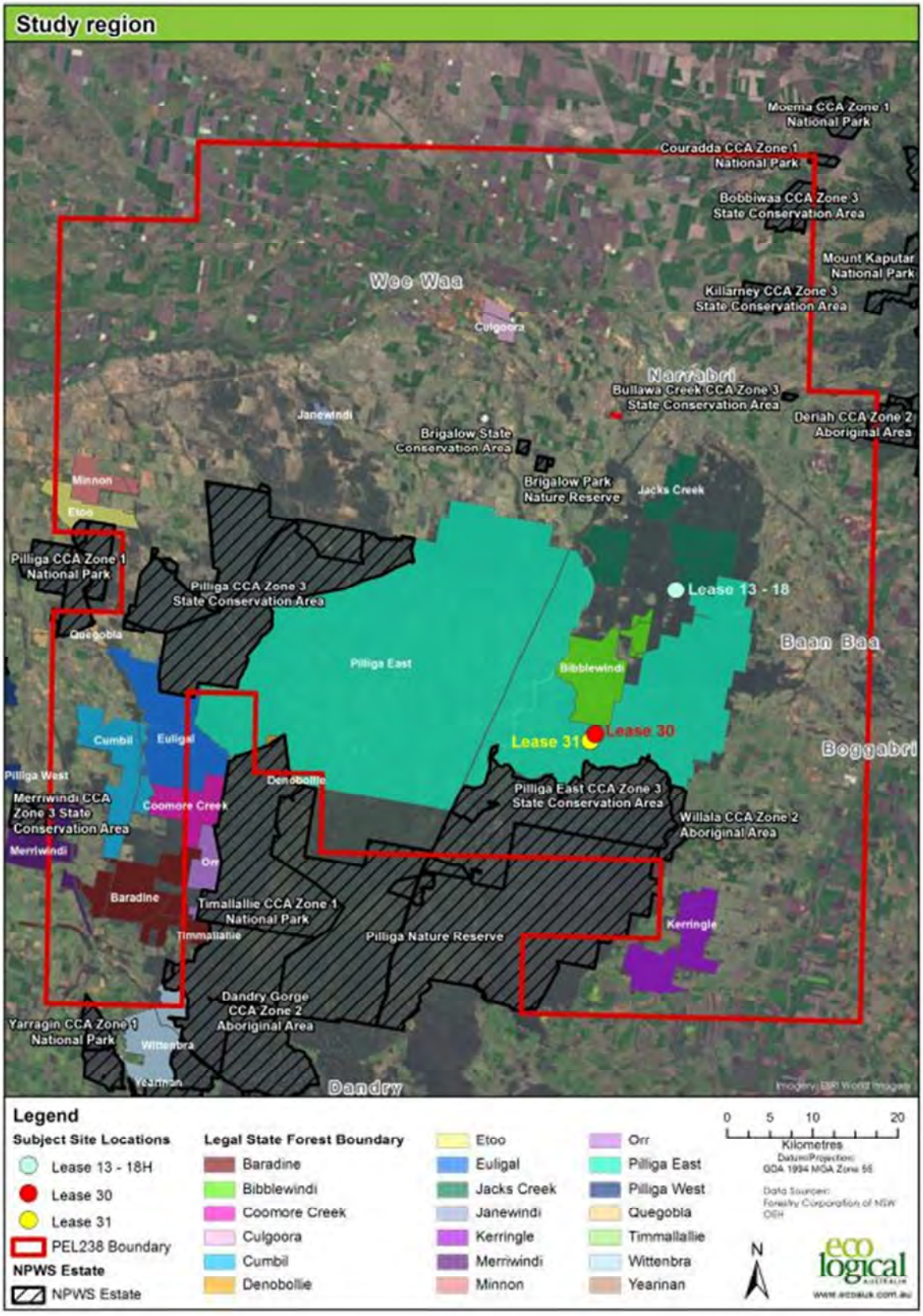


Figure 1: Study region

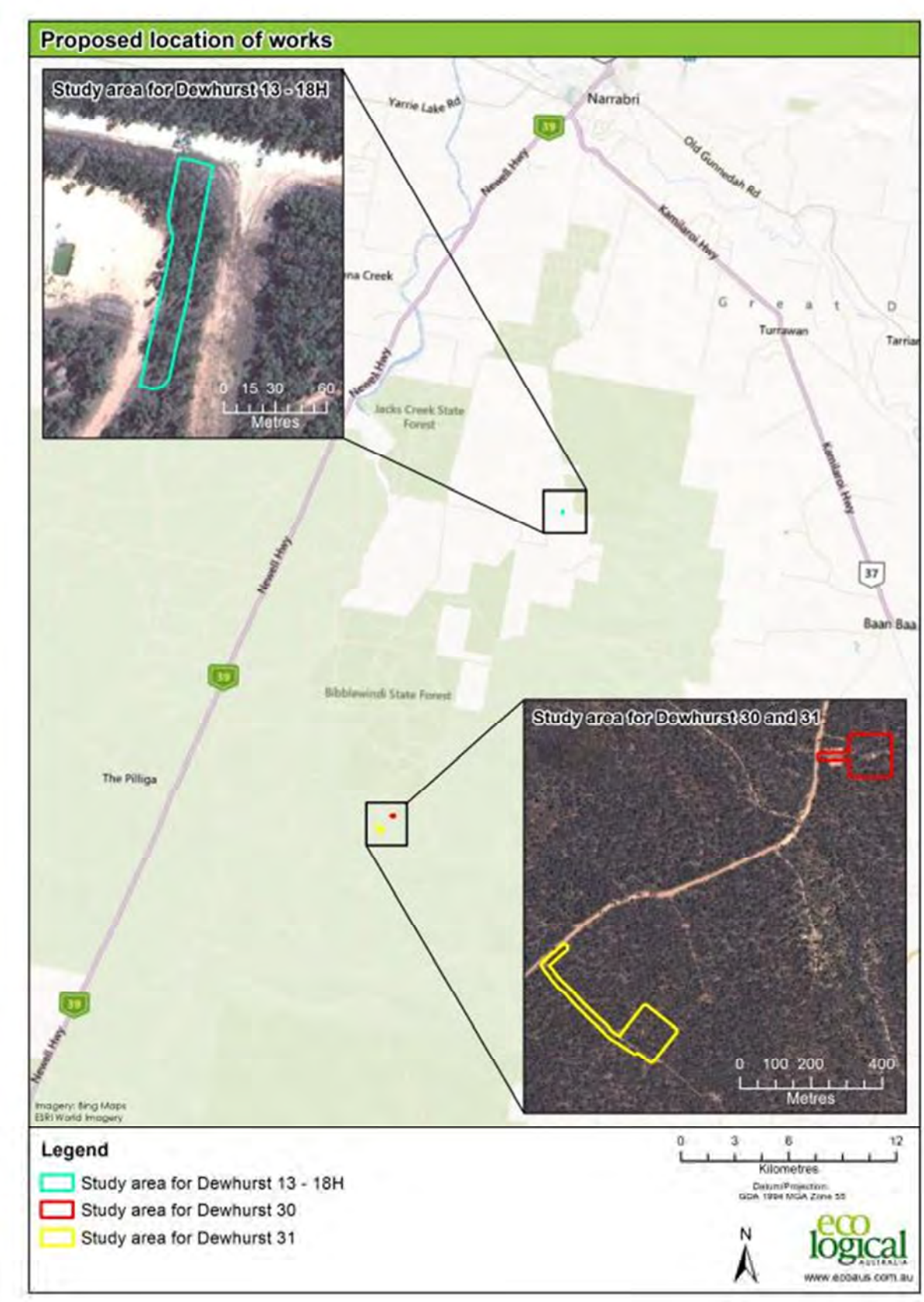


Figure 2: Proposed location of works

1.5 Statutory framework

1.5.1 Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999

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

Environmental approvals under the EPBC Act are required for an 'action' that is likely to have a significant impact on Matters of National Environmental Significance (known as 'MNES') including:

- World Heritage Area.
- National Heritage Places.
- Ramsar wetlands of international importance.
- Nationally listed threatened species and ecological communities.
- Listed migratory species.
- Commonwealth marine areas.
- Nuclear actions.
- Great Barrier Reef Marine Park.
- A water source, in relation to coal seam gas development and large coal mining development.

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

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

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

Ecological MNES relevant to the study area are nationally listed threatened species and ecological communities and listed migratory species. Ecological MNES that were recorded or have the potential to be present or use the study area are listed in **Appendix A**. An assessment of the potential impacts of the proposed activity in accordance with the EPBC Act has been undertaken and provided in **Appendix G**.

Santos referred the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program (the program) to the Australian Government Department of the Environment (DoE) (formerly Commonwealth Department of Sustainability, Environment, Water, Population and Communities, SEWPaC) as part of the Energy NSW Coal Seam Gas (CSG) Exploration and Appraisal Program (the Program) on 27 June 2013. A 'not controlled action if undertaken in a particular manner' decision was made on 1 October 2013 by the Minister for the Environment, meaning the program does not require Australian Government approval, provided it is undertaken in the particular manner set out in the decision notification.

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1.5.2 New South Wales legislation

Environmental Planning and Assessment Act 1979

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

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

Threatened Species Conservation Act 1995

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

Threatened species, populations and ecological communities that were recorded or have the potential to be present on or use the study area are listed in **Appendix A.**

Fisheries Management Act 1994

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

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

Noxious Weeds Act 1993

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

The objectives of the NW Act include:

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

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

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1.5.3 State Environmental Planning Policies (SEPPs)

State Environmental Planning Policy 44 (Koala Habitat)

State Environmental Planning Policy 44 (Koala Habitat) (SEPP 44) aims to encourage the proper conservation and management of areas of natural vegetation that provide habitat for koalas to ensure a permanent free-living population over their present range and reverse the current trend of koala population decline. As the proposed activity is over 1 ha in size and SEPP 44 applies to the Narrabri Shire Council LGA, an assessment under SEPP 44 is required. As Koala is listed as a threatened species, impacts to Koalas and their habitat have also been assessed.

1.5.4 Local Environment Plans (LEPs)

The Narrabri Local Environment Plan 1992 (Narrabri LEP 1992) applies to Narrabri Shire Council LGA not including Boggabri and Narrabri municipal areas. The objectives of the Narrabri LEP1992 that are relevant to the proposed activity include:

- To encourage the proper management, development and conservation of natural and man-made resources within the Shire of Narrabri by protecting, enhancing or conserving:
    - timber, mineral, soil, water and other natural resources
    - areas of ecological significance
    - areas of high scenic or recreational value
    - the environmental heritage of the Shire of Narrabri.

1.5.5 Director General's Requirements (DGRs)

The Director General of NSW Department of Planning and Infrastructure (DoP&I) issued DGRs, including ones specifically related to ecology, for the assessment of the Dewhurst Gas Exploration Pilot Expansion, on 22 July 2013. **Table 1** lists the key issues and requirements of the DGRs relevant to ecology, and the sections of this document that address these.

Table 1: DGRs and sections of the report where these have been addressed

Key issue	Requirement	Relevant section of this document
General	An assessment of the potential impacts of all stages of the development, including any cumulative impacts.	Section 5
	A description of the measures that would be implemented to avoid, minimise and if necessary, offset the potential impacts of the development, including proposals for adaptive management and/or contingency plans to manage any significant risks to the environment.	Section 5 and Section 6
Biodiversity	Accurate estimates of any proposed vegetation clearing.	Section 5
	An assessment of potential impacts of the development on any: • terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems • regionally significant remnant vegetation, or vegetation/wildlife corridors	Appendix F & Appendix G
	Impacts on the Pilliga State Forest, including impacts on conservation and recreational values.	Appendix F & Appendix G
	Measures taken to avoid, reduce or mitigate impacts on biodiversity.	Section 5 and Section 6

2 Existing environment

2.1 Pilliga Forest

The Pilliga Forest represents the largest block of remnant vegetation in NSW, west of the Great Dividing Range. The Pilliga Forests are comprised primarily of State Forests managed for timber production, as well as conservation reserves and other landholdings. There are 24 State Forests within the study region, with the Dewhurst 26-31 pilot being located within the Pilliga East State Forest. There are four National Parks, two Aboriginal Areas, six State Conservation Areas and two Nature Reserves within the study region. The study area does not intersect any of these conservation reserves.

The Pilliga Forests have the following conservation values (NPWS 2000):

- Contain provisionally identified wilderness areas that are important recharge areas for the Great Artesian Basin and represent important areas for carbon recycling.
- Support areas of "old growth" not surviving in other locations.
- Represent significant and intact refugia within the region.
- Contain high levels of biodiversity, due to its location between the dry inland (Eyrean) and wetter coastal (Bassian) zones.
- Contain at least one endemic species, *Pseudomys pilligaensis* (Pilliga Mouse). However, it is important to note that the Pilliga Mouse is now considered a southern population of the widespread *Pseudomys delicatulus* (Delicate Mouse) based on genetic analyses, morphological studies and recent surveys which revealed a continuous distribution of the Delicate Mouse to the Pilliga region (Breed and Ford 2007; Ford 2008, as cited in SEWPaC 2011). It is important to note that this taxonomic change has not yet been formally recognised; hence this assessment considers the Pilliga Mouse as currently listed.
- Contain threatened ecological communities.
- Contain a high diversity of threatened flora and fauna species.
- Contain large populations of threatened species, such as *Ninox connivens* (Barking Owl), *Nyctophilus corbeni*) (South-eastern Long-eared Bat), *Polygala linariifolia* (Native Milkwort), *Rulingia procumbens* and *Philotheca ericifolia.*
- Provide habitat for species and populations that have become isolated due to the fragmentation of forest in the bioregion.

The Pilliga Forests have been variously disturbed by a long history of forestry, fire and small-scale agriculture. Existing forestry tracks and fire trails (both formal and informal) form a fragmented network across the study region. There are however still large patches (>1,000 ha) of contiguous vegetation that have not been dissected by forestry activities. Dewhurst 30 & 31 are located within the Pilliga East State Forest, while the Dewhurst 13 – 18H pilot is located on private and Crown land.

2.2 Landscape context

2.2.1 The Brigalow Belt South Bioregion

Location and bioregional provinces

The Pilliga Forests and the study region are located within the southern part of the Brigalow Belt South Bioregion. This bioregion extends over NSW and Queensland, with the majority occurring in Queensland. In NSW, the bioregion covers an area of 52,409 km², which represents 18.7% of the total bioregion (NPWS 2000).

The Brigalow Belt South Bioregion shares its borders with five other bioregions: the Nandewar and North Coast Bioregions to the east, the Sydney Basin and South Western Slopes Bioregions to the south, and the Darling Riverine Plains Bioregion to the west. Within the NSW section of the Brigalow Belt South Bioregion, major towns include Baradine, Binnaway, Coonabarabran, Dubbo, Gunnedah, Merriwa, Moree and Narrabri. Major rivers include the MacIntyre, Gwydir, Namoi, Castlereagh, Goulburn, Talbragar and Macquarie Rivers (NPWS 2000; 2010).

The Brigalow Belt South Bioregion is divided into seven provinces in NSW: Northern Outwash, Liverpool Plains, Pilliga Outwash, Liverpool Range, Northern Basalt, Pilliga, and Talbragar Valley. Of these, the proposed activity is situated in the Pilliga and Pilliga Outwash provinces (southern and northern portions of the proposed activity, respectively (**Figure 3**). These provinces are characterised by occurring on Mesozoic bedrock containing extensive sandstone hills and coarse sandy soils (Pilliga), and on the plains of deep sandy texture dominated by alluvial and colluvial sediments (Pilliga Outwash) (NPWS 2000).

The Pilliga sandstones over which the study area lies form the intake area and aquifer beds in NSW for the Great Artesian Basin. The alluvial soils of the Namoi River and its larger tributaries are an important source of groundwater (NPWS 2000).

2.3 Land use

Within the NSW section of the Brigalow Belt South Bioregion, the majority of land (approximately 85%) is freehold land. Much of the freehold land is used for agricultural purposes, where cropping (dryland and irrigation farming) and grazing/pastoral activities dominate (NPWS 2000).

Approximately 11% of the NSW sections of the bioregion are used by the forestry industry. Goonoo Forest and Pilliga Forests managed by Forests NSW are the two largest areas of forestry in the NSW sections of the bioregion. There are many small forest and flora reserves in addition to these forests.

Crown lands and conservation reserves form approximately 4% of the bioregion in NSW. Other land uses within the bioregion include mining and apiary industries (NPWS 2000). The mining industry is based mainly on coal, as the region lies mostly within the Gunnedah Basin, which is a major coal-bearing sedimentary basin. Current mining titles are held for coal and some industrial minerals while exploration titles are held for coal, petroleum, gold, base metals, zeolites and clay minerals (NPWS 2010).

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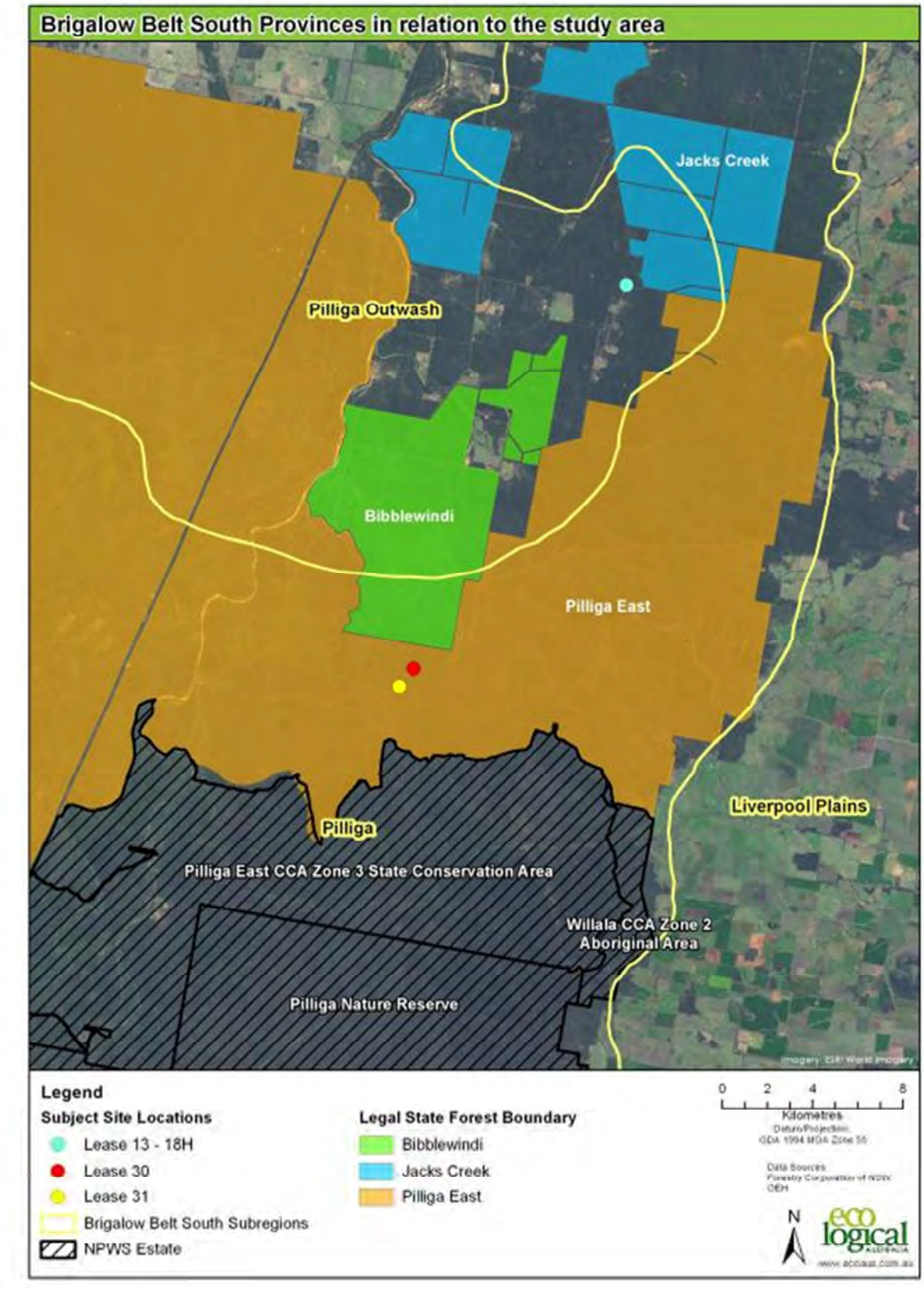


Figure 3: Brigalow Belt South Provinces in relation to the study area

2.4 Mitchell landscapes

Mitchell Landscapes are a system of ecosystem classification mapped at the 1:250,000 scale, based on a combination of soils, topography and vegetation (DECC 2008). Mitchell Landscapes are used in regional conservation planning in NSW and form a component of the BioBanking Assessment Methodology (BBAM). Two Mitchell Landscape have been mapped in the study area (**Table 2** and **Figure 4**).

Table 2: Mitchell Landscapes within the study area

Mitchell landscape	Landscape description (Mitchell 2002)	Location
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. A few patches of heavy clay. General elevation 400 to 550m, local relief 50m. On sandstone, the ridge tops have thin discontinuous soils with stony, sandy profiles and low nutrients. Down slope texture-contrast soils are more common typically with harsh clay subsoils and in the valley floors sediments tend to be sorted into deep sands with yellow earthy profiles, harsh grey clays, or more texture-contrast soils with a greater concentration of soluble salts. The sandstone outcrop areas support various forests and woodlands including; *E. nubila* (Blue-leaved Ironbark), *E. rossii* (Inland Scribbly Gum), *C. endlicheri* (Black Cypress Pine), *Atalaya hemiglauca* (Whitewood), and *Angophora floribunda* (Rough-Barked Apple). Stony hills in the north of the region carry mallee patches with; *E. melanophloia*, *Corymbia maculata* (Spotted Gum), and *A. leiocarpa* (Smooth-barked Apple). Gentler sandstone slopes over most of the region carry; *E. crebra* (Narrow-leaved Ironbark), *C. glaucophylla*, *E. macrorhyncha* (Red Stringybark), patches of *E. viridis* (Green Mallee) and *Melaleuca uncinata* (Broombush) heath. In western and northern sections on texture-contrast or more uniform harsh clay soils forests of *E. pilligaensis*, *E. microcarpa* (Grey Box), *E. populnea*, and *E. conica* (Fuzzy Box) are found with stands of *Allocasuarina. luehmannii*, *Alectryon oleifolium* (Rosewood), *Atalaya hemiglauca*, *Geijera parviflora* (Wilga), *Casuarina cristata* (Belah), *Acacia homalophylla* (Yarran), and *Eremophila mitchellii* (Budda).	Extends over Dewhurst 30 & 31
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 (sand monkeys), patches of heavy grey clay, and contemporary incised stream channels. General elevation 200 to 280m, local relief 5 to 9m. Deep texture-contrast soils with harsh clay subsoils, grey clay with gilgai. Open forest of *C. glaucophylla*, *E. populnea*, *E. pilligaensis*, *E. blakelyi* and *E. sideroxylon*. *Corymbia trachyphloia* (Brown Bloodwood) and *Xanthorrhoea* sp. (Grass Trees) on sand monkeys (abandoned stream channels). Patches of *Allocasuarina luehmannii* (Bull Oak) or *Acacia harpophylla* (Brigalow) on gilgai in heavy clay. *E. chloroclada* (Dirty Gum) and *E. camaldulensis* in creek lines.	Extends over Dewhurst 13-18

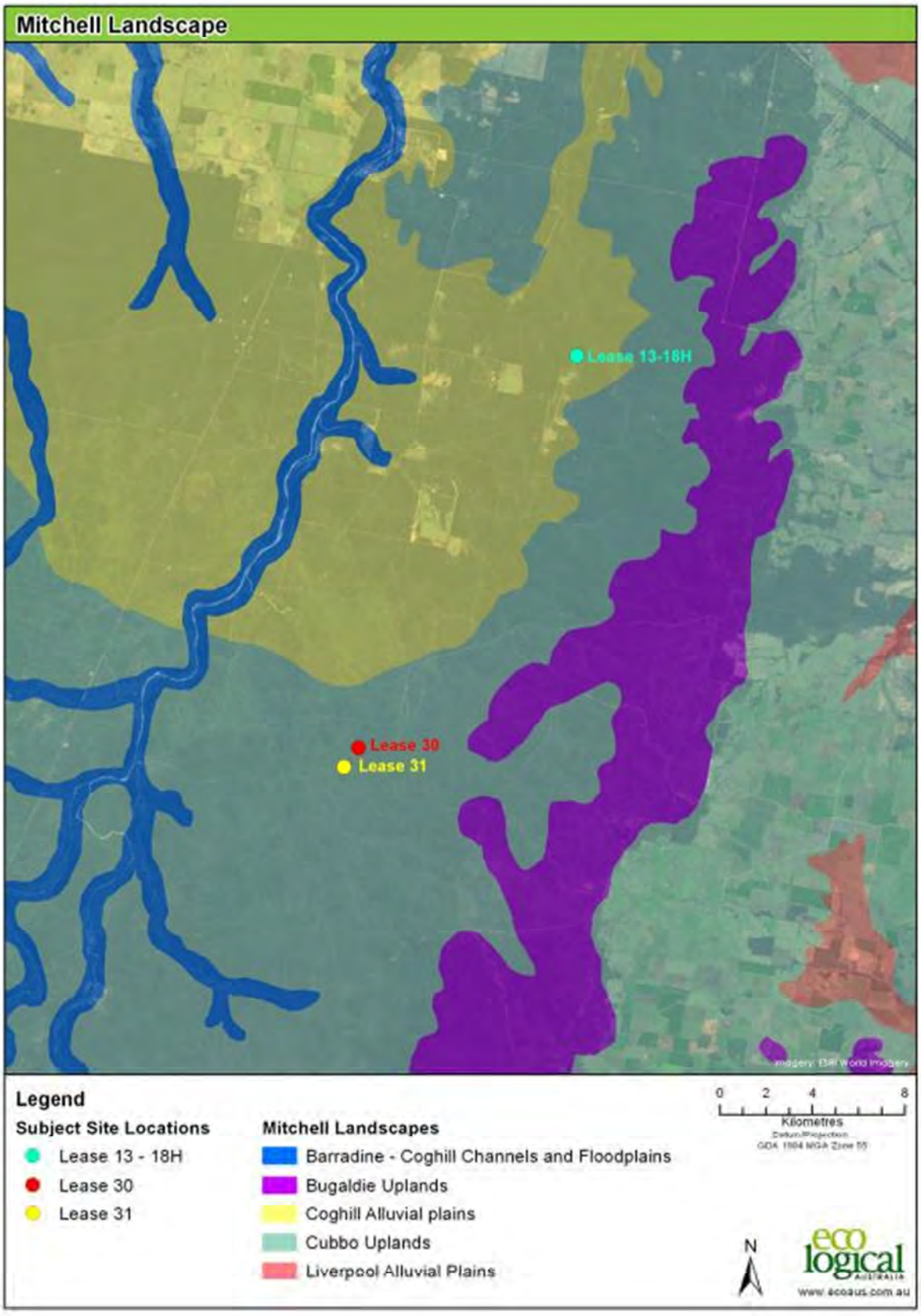


Figure 4: Mitchell Landscapes

2.5 Geology

The study area is underlain by a geological formation described as the Orallo Formation (often referred to as Keelindi Beds), consisting of Clastic sediment, Colluvial polymictic gravel, sand, silt and clay. The study area may include some alluvial *in situ* regolith deposits with fine to coarse grained quartzose sandstone, pebbly sandstone and conglomerate interbedded with minor shale (DMR 2002).

2.6 Climate

The Brigalow Belt South Bioregion is located within an ecological gradient, or ecotone, between the dry inland or Eyrean zone and the wetter coastal or Bassian zone. Within the south eastern section of the bioregion where the study area is located, the climate is classed as subhumid: there is no dry season and the area experiences hot summers (NPWS 2000).

Substantial rainfall can occur at any time of the year but there is a peak in summer and a smaller peak in winter. In summer, high intensity rain or thunderstorms can cause significant erosion. Evaporation rates are high in summer and often exceed precipitation rates, so the net penetration of rainfall is greater in winter than in summer (NPWS 2000). Mean annual rainfall in the NSW section of the Brigalow Belt South Bioregion varies from 550 mm in the west (in Gilgandra) to 823 mm on the east of the bioregion (at Murrurundi). On the north-south gradient, mean annual rainfall is 587 mm in Dubbo, 651 mm at Narrabri, and 659 mm on the Queensland border (at Texas).

Temperatures vary with altitude throughout the bioregion and have large daily variation (daily maximum can reach 45 °C in summer and stay above 40 °C for several days, and minimum temperatures can be as low as -9 °C). However, mean monthly temperatures (based on 6 weather stations in NSW) range from a maximum of 33 °C in January to a minimum of 3 °C in July (NPWS 2000).

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3 Methods

3.1 Database review

A number of key datasets and mapping were available to determine ecological values and constraints within the study region. These included:

- NPWS BioNet Database (Atlas of NSW Wildlife) (OEH 2013a)
- EPBC Act Protected Matters Search Tool (DoE 2013a)
- NSW geology mapping (DMR 2003)
- ELA drainage mapping
- Namoi CMA vegetation mapping (ELA 2009)
- Namoi CMA wetland mapping (ELA 2008)

High resolution aerial photographs and high resolution surface contours (captured through LiDAR) of the study region were also used to investigate the extent of vegetation cover, landscape features and disturbance patterns in the area.

Databases and maps were searched for state and federally listed threatened species, populations and Threatened Ecological Communities (TECs). Searches were conducted for a 50 km area around the study area due to an initial paucity of records within a 10 km area surrounding the proposed activity. It is noted that this large search area included regions of different topography, geology and climate, and thus species that will not have suitable habitat in the study area.

3.2 Literature reviewed

A number of additional ecological impact assessments, and flora and fauna surveys conducted in the north-east Pilliga Forest, were also reviewed for records of threatened vegetation communities and flora and fauna species occurring in the study area. These flora and fauna assessments and surveys are listed below:

- Dewhurst 26 – 29, *Pseudomys pilligaensis* (Pilliga Mouse) Assessment of Significance, Prepared for Santos Limited (ELA 2013a)
- Dewhurst 26 – 29 Pilot Wells, PEL 238, Narrabri – Ecological Assessment, Prepared for Santos Limited (RPS 2013)

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3.3 Field survey

The field survey was undertaken in a two part process with initial surveys undertaken by RPS and subsequent field surveys completed by ELA. RPS conducted ecological surveys for Dewhurst 26-29 in 2012 which are located directly adjacent to Dewhurst 30 and 31 (RPS 2013). Due to the location of these surveys and their relevance to the current study, the survey effort undertaken by RPS has been closely integrated into this study. The fauna survey effort and results obtained by RPS have been included in this assessment.

The RPS field surveys were conducted between 12 November and 16 November 2012. The subsequent ELA field surveys were undertaken between 25 and 30 August 2013 for a total of approximately 104 person hours.

The ELA survey was conducted by eight ELA ecologists in four teams of two. The field staff included senior ecologists Peter Knock, Martin Sullivan and Will Introna and ecologists Andrea Sabella, Kurtis Lindsay, Emily Southwell, Daniel McKenzie and Ben Martin. A summary of field survey effort is provided in **Table 3.**

ELA has conducted extensive fieldwork within the vicinity of the study area between 2010 and 2013 as part of ongoing investigations into the biodiversity values of the north-east Pilliga Forest. Results from these studies have been used in this report where applicable.

Table 3: ELA field survey effort

Survey method	ELA person hours
Flora survey	8
Habitat Assessment	6
Bat survey	30
Remaining fauna survey	60

During the RPS survey (2012), temperature ranged from 9.2 to 37.3 degrees Celsius (°C) and conditions were fine with moderate winds. During the ELA survey period (2013), temperature ranged from 1.8 to 29 °C and conditions were fine with little wind or cloud cover (**Table 4**).

Table 4: Weather conditions during field surveys

Date	Minimum daily temperature (°C)	Maximum daily temperature (°C)	Daily rainfall (mm)
12 November 2013	9.2	30.3	0
13 November 2013	17.5	33.6	0
14 November 2013	16.0	36.2	0
15 November 2013	17.0	37.3	0
16 November 2013	18.2	29.1	0
26 August 2013	1.8	24.4	0
27 August 2013	4.4	25.7	0
28 August 2013	5.5	25.9	0

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Date	Minimum daily temperature (°C)	Maximum daily temperature (°C)	Daily rainfall (mm)
29 August 2013	6.8	27.6	0
30 August 2013	16.0	29.0	0

Source: Bureau of Meteorology (BoM): http://www.bom.gov.au/climate/data/index.shtml Narrabri Weather Station 054038

3.3.1 Vegetation

The vegetation survey involved validating the mapped vegetation communities, delineating the boundaries of mapped vegetation and assessment of community condition. Vegetation quadrats and transects were undertaken by ELA botanists at each pilot well following the BBAM.

Quadrats included 0.04 ha (20 m x 20 m) surveys to record the presence of visible vascular flora species, along with cover and abundance for each species using a modified Braun-Blanquet scale (measures of cover and abundance taken to determine species dominating each stratum). Vegetation structure and fauna habitat features were determined over 0.1 ha survey (50 m x 20 m quadrats); measures included number of hollow bearing trees and length of fallen dead timber greater than 10 cm diameter. Within the 0.1 ha quadrats, projected foliage cover of each strata level and exotic flora was assessed along a 50 m transect.

The physical characteristics (such as aspect, slope and disturbance) of each location were noted and photos were taken of the quadrats along the 50 m transect line as well at points along the random meander traverses for threatened flora species. Species were identified to the lowest taxonomic level possible, following the Flora of NSW (Harden 1992-2002) and NSW Flora online (www.plantnet.rbgsyd.nsw.gov.au). Quadrat locations are shown in **Figure 5**.

3.3.2 Targeted threatened flora survey

The survey involved two ELA botanists traversing the study area on foot walking approximately 10 m apart along transects. Transects were repeated until the entire study area was considered adequately traversed. The location of all threatened flora individuals located within the study area was recorded using a Personal Digital Assistant (PDA) with a Global Positioning System (GPS) accuracy of 3 m. Where records for threatened flora existed within or in proximity to the study area, these areas were visited to determine the flowering status of the species. Species predicted to occur in the study area are outlined in **Table 5.** Survey effort for the targeted threatened flora survey is shown in **Figure 5.**

Results from previous surveys have also been used in this assessment (ELA 2012).

Table 5: Threatened flora species targeted during field survey

Scientific name	Common name	Status	
		TSC Act	EPBC Act
Bertya opponens	Coolabah Bertya	V	V
Cyperus conicus		E	
Diuris tricolor	Pine Donkey Orchid / Painted Diuris	V	Delisted
Homopholis belsonii	Belson's Panic	E1	V
Philotheca ericifolia		Delisted	V
Polygala linariifolia	Native Milkwort	E	~
Pomaderris queenslandica	Scant Pomaderris	E	~
Pterostylis cobarensis	A Greenhood Orchid	V	V

Scientific name	Common name	Status	
		TSC Act	EPBC Act
Rulingia procumbens		V	V
Tylophora linearis		V	E

3.3.3 Hollow bearing trees

Searches for hollow-bearing trees (HBTs) followed similar methodology undertaken for threatened flora species (**Section 3.3.2**) within the study area. All Hollow Bearing Trees (HBT's) observed were recorded with a PDA of 3 m accuracy and later mapped. Survey effort for HBT's is shown in **Figure 5**.

3.3.4 Fauna survey effort

The fauna survey was designed to target key threatened fauna species identified as having suitable habitat within the study area. Surveys followed recommended survey methods and habitat stratification procedures of the draft *Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004) and relevant EPBC survey guidelines (SEWPaC 2010a, SEWPaC 2010b, SEWPaC 2011). Survey effort for fauna stratified by habitat type as per the DEC (2004) guidelines is shown in **Appendix H**. This assessment includes survey effort undertaken by ELA and RPS (**Figure 6** and **Figure 7**).

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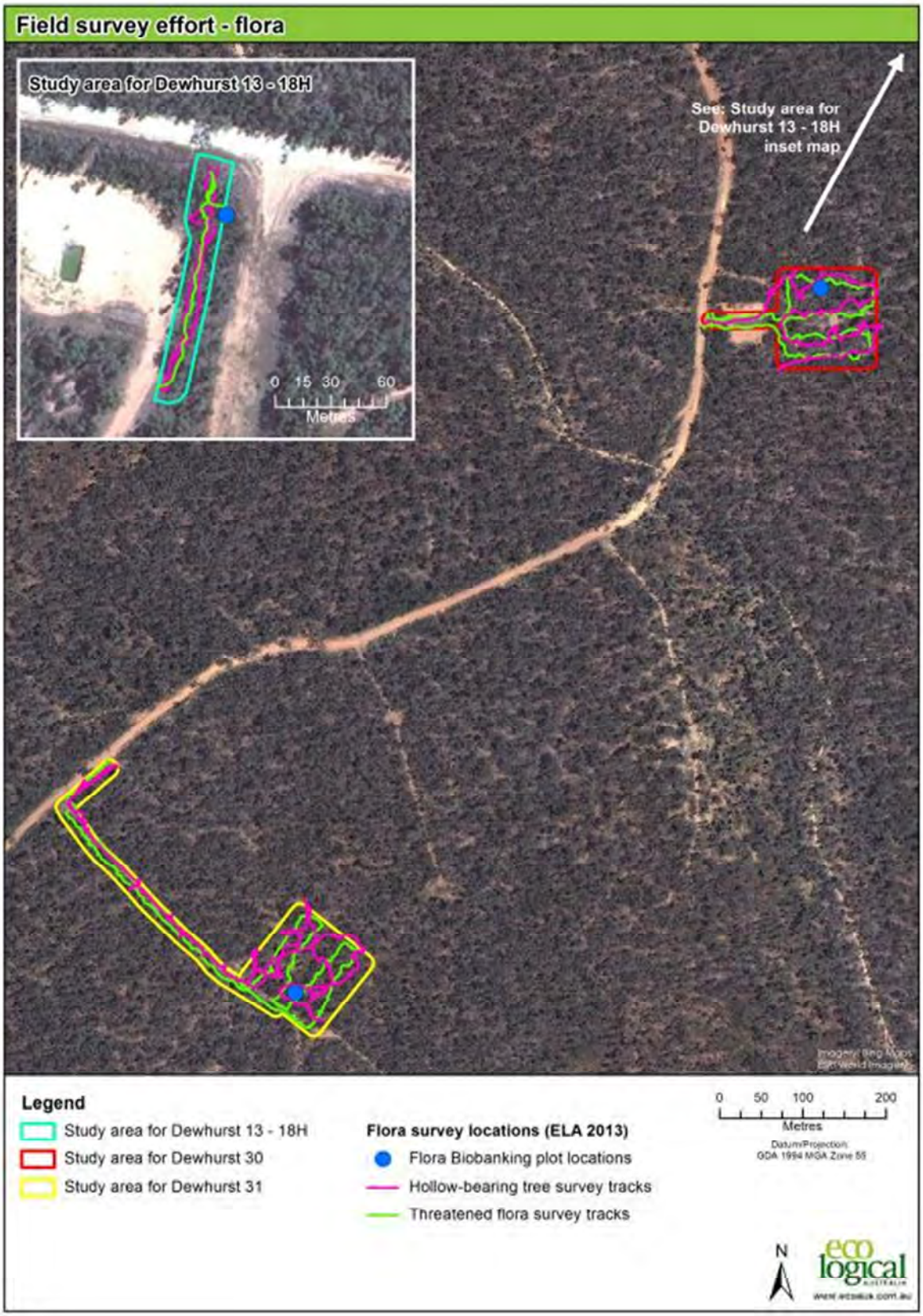


Figure 5: Field survey effort- flora

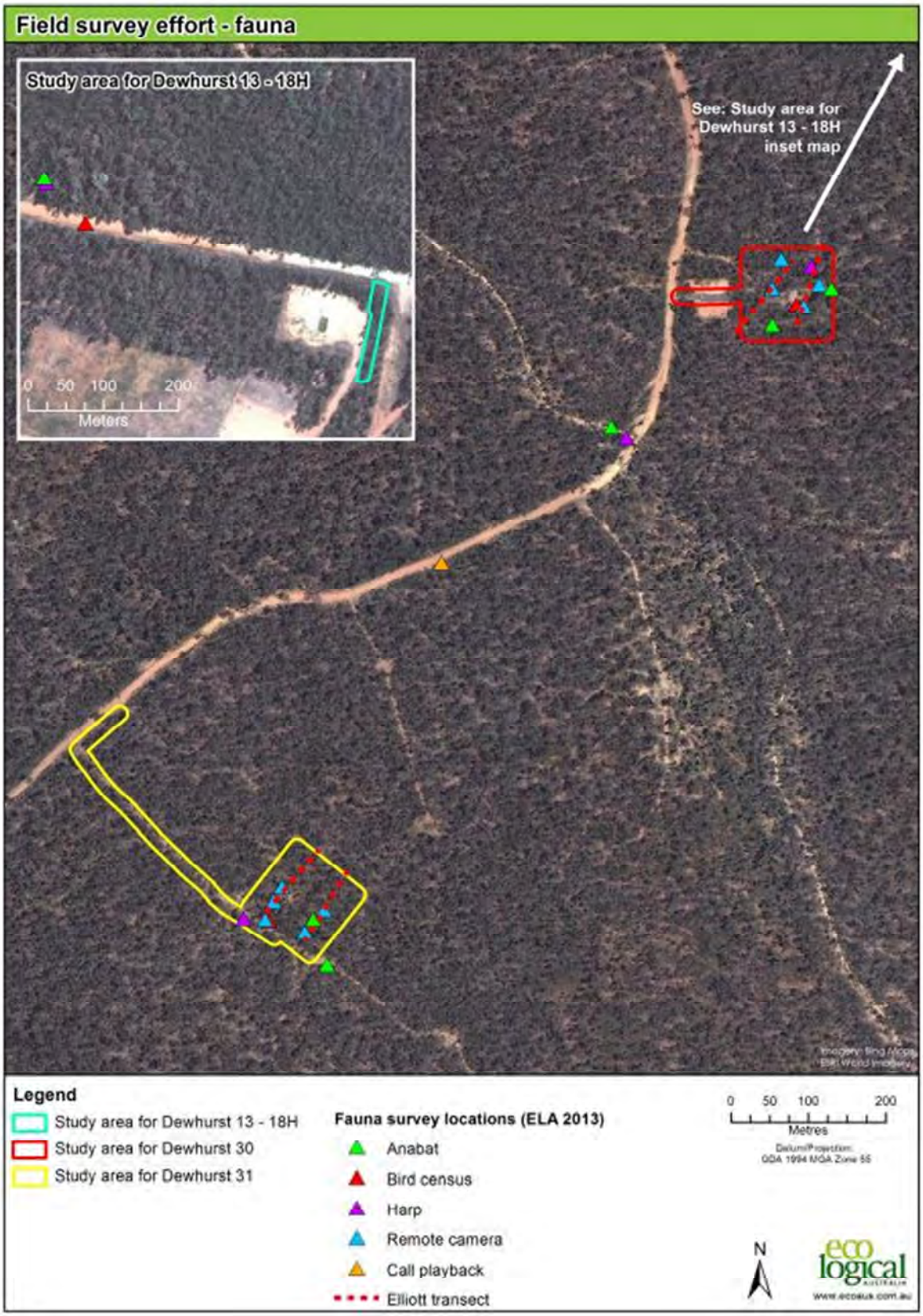


Figure 6: Field survey effort - fauna

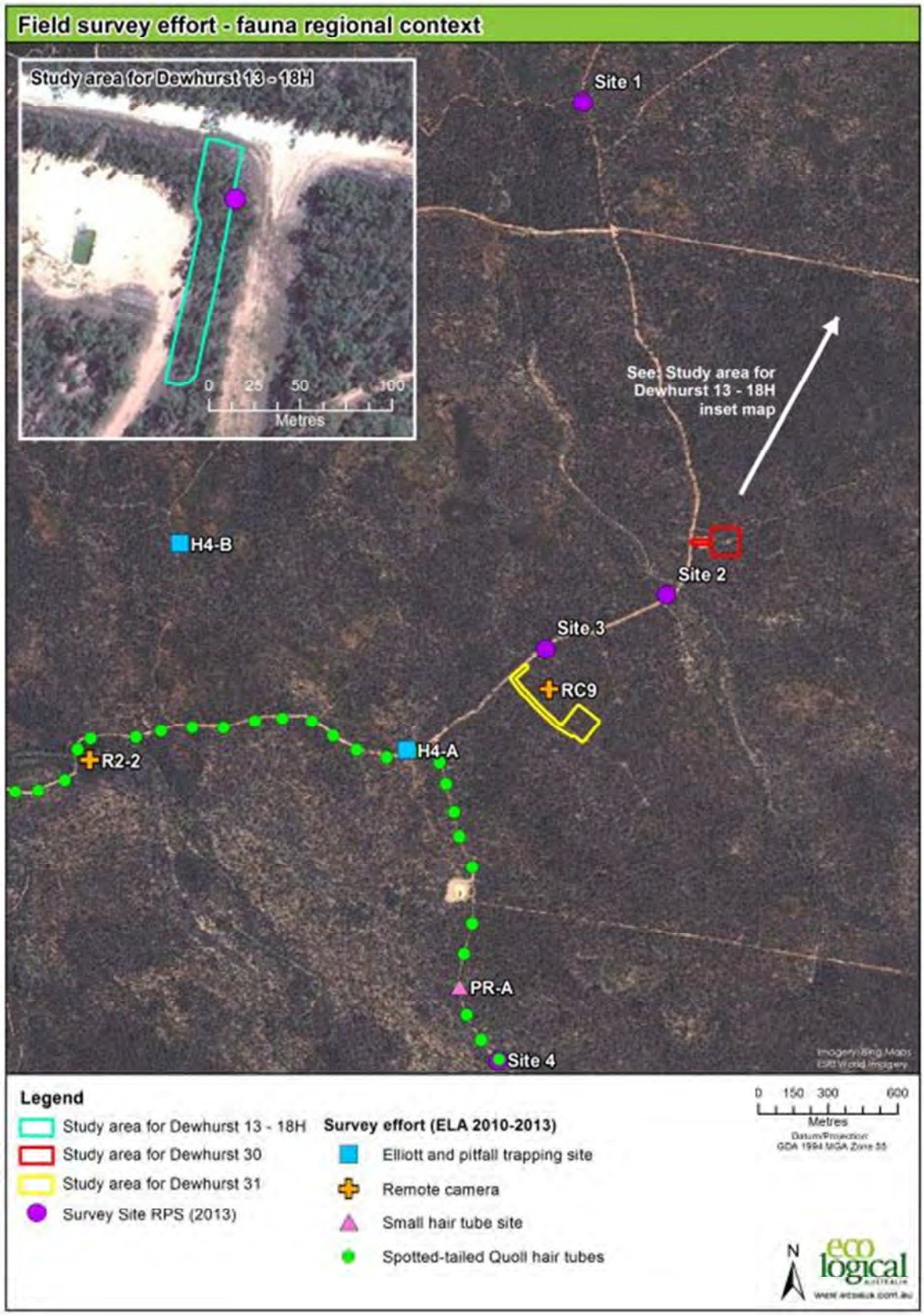


Figure 7: Regional survey locations - fauna

3.3.5 Habitat assessment

A habitat assessment was conducted for all survey sites by RPS. Data collected included the amount of foraging substrate (sap trees, blossoms, she-oaks, acacias) for fauna, the presence of sheltering resources (trees with hollows, shrub and ground layer, fallen logs, and rocks) and the level of disturbance from tracks, fire, grazing, logging, weeds, introduced fauna and rubbish.

3.3.6 Mammal survey (non-flying small and medium sized mammals)

The active and passive survey techniques used to detect small and medium sized mammal species are outlined in the sections below. Survey techniques employed were terrestrial and arboreal Elliott A and B traps, terrestrial Elliott E traps, pitfall traps and remote cameras.

Terrestrial trapping

Terrestrial trapping was undertaken by RPS using 73 Elliott A traps, seven Elliott B traps, nine Elliott E traps, 14 snake funnel traps, four camera traps, 40 hair funnels and 15 pitfall traps set over three, four or five nights.

Elliott traps were baited with a mixture of rolled oats and peanut butter, except for half the Elliot B traps which were baited with a mixture of sardines and flour. Traps were checked early each morning and any captures were identified and immediately released at the point of capture. All bait was collected each morning and traps were closed for the day and then re-baited each evening.

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 and hair funnels targeted larger mammals (e.g. bettongs).

Terrestrial trapping was undertaken by ELA using 50 Elliott B traps. Twenty five traps were set up at both Dewhurst 30 and Dewhurst 31 study areas. Traps were placed at the base of shrubs, trees or along fallen logs. All Elliott traps were baited with a mixture of rolled oats, peanut butter and honey.

The trap lines were set for four consecutive nights from 26 to 30 August 2013 at both Dewhurst 30 and 31. The numbers of trap nights per site are shown in **Table 6**. Survey and trap locations are shown in **Figure 6**. Traps were checked by two people from 0630 hrs, with checks completed by 0900 hrs. Any mammals caught were identified to species level.

Within 2 km of the study area, two previous terrestrial Elliott and pitfall trapping sites (H4-A and H4-B), one previous small hair tube site (PR-A) and one previous large hair tube transect (R2-2) were installed by ELA (**Figure 7**). These sites were part of a survey targeting Pilliga Mouse and were undertaken in between 5 May and 1 June 2013. At each Elliott and pitfall trapping site, 36 Elliott traps were placed in a grid of 6 x 6 traps, spaced approximately 10 metres apart. Grids included twenty-eight standard A-size Elliotts and eight smaller E-size Elliotts. Traps were baited with rolled oats, peanut butter and honey and set for four or five nights. Traps were checked over four or five mornings. Weight, head and rear pes of captured animals were measured and photos were taken. Any animals captured were released on the morning of capture.

Pitfalls traps were set at the same sites as the Elliotts. Three separate pitfalls were located adjacent to each Elliot trap grid. Pitfall traps were located approximately 10 – 20 m from each other and consisted of PVC tubing (30 – 50 cm depth) with 5 – 10 m of drift fences each. Traps were checked over four or five mornings. Any animals captured were released on the morning of capture. Weight, head and rear pes of captured animals were measured and photos were taken. Any animals captured were released on the morning of capture.

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At the small hair tube site, 20 small (30 mm diameter) hair tubes were set in 4 transects of 5 hair tubes. Two transects were placed on opposite sides of and perpendicular to a road, approximately 10 – 20 metres apart. Hair tubes within each transect were set approximately 10 metres apart. All hair tubes were baited with rolled oats, peanut butter and honey and set for 19 nights.

A transect of 40 large (90 mm diameter) hair tubes were installed approximately 100 m apart. All hair tubes were baited with pilchards, tuna oil and flour and were set for 25 nights, with a total effort of 600 trap nights. The transect traversed habitat similar to study area.

Arboreal trapping

ELA surveys involved six A and six B-sized Elliott traps (tree mounted) and 25 B-sized Elliott traps (ground traps) set at both Dewhurst 30 and 31. At each site, traps were set in two line transects spaced approximately 50 m apart, with each trap approximately 10-15 m apart.

Tree-mounted Elliott traps were mounted on wooden platforms attached to tree trunks 2 to 2.5 m above ground level. All Elliott traps were baited with a mixture of rolled oats, peanut butter and honey. A honey and water mixture (approximately 1:5 ratio) was sprayed on tree trunks where tree-mounted Elliott traps were positioned as a lure.

The terrestrial and arboreal trap lines at Dewhurst 30 and the terrestrial Elliott B trap lines at Dewhurst 31 were set for four consecutive nights from 26 to 30 August 2013. The Elliott A arboreal traps at Dewhurst 31 were set for three consecutive nights due to time constraints setting up the site (**Figure 6**). This survey effort satisfies the draft *Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004). The numbers of trap nights per site are shown in **Table 6**.

Traps were checked by two ecologists from 0630 hrs, with checks completed by 0900 hrs. Any mammals caught were identified to species level.

Table 6: Details of Elliott trapping survey details

Site	No. of survey nights	Number of trap nights per trap type						Total no. of trap nights	
		Elliott A: tree-mounted	Elliot A: ground	Elliott B: tree-mounted	Elliott B: ground	Elliot E: ground	Hair funnels	Arboreal	Terrestrial
Dewhurst 30	3-4	18	0	24	100	0	0	42	100
Dewhurst 31	4	24	0	24	100	0	0	48	100
Site 1 (RPS 2012)	4	0	0	0	6	0	30	0	36
Site 2 (RPS 2012)	4	0	65	0	5	14	50	0	134
Site 3 (RPS 2012)	4	0	60	0	6	6	30	0	102
Site 4 (RPS 2012)	4	0	60	0	0	6	0	0	66
Site 5 (RPS 2012)	4	0	77	0	8	8	40	0	133

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Site	No. of survey nights	Number of trap nights per trap type						Total no. of trap nights	
		Elliott A: tree-mounted	Elliot A: ground	Elliott B: tree-mounted	Elliott B: ground	Elliot E: ground	Hair funnels	Arboreal	Terrestrial
Total number of trap nights		**42**	**262**	**48**	**225**	**34**	**150**	**90**	**671**

Remote camera

The RPS survey installed four motion activated remote cameras over 60 trap nights, targeting terrestrial fauna. The ELA survey installed nine motion activated remote cameras that were attached to trees and placed facing tree mounted Elliott traps within the study area. Remote cameras, configured to take three photos on detecting movement were set on the 26 August 2013, and were left undisturbed for four nights. The photographs from the cameras were analysed by ELA ecologist Dr Rodney Armistead.

Two remote cameras were previously installed by ELA within 2 km of the study area (R2-2 and RC9). One was in riparian woodland and baited with fish and the second was in habitat similar to that in the study area and baited with oats, peanut butter and honey (**Figure 7**).

The total effort of remote camera surveys is presented in **Table 7**.

Table 7: Remote camera survey details

Site	No. of trap nights
Dewhurst 30	16
Dewhurst 31	20
Site 1 (RPS 2012)	12
Site 2 (RPS 2012)	20
Site 3 (RPS 2012)	12
Site 4 (RPS 2012)	0
Site 5 (RPS 2012)	16
Riparian 2-2 (ELA 2013 – not yet reported on)	20
RC9 (ELA 2011 – not yet reported on)	8
Total number of trap nights	**96**

3.3.7 Microbat survey

Microbat species were surveyed by using harp traps and through Anabat detection. Harp traps were installed by ELA and were placed in flyways that were likely to be used by bats. Harp traps were assembled just prior to dusk and checked each morning before 0930 hrs. The harp traps were set for two consecutive nights from 26 to 28 August 2013 at Dewhurst 30 and 31 and from 28 August to 30 August at Dewhurst 13 – 18H. Any bats caught were identified to the lowest taxonomic level possible, kept in canvas bags during the day (which were left hanging in the cool of an air-conditioned or ventilated vehicle out of direct sunlight followed by indoors in a cool, ventilated area), and released at the point of capture at dusk. **Table 8** details site locations and number of harp traps used. The locations of the harp traps are shown in **Figure 6.**

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Microbats were also surveyed for using Anabat detectors equipped with ZCAIM recording devices by both RPS and ELA. RPS surveys involved placing an Anabat detector for one to two nights in suitable flyways located adjacent to two survey sites. 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 in the morning after sunrise.

Anabat detectors were set by ELA for two consecutive nights from 26 to 28 August 2013 and placed in flyways that were likely to be used by bats (**Figure 6**). **Table 8** details site locations and number of Anabat detectors used. On each night of survey the Anabats were turned on time-delayed recording prior to dusk and then turned off the following morning by 0930 hrs.

Anabat call identification of RPS data was analysed by Greg Ford of Balance Environmental, who 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 (1998).

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. Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (1998) and Van Dyck & Strahan (2008).

Anabat call identification of ELA data was analysed by Alicia Scanlon (ELA bat call analysis specialist). Analysis assigned bat calls to four levels of confidence as per Mills *et al.* (1996): definite, probable, possible, and unknown. Definite calls were calls of bat species that were not in doubt, probable calls were those calls of bat species with a low probability of confusion with species of similar calls, possible calls were calls of bat species with a medium to high probability of confusion with species of similar calls, and unknown calls were calls of bat species which could not be identified to even a species group.

Table 8: Details of microbat survey site locations

Site	Number of Anabat detector trap nights	Number of harp trap nights
Dewhurst 30	4	2
Dewhurst 31	4	2
Midway 30 & 31	2	2
Dewhurst 13-18H	2	2
RPS sites	2 - 4	0
Total number of trap nights	**14 – 16**	**8**

3.3.8 Diurnal bird survey

Two sites were surveyed by RPS, with one AM (four hours after sunrise) and one PM (four hours before sunset) survey undertaken at each site. Each survey consisted of a 30 minute survey identifying birds by direct observation or by recognition of calls or distinctive features such as nests, feathers and owl pellets.

Three sites were surveyed for birds by two ELA ecologists, one AM and one PM survey at Dewhurst 30 and Dewhurst 13-18H and one AM survey at Dewhurst 31 between 25 and 30 August 2013 (**Figure 6**). Each survey consisted of an initial 20 minute census recording all bird calls and observations. If new species are added to the list in the last 5 minute period of the survey, an extra five minutes of survey is

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undertaken. This method was repeated to make a species-time curve until no new species were identified. All bird calls and observations were recorded.

Opportunistic survey was also undertaken for the duration of the field assessments by both RPS and ELA.

The total amount of survey effort for diurnal bird surveys is presented in **Table 9**.

Table 9: Diurnal bird survey effort

Site *	Number of surveys	Person hours
Dewhurst 30	2	1.5
Dewhurst 31	1	0.67
Dewhurst 13-18H	2	1.67
RPS sites	4	2
Total	**9**	**5.84**

3.3.9 Spotlighting and call playback

Spotlighting and call playback was conducted to search for nocturnal fauna species. Species targeted during call playback are shown in **Table 10**. Spotlighting by foot or by vehicle and dedicated listening periods for fauna vocalisations were undertaken by RPS over two nights. Spotlighting was conducted by two ELA ecologists over five separate nights on foot for approximately 20 minutes each night.

Call playback and quiet listening was undertaken by two ELA ecologists for approximately 40 minutes (**Figure 6**). Call playback involved playing recorded calls of the targeted threatened fauna species (**Table 10**) over a loudspeaker in an attempt to illicit a response from each species in the study area. A five minute listening period and five minute spotlighting session preceded each call playback event. The call of each species was then broadcast for approximately five minutes with a listening period of five minutes in between each call; this was then followed by a further five to ten minutes of listening for a response and spotlighting.

Table 10: Threatened fauna species targeted during call playback

Scientific name	Common name	Status	
		TSC Act	EPBC Act
Ninox connivens	Barking Owl	V	-
Phascolarctos cinereus	Koala	V	V
Burhinus grallarius	Bush-stone Curlew	E	-
Tyto novaehollandiae	Masked Owl	V	-

3.3.10 Reptile trapping

Reptile trapping was undertaken by RPS and involved 14 snake funnel traps and 15 pitfall traps over three to five nights. The number of trap nights achieved is represented in **Table 11**.

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Table 11: Details of reptile survey effort

Site	Number of trap nights per trap type		Total no. of trap nights
	Snake funnels	Pitfalls	
Site 1 (RPS 2012)	16	12	28
Site 2 (RPS 2012)	20	20	40
Site 3 (RPS 2012)	12	12	24
Site 4 (RPS 2012)	6	9	15
Site 5 (RPS 2012)	16	16	32
Total number of trap nights	**70**	**69**	**139**

3.3.11 Active searches

Active searches were undertaken by RPS at two sites. Broad fauna searches looked for evidence of ground-dwelling mammals (bandicoots, native rats etc.) and were focused around key habitat features, such as extensive grassy ground cover and fallen woody debris, hollow logs and burrows that offer potential suitable shelter.

Reptile searches involved active searches to identify potential habitat for reptile species. Survey techniques employed included:

- Diurnal searches for sheltering or basking reptiles as well as indirect evidence of fauna e.g. tracks scratches, burrows etc.
- Rock, log and debris rolling.
- Spotlight surveys for nocturnally active species.

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4 Results

4.1 Database review

Twenty eight threatened flora species listed under either the TSC Act and/or EPBC Act have been identified through the database review as known or with the potential to occur within a 50 km radius of the study area. The likelihood of these species occurring on site is presented in **Appendix A.**

Eighty nine threatened or migratory fauna species listed under either the TSC Act and/or EPBC Act have been identified through the database review as known or with the potential to occur within a 50 km radius of the study area. An assessment of the likelihood of threatened and migratory species potentially occurring at the study area is presented in **Appendix A.**

4.2 SEPP 44 assessment

An assessment of Koala habitat is required under SEPP 44 for the study area as it is greater than 1 ha, is within an LGA that is listed under Schedule 1 and is being assessed under Part 4 of the EP&A Act. The assessment requires three steps to be addressed:

Step 1: Is the land potential Koala habitat?

The study area does not support any tree species which are listed in Schedule 2 as feed tree species. Therefore, the study area does not constitute potential Koala habitat. No further assessment is required.

4.3 Field survey

4.3.1 Vegetation

Vegetation over the entire study area is consistent with the vegetation community *Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion* (Benson et al. 2006) (**Figure 8**). This vegetation community is commensurate with the BioMetric Vegetation Type *White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion.*

Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest is not commensurate with any Threatened Ecological Communities (TECs) listed under the TSC Act or EPBC Act.

Dominant canopy species include *Eucalyptus crebra* (Narrow-leaved Ironbark)*, Allocasuarina luehmannii* (Bulloke) and *Callitris glaucophylla* (White Cypress Pine). The height of the canopy was variable between 8 m - 20 m with 15 % - 20 % projected foliage cover. The mid storey was sparse with scattered occurrences of *Acacia deanei* subsp. *deanei* (Deane's Wattle), *A. caroleae, Allocasuarina luehmannii* and *Callitris glaucophylla.* The height of the mid storey was between 1 m - 10 m with less than 5 % cover. The ground layer consists of *Panicum decompositum* (Native Millet), *Aristida jerichoensis var. jerichoensis* (Jericho Wiregrass), *Lomandra multiflora* (Many-flowered Mat-rush) and shrubs including *Pultenaea foliolosa* and *A. parviflora* (Coil-pod Wattle). The height of the ground layer was between 0.3 m - 1 m with less than 10 % cover.

Dewhurst 13-18 was observed to be dominated by *Allocasuarina luehmannii* regrowth, Dewhurst 30 is heavily disturbed by previous logging activities and Dewhurst 31 consists of a moderately dense shrub layer however the thin-leaved shrub species create an appearance of sparseness within the site. Weed

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incidence is low across the study area. Occasionally recorded species include *Anagallis arvensis* (Pimpernel), *Opuntia stricta* (Prickly Pear), *Hypochaeris radicata* (Catsear) and *Sonchus oleraceus* (Common Sow-thistle). Prickly Pear is a Class 4 noxious weed under the NW Act and a Weed of National Significance. The legal requirements for Class 4 noxious weeds specifies that "*growth of the plant must be managed in a manner that reduces its numbers, spread and incidence and continuously inhibits its reproduction and the plant must not be sold, propagated or knowingly distributed*".

Results of vegetation surveys are provided in **Appendix B.**

A drainage line runs south-east to north-west between Dewhurst 30 and Dewhurst 31. The drainage line is predominantly of the same vegetation as the study area, however, *E. chloroclada* is scattered along the drainage line.

4.3.2 Targeted threatened flora survey

Three threatened flora species have been recorded within the study area during field investigations:

- *Tylophora linearis*, listed as vulnerable under the TSC Act and endangered under the EPBC Act (three individuals at the Dewhurst 30 subject site).
- *Polygala linariifolia (*Native Milkwort), listed as endangered under the TSC Act (one individual at the Dewhurst 31 subject site).
- *Pterostylis cobarensis* (Greenhood Orchid), listed as vulnerable under the TSC Act and EPBC Act (three individuals at the Dewhurst 30 subject site).

The location of threatened flora species recorded within the study area is shown in **Figure 9**.

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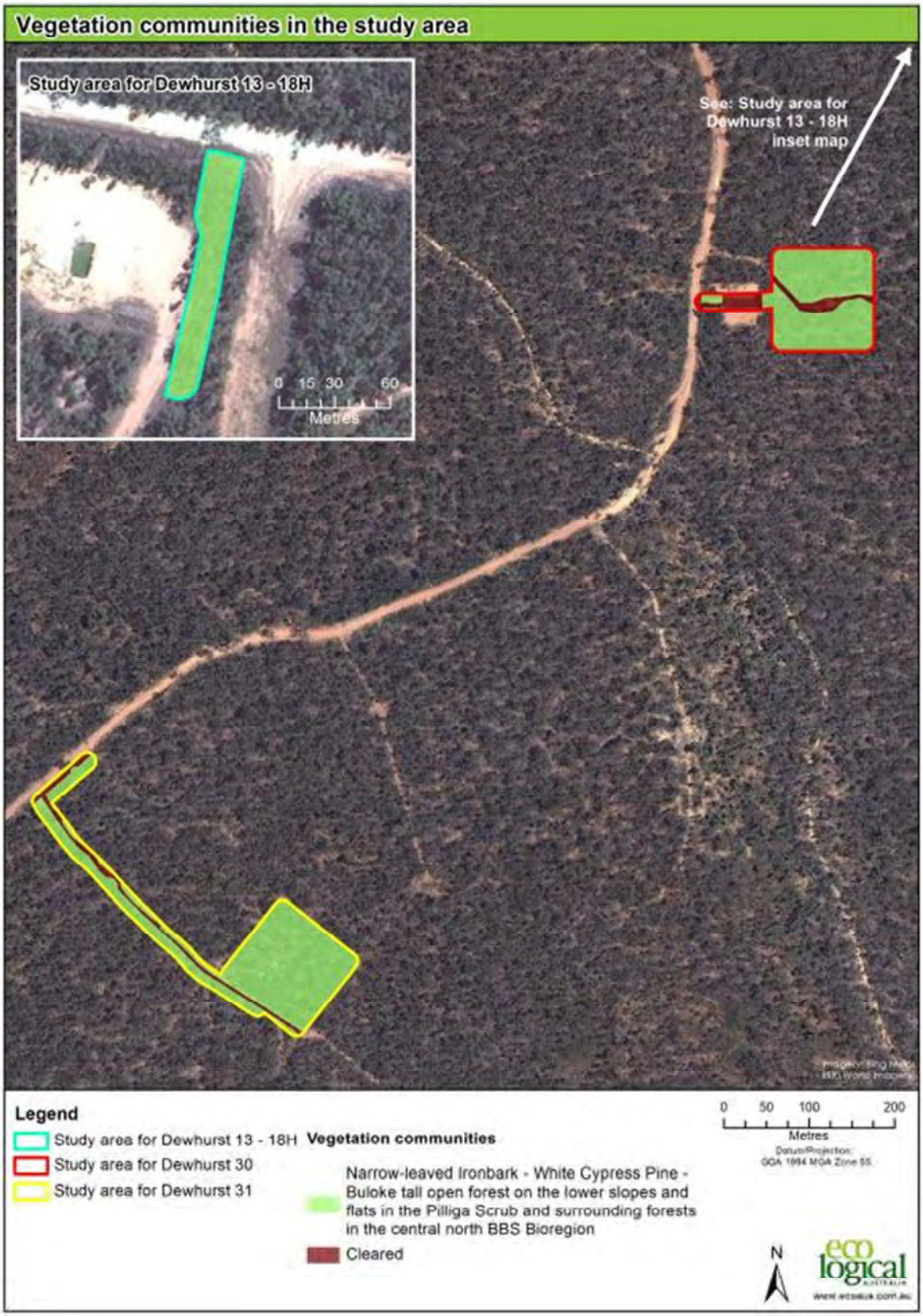


Figure 8: Vegetation communities in the study area

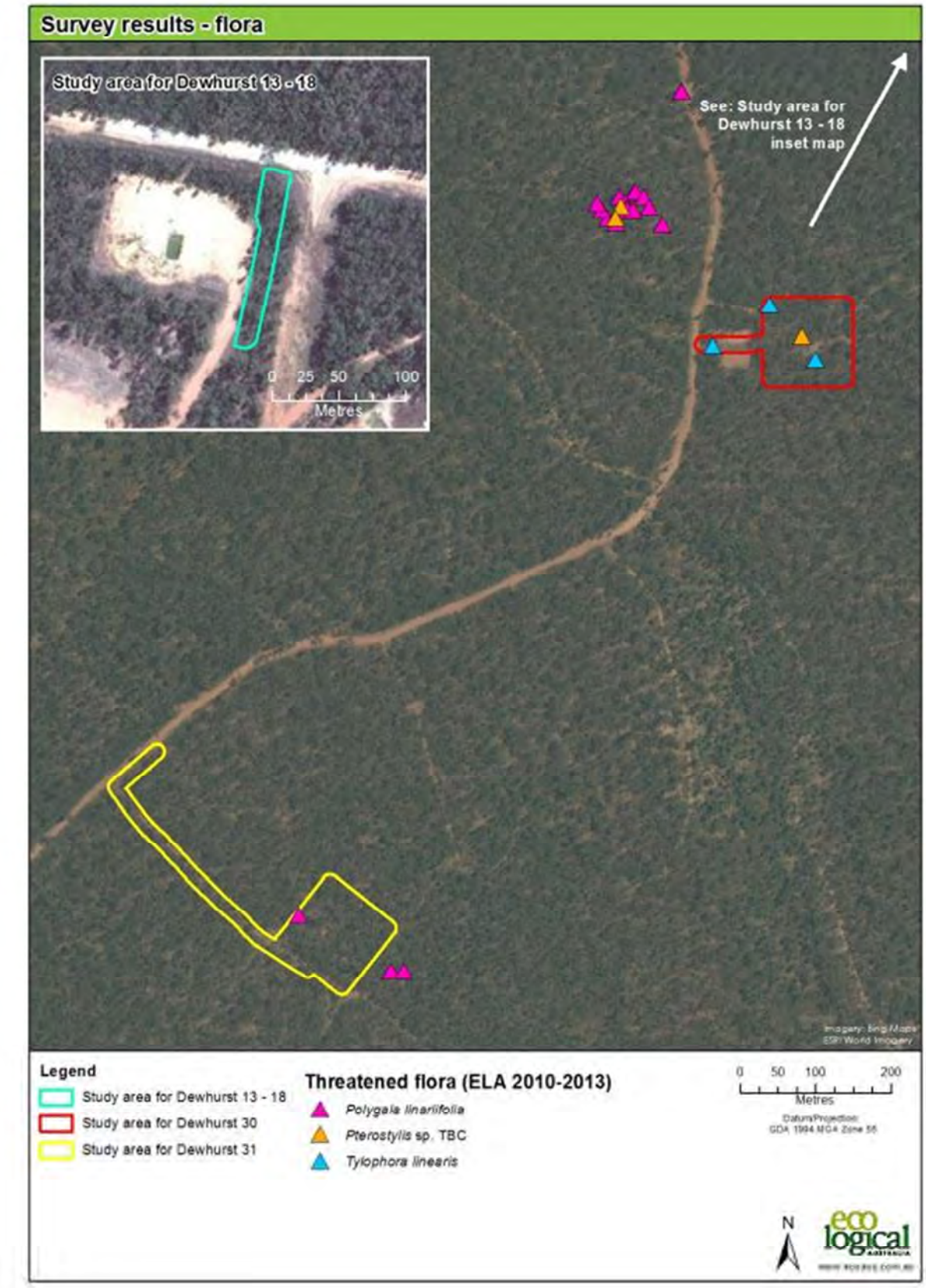


Figure 9: Survey results - flora

4.3.3 Fauna

Habitat assessment

Habitat within the study area provides potential foraging, roosting, breeding and nesting resources. A range of fauna habitat features are present throughout the study area and are identified in **Table 12** below.

Table 12: Key fauna habitat features present across the study area

Habitat features	Species
Vegetated areas of open forest	Arboreal mammals, microchiropteran bats and owls
HBT's and Stags	Birds, microchiropteran bats and arboreal mammals.
Fallen timber	Reptiles, molluscs and birds
Leaf litter (sparse to moderate)	Foraging resources for birds and mammals
Winter flowering eucalypts	Migratory birds, arboreal mammals
Foraging resources (nectar, fruits, seeds)	Mammals, birds

Hollow bearing trees

Twenty five HBT's were recorded within the study area during ELA field surveys. Hollows range in size from 5 cm to 30 cm width providing habitat for a variety of fauna species including microbats, birds, and arboreal mammals.

HBT's were identified at Dewhurst 30 and 31. No HBT's were recorded at Dewhurst 13-18. The location of HBT's within the study area is shown in **Figure 10**.

and details of tree species and hollow size for each HBT are provided in **Appendix C.**

Mammal survey (non-flying small and medium sized mammals)

Trapping

One species of small mammal; *Antechinus flavipes* (Yellow-footed Antechinus) was captured during the ELA field surveys within the Dewhurst 30 study area. It was recorded in an arboreal Elliott A trap.

Results from the RPS trapping survey have not been reported. However, a list of all fauna recorded during the RPS survey is provided in **Appendix E**.

Previous trapping by ELA in the study region recorded Yellow-footed Antechinus in terrestrial Elliott A traps, *Rattus* sp. and *Vulpes vulpes* (European Red Fox) in small hair tubes and possible records of *Macropus giganteus* (Eastern Grey Kangaroo) and *Trichosurus vulpecular* (Common Brushtail Possum) in large hair tubes.

Remote camera

Few vertebrate fauna species were detected via remote camera during the ELA survey. The tail of European Red Fox was photographed at Dewhurst 30 and several unidentified skink species can be seen in the background of several photographs at Dewhurst 31.

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Results from the RPS remote camera survey have not been reported. However, a list of all fauna recorded during the RPS survey is provided in **Appendix E**.

No threatened mammal species (excluding bats) listed under the TSC Act and/or EPBC Act were recorded during the surveys.

Microbat survey

Harp Trapping

Three common species of microbat were captured via harp trap during the ELA survey. These included *Nyctophilus geoffroyi* (Lesser long-eared bat), *Nyctophilus gouldi* (Gould's long-eared bat) and *Vespadelus vulturnus* (Little forest bat). Locations of microbat species captured within the study area are shown in **Table 13.**

Table 13: Number of captures per species

Common Name	Species	Dewhurst 30	Dewhurst 31	Midway 30 & 31	Dewhurst 13-18
Lesser long-eared Bat	*Nyctophilus geoffroyi*	1	1	3	-
Gould's long-eared Bat	*Nyctophilus gouldi*	-	-	5	-
Little Forest Bat	*Vespadelus vulturnus*	2	4	4	1

Anabat- microbat call identification

A large number of species were recorded by Anabat detectors during field surveys.

Up to 14 species of microbat species were potentially recorded during the RPS survey. However, only 12 of these species were positively identified. Although its calls were not confirmed, *Mormopterus eleryi* (Bristle-faced Free-tailed bat), listed as Endangered under the TSC Act may also have been recorded, however due to uncertainty in the call identification and unconfirmed distribution of the species in the Pilliga Forest, the Bristle-faced Free-tailed bat has not been considered included in the impact assessment (**Appendix D**). Fourteen microbat species were recorded during the ELA survey including six (potentially seven) vulnerable species listed under the NSW TSC Act (**Table 14**). A full species list can be found in **Appendix D.**

The calls of two threatened species are difficult to distinguish from other more commonly recorded species and may have been recorded but not positively identified. It is also possible that the threatened *Nyctophilus corbeni* (South-eastern Long-eared Bat) was recorded. However the calls of *Nyctophilus* species cannot be differentiated based on call characteristics.

General bat activity was high at Dewhurst 31 and Midway 30 & 31 during the ELA survey with calls recorded more often than every two minutes throughout the evening. Most bat activity occurred between dusk and midnight across all sites and all nights. There were many long sequences recorded and feeding buzzes were regularly observed in the data set indicating that bats were actively foraging in the area rather than just passing through.

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The most recorded species overall was *Chalinolobus gouldii* (Gould's Wattled Bat) which made up more than half of all definitely identified call sequences. The threatened *Miniopterus schreibersii oceanensis* (Eastern Bentwing Bat) was also represented by numerous call sequences, including feeding buzzes.

The calls recorded as *Falsistrellus tasmaniensis* (Eastern False Pipistrelle) and *Scoteanax rueppellii* (Greater Broad-nosed Bat) are only considered possible due to the species' unconfirmed distribution in the Pilliga Forest and the possibility of confusing call identification between these and other species. Further explanation can be found in **Appendix D**. These species have not been included in the impact assessment.

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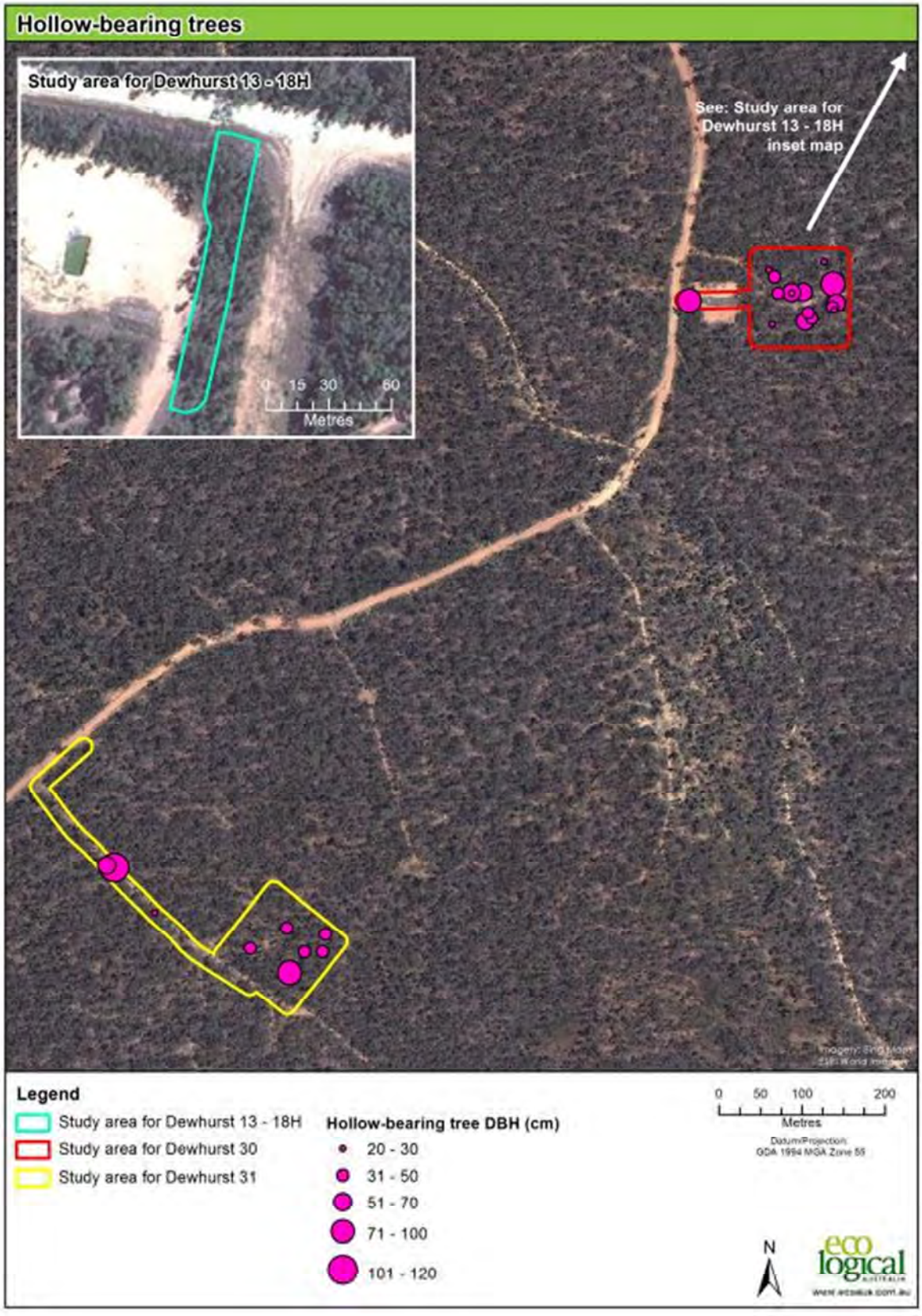


Figure 10: Hollowing-bearing trees

Table 14: The number of definite and probable identification calls for listed threatened microbat species at each site

Species		TSC	EPBC	ELA survey				RPS survey
Common name	Scientific name			Dewhurst 30	Dewhurst 31	Midway 30 & 31	Dewhurst 13-18	
Little Pied Bat	*Chalinolobus picatus*	V	-	0	2	0	0	Yes
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V	-	(5)	(91)	(8)	0	No
Eastern Bentwing Bat	*Miniopterus schreibersii oceanensis*	V	-	7	66	7	7	Not positively identified
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	V	-	0	0	1	3	Yes
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	-	(1)	0	(2)	0	No
Eastern Cave Bat	*Vespadelus troughtoni*	V	-	0	0	(1)	0	No

() = possible identification only – medium to high probability of confusion with species with similar calls

Diurnal bird survey

Sixty eight bird species were recorded during ELA and RPS field surveys. Five vulnerable species listed under the TSC Act and two migratory species listed under the EPBC Act were recorded (**Figure 11**). A full list of bird species recorded in the study area is provided as **Appendix E.** Threatened and migratory species recorded within the study area are shown in **Table 15**.

Table 15: Listed threatened and migratory species detected at or adjacent to the study area

Species		TSC	EPBC	ELA survey			RPS survey
Common name	Scientific name			Dewhurst 30	Dewhurst 31	Dewhurst 13-18	
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V	-	W	-	-	-
Grey-crowned Babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	V	-	W	E	-	Yes
Hooded Robin	*Melanodryas cucullata*	V	-	-	-	O	
Speckled Warbler	*Chthonicola sagittata*	V	-	-	W	-	Yes
Varied Sittella	*Daphoenositta*	V	-	-	O/W	-	-

	chrysoptera						
White-bellied Sea-eagle	*Haliaeetus leucogaster*	~	M	-	-	O	-
White-throated Needletail	*Hirundapus caudacutus*	~	M				

O = observed; W= heard; O/W= observed and heard; E= nest observed

V = Vulnerable; M = migratory

Reptiles

RPS and ELA surveys combined recorded 12 reptile species including two geckos, six skinks, two dragons and two monitor species.

No threatened reptile species listed under the TSC Act and/or EPBC Act were recorded during the surveys.

Amphibians

RPS recorded three amphibian species. The low number of amphibian captures can be attributed to dry conditions experienced throughout the survey.

No threatened amphibian species listed under the TSC Act and/or EPBC Act were recorded during the surveys.

Feral fauna

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

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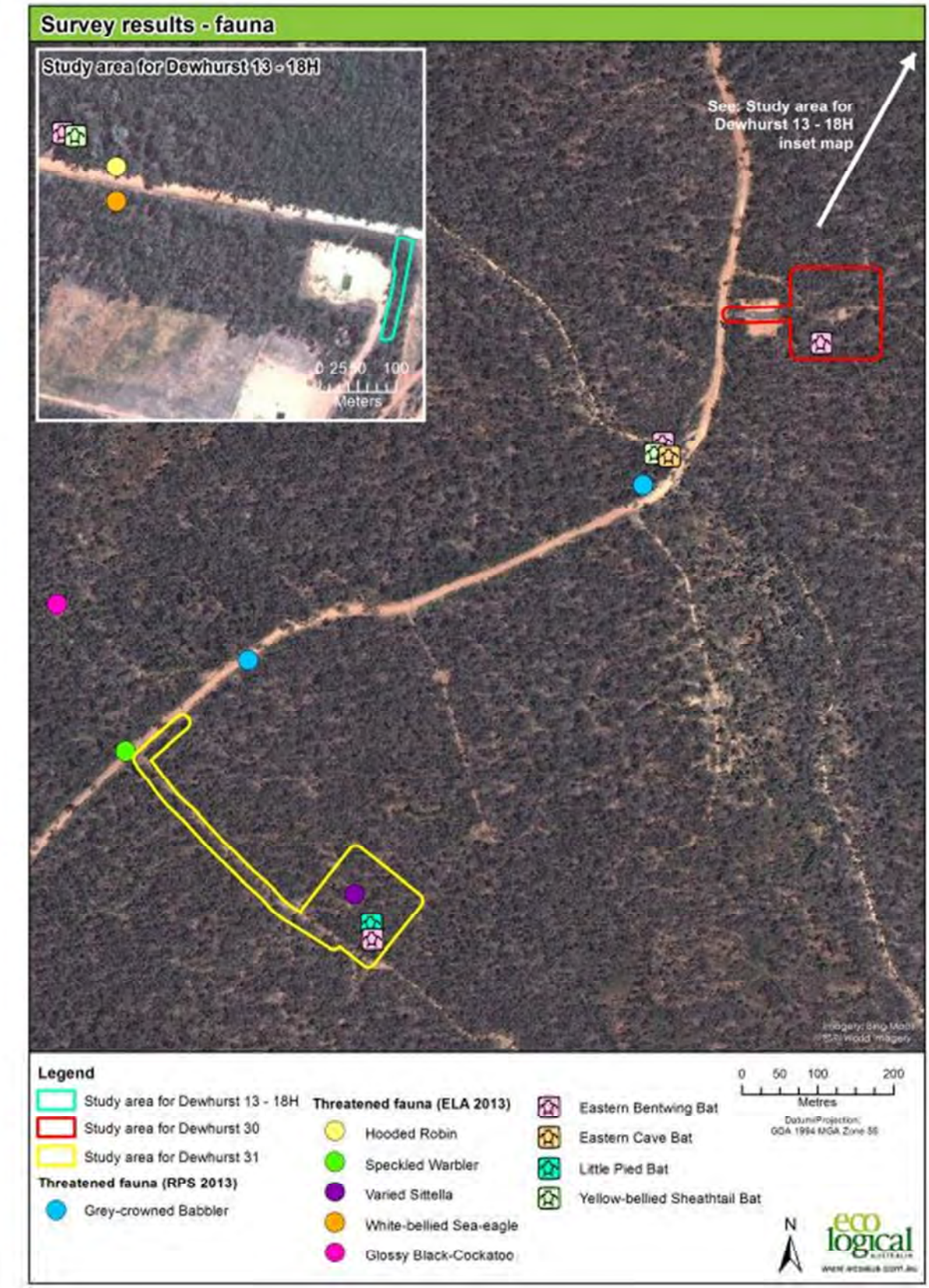


Figure 11: Survey results – fauna

5 Impact assessment

Based on searches of the Atlas of NSW Wildlife (OEH 2013a), review of relevant literature, vegetation mapping, results of flora and fauna surveys, presence of suitable habitat and professional judgement, a number of threatened species and ecological communities listed under the NSW TSC Act and/or Commonwealth EPBC Act have been identified as having the potential to be impacted by the proposed activity.

The likelihood of presence or absence of species and ecological communities has been assessed with full details provided in **Appendix A**.

Twenty-five bird species, twelve mammals and four plants which are listed under the TSC Act and/or EPBC Act are determined to have a likelihood of occurrence of 'known', 'likely', or 'potential' to occur within the study area (**Table 16**).

Impacts to these species have been considered in the various ecological reports and Review of Environmental Factors (REFs) for existing and planned exploration activities. A number of additional species have also been considered in relation to their likelihood of occurrence within the study area and determined to be unlikely to occur, as the area is outside of their distribution, and/or suitable habitat is not present. These species are not addressed in detail in this report, but have been considered in supporting ecological reports and are outlined in a full likelihood of occurrence table in **Appendix A**.

Assessments of Significance under the EP&A Act and/or EPBC Act have been carried out for the species listed below in **Table 16**. The Assessments of Significance for these species can be found in **Appendix F** (EP&A Act) and **Appendix G** (EPBC Act)**.**

Table 16: Threatened flora, fauna and migratory species known, considered likely or have potential to be impacted by the proposed activity

Scientific name	Common name	TSC Act	EPBC Act	Conclusion
Flora				
Diuris tricolor	Painted Diuris	V	~	No significant impact proposed
Polygala linariifolia	Native Milkwort	E1	~	No significant impact proposed
Pterostylis cobarensis	Greenhood Orchid	V	V	No significant impact proposed
Tylophora linearis	-	V	E	No significant impact proposed
Birds				
Anthochaera phrygia	Regent Honeyeater	CE	E, M	No significant impact proposed
Apus pacificus	Fork-tailed Swift	~	M, Mar	No significant impact proposed
Burhinus grallarius	Bush Stone-curlew	E1	~	No significant impact proposed
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~	No significant impact proposed

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Scientific name	Common name	TSC Act	EPBC Act	Conclusion
Chthonicola sagittata	Speckled Warbler	V	~	No significant impact proposed
Circus assimilis	Spotted Harrier	V	~	No significant impact proposed
Daphoenositta chrysoptera	Varied Sittella	V	~	No significant impact proposed
Glossopsitta pusilla	Little Lorikeet	V	~	No significant impact proposed
Grantiella picta	Painted Honeyeater	V	~	No significant impact proposed
Haliaeetus leucogaster	White-bellied Sea-eagle	~	M, Mar	No significant impact proposed
Hamirostra melanosternon	Black-breasted Buzzard	V	~	No significant impact proposed
Hieraaetus morphnoides	Little Eagle	V	~	No significant impact proposed
Hirundapus caudacutus	White-throated Needletail	~	M, Mar	No significant impact proposed
Lathamus discolor	Swift Parrot	E1	E	No significant impact proposed
Lophoictinia isura	Square-tailed Kite	V	~	No significant impact proposed
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	~	No significant impact proposed
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	~	No significant impact proposed
Merops ornatus	Rainbow Bee-eater	~	M, Mar	No significant impact proposed
Neophema pulchella	Turquoise Parrot	V	~	No significant impact proposed
Ninox connivens	Barking Owl	V	~	No significant impact proposed
Pachycephala inornata	Gilbert's Whistler	V	~	No significant impact proposed
Petroica boodang	Scarlet Robin	V	~	No significant impact proposed
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~	No significant impact proposed
Stagonopleura guttata	Diamond Firetail	V	~	No significant impact proposed
Tyto novaehollandiae	Masked Owl	V	~	No significant impact proposed
Mammals				
Aepyprymnus rufescens	Rufous Bettong	V	~	No significant impact proposed
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	No significant impact proposed
Chalinolobus picatus	Little Pied Bat	V	~	No significant impact proposed

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Scientific name	Common name	TSC Act	EPBC Act	Conclusion
Dasyurus maculatus	Spotted-tailed Quoll	V	E	No significant impact proposed
Macropus dorsalis	Black-striped Wallaby	E1	~	No significant impact proposed
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	~	No significant impact proposed
Nyctophilus corbeni	South-eastern Long eared Bat / Corben's Long-eared Bat	V	V	No significant impact proposed
Petaurus norfolcensis	Squirrel Glider	V	~	No significant impact proposed
Pseudomys pilligaensis	Pilliga Mouse	V	V	No significant impact proposed
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	No significant impact proposed
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	~	No significant impact proposed
Vespadelus troughtoni	Eastern Cave Bat	V	~	No significant impact proposed

V- vulnerable; E1- endangered under the TSC Act; E- endangered under the EPBC Act; M- migratory under the EPBC Act and Mar – Marine under the EPBC Act

5.1 Avoidance

The locations of Dewhurst 30 & 31 have been identified to avoid the following key ecological values:

1. Endangered Ecological Communities (EECs)
2. Riparian zone (at least 40 m from the top of bank of a drainge line)

5.2 Minimising impacts

The locations of the following ecological values have been recorded to reduce impact:

1. Hollow-bearing trees
2. Threatened flora locations

The location of HBTs has been mapped so that the clearing can be undertaken to minimise the removal of as many HBTs as possible. HBTs that are close to the edge of a lease area or access track will be retained where possible. A maximum of 25 HBTs would be removed by the proposed activity.

5.3 Impacts to vegetation communities

A total of 2.44 ha of *White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion* would be removed by the proposed activity. A 10 m buffer has been assessed surrounding the areas of vegetation removal as it is expected that any indirect impacts to vegetation communities would be contained within 10 m from the area to be cleared.

There is approximately 22,878 ha of this vegetation type mapped in the study region and therefore the removal of 2.44 ha constitutes <0.01% reduction of this vegetation community in the study region.

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5.4 Impacts to threatened flora

Threatened flora species have been located within the study area and would be removed by the proposed activity. The numbers of threatened flora species within each subject site are:

- *Tylophora linearis* (three individuals at Dewhust 30 subject site)
- *Polygala linariifolia* (one individual at Dewhurst 31 subject site)
- *Pterostylis cobarensis* (three individuals at Dewhurst 30 subject site)

Detailed targeted surveys within the broader north-east Pilliga Forest have identified significant populations of these threatened species. Modelled data predicts the existence of 122,713 *Polygala linariifolia*, 3,349,724 *Pterostylis cobarensis* and 183,908 *Tylophora linearis* individuals in the Pilliga and Pilliga Outwash CMA subregions (ELA 2012).

5.5 Impacts to fauna habitat

The total amount of potential foraging, breeding and roosting/sheltering habitat has been calculated for the disturbance areas within the study area to inform the significant impact assessments of the proposed activities (**Table 17**). The amount of loss of potential habitat in relation to the vegetation present within the study region has also been calculated.

Determination of the different types of habitat (foraging, breeding, roosting/sheltering) for individual threatened fauna species was made by first allocating vegetation types that would be used for foraging, breeding, and roosting/sheltering to individual species. The areas impacted were then summed for all vegetation types representing the type of habitat used by individual species within the study region.

The calculations include areas of clearing for all proposed impacts at Dewhurst 13-18H, Dewhurst 30 and Dewhurst 31.

Table 17: Direct impact areas to potential threatened fauna habitat

Species	Foraging (ha) loss within study area / loss in study region (%)[##]	Breeding (ha) loss within study area / loss in study region (%)[##]	Roosting (ha) loss within study area / loss in study region (%)[##]
Parrots			
Glossy Black-Cockatoo	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Little Lorikeet	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Swift Parrot	2.44 ha / <0.01%	N/A[#]	2.44 ha / <0.01%
Turquoise Parrot	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Owls			
Barking Owl	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Masked Owl	2.44 ha / <0.01%	N/A[#]	N/A[#]
Birds of prey			
Black-breasted Buzzard	2.44 ha / 0.03%	0.0	0.0
Little Eagle	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Spotted Harrier	2.44 ha / 0.03%	0.0	0.0
Square-tailed Kite	2.44 ha / <0.01%	0.0	0.0
Woodland birds – large ground foraging			
Bush Stone-curlew	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Woodland birds – ground and mid-storey foraging (passerines)			

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Species	Foraging (ha) loss within study area / loss in study region (%)[##]	Breeding (ha) loss within study area / loss in study region (%)[##]	Roosting (ha) loss within study area / loss in study region (%)[##]
Diamond Firetail	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Gilbert's Whistler	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Grey-crowned Babbler (eastern subspecies)	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Hooded Robin	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Scarlet Robin	2.44 ha / <0.01%	N/A[#]	2.44 ha / <0.01%
Speckled Warbler	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Varied Sittella	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Woodland birds – canopy foraging (excluding parrots)			
Black-chinned Honeyeater (eastern subspecies)	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Painted Honeyeater	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Regent Honeyeater	2.44 ha / <0.01%	N/A[#]	2.44 ha / <0.01%
Arboreal mammals and megabats			
Grey-headed Flying-fox	2.44 ha / <0.01%	N/A[#]	N/A[#]
Squirrel Glider	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Ground and log dependent mammals			
Black-striped Wallaby	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Pilliga Mouse	0.0	0.0	0.0
Spotted-tailed Quoll	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Grassy woodland mammals			
Rufous Bettong	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Predominantly tree-roosting bats			
Yellow-bellied Sheathtail-bat	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
South-eastern Long-eared Bat	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%
Predominantly cave-roosting bats			
Eastern Bentwing-bat	2.44 ha / <0.01%	N/A[#]	N/A[#]
Eastern Cave Bat	2.44 ha / <0.01%	N/A[#]	N/A[#]
Large-eared Pied Bat	2.44 ha / <0.01%	N/A[#]	N/A[#]
Little Pied Bat	2.44 ha / <0.01%	2.44 ha / <0.01%	2.44 ha / <0.01%

[#] Breeding and/or roosting habitat has not been impacted or is not present for these species within the study region

[##] The regional vegetation class data utilised in this report is derived from a regional scale map that contains a proportion of modelling. Other datasets utilised are of varying scales and accuracies.

5.6 Impacts to aquatic habitat

No aquatic habitat occurs in the study area and it is unlikely that any aquatic habitat would be directly or indirectly impacted by the proposed activity.

5.7 Impacts to groundwater dependent ecosystems

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

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

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

Within the study region groundwater is generally close to the surface (<5m) in the quaternary alluvium associated with the major creeks and floodplains (e.g. Bohena Creek), while generally being much deeper in those areas characterised by Jurassic quartz sandstone (20 – 50m) (SKM 2010). The majority of the vegetation within the study region on alluvial soils is likely to have a proportional association with groundwater. Vegetation along the major creeks and floodplains has the potential to be dependent on base-flow groundwater, whilst the vegetation on the alluvial plains is likely to utilise groundwater resources proportionally (depending on rainfall) whilst vegetation on Jurassic quartz sandstone is unlikely to be groundwater dependant. Further to this, there are minimal areas of permanent surface water within the study region over the course of a year. The exception being constructed dams and a number of relatively small groundwater fed springs. Following significant rainfall, the creeks within the study region were observed to flow for a period of days to weeks (depending on stream order) and then cease flowing.

The vegetation in the study area is considered a terrestrial ecosystem (EAMUS *et al.* 2006) and has potential to be proportionally dependent on groundwater (Hatton & Evans 1990). This dependency would be stronger during periods of drought. In periods of rainfall, the vegetation in the study area would draw its water source from rainfall and subsequent soil moisture.

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

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

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

5.8 Indirect impacts

The proposed activity has potential to indirectly impact on vegetation communities and flora and fauna species present in the study area through habitat fragmentation, sedimentation and erosion, introducing additional light, changing microclimates, increases in noise, traffic and dust and encouraging weed invasion and feral animal predators.

Due to the scale of the proposed activity, a 10 m buffer has been assessed around the subject sites in which it is predicted that the majority of potential indirect impacts would be contained. This would not hold true for short-term increases in noise.

Habitat fragmentation is considered to be minimal due to the nature of the subject sites and the use of existing roads where possible to reduce fragmentation. No patches of habitat would be isolated as a result of the proposed activity. Habitat fragmentation is known to encourage the movement of feral animal predators through the landscape. The proposed activity does not provide any new links between areas of habitat, although it is situated in an area that is already intersected by roads and is known to support a range of feral animal predators.

The removal of vegetation and transport of soil would increase the risk of sedimentation and erosion potentially leading to increased sediment load in aquatic systems and dust formation. This issue is addressed in the mitigation measures in **Section 6** to reduce the risk of this indirect impact.

Vegetation on the edge of the subject sites will be subject to increased light, changes to microclimate, increased dust and risk of weed invasion. The proposed activity has the potential to impact on the vegetation structure and health in the study area once the subject site has been cleared. Mitigation measures including avoiding activity outside of the study area, reducing speed limits on roads and rehabilitation measures have been presented in **Section 6** to address these indirect impacts.

Increases in noise during construction and operation of the proposed activity have potential to indirectly impact fauna both within the study area and in adjacent habitat. Mitigation measures addressing behaviour of construction teams have been presented in **Section 6** to address this indirect impact. Noise during operation would largely be kept to a minimum and constant, rather than intermittent which is considered to be less of an impact on fauna.

5.9 Cumulative impacts

Cumulative impacts for the Program have been assessed under the TSC Act (ELA 2013b) and the EPBC Act (ELA 2013c). These assessments address the removal of vegetation communities and habitat for threatened species at two different scales. The ‘study area’ as defined in the EPBC Act Impact Assessment (ELA 2013c) included an approximately 48,000 ha area within which detailed studies into the biodiversity values of the north-east Pilliga Forest were conducted. The ‘study area’ in the EPBC Act Impact Assessment contained all existing and proposed exploration and appraisal activities for the Program within the Pilliga Forest. The TSC Act assessment (ELA 2013b) had a

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broader focus and addressed the cumulative impact associated with all existing and proposed exploration and production appraisal activities associated within PEL 238 (the study region as defined in this assessment). For the purposes of this assessment, the cumulative impacts have been reported against the same study region as included in the TSC Act assessment (ELA 2013b).

At the date of this report, a total of 78.08 ha of *White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion* has been removed for exploration activities from the study region since 2002. Of the vegetation that has been removed, 14.84 ha of this vegetation type is currently regenerating. A further 31.69 ha of this vegetation type is proposed to be removed from 2013 onwards which includes the 2.44 ha addressed in this ecological assessment. This equates to a cumulative total of 109.77 ha of removal of this vegetation type.

The study region has approximately 113,735 ha of this vegetation type and hence removal of 109.77 ha equates to less than 0.01 % removal of this vegetation type in the study region.

Cumulative impacts on threatened fauna addressed in this ecological assessment are presented in **Table 18**. These values include the 2.44 ha of vegetation removal for the proposed activity addressed in this ecological assessment.

Table 18: Cumulative direct impacts areas to potential threatened fauna habitat from 2002 to the Program

Species	Foraging (ha) loss within study region / loss in study region (%)[##]	Breeding (ha) loss within study region / loss in study region (%)[##]	Roosting (ha) loss within study region / loss in study region (%)[##]
Glossy Black-Cockatoo	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Little Lorikeet	237.1 / 0.08	159.9 / 0.05	159.9 / 0.05
Superb Parrot	237.1 / 0.08	N/A[#]	159.9 / 0.05
Swift Parrot	237.1 / 0.08	N/A[#]	159.9 / 0.05
Turquoise Parrot	237.1 / 0.08	159.9 / 0.05	159.9 / 0.03
Barking Owl	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Masked Owl	237.1 / 0.08	N/A[#]	N/A[#]
Black-breasted Buzzard	113.5 / 0.63	N/A[#]	12.3 / 0.09
Little Eagle	237.1 / 0.08	159.9 / 0.05	159.9 / 0.05
Spotted Harrier	110.9 / 0.36	36.0 / 0.20	36.0 / 0.20
Square-tailed Kite	237.1 / 0.05	12.3 / 0.09	12.3 / 0.09
Australian Bustard	220.7 / 0.17	N/A[#]	145.8 / 0.11
Bush Stone-curlew	220.7 / 0.17	145.8 / 0.11	145.8 / 0.11
Diamond Firetail	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Gilbert's Whistler	223.0 / 0.17	145.8 / 0.11	145.8 / 0.11
Grey-crowned Babbler (eastern subspecies)	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Hooded Robin	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Scarlet Robin	237.1 / 0.08	N/A[#]	159.9 / 0.05
Speckled Warbler	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05
Varied Sittella	237.1 / 0.08	159.9 / 0.05	159.9 / 0.05

Species	Foraging (ha) loss within study region / loss in study region (%)##	Breeding (ha) loss within study region / loss in study region (%)##	Roosting (ha) loss within study region / loss in study region (%)##
Black-chinned Honeyeater (eastern subspecies)	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Painted Honeyeater	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Regent Honeyeater	159.9 / 0.05	N/A#	159.9 / 0.05
Yellow-bellied Sheathtail-bat	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
South-eastern Long-eared Bat	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Eastern Bentwing-bat	237.1 / 0.05	N/A#	N/A#
Eastern Cave Bat	237.1 / 0.05	N/A#	N/A#
Large-eared Pied Bat	237.1 / 0.05	N/A#	N/A#
Little Pied Bat	237.1 / 0.05	159.9 / 0.03	159.9 / 0.03
Grey-headed Flying-fox	159.9 / 0.05	N/A#	N/A#
Koala	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Squirrel Glider	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Black-striped Wallaby	224.9 / 0.05	147.6 / 0.03	147.6 / 0.03
Eastern Pygmy-possum	159.9 / 0.05	147.6 / 0.05	147.6 / 0.05
Pilliga Mouse	26.3 / 0.01	N/A#	N/A#
Spotted-tailed Quoll	159.9 / 0.05	159.9 / 0.05	159.9 / 0.05
Rufous Bettong	212.8 / 0.16	135.6 / 0.10	135.6 / 0.10
Pale-headed Snake	237.1 / 0.05	159.9 / 0.05	159.9 / 0.05

Breeding and/or roosting habitat has not been impacted or is not present for these species within the study region

##The regional vegetation class data utilised in this report is derived from a regional scale map that contains a proportion of modelling. Other datasets utilised are of varying scales and accuracies.

5.10 Assessment of significance under the EP&A Act

The following section provides an overview of the assessment process of the potential significance of the impacts from the proposed activity on ecological values listed under the TSC Act. The ecological values considered relevant to this assessment are identified in Section 4.2 of this report. The full assessments are found in **Appendix F** with results presented in **Table 16**.

The assessment of impact has been conducted where necessary with consideration to the 7-part test criteria (or assessment of significance). The flora and fauna species have been grouped for the assessment process with species that contain similar characteristics and are likely to be impacted in a similar manner.

The flora and fauna groupings for the assessment of significance for species listed under the TSC act include:

Flora

- *Diuris tricolor, Polygala linariifolia, Pterostylis cobarensis* and *Tylophora linearis*

Birds

- Parrots:
    - Glossy Black-Cockatoo, Little Lorikeet, Swift Parrot and Turquoise Parrot
- Owls:
    - Barking Owl & Masked Owl
- Birds of prey:
    - Spotted Harrier, Black-breasted Buzzard, Little Eagle and Square-tailed Kite
- Woodland birds – large ground foraging:
    - Bush Stone-curlew
- Woodland birds – ground and mid-storey foraging (passerines):
    - Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin
- Woodland birds – canopy foraging (excluding parrots):
    - Regent Honeyeater, Painted Honeyeater and Black-chinned Honeyeater

Mammals

- Arboreal mammals and Flying Fox*:*
    - Grey-headed Flying Fox and Squirrel Glider
- Ground and log dependent mammals*:*
    - Black-striped Wallaby, Pilliga Mouse and Spotted-tailed Quoll
- Grassy woodland mammals*:*
    - Rufous Bettong
- Predominantly tree-roosting bats*:*
    - Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat
- Predominantly cave-roosting bats*:*
    - Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat

The assessment of significance completed for each of these species (Appendix F) has shown the proposed activity is unlikely to constitute a significant impact.

5.11 Assessment of significance under the EPBC Act

This section provides an overview of the assessment process of potential significance of impacts from the proposed activity on Matters of National Environmental Significance (MNES). The EPBC Act Administrative Guidelines on Significance set out 'Significant Impact Criteria' that are to be used to assist in determining whether a proposed action is likely to have a significant impact on MNES.

Specific 'Significant Impact Criteria' are provided for each MNES, except for threatened species and ecological communities, in which case separate criteria are provided for species listed as endangered and vulnerable under the EPBC Act (**Table 19**).

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Table 19: Significant impact criteria

Status	Significant impact criteria
Critically endangered and endangered species	An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of a population • reduce the area of occupancy of the species • fragment an existing population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of a population • modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat • introduce disease that may cause the species to decline, or • interfere with the recovery of the species.
Vulnerable species	An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will: • lead to a long-term decrease in the size of an important population of a species • reduce the area of occupancy of an important population • fragment an existing important population into two or more populations • adversely affect habitat critical to the survival of a species • disrupt the breeding cycle of an important population • modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline • result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat • introduce disease that may cause the species to decline, or • interfere substantially with the recovery of the species.
Migratory species	An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will: • substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species • result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or • seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

MNES considered relevant to this assessment include:

Flora

- *Pterostylis cobarensis* and *Tylophora linearis.*

Mammals

- South-eastern Long-eared Bat, Large-eared Pied Bat, Grey-headed Flying-fox, Spotted-tailed Quoll and Pilliga Mouse.

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Birds

- Regent Honeyeater and Swift Parrot.

Migratory species

- Regent Honeyeater, White-bellied Sea Eagle, White-throated Needletail, Rainbow Bee-eater and Fork-tailed Swift.

The relevant Significant Impact Criteria have been applied to these threatened and migratory species to determine the significance of impact of the proposed activity, and are provided in **Appendix G** with results presented in **Table 16**.

The assessment of impact completed for each of these species (**Appendix G**) utilising the Significant Impact Criteria has shown the proposed activity is unlikely to constitute a significant impact.

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6 Mitigation measures

6.1 Mitigation

Actions to mitigate the potential impacts of the proposed activity on ecological values have been provided below. These actions have been drawn from mitigation measures recommended for the associated proposed works where applicable.

- All personnel should be informed of their responsibilities whilst working on site in relation to ecological values and undertake a site specific induction.
- The site boundary should be clearly marked in the field to ensure all clearing and construction activities occur within the approved footprint.
- All access during the pre-construction, construction, operational and rehabilitation phases should be through existing roads and designated access tracks.
- Weed control measures should be in place during pre-construction, construction, operational and rehabilitation phases. These should include:
    - The establishment of wash down points for vehicles to prevent the transportation of seeds and soil.
    - Inspections of all equipment (machinery, tools, vehicles) brought on site to ensure that all equipment is free of materials where practicable (such as soils and seeds).
    - Documentation and records that detail the use of wash down points and inspections.
    - Measures to ensure that all weed growth is regularly and appropriately controlled in accordance with the NW Act.
- Removal of HBTs should be undertaken with the supervision of an ecologist and following the clearing procedure developed by ELA and Santos.
- Open trenches should be inspected twice daily by a suitably qualified fauna handler.
- Appropriate sediment and erosion control measures should be installed and maintained as specified in the EIS.
- Only 'fauna friendly' exclusion fencing (without barbed wire) in accordance with Santos policies should be installed around well infrastructure.
- 40 km/h speed limits will be implemented in the study area (i.e. lease areas and access tracks constructed for the activity). Otherwise the posted speed limit will apply.
- The subject sites should be progressively rehabilitated as soon as practicable following best practice guidelines.

6.2 Rehabilitation

Rehabilitation of existing exploration and appraisal activities is currently being undertaken. These activities provide a benchmark for understanding the potential reduction in impact as a result of rehabilitation works identified for the proposed activity.

Santos has commenced a program of rehabilitation works throughout PEL 238 and PAL 2. Rehabilitation works include:

- Reducing the size of existing well leases back to the minimum area required for operations.
- Plugging and abandoning, according to legislative requirements, wells that are no longer required for exploration and appraisal and rehabilitating associated well leases.
- Rehabilitating a number of water storage ponds that are no longer required for exploration and appraisal activities.

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Actions undertaken during the clearing of vegetation include stockpiling 'waste' timber from felled trees not suitable for forestry activities, fallen logs and bush rock for later use in habitat restoration; slashing and mulching low vegetation onsite; and striping and stockpiling topsoil. Rehabilitation actions include; replacing topsoil; re-installing habitat features such as fallen timber and bush rock; natural re-establishment of slashed and cleared native vegetation; and direct seeding where required.

Monitoring of rehabilitation activities has shown an overall site value close to 45% of nearby reference sites after two years. This site value indicates that after two years, the community structure (measurement addressing native and exotic species richness and abundance, ground cover composition and habitat values) is at 45% of remnant condition. The replacement of topsoil is producing encouraging results, with sites showing a high number of native species when compared to reference sites. Rehabilitation measures undertaken have been considered using adaptive management principles with monitoring informing future modifications to works and methodology.

Rehabilitation works associated with the proposed activity should follow the methods developed for the existing exploration and appraisal activities.

6.3 Offsetting

Following consideration of the avoidance, minimisation and mitigation measures proposed, offsetting is not considered necessary due to the relatively small magnitude of impact, the short timeframe of the operation of the proposed activity and the recommended rehabilitation following completion of operations.

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7 Conclusion

The vegetation in the study area is consistent with the vegetation community *Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion* which corresponds to the *White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion* vegetation type. This vegetation type provides habitat for a range of threatened flora and foraging, breeding and roosting habitat for a range of threatened fauna addressed this impact assessment.

A total of four threatened flora and 33 threatened fauna including 21 birds and 12 mammals have been assessed as potential, likely or known to occur in the study area.

The field surveys found three threatened flora within the study area; namely *Tylophora linearis*, listed as vulnerable under the TSC Act and endangered under the EPBC Act (three individuals at the Dewhurst 30 subject site), *Pterostylis cobarensis*, listed as vulnerable under the TSC Act and EPBC Act (three individuals at the Dewhurst 30 subject site) and *Polygala linariifolia* (Native Milkwort), listed as endangered under the TSC Act (one individual at the Dewhurst 31 subject site).

The field surveys recorded five birds listed as Vulnerable under the TSC Act (Grey-crowned Babbler, Hooded Robin, Speckled Warbler, Varied Sittella and Glossy Black-cockatoo) and White-bellied Sea-eagle and White-throated Needletail listed as Migratory under the EBPC Act in or adjacent to the study area.

The proposed activity involving the removal of 2.44 ha of vegetation is not considered likely to have a significant impact on ecological values listed under the TSC Act or EPBC Act or on the environment more broadly, provided the measures described in **Section 6** are adhered to.

Avoidance, minimisation and mitigation measures have been addressed in order to reduce the impact of the proposed activity on ecological values and the environment.

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Appendix A: Likelihood of occurrence

Provided below are the likelihood tables for threatened species listed under the NSW TSC Act and Commonwealth EPBC Act. Species, populations and communities considered to have the potential to occur are highlighted in yellow, those likely to occur are highlighted in brown, and those which are known occur are highlighted in green.

The analysis of the likelihood of occurrence table included previous reports conducted by Eco Logical Australia (ELA) and RPS.

Key to the table:

- TSC Status = Listing under the *Threatened Species Conservation Act 1995*
- EPBC Status = Listing under the *Environment Protection and Biodiversity Conservation Act 1999*
- CE = Critically Endangered
- E = Endangered (EPBC Act)
- E1 = Endangered (TSC Act)
- E2 = Endangered Population (TSC Act)
- E4 = Extinct (TSC Act)
- V = Vulnerable
- M = Migratory (EPBC Act)
- Mar = Marine (EPBC Act)

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
FAUNA										
Aepyprymnus rufescens	Rufous Bettong	V	~	The original range from Coen in north Queensland to central Victoria has been reduced to a patchy distribution from Cooktown, Queensland, to north-eastern NSW as far south as Mt Royal National Park. In NSW it has largely vanished from inland areas but there are sporadic, unconfirmed records from the Pilliga and Torrington districts. (OEH 2013b)	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of GDR (OEH 2013b). It is most commonly found on sites derived from sedimentary rock and in north eastern NSW in forests characterised by *Corymbia maculata* (Spotted Gum) and *C. henryi* (OEH 2013b). It has been known to feed on introduced pasture species (OEH 2013b).	Moderate	Potential	Moderate	Potential	The study area has moderate habitat of open woodland. There is potential for impact by the proposed activity and hence an AoS has been undertaken for this species.
Alectura lathami	Australian Brush-turkey	E2	~	The Australian Brush-turkey has a largely coastal distribution from Cape York south as far as the Illawarra in NSW. A population of the Australian Brush-turkey is known from the Nandewar and Brigalow Belt South Bioregions. Recent records for the species show the population to range from north east of Warialda, to Narrabri, approximately 115 km to the south-west, and occur within the local government areas of Yallaroi, Bingara, Narrabri, Barraba and Moree Plains. (OEH 2013b)	It occurs in forested and wooded areas of tropical and warm-temperate districts, particularly above 300 m to at least 1200 m altitude. In NSW the inland vegetation type preferred by the Australian Brush-turkey is a dry rainforest community that is found within the Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions Endangered Ecological Community (OEH 2013b)	No habitat	No	No habitat	No	No potential
Anomalopus mackayi	Five-clawed Worm-skink	E1	V	Patchy distribution on the North West Slopes and Plains of north-east NSW and south-east Queensland, from the Ashford area west to Mungindi and Walgett in NSW and north to Dalby in Queensland (OEH 2013b)	Close to or on the lower slopes of slight rises in grassy White Box woodland on moist black soils, and River Red Gum-Coolibah-Bimble Box woodland on deep cracking loose clay soils. May also occur in grassland areas and open paddocks with scattered trees. Live in permanent deep tunnel-like burrows and deep soil cracks, coming close to the surface under fallen timber and litter, especially partially buried logs (OEH 2013b)	Low	Unlikely	Low	Unlikely	Unlikely
Anseranas semipalmata	Magpie Goose	V	~	The Magpie Goose is still relatively common in the Australian northern tropics, but had disappeared from south-east Australia by 1920 due to drainage and overgrazing of reed swamps used for breeding. Since the 1980s there have been an increasing number of records in central and northern NSW. Vagrants can follow food sources to south-eastern NSW (OEH 2013b)	Activities centred on terrestrial sedge-dominated wetlands; mainly those on floodplains of rivers (Marchant & Higgins 1993 Simpson & Day 1999).	Low	Unlikely	No habitat	No	No potential
Anthochaera phrygia	Regent Honeyeater	CE	E, M	The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia. Birds are also found in drier coastal woodlands and forests in some years. Once recorded between Adelaide and the central coast of Queensland, its range has contracted	Associated with temperate eucalypt woodland and open forest including forest edges, wooded farmland and urban areas with mature eucalypts, and riparian forests of *Casuarina cunninghamiana* (River Oak) (Garnett 1993). Areas containing *Eucalyptus robusta* (Swamp	High	Potential	Moderate	Potential	Study area provides foraging habitat when *E. crebra* is in flower. Due to sporadic flowering of *E. crebra*, the study area is unlikely to provide a

Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
				dramatically in the last 30 years to between north-eastern Victoria and south-eastern Queensland (OEH 2013b)	Mahogany) in coastal areas have been observed to be utilised. The Regent Honeyeater primarily feeds on nectar from box and ironbark eucalypts and occasionally from banksias and mistletoes (NPWS 1995). As such it is reliant on locally abundant nectar sources with different flowering times to provide reliable supply of nectar (Environment Australia 2000).					reliable or abundant foraging habitat. However, it is possible that this species may use the study area sporadically as sub-optimal foraging habitat. There is a potential for impact by the proposed activity and an AoS has been undertaken for this species.
Aprasia parapulchella	Pink-tailed Legless Lizard	V	V	It is known only to occur in the Central and Southern Tablelands and South Western Slopes of NSW. Populations have been recorded in the Queanbeyan/Canberra district, Cooma, Yass, Bathurst, Albury and West Wyalong areas (DECC 2007)	It inhabits open woodland that has a predominately native grass understorey that is situated on sloping, well-drained soils with rocky outcrops or scattered partially buried rocks present. Burrows are formed beneath small, partially embedded rocks that are often inhabited by small black ants and termites. The Pink-tailed Worm-lizard feeds on the larvae and eggs of the ants with which it shares its burrows. In the summer months 2 eggs are laid inside the ant nests with the young first appearing in March. (DECC 2007)	Low	Unlikely	Low	Unlikely	Unlikely
Apus pacificus	Fork-tailed Swift	-	M Mar	The Fork-tailed Swift is a non-breeding visitor to all states and territories of Australia. In NSW, the Fork-tailed Swift is recorded in all regions. Many records occur east of the Great Divide, however, a few populations have been found west of the Great Divide. These are widespread but scattered further west of the line joining Bourke and Dareton. Sightings have been recorded at Milparinka, the Bulloo River and Thurloo Downs (DoE 2013b)	Sometimes travels with Needletails. Varied habitat with a possible tendency to more arid areas but also over coasts and urban areas (Simpson & Day 1999).	High	Known	High	Likely	Potential. An AoS has been undertaken for this species.
Ardea alba	Great Egret, White Egret	~	M, Mar	Eastern Great Egrets are widespread in Australia. They occur in all states/territories of mainland Australia and in Tasmania. They have also been recorded as vagrants on Lord Howe, Norfolk and Macquarie Islands (DoE 2013b)	The Great Egret is common and widespread in Australia (McKilligan 2005). It forages in a wide range of wet and dry habitats including permanent and ephemeral freshwaters, wet pasture and estuarine mangroves and mudflats. (McKilligan 2005).	Moderate	Likely	Low	Unlikely	Unlikely
Ardea ibis	Cattle Egret	~	M, Mar	The Cattle Egret is widespread and common according to migration movements and breeding localities surveys. Two major distributions have been located; from north-east Western Australia to the Top End of the Northern Territory and around south-east Australia. In Western Australia and the Northern Territory, the Cattle Egret is	Cattle Egrets forage on pasture, marsh, grassy road verges, rain puddles and croplands, but not usually in the open water of streams or lakes and they avoid marine environments (McKilligan 2005). Some individuals stay close to the natal heronry from one nesting season to the next, but the majority	Moderate	Likely	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
				located from Wyndham to Arnhem Land. In south-east Australia it is found from Bundaberg, inland to Roma, Thargominda, and then down through Inverell, Walgett, Nyngan, Cobar, Ivanhoe, Balranald to Swan Hill, and then west to Pinnaroo and Port Augusta (DoE 2013b)	leave the district in autumn and return the next spring. Cattle Egrets are likely to spend the winter dispersed along the coastal plain and only a small number have been recovered west of the Great Dividing Range (McKilligan 2005).				
Ardeotis australis	Australian Bustard	E1	~	The Australian Bustard mainly occurs in inland Australia and is now scarce or absent from southern and south-eastern Australia. In NSW, they are mainly found in the north-west corner and less often recorded in the lower western and central west plains regions. Occasional vagrants are still seen as far east as the western slopes and Riverine plain. Breeding now only occurs in the north-west region of NSW (OEH 2013b)	Mainly inhabits tussock and hummock grasslands, though prefers tussock grasses to hummock grasses; also occurs in low shrublands and low open grassy woodlands; occasionally seen in pastoral and cropping country, golf courses and near dams (OEH 2013b)	High	Potential	Low	Unlikely	Unlikely
Botaurus poiciloptilus	Australasian Bittern	E1	E	Australasian Bitterns are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west (OEH 2013b)	Terrestrial wetlands with tall dense vegetation, occasionally estuarine habitats (Marchant & Higgins 1993). Reedbeds, swamps, streams, estuaries (Simpson & Day 1999).	Low	Unlikely	Low	Unlikely	Unlikely
Burhinus grallarius	Bush Stone-curlew	E1	~	The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range.	Associated with dry open woodland with grassy areas, dune scrubs, in savanna areas, the fringes of mangroves, golf courses and open forest / farmland (Pittwater Council 2000; Marchant & Higgins 1993). Forages in areas with fallen timber, leaf litter, little undergrowth and where the grass is short and patchy (Environment Australia 2000; Marchant & Higgins 1993). Is thought to require large tracts of habitat to support breeding, in which there is a preference for relatively undisturbed to lightly disturbed	High	Known	Moderate	Potential	The study area has areas of open woodland with fallen timber, leaf litter and little undergrowth. However, much of the study area is dense with regrowth from fire and logging disturbance and this high level of disturbance is not preferable for this species. There is a potential for impact by the proposed activity and an AoS has been undertaken for this species.
Calyptorhynchus banksii (inland subspecies)	Red-tailed Black-Cockatoo	V	~	The Red-tailed Black-Cockatoo is the most widespread of the Black-Cockatoos, ranging broadly across much of northern and western Australia as well as western Victoria. In NSW, one population occurs on the north-western slopes and plains but another small isolated population is found in the coastal north-east. (OEH 2013b).	Occurs in coastal forests and woodlands or inland open shrubland near water (Simpson & Day 1999). This species is noted to feed mainly on seeds, especially of eucalypts, casuarinas, acacia and banksias. May also take berries, nectar, flowers and occasionally insects and their larvae (Marchant & Higgins 1993).	Low	Unlikely	Low	Unlikely	The study area is situated outside of the regular range of this species. This species is unlikely to be reliant on the habitat in the study area and there is a low potential for impact by the proposed activity. As such, an AoS is

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
										not required.
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	~	The species is uncommon although widespread throughout suitable forest and woodland habitats, from the central Queensland coast to East Gippsland in Victoria, and inland to the southern tablelands and central western plains of NSW, with a small population in the Riverina. An isolated population exists on Kangaroo Island, South Australia (OEH 2013b)	Associated with a variety of forest types containing *Allocasuarina* species, usually reflecting the poor nutrient status of underlying soils (Environment Australia 2000; OEH 2013b). Intact drier forest types with less rugged landscapes are preferred (OEH 2013b). Nests in large trees with large hollows (Environment Australia 2000).	High	Known	Moderate	Likely	This species is commonly found in the study region. It feeds predominantly on comes from *Casuarina diminuta* subsp. *diminuta* which is found in the vegetation type that occurs in the study area. Large hollows in the study area provide suitable nesting habitat. An AoS has been undertaken for this species.
Cercartetus nanus	Eastern Pygmy-possum	V	~	The Eastern Pygmy-possum is found in south-eastern Australia, from southern Queensland to eastern South Australia and in Tasmania. In NSW it extends from the coast inland as far as the Pilliga, Dubbo, Parkes and Wagga Wagga on the western slopes. (OEH 2013b). It occupies small home ranges, rarely greater than 1 ha.	Found in wet and dry eucalypt forest, subalpine woodland, coastal banksia woodland and wet heath (Menkhorst & Knight 2004). Pygmy-Possums feed mostly on the pollen and nectar from banksias, eucalypts and understorey plants and will also eat insects, seeds and fruit (Turner & Ward 1995). The presence of *Banksia* sp. and *Leptospermum* sp. are an important habitat feature (OEH 2013b). Small tree hollows are favoured as day nesting sites, but nests have also been found under bark, in old birds nests and in the branch forks of tea-trees (Turner & Ward 1995).	High	Known	Low	Unlikely	Unlikely, whilst the broader north-east Pilliga Forest contains known habitat for the Eastern Pygmy-possum, the study area does not support suitable habitat for this species (i.e. the study area does not have a heathy understorey suitable for foraging). As such, an AoS is not required.
Certhionyx variegatus	Pied Honeyeater	V	~	Widespread throughout acacia, mallee and Spinifex scrubs of arid and semi-arid Australia. Occasionally occurs further east, on the slopes and plains and the Hunter Valley, typically during periods of drought (OEH 2013b).	Inhabits wattle shrub (primarily Mulga, *Acacia aneura*), mallee, Spinifex and eucalypt woodlands, usually when shrubs are flowering; feeds on nectar, predominantly from various species of emu-bushes (*Eremophila* spp.); also from mistletoes and various other shrubs (e.g. *Brachystema* spp. and *Grevillea* spp.); also eats saltbush fruit, berries, seed, flowers and insects. Highly nomadic, following the erratic flowering of shrubs; can be locally common at times (OEH 2013b)	Low	Unlikely	Low	Unlikely	Unlikely
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Found mainly in areas with extensive cliffs and caves, from Rockhampton in Queensland south to Bungonia in the NSW Southern Highlands. It is generally rare with a very patchy distribution in NSW. There are scattered records from the New England Tablelands and North West Slopes.	The Large-eared Pied Bat has been recorded in a variety of habitats, including dry sclerophyll forests, woodland, sub-alpine woodland, edges of rainforests and wet sclerophyll forests (Churchill 1998; DECC 2007). This species roosts in caves, rock overhangs and disused	High	Potential	High	Potential	No breeding habitat for this species is present in the study area. The woodland in the study area is suitable for foraging. An AoS

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				(OEH 2013b)	mine shafts and as such is usually associated with rock outcrops and cliff faces (Churchill 1998).					has been undertaken for this species.
Chalinolobus picatus	Little Pied Bat	V	~	The Little-Pied Bat is found in inland Queensland and NSW (including Western Plains and slopes) extending slightly into South Australia and Victoria.	Occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, Bimbil box. Roosts in caves, rock outcrops, mine shafts, tunnels, tree hollows and buildings. Feeds on moths and possibly other flying invertebrates.	High	Known	High	Known	This species has been recorded within Dewhurst 31 and is likely to use habitat within the study areas for roosting and foraging. An AoS has been undertaken for this species.
Chthonicola sagittata	Speckled Warbler	V	~	The Speckled Warbler has a patchy distribution throughout south-eastern Queensland, the eastern half of NSW and into Victoria, as far west as the Grampians. The species is most frequently reported from the hills and tablelands of the Great Dividing Range, and rarely from the coast. There has been a decline in population density throughout its range, with the decline exceeding 40% where no vegetation remnants larger than 100ha survive. (OEH 2013b)	Occupies a wide range of eucalypt dominated communities with a grassy understorey, often on rocky ridges or in gullies (OEH 2013b). Typical habitat would include scattered native tussock grasses, a sparse shrub layer, some eucalypt regrowth and an open canopy (OEH 2013b). Large, relatively undisturbed remnants are required for the species to persist in an area (OEH 2013b). Pairs are sedentary and occupy a breeding territory of about ten hectares, with a slightly larger home-range when not breeding (OEH 2013b)	High	Known	High	Known	This species is known to forage in the study area and is likely to breed in habitat in the study area. An AoS has been undertaken for this species.
Circus assimilis	Spotted Harrier	V	~	The Spotted Harrier occurs throughout the Australian mainland, except in densely forested or wooded habitats of the coast, escarpment and ranges, and rarely in Tasmania. Individuals disperse widely in NSW and comprise a single population. (OEH 2013b)	Occurs in grassy open woodland including acacia and mallee remnants, inland riparian woodland, grassland and shrub steppe. It is found most commonly in native grassland, but also occurs in agricultural land, foraging over open habitats including edges of inland wetlands. Builds a stick nest in a tree and lays eggs in spring (or sometimes autumn), with young remaining in the nest for several months. Preys on terrestrial mammals (e.g. bandicoots, bettongs, and rodents), birds and reptile, occasionally insects and rarely carrion.	Moderate	Potential	Moderate	Potential	Breeding and foraging habitat for this species is present in the study area. An AoS has been undertaken for this species.

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Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V	~	The Brown Treecreeper is endemic to eastern Australia and occurs in eucalypt forests and woodlands of inland plains and slopes of the Great Dividing Range. It is less commonly found on coastal plains and ranges. The western boundary of the range of Climacteris picumnus victoriae runs approximately through Corowa, Wagga Wagga, Temora, Forbes, Dubbo and Inverell and along this line the subspecies intergrades with the arid zone subspecies of Brown Treecreeper Climacteris picumnus picumnus which then occupies the remaining parts of the state (OEH 2013b)	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 mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey, sometimes with one or more shrub species; also found in mallee and *Eucalyptus camaldulensis* (River Red Gum) Forest. Generally not found in woodlands with a dense shrub layer. Fallen timber is an important habitat component for foraging. It is sedentary and nests in tree hollows within permanent territories (OEH 2013b).	High	Unlikely The north-east Pilliga Forest lies outside of the geographically defined area for the eastern subspecies	High	Unlikely The north-east Pilliga Forest lies outside of the geographically defined area for the eastern subspecies	Unlikely
Crinia sloanei	Sloane's Froglet	V	~	Sloane's Froglet has been recorded from widely scattered sites in the floodplains of the Murray-Darling Basin, with the majority of records in the Darling Riverine Plains, NSW South Western Slopes and Riverina bioregions in New South Wales. It has not been recorded recently in the northern part of its range and has only been recorded infrequently in the southern part of its range in NSW (OEH 2013b)	It is typically associated with periodically inundated areas in grassland, woodland and disturbed habitats.	Low	Unlikely	Low	Unlikely	Unlikely
Daphoenositta chrysoptera	Varied Sittella	V	~	Varied Sittellas are endemic and widespread in mainland Australia. (OEH 2013b)	Varied Sittellas are found in eucalypt woodlands and forests throughout their range. They prefer rough-barked trees like stringybarks and ironbarks or mature trees with hollows or dead branches (OEH 2013b)	High	Known	High	Known	This species is likely to forage and breed in the study area. An AoS has been undertaken for this species.
Dasyurus maculatus	Spotted-tailed Quoll	V	E	The range of the Spotted-tailed Quoll has contracted considerably since European settlement. It is now found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Queensland. Only in Tasmania is it still considered common. (OEH 2013b)	It inhabits a range of environments including rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline. Den sites are found in hollow-bearing trees, fallen logs, small caves, rock crevices, boulder fields and rocky-cliff faces. Females occupy home ranges of up to 750 ha and males up to 3,500 ha, which are usually traversed along densely vegetated creek lines. (OEH 2013b).	Moderate	Potential	Low	Potential	This species has potential to forage and breed in the study area. An AoS has been undertaken for this species.

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Delma torquata	Collared Delma	~	V	The main concentrations of records are from the western suburbs of Brisbane. Urban development in these suburbs has resulted in a contraction of previously recorded populations in this area (Ryan 2006a). The species is also known from the following sites: the Bunya Mountains; Blackdown Tableland National Park (NP); Bullyard Conservation Park (CP); D'Aquilar Range NP, Expedition NP; Naumgna and Lockyer Forest Reserves (inside Bunya Mountains NP; Western Creek, near Millmerran; and the Toowoomba Range (Davidson 1993; Ryan 2006a).	The Collared Delma normally inhabits eucalypt or acacia dominated woodland and open forest where it is associated with suitable microhabitats (exposed rocky outcrops, or a sparse understorey of tussock grass, shrubs or semi-evergreen vine thickets). *Corymbia citriodora* (Lemon-scented Gum) is typically the dominant canopy species. Other dominant canopy species include *Eucalyptus crebra*, E. melanophloia, *E. tessellaris*, *E. moluccana*, *E. microcorys*, *E. tereticornis*, *Angophora* sp. and *Acacia harpophylla* (Brigalow) (Peck 2003, cited in Peck & Hobson 2007; Ryan 2006a). Leaf Litter appears to be an essential part of the microhabitat and is always present. (DoE 2013b)	Low	Unlikely	Low	Unlikely	Unlikely
Drymodes brunneopygia	Southern Scrub-robin	V	~	This species is restricted to mallees and shrublands across southern Australia and in NSW is confined to two main areas. The first is in central NSW and is centred on Round Hill and Nombinnie Nature Reserves, though suitable habitat probably exists on adjoining leasehold lands. The other population occurs in the far south west of NSW, mainly within the Scotia mallee centred on Tarawi NR and Scotia Sanctuary	Inhabits mallee and acacia scrub, particularly with dense sub-shrubs in the understorey, including Broombush and other dry shrubs	Moderate	Unlikely	Moderate	Unlikely	The study area is situated outside of the regular range of this species. This species is unlikely to be reliant on the habitat in the study area and there is a low potential for impact by the proposed activity. As such, an AoS is not required.
Ephippiorhynchus asiaticus	Black-necked Stork	E1	~	In Australia, Black-necked Storks are widespread in coastal and subcoastal northern and eastern Australia, south to central-eastern NSW and with vagrants recorded at scattered sites well away from the coast (for example, near Moree, north-east of Hay and in Victoria). In NSW, the species becomes	Associated with tropical and warm temperate terrestrial wetlands, estuarine and littoral habitats, and occasionally woodlands and grasslands floodplains (Marchant & Higgins 1993). Forages in fresh or saline waters up to 0.5m deep, mainly in open fresh waters,	Low	Unlikely	Low	Unlikely	Unlikely

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				more uncommon south of the Northern Rivers region, and rarely occurs south of Sydney (OEH 2013b)	extensive sheets of shallow water over grasslands or sedgeland, mangroves, mudflats, shallow swamps with short emergent vegetation and permanent billabongs and pools on floodplains (Marchant & Higgins 1993; OEH 2013b).					
Epthianura albifrons	White-fronted Chat	V	~	The White-fronted Chat is found across the southern half of Australia, It is found mostly in temperate to arid climates and very rarely sub-tropical areas, it occupies foothills and lowlands up to 1000 m above sea level. In NSW, it occurs mostly in the southern half of the state, in damp open habitats along the coast, and near waterways in the west. Along the coast, it is found mostly in saltmarsh vegetation but also in open grasslands and sometimes in low shrubs bordering wetland areas. (OEH 2013b)	Gregarious species, usually found foraging on bare or grassy ground in wetland areas, singly or in pairs. They are insectivorous, feeding mainly on flies and beetles caught from or close to the ground. Have been observed breeding from late July through to early March, with 'open-cup' nests built in low vegetation. Nests in the Sydney region have also been seen in low isolated mangroves. Nests are usually built about 23 cm above the ground (but have been found up to 2.5 m above the ground). (OEH 2013b)	Low	Unlikely	Low	Unlikely	Unlikely
Erythrotriorchis radiatus	Red Goshawk	CE	V	Red Goshawks are found from across northern Australia, down the east coast of Qld and into the northern coast of NSW. In NSW records are rare. Listed as having occurred south to Port Stephens.	Its habitat consists of wooded and forested areas. Prefers forest and woodland with a mosaic of vegetation types, large populations of birds for prey and permanent water. Riverine vegetation is highly utilised by this species. Its habits are not well known, but it is considered to be a solitary, sedentary bird. They nest in tree forks of *Eucalypt* sp. and *Melaleuca* sp. or those nests of other large birds such as Magpies or Crows. The nests are generally built of sticks, which are lined with soft twigs and leaves	Moderate	Unlikely	Moderate	Unlikely	Unlikely
Falco hypoleucos	Grey Falcon	E1	~	The Grey Falcon is sparsely distributed in NSW, chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. The breeding range has contracted since the 1950s with most breeding now confined to arid parts of the range. There are possibly less than 5000 individuals left. Population trends are unclear, though it is believed to be extinct in areas with more than 500 mm rainfall in NSW (OEH 2013b)	Usually restricted to shrubland, grassland and wooded watercourses of arid and semi-arid regions, although it is occasionally found in open woodlands near the coast. Also occurs near wetlands where surface water attracts prey (OEH 2013b)	Moderate	Potential	Low	Unlikely	Unlikely
Gallinago hardwickii	Latham's Snipe, Japanese Snipe	~	M, Mar	The species has been recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia. The range extends inland over the eastern tablelands in south-eastern Queensland (and occasionally from Rockhampton in the north), and to west of the Great Dividing Range in New South Wales (DoE 2013b).	This species occurs in permanent and ephemeral wetlands up to 2000 m above sea-level, usually inhabiting open, freshwater wetlands with low, dense vegetation such as swamps, flooded grasslands or heathlands, around bogs and other water bodies. This species can also occur in habitats with saline or brackish water and in modified or artificial habitats.	Low	Potential	Low	Unlikely	Unlikely

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					It feeds in mud, either exposed or in very shallow water with low, dense vegetation. Roosting occurs on the ground near or in foraging areas beside or under clumps of vegetation, among dense tea-tree, in forests, in drainage ditches or plough marks, among boulders, or in shallow water if cover is unavailable. They feed on a variety of seeds, plant material, and insects.					
Geophaps scripta scripta	Squatter Pigeon	E	V	The Squatter Pigeon (southern) occurs on the inland slopes of the Great Dividing Range. Its distribution extends from the Burdekin-Lynd divide in central Queensland, west to Charleville and Longreach, east to the coastline between Proserpine and Port Curtis (near Gladstone), and south to scattered sites though out south-eastern Queensland. It's distribution historically extended into NSW, however, there have been no confirmed records of the species in NSW since the 1970s.	The Squatter Pigeon (southern) occurs mainly in grassy woodlands and open forests that are dominated by eucalypts . It has also been recorded in sown grasslands with scattered remnant trees, disturbed habitats (i.e. around stockyards, along roads and railways, and around settlements, in scrub and acacia growth, and remains common in heavily-grazed country north of the Tropic of Capricorn (EPA 2006). The species is commonly observed in habitats that are located close to bodies of water.	Low	Unlikely	Low	Unlikely	Unlikely
Glossopsitta pusilla	Little Lorikeet	V	~	The Little Lorikeet is distributed widely across the coastal and Great Divide regions of eastern Australia from Cape York to South Australia. NSW provides a large portion of the species' core habitat, with lorikeets found westward as far as Dubbo and Albury. Nomadic movements are common, influenced by season and food availability, although some areas retain residents for much of the year and 'locally nomadic' movements are suspected of breeding pairs (OEH 2013b).	Little Lorikeets 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, but also on a variety of other species including melaleucas and mistletoes. On the western slopes and tablelands *Eucalyptus albens* and *E. melliodora* are important food sources for pollen and nectar respectively.	High	Known	High	Likely	This species has been observed numerously in the study region and is likely to use the study area for foraging (especially for *E. crebra*) and nesting in hollows. An AoS has been undertaken for this species.
Grantiella picta	Painted Honeyeater	V	~	The Painted Honeyeater is nomadic and occurs at low densities throughout its range. The greatest concentrations of the bird (and almost all breeding), occurs on the inland slopes of the Great Dividing Range in NSW, Victoria and southern QLD. During the winter it is more likely to be found in the north of its distribution (OEH 2013b)	The Painted Honeyeater inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. It feeds on mistletoes growing on woodland eucalypts and acacias. It nests from spring to autumn in a small, delicate nest hanging within the outer canopy of drooping eucalypts, she-oak, paperbark or mistletoe branches.	High	Likely	High	Likely	This species is likely to use the study area for foraging (especially for *E. crebra*) and breeding. An AoS has been undertaken for this species.
Grus rubicunda	Brolga	V	~	The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It still abundant in the northern tropics, but very sparse across the southern part of its range	The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It still abundant in the northern tropics, but very sparse across the southern	Low	Unlikely	Low	Unlikely	Unlikely

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				(OEH 2013b).	part of its range (OEH 2013b).					
Haliaeetus leucogaster	White-bellied Sea-Eagle	~	M, Mar	The White-bellied sea-eagle is distributed along the coastline of mainland Australia and Tasmania. It also extends inland along some of the larger waterways, especially in eastern Australia. The inland limits of the species are most restricted in south-central and south-western Australia, where it is confined to a narrow band along the coast (DoE 2013b).	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Marchant & Higgins 1993, Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1993)	Moderate	Known	Low	Potential	This species may potentially forage in the study area. An AoS has been undertaken for this species.
Hamirostra melanosternon	Black-breasted Buzzard	V	~	The Black-breasted Buzzard is found sparsely in areas of less than 500 mm rainfall, from north-western NSW and north-eastern South Australia to the east coast at about Rockhampton, then across northern Australia south almost to Perth, avoiding only the Western Australian deserts (OEH 2013b)	This species lives in a range of inland habitats including open forests, riverine woodlands, scrubs and heathlands. It is often found along timbered watercourses, which is preferred breeding habitat. It can also hunt over grasslands and includes reptiles, small mammals, birds and large eggs in its prey.	Low	Potential	Low	Potential	There is potential for this species to forage although unlikely to breed in the study area. An AoS has been undertaken for this species.
Hieraaetus morphnoides	Little Eagle	V	~	The Little Eagle is found throughout the Australian mainland excepting the most densely forested parts of the Dividing Range escarpment. It occurs as a single population throughout NSW.	The Little Eagle is seen over woodland and forested lands and open country, extending into the arid zone. It tends to avoid rainforest and heavy forest (OEH 2013b)	High	Likely	Moderate	Potential	This species has potential to fly over the study area or forage in the study area. It is unlikely to breed in the study area. An AoS has been undertaken for this species.
Hirundapus caudacutus	White-throated Needletail	-	M, Mar	The White-throated Needletail is found throughout eastern and south-eastern Australia. In eastern NSW, it is found to extend inland to the western slopes of the Great Divide and occasionally to the adjacent inland plains (DoE 2013b).	In Australia, this species is almost exclusively aerial and found over most types of habitat (DoE 2013b).	High	Known	High	Likely	This species was recorded by RPS adjacent to the study area. An AoS has been undertaken for this species.
Hoplocephalus bitorquatus	Pale-headed Snake	V	~	A patchy distribution from north-east Queensland to north-east NSW. In NSW it occurs from the coast to the western side of the Great Divide as far south as Tuggerah (OEH 2013b).	Wide range of habitats from rain or wet sclerophyll forest to drier eucalypt forests and favours streamside habitat in drier areas (OEH 2013b).	High	Likely	Low	Unlikely	Unlikely
Jalmenus eubulus	Pale Imperial Hairstreak	CE	~	It is found in Queensland and NSW. In Queensland it is restricted to the seasonally sub-humid central and southern areas of the state. In NSW it is found only in Brigalow -dominated open forests and woodlands in northern areas of the state.	Suitable habitat is dominated by *Acacia harpophylla* (Brigalow) and *Casuarina cristata* (Buloke) on clay soils on flat to gently undulating plants, usually with scattered emergent eucalypts. It is only known to breed in old-growth forest or woodland and does not appear to colonise regrowth habitats after clearing	Low	Unlikely	Low	Unlikely	Unlikely
Lagorchestes leporides	Eastern Hare-wallaby	E4	Ex	The Eastern Hare-wallaby was common in open plains country around the Murray River and in the grasslands and woodlands of western Victoria and	This species generally spent the day sheltering and foraged at night, it sheltered under large tussocks which it excavated itself.	Low	No	Low	No	No

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				southeastern South Australia, but it has not been seen alive this century. Last South Australian record: Lucindale, 1892 (South Australia Museum n.d)						
Lathamus discolor	Swift Parrot	E1	E, Mar	Breeds in Tasmania between September and January. Migrates to mainland in autumn, where it forages on profuse flowering Eucalypts (Blakers et al. 1984; Schodde and Tidemann 1986; Forshaw and Cooper 1981).	On mainland, autumn and winter flowering eucalypts are important for this species. Favoured feed trees include winter flowering species such as *Eucalyptus robusta*, *Corymbia maculata*, *C. gummifera* (Red Bloodwood), *E. sideroxylon* (Mugga Ironbark and *E. albens* (OEH 2013b).	High	Potential	Moderate	Potential	Study area provides foraging habitat when *E. crebra* is in flower. Due to sporadic flowering of *E. crebra*, the study area is unlikely to provide a reliable or abundant foraging habitat. However, it is possible that this species may use the study area sporadically as sub-optimal foraging habitat. There is a potential for impact by the proposed activity and an AoS has been undertaken for this species.
Leipoa ocellata	Malleefowl	E1	V, M	The stronghold for this species in NSW is the mallee in the south west centred on Mallee Cliffs NP and extending east to near Balranald and as far north as Mungo NP. In central NSW it has been significantly reduced through land clearance and fox predation and now occurs chiefly in Yathong, Nombinnie and Round Hill NRs and surrounding areas, though birds continue to survive in Loughnan NR (OEH 2013b).	Dry inland scrub, mallee. Males tend large sand nest-mound (Simpson & Day 1999).	Low	Unlikely	Low	Unlikely	Unlikely
Leporillus apicalis	Lesser Stick-nest Rat	E4	Ex	The last specimen of the Lesser Stick-nest Rat was captured near Mt Crombie. south-west of the present Amata settlement, South Australia in 1933. However, in the nineteenth century it occupied a broad area stretching from the Riverina in New South Wales, through most of inland South Australia and into the Gibson Desert, reaching the Western Australian coast in the Gascoyne region (Burbidge et al. 1988; Cole & Woinarski 2000; Finlayson 1961).	The Lesser Stick-nest Rat occupied arid and semi-arid lands (Burbidge et al. 1988; Cole & Woinarski 2000).	Low	No	Low	No	Unlikely
Limosa limosa	Black-tailed Godwit	V	~	In NSW, it is most frequently recorded at Kooragang Island (Hunter River estuary). Records in western NSW indicate that a regular inland passage is used by the species, as it may occur around any of the large lakes in the western areas during summer, when the muddy shores are exposed. It has been recorded within the Murray-Darling	The Black-tailed Godwit is a migratory wading bird that breeds in Mongolia and Eastern Siberia (Palaearctic) and flies to Australia for the southern summer, arriving in August and leaving in March. Primarily a coastal species, it is usually found in sheltered bays, estuaries and lagoons with large	Low	Unlikely	Low	Unlikely	Unlikely

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				Basin, on the western slopes of the Northern Tablelands and in far north-western NSW.	intertidal mudflats and/or sandflats. Further inland, it can also be found on mudflats and in water less than 10 cm deep, around muddy lakes and swamps.					
Litoria booroolongensis	Booroolong Frog	E1	E	It is restricted to the tablelands and slopes from 200 to 1300 m above sea level in NSW and north eastern Victoria. The species is mostly found along the western-flowing streams and their headwaters of the Great Dividing Range. Catchments drain from the Northern Tablelands to the Tumut River in the Southern Highlands, and other tributaries of the Murrumbidgee River. The only records of the species in northern NSW outside the Northern Tablelands are from two streams near Tamworth, NSW.	Typically inhabits rocky western-flowing creeks and their headwaters, although a small number of animals have also been recorded in eastern-flowing streams. along permanent streams with some fringing vegetation cover such as ferns, sedges or grasses (DoE 2013b)	No habitat	No	No habitat	No	No
Lophochroa leadbeateri (*Cacatua leadbeateri*)	Major Mitchell's Cockatoo / Pink Cockatoo	V	~	Found across the arid and semi-arid inland, from south-western Queensland south to north-west Victoria, through most of South Australia, north into the south-west Northern Territory and across to the west coast between Shark Bay and about Jurien. In NSW it is found regularly as far east as about Bourke and Griffith, and sporadically further east than that. (OEH 2013b)	Inhabits a wide range of tree and treeless inland habitats, always within easy reach of water. Feeds mostly on the ground, especially on the seeds of native and exotic melons and on the seeds of species of saltbush, wattles and cypress pines. (OEH 2013b)	Moderate	Unlikely	Moderate	Unlikely	The study area is situated outside of the regular range of this species. This species is unlikely to be reliant on the habitat in the study area and there is a low potential for impact by the proposed activity. As such, an AoS is not required.
Lophoictinia isura	Square-tailed Kite	V	~	The Square-tailed Kite ranges along coastal and subcoastal areas from south-western to northern Australia, Queensland, NSW and Victoria. In NSW, scattered records of the species throughout the state indicate that it is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast, from September to March	In coastal areas, this species is associated with tropical and temperate forests and woodlands on fertile soils with an abundance of passerine birds (Marchant & Higgins 1993, OEH 2013b). May be recorded inland along timbered watercourses (OEH 2013b). In NSW it is commonly associated with ridge or gully forests dominated by *Eucalyptus longiflora* (Woollybutt), C. *maculata*, or *E. elata* and *E. smithii* (OEH 2013b).	High	Likely	Moderate	Potential	This species has potential to breed and forage in the study area. An AoS has been undertaken for this species.
Maccullochella peelii	Murray Cod	-	V	The Murray Cod remains patchily distributed throughout the Murray-Darling Basin, but has undergone an extensive decline in abundance (Koehn and Clunie 2010). Commercial fisheries data indicate that natural populations declined in the 1920s and then again dramatically in the 1950s (Lintermans 2007). More recent survey data from the Basin states indicates some NSW populations may be recovering (Koehn and Clunie 2010). Murray Cod	The Murray Cod is the largest Australian freshwater fish, and is endemic to the Murray-Darling River system (Lintermans 2007). It is a top order 'sit and wait' aquatic predator, which prefers deep holes in rivers with instream cover such as rocks, stumps, fallen trees or undercut banks (Lintermans 2007).	No habitat	No	No habitat	No	No

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				populations in the Border Rivers, Gwydir, Namoi, mid-Murrumbidgee, lower Darling and lower Murray rivers appear to be in good condition (defined as widespread, abundant and recruiting) (Koehn and Clunie 2010).						
Macropus dorsalis	Black-striped Wallaby	E1	~	From the Townsville area in Queensland to northern NSW where it occurs on both sides of the Great Divide. On the North West Slopes of NSW it occurs in Brigalow remnants to south of Narrabri. On the north coast it is confined to the upper catchments of the Clarence and Richmond Rivers	Preferred habitat is characterised by dense woody or shrubby vegetation within three metres of the ground. This dense vegetation must occur near a more open, grassy area to provide suitable feeding habitat. On the North West Slopes, it is associated with dense vegetation, including brigalow, ooline and semi-evergreen vine thicket. On the north coast, it is closely associated with dry rainforest but also occur in moist eucalypt forest with a rainforest understorey or a dense shrub layer.	High	Known	High	Likely	This species has been recorded in similar habitat adjacent to the study area and is likely to use the study area. An AoS has been undertaken for this species.
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V	~	The Hooded Robin is, found across Australia, except for the driest deserts and the wetter coastal areas - northern and eastern coastal Queensland and Tasmania. However, it is common in few places, and rarely found on the coast. The south-eastern form (subspecies *cucullata* is found from Brisbane to Adelaide and throughout much of inland NSW, with the exception of the extreme north-west, where it is replaced by subsp. *picata*	Associated with a wide range of Eucalypt woodlands, Acacia shrubland and open forests. In temperate woodlands, the species favours open areas adjoining large woodland blocks, with areas of dead timber and sparse shrub cover. Hooded Robin home ranges are relatively large, averaging 18ha for birds from the New England Tableland. It is considered a sedentary species, but local seasonal movements are possible.	High	Known	High	Likely	This species was recorded at Dewhurst 13-18 just outside of the study area and has potential to breed and forage in the study area. An AoS has been undertaken for this species.
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V	~	This subspecies extends south from central Queensland, through NSW, Victoria into south eastern SA. In NSW it is widespread, with records from the tablelands and western slopes of the Great Dividing Range to the north-west and central-west plains and the Riverina. It is rarely recorded east of the Great Dividing Range, although regularly observed from the Richmond and Clarence River areas. It has also been recorded at a few scattered sites in the Hunter, Central Coast and Illawarra regions	Predominantly associated with box-ironbark association woodlands, especially *Eucalyptus sideroxylon*, *E. albens*, *E. microcarpa* and *E. tereticornis*. Also inhabits open forests of smooth-barked gums, stringybarks, ironbarks and tea-trees, and River Red Gum (OEH 2013b).	High	Likely	High	Likely	This species has potential to breed and forage in the study area. An AoS has been undertaken for this species.

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Merops ornatus	Rainbow Bee-eater	~	M, Mar	The Rainbow Bee-eater is distributed across much of mainland Australia, and occurs on several near-shore islands. It is not found in Tasmania, and is thinly distributed in the most arid regions of central and Western Australia (DoE 2013b).	Occurs in open country, chiefly at suitable breeding places in areas of sandy or loamy soil: sand-ridges, riverbanks, road-cuttings, sand-pits, occasionally coastal cliffs (ibid). Nest is a chamber at the end of a burrow, up to 1.6 m long, tunnelled in flat or sloping ground, sandy back or cutting (ibid).	High	Known	High	Likely	Potential. This species is likely to forage or roost in the study area and there is potential for burrowing in the sandy soil. An AoS has been undertaken for this species.
Miniopterus australis	Little Bentwing-bat	V	~	This species occurs along the East coast and ranges of Australia from Cape York in Queensland to Wollongong in NSW.	Prefers well-timbered areas including rainforest, wet and dry sclerophyll forests, Melaleuca swamps and coastal forests (Churchill 1998). This species shelters in a range of structures including culverts, drains, mines and caves (Environment Australia 2000). Relatively large areas of dense vegetation of either wet sclerophyll forest, rainforest or dense coastal banksia scrub are usually found adjacent to caves in which this species is found (OEH 2013b). Breeding occurs in caves, usually in association with *M. schreibersii* (OEH 2013b).	Low	Unlikely	Low	Unlikely	Unlikely
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	~	Eastern Bentwing-bats occur along the east and north-west coasts of Australia	Associated with a range of habitats such as rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland (Churchill 1998). It forages above and below the tree canopy on small insects (Dwyer 1995, Dwyer 1981). Will utilise caves, old mines, and stormwater channels, under bridges and occasionally buildings for shelter (Environment Australia 2000, Dwyer 1995).	High	Known	High	Known	This species is known in the study area and is likely to forage in the study area. An AoS has been undertaken for this species.
Monarcha melanopsis	Black-faced Monarch	~	M, Mar	Widespread in eastern Australia. In NSW, the species occurs around the slopes and tablelands inland to Armidale. It is rarely recorded further inland (DoE 2013b).	The Black-faced Monarch mainly occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll vine-forest, tropical (mesophyll) rainforest, subtropical (notophyll) rainforest, mesophyll (broadleaf) thicket/shrubland, warm temperate rainforest, dry (monsoon) rainforest and (occasionally) cool temperate rainforest (DoE 2013b)	Low	Unlikley	Low	Unlikely	Unlikely
Mormopterus norfolkensis	Eastern Freetail-bat	V	~	The Eastern Freetail-bat is found along the east coast from south Queensland to southern NSW.	Most records of this species are from dry eucalypt forest and woodland east of the Great Dividing Range (Churchill 1998). Individuals have, however, been recorded flying low over a rocky river in rainforest and wet sclerophyll forest and foraging in clearings at forest edges (Environment Australia 2000; Allison & Hoye 1998). Primarily roosts in	Low	Unlikely	Low	Unlikely	Unlikely

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					hollows or behind loose bark in mature eucalypts, but have been observed roosting in the roof of a hut (Environment Australia 2000; Allison & Hoye 1998).					
Myiagra cyanoleuca	Satin Flycatcher	~	M, Mar	In NSW, they are widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains (DoE 2013b)	Satin Flycatchers 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 (DoE 2013b)	High	Known	High	Unlikely	Unlikely
Myotis macropus	Large-footed / Southern Myotis	V	~	The Large-footed Myotis is found in the coastal band from the north-west of Australia, across the top-end and south to western Victoria. It is rarely found more than 100 km inland, except along major rivers	Generally roost in groups of 10 - 15 close to water in caves, mine shafts, hollow-bearing trees, storm water channels, buildings, under bridges and in dense foliage. Forage over streams and pools catching insects and small fish by raking their feet across the water surface	Low	Unlikely	Low	Unlikely	Unlikely
Neophema pulchella	Turquoise Parrot	V	~	The Turquoise Parrot's range extends from southern Queensland through to northern Victoria, from the coastal plains to the western slopes of the Great Dividing Range (OEH 2013b)	Steep rocky ridges and gullies, rolling hills, valleys and river flats and the plains of the Great Dividing Range compromise the topography inhabited by this species (Marchant & Higgins 1993). Spends much of the time on the ground foraging on seed and grasses (OEH 2013b). It is associated with coastal scrubland, open forest and timbered grassland, especially low shrub ecotones between dry hardwood forests and grasslands with high proportion of native grasses and forbs (Environment Australia 2000).	High	Known	High	Likely	This species is known in the study region and is likely to forage and breed in the study area. An AoS has been undertaken for this species.
Ninox connivens	Barking Owl	V	~	The Barking Owl is found throughout continental Australia except for the central arid regions. Although common in parts of northern Australia, the species has declined greatly in southern Australia and now occurs in a wide but sparse distribution in NSW. Core populations exist on the western slopes and plains (especially the Pilliga) and in some northeast coastal and escarpment forests (OEH 2013b)	Associated with a variety of habitats such as savanna woodland, open eucalypt forests, wetland and Riverine forest. Habitat is typically dominated by Eucalypts (often Redgum species), but can also be dominated by *Melaleuca* species in the tropics (OEH 2013b). It usually roosts in dense foliage in large trees such as *Casuarina cunninghamiana*, other *Casuarina* and *Allocasuarina*, eucalypts, *Angophora*, *Acacia* and rainforest species from streamside gallery forests (NPWS 2003). It usually nests near watercourses or wetlands (NPWS 2003) in large tree hollows with entrances averaging 2-29 metres above ground.	High	Known	High	Potential	This species is known in the study region and is likely to forage and roost and potentially to breed in the study area. An AoS has been undertaken for this species.
Ninox strenua	Powerful Owl	V	~	It is endemic to eastern and south-eastern Australia, mainly on the coastal side of the Great Dividing Range from Mackay to south-western Victoria. In NSW, it is widely distributed throughout the eastern forests from the coast inland	It inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The species breeds and hunts in open or closed sclerophyll forest or woodlands and	Low	Unlikely	Low	Unlikely	Unlikely

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				to tablelands, with scattered, mostly historical records on the western slopes and plains. Now uncommon throughout its range where it occurs at low densities	occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine, Black She-oak, Blackwood, Rough-barked Apple, Cherry Ballart and a number of eucalypt species					
Nyctophilus corbeni (syn. *Nyctophilus timoriensis* (South-eastern form))	South-eastern Long eared Bat / Corben's Long-eared Bat	V	V	The distribution of the south eastern form coincides approximately with the Murray Darling Basin with the Pilliga Scrub region being the distinct stronghold for this species (OEH 2013b)	It inhabits a variety of vegetation types including mallee, bulloke and box eucalypt dominated communities. However, it is more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland. Roosts in tree hollows, crevices and under loose bark.	High	Known	High	Likely	This species is known in the study region and is likely to forage and breed in the study area. An AoS has been undertaken for this species.
Oxyura australis	Blue-billed Duck	V	~	The Blue-billed Duck is endemic to south-eastern and south-western Australia. It is widespread in NSW, but most common in the southern Murray-Darling Basin area. Birds disperse during the breeding season to deep swamps up to 300 km away. It is generally only during summer or in drier years that they are seen in coastal areas. (OEH 2013b)	The Blue-billed Duck prefers deep water in large permanent wetlands and swamps with dense aquatic vegetation (OEH 2013b). The species is completely aquatic, swimming low in the water along the edge of dense cover (OEH 2013b). They are partly migratory, with short-distance movements between breeding swamps and over-wintering lakes with some long-distance dispersal to breed during spring and early summer (OEH 2013b).	Low	Unlikely	No habitat	Unlikely	Unlikely
Pachycephala inornata	Gilbert's Whistler	V	~	This species occurs across most of NSW's semi-arid and arid regions. The eastern population extends from the central NSW mallee (Yathong, Nombinnie and Round Hill NRs), south and east through the Cocoparra Range to Pomingalama Reserve (near Wagga Wagga) then north through the South West Slopes east as far as Cowra and Burrendong Dam, to the Goonoo reserves (with scattered records as far north as Pilliga (OEH 2013b).	This species occurs in arid and semi-arid timbered habitats in mallee shrubland, and occasionally in box-ironbark woodlands, Cypress Pine and Belah woodlands and River Red Gum forests. Within mallee the species often occurs in association with an understorey of Spinifex and low shrubs of acacias, hakeas, sennas and grevilleas. In woodland habitats, the understorey contains areas of dense shrubbery (OEH 2013b).	Moderate	Potential	Moderate	Potential	This species has potential to forage and breed in the study area. An AoS has been undertaken for this species.
Petaurus australis	Yellow-bellied Glider	V	~	This species is found along the eastern coast to the western slopes of the Great Dividing Range, from southern Queensland, through NSW to Victoria	This species occurs in tall mature eucalypt forest generally in areas with high rainfall and nutrient rich soils. Forest type preferences vary, with mixed coastal forests to dry escarpment forests in the north; moist coastal gullies and creek flats to tall montane forests in the south. Their den sites are in hollows of large trees. They can occupy large home ranges between 20 to 85 ha to encompass dispersed and seasonally variable food resources	Low	Unlikely	Low	Unlikely	Unlikely
Petaurus norfolcensis	Squirrel Glider	V	~	The species is widely though sparsely distributed in eastern Australia, from	Associated with dry hardwood forest and woodlands (Menkhorst et al.	High	Likely	Moderate	Potential	This species has potential to forage

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				northern Queensland to western Victoria. (OEH 2013b)	1988; Quin 1995). Habitats typically include gum barked and high nectar producing species, including winter flower species (Menkhorst et al. 1988). The presence of hollow bearing eucalypts is a critical habitat value (Quin 1995).					and breed in the study area. An AoS has been undertaken for this species.
Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V	The range of this species extends from south-east Queensland to the Grampians in western Victoria, roughly following the line of the Great Dividing Range. However the distribution across its original range has declined significantly in the west and south and has become more fragmented. In NSW they occur from the Queensland border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit (OEH 2013b).	This species occupies rocky areas (escarpments and outcrops) in a variety of habitats, typically north facing sites with numerous ledges, caves and crevices (Strahan 1995). They generally browse on vegetation in and adjacent to rocky areas, eating grasses and forbs as well as the foliage and fruits of shrubs and trees.	Moderate	Unlikely	Low	Unlikely	Unlikely
Petroica boodang	Scarlet Robin	V	~	The Scarlet Robin is found from SE Queensland to SE South Australia and also in Tasmania and SW Western Australia. In NSW, it occurs from the coast to the inland slopes. After breeding, some Scarlet Robins disperse to the lower valleys and plains of the tablelands and slopes. Some birds may appear as far west as the eastern edges of the inland plains in autumn and winter.	The Scarlet Robin is primarily a resident in forests and woodlands, but some adults and young birds disperse to more open habitats after breeding. It lives in dry eucalypt forests and woodlands with an understorey that is usually open and grassy with few scattered shrubs. It can live in both mature and regrowth vegetation with an abundance of logs and fallen timber an important component of its habitat.	High	Potential	High	Potential	This species has potential to forage and breed in the study area. An AoS has been undertaken for this species.
Petroica phoenicea	Flame Robin	V	~	The Flame Robin is endemic to SE Australia, and ranges from near the Queensland border to SE South Australia and also in Tasmania. In NSW, it breeds in upland areas and in winter, many birds move to the inland slopes and plains. It is likely that there are two separate populations in NSW, one in the Northern Tablelands, and another ranging from the Central to Southern Tablelands (OEH 2013b).	It breeds in upland tall moist eucalypt forests and woodlands, often on ridges and slopes. The species prefers clearings or areas with open understoreys. The ground layer of the breeding habitat is dominated by native grasses and the shrub layer may be either sparse or dense. It occasionally occurs in temperate rainforest, and also in herbfields, heathlands, shrublands and sedgelands at high altitudes (OEH 2013b).	Low	Unlikely	Low	Unlikely	Unlikely
Phaethon rubricauda	Red-tailed Tropicbird	V	Mar	This species of Marine bird occurs throughout tropical and subtropical zones of the Indian and West Pacific Oceans. Breeding occurs on oceanic islands, with the largest breeding site occurring on Lord Howe Island. Vagrant birds occur in coastal water of NSW, and occasionally inland, particularly after storm events (OEH 2013b)	It is a Marine species that breeds in coastal cliffs and under bushes in tropical Australia. It nests on cliffs of the northern hills and southern mountains on the main island at Lord Howe Island (OEH 2013b)	Low	Unlikely	No habitat	Unlikely	Unlikely

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Phascogale tapoatafa	Brush-tailed Phascogale	V	~	The Brush-tailed Phascogale has a patchy distribution around the coast of Australia. In NSW it is mainly found east of the Great Dividing Range although there are some records west of the divide (OEH 2013b).	It prefers dry sclerophyll open forest with sparse groundcover of herbs, grasses, shrubs or leaf litter, but can also inhabit heath, swamps, rainforest and wet sclerophyll forest. It nests and shelters in tree hollows, with entrances 2.5 - 4 cm wide and can use many hollows over a short time span (OEH 2013b).	Low	Unlikely	Low	Unlikely	Unlikely
Phascolarctos cinereus	Koala	V	V	The Koala has a fragmented distribution throughout eastern Australia from north-east Queensland to the Eyre Peninsula in South Australia. In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. It was briefly historically abundant in the 1890s in the Bega District on the south coast of NSW, although not elsewhere, but it now occurs in sparse and possibly disjunct populations. Koalas are also known from several sites on the southern tablelands (OEH 2013b).	Associated with both wet and dry Eucalypt forest and woodland that contains a canopy cover of approximately 10 to 70% (Reed et al. 1990), with acceptable Eucalypt food trees. Some preferred *Eucalyptus* species are: *Eucalyptus tereticornis*, *E. punctata*, *E. cypellocarpa* and *E. viminalis.*	High	Likely	Low	Unlikely	Unlikely
Polytelis anthopeplus monarchoides	Regent Parrot (Eastern Subspecies)	E1	V	The Regent Parrot (eastern) is confined to the semi-arid interior of southeastern mainland Australia. In NSW, the Regent Parrot (eastern) is confined to the southern Lower Western Region, mainly along the Murray River, from Kyalite, north west to Mallee Cliffs State Forest, and is also recorded near Wentworth and the Rufous River. Away from the Murray River, the subspecies is recorded at isolated localities including west of Moonlight Lake, Arumpo Station, and near Pooncarie	The Regent Parrot (eastern) primarily inhabits riparian or littoral *Eucalyptus camaldulensis* (River Red Gum) forests or woodlands and adjacent *E. largiflorens* (Black Box) woodlands. Nearby open mallee woodland or shrubland, usually with a ground cover of *Triodia* spp. (spinifex) or other grasses, supporting various eucalypts, especially *E. socialis* (Christmas Mallee) and *E. costata* (Yellow Mallee), as well as *Allocasuarina cristata* (Belah), *A. leuhmannii* (Buloke) or *Callitris preissii* (Slender Cypress Pine) also provide important habitat for this subspecies. They often occur in farmland, especially if the farmland supports remnant patches of woodland along roadsides or in paddocks. The subspecies seldom occurs in more extensively cleared areas	Moderate	Unlikely	Moderate	Unlikely	Unlikely
Polytelis swainsonii	Superb Parrot	V	V	The Superb Parrot is found throughout eastern inland NSW. On the South-western Slopes their core breeding area is roughly bounded by Cowra and Yass in the east, and Grenfell, Cootamundra and Coolac in the west. Birds breeding in this region are mainly absent during winter, when they migrate north to the region of the upper Namoi and Gwydir Rivers. The other main breeding sites are in the Riverina along the corridors of the Murray, Edward and Murrumbidgee Rivers where birds are present all year round.	The Superb Parrot inhabits box-gum woodland, Box-Cypress-pine and Boree Woodlands and River Red Gum Forest. It forages at or near the ground and nest in hollows in small colonies (OEH 2013b).	Moderate	Potential	Low	Unlikely	Unlikely

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Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subspecies)	V	~	This species has two distinctive subspecies that intergrade to the south of the Gulf of Carpentaria. West of here the subspecies *rubeculus*, formerly considered a separate species (Red-breasted Babbler) is still widespread and common. The eastern subspecies (*temporalis*) occurs from Cape York south through QLD, NSW and Vic and formerly to the south east of SA. This subspecies also occurs in the Trans-Fly Region in southern New Guinea. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in some locations on the north coast.	This species is found in open woodlands dominated by mature eucalypts with regenerating trees, tall shrubs, and an intact ground cover of grass and forbs (OEH 2013b). This species avoids very wet areas (Blakers et al. 1984).	High	Known	High	Likely	This species was observed just outside of the study area and is likely to breed and forage in the study area. An AoS has been undertaken for this species.
Pseudomys pilligaensis	Pilliga Mouse	V	V	Distribution restricted to the Pilliga region of New South Wales. Fox and Briscoe first described this species in 1980 (Fox and Briscoe 1980).	This species of small rodent occurs in Pilliga Scrub on an isolated area of low-nutrient deep sand predominantly in recently burnt moist gullies, areas dominated by Broombush and areas containing an understorey of Kurricabah (Acacia burrowii) with a *Corymbia trachyphloia* overstorey in the Pilliga region of NSW. They seem to prefer areas with a high species diversity and dense low shrub layer. The species is thought to live in burrows and is nocturnal. (OEH 2013b).	High	Known	Low	Potential	The study area doesn't support core habitat for this species. However, during a population boom, it is possible the study area could be used as dispersal habitat. An AoS has been undertaken for this species.
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Grey-headed Flying-foxes are found within 200 km of the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. They show a regular pattern of seasonal movement with much of the population moving to northern NSW and QLD during May and June where they exploit the winter flowering trees such as *Eucalyptus robusta*, *E. tereticornis* and Paperbark (OEH 2013b).	This species roosts in camps generally located within 20 km of a regular food source and are commonly found in gullies, close to water and in vegetation with a dense canopy. This species is known to forage in areas supporting subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps on the nectar and pollen of native trees, in particular eucalypts, melaleucas and banksias.	Moderate	Potential	Moderate	Potential	A camp is not known within 20 km of the study area. Due to sporadic flowering of dominant canopy species in the Pilliga Forest, the study area is unlikely to provide a reliable or abundant foraging habitat, however, this species has potential to forage in the study area on occasion. An AoS has been undertaken for this species.

Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Rhipidura rufifrons	Rufous Fantail	~	M, Mar	The Rufous Fantail occurs in coastal and near coastal districts of northern and eastern Australia (DoE 2013b)	the Rufous Fantail mainly inhabits wet sclerophyll forests, often in gullies (DoE 2013b)	Low	Unlikely	Low	Unlikely	Unlikely
Rostratula australis (syn. *Rostratula benghalensis australis*)	Australian Painted Snipe	E1	E, Mar	The Australian Painted Snipe has been recorded at wetlands in all states of Australia. It is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, NSW, Victoria and south-eastern South Australia. It has been recorded less frequently at a smaller number of more scattered locations farther west in South Australia, the Northern Territory and Western Australia.	Prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber (OEH 2013b). Nests on the ground amongst tall vegetation, such as grasses, tussocks or reeds (*ibid.*). Breeding is often in response to local conditions; generally occurs from September to December (OEH 2013b). Roosts during the day in dense vegetation (OEH 2013b). Forages nocturnally on mud-flats and in shallow water (OEH 2013b). Feeds on worms, molluscs, insects and some plant-matter (*ibid.*).	Low	Unlikely	Low	Unlikely	Unlikely
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	~	The Yellow-bellied Sheathtail-bat is a wide-ranging species found across northern and eastern Australia. In the most southerly part of its range - most of Victoria, south-western NSW and adjacent South Australia - it is a rare visitor in late summer and autumn. There are scattered records of this species across the New England Tablelands and North West Slopes.	Found in almost all habitats, from wet and dry sclerophyll forest, open woodland (Churchill 1998), open country, mallee, rainforests, heathland and waterbodies (SFNSW 1995). It roosts in tree hollows and may also use caves. The species has also been recorded in a tree hollow in a paddock (Environment Australia 2000) and in abandoned sugar glider nests (Churchill 1998). It is dependent on suitable hollow-bearing trees to provide roost sites, which may be a limiting factor on populations in cleared or fragmented habitats (Environment Australia 2000).	High	Known	High	Known	This species has been recorded in the study area and has potential to forage, roost and breed in the study area. An AoS has been undertaken for this species.
Sminthopsis macroura	Stripe-faced Dunnart	V	~	Throughout much of inland central and northern Australia, extending into central and northern NSW, western Queensland, Northern Territory, South Australia and Western Australia. They are rare on the NSW Central West Slopes and North West Slopes with the most easterly records of recent times located around Dubbo, Coonabarabran, Warialda and Ashford. (OEH 2013b)	Native dry grasslands and low dry shrublands, often along drainage lines. During periods of hot weather they shelter in cracks in the soil, in grass tussocks or under rocks and logs (OEH 2013b)	Low	Unlikely	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Stagonopleura guttata	Diamond Firetail	V	~	The Diamond Firetail is endemic to south-eastern Australia, extending from central QLD to the Eyre Peninsula in SA. It is widely distributed in NSW, with a number of records from the Northern, Central and Southern Tablelands, the Northern, Central and South Western Slopes and the North West Plains and Riverina. Not commonly found in coastal districts, though there are records from near Sydney, the Hunter Valley and the Bega Valley. This species has a scattered distribution over the rest of NSW, and is rare west of the Darling River	Typically found in grassy eucalypt woodlands, but also occurs in open forest, mallee, Natural Temperate Grassland, and in secondary grassland derived from other communities (OEH 2013b). It is often found in riparian areas and sometimes in lightly wooded farmland (OEH 2013b). Appears to be sedentary, though some populations move locally, especially those in the south (OEH 2013b).	High	Known	High	Likely	This species is known in the study region and is likely to forage and breed in the study area. An AoS has been undertaken for this species.
Stictonetta naevosa	Freckled Duck	V	~	The Freckled Duck is found primarily in south-eastern and south-western Australia, occurring as a vagrant elsewhere. It breeds in large temporary swamps created by floods in the Bulloo and Lake Eyre basins and the Murray-Darling system, particularly along the Paroo and Lachlan Rivers, and other rivers within the Riverina (OEH 2013b)	This species prefers permanent freshwater swamps and creeks with heavy growth of Typha, Lignum or Tea-tree. During drier times they move from ephemeral breeding swamps to more permanent waters such as lakes, reservoirs, farm dams and sewage ponds. They generally rest in dense cover during the day in deep water. They feed at dawn and dusk and at night on algae, seeds and aquatic grasses and sedges and small invertebrates. Nesting usually occurs between October and December but can take place at other times when conditions are favourable (OEH 2013b).	Low	Unlikely	No habitat	Unlikely	Unlikely
Tyto longimembris	Eastern Grass Owl	V	~	Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues (OEH 2013b).	This species is found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains. They rest by day in a 'form' - a trampled platform in a large tussock or other heavy vegetative growth. They breeds on the ground and nests are found in trodden grass, and often accessed by tunnels through vegetation OEH 2013b.	Low	Unlikely	Low	Unlikely	Unlikely
Tyto novaehollandiae	Masked Owl	V	~	Extends from the coast where it is most abundant to the western plains. Overall records for this species fall within approximately 90% of NSW, excluding the most arid north-western corner. There is no seasonal variation in its distribution. (OEH 2013b)	The species is associated with forest with sparse, open, understorey, typically dry sclerophyll forest and woodland (OEH 2013b) and especially the ecotone between wet and dry forest, and non forest habitat (Environment Australia 2000). The species is known to utilise forest margins and isolated stands of trees within agricultural land (Hyem 1979) and heavily disturbed forest where its prey of small and medium sized mammals can be readily obtained (Kavanagh & Peake 1993).	High	Known	High	Likely	This species has the potential to forage in the study area. An AoS has been undertaken for this species.
Uvidicolus sphyrurus (syn.	Border Thick-tailed	V	V	The Border Thick-tailed Gecko is found only on the tablelands and slopes of	The Border Thick-tailed Gecko is found in rocky hills with dry open	Low	Unlikely	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Underwoodisaurus sphyrurus)	Gecko			northern NSW and southern Queensland, reaching south to Tamworth and west to Moree (OEH 2013b). Most common in the granite country of the New England Tablelands (OEH 2013b).	eucalypt forest or woodland (OEH 2013b). Favours forest and woodland areas with boulders, rock slabs, fallen timber and deep leaf litter (OEH 2013b).					
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 inhabits tropical mixed woodland and wet sclerophyll forest on the coast and the dividing range but extend into the drier forest of the western slopes and inland areas (Churchill 1998). It has been found roosting in sandstone overhand caves, boulder piles, mine tunnels and occasionally in buildings (Churchill 1998).	High	Known	High	Likely	This species was possibly recorded in the study area and is likely to forage in the study area. An AoS has been undertaken for this species.

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
FLORA										
Acacia jucunda	Yetman Wattle	E1	~	The Yetman Wattle is found in the Yetman district near the Queensland border on the North West Slopes of NSW. It also occurs in Queensland where it is reasonably common (OEH 2013b).	The Yetman Wattle is mainly restricted to the dry eucalypt forests or woodlands on sandy to sandy-loam soils. It is associated with other species in NSW including, *Acacia polybotrya* (Western Silver Wattle) and *Callitris endlicheri* (Black Cypress Pine). The species is known to occur within the Border Rivers – Gwydir CMA area but mostly restricted to the Yetman area.	Low	Unlikely	Low	Unlikely	Unlikely
Bertya opponens	Coolabah Bertya	V	V	Known from scattered sites in NSW including Coolabah, south of Narrabri on the North West Slopes (including Jacks Creek State Forest), Cobar and the North Coast.	Ranges from stony mallee ridges and cypress pine forest on red soils.	Moderate	Known	Low	Unlikely	Unlikely
Boronia granitica	Granite Boronia	V	E	Granite Boronia is known from scattered localities on the New England Tablelands and North West Slopes north from the Armidale area to the Stanthorpe district in southern Queensland	Granite Boronia grows amongst granite outcrops, often in rock crevices, north from Inverell district.	No habitat	No	No habitat	No	Unlikely
Bothriochloa biloba	Lobed Blue-grass	~	V	Woodlands and grasslands on the western slopes and plains of NSW and QLD	Commonly found on clay soils	Low	Unlikely	Low	Unlikely	Unlikely
Cadellia pentastylis	Ooline	V	V	This species occurs along the western edge of the North West Slopes from north of Gunnedah to west of Tenterfield with some records from in Queensland. The natural range of Ooline is from 24ºS to 30ºS in the 500 to 750 mm per annum rainfall belt.	Ooline occurs in low- to medium-nutrient soils of sandy clay or clayey consistencies, with a typical soil profile having a sandy loam surface layer, grading from a light clay to a medium clay with depth.	Low	Unlikely	Low	Unlikely	Unlikely
Cyperus conicus	A sedge	E1	~	This species occurs rarely in the Pilliga area of NSW and is also found in Victoria, Qld, the NT and WA	The species grows in open woodland on sandy soil. In central Australia, it grows near waterholes and on the banks of streams in sandy soils. In Qld the species is usually found on heavy soils. It has been recorded from Callitris forest in the Pilliga area, growing in sandy soil with *Cyperus gracilis*, *C. squarrosus* and *C. fulvus*.	Moderate	Potential	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Desmodium campylocaulon	Creeping Tick-Trefoil	E1	~	Occurs chiefly in the Collarenebri and Moree districts in the north-western plains of NSW. Also occurs in the NT and Darling Downs district of south-eastern Queensland (OEH 2013b)	In NSW the species grows on cracking black soils in the Narrabri, Moree and Walgett local government areas. It is associated with other species including *Acacia harpophylla, Astrebla pectinata* and *Sorghum, Dichanthium* and *Panicum* species. It flowers summer and autumn (OEH 2013b)	Low	Unlikely	No habitat	No	Unlikely
Dichanthium setosum	Bluegrass	V	V	New England Tablelands, North West Slopes and Plains and the Central Western Slopes of NSW, as well as in Queensland and Western Australia.	Associated with heavy basaltic black soils. Often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture.	Low	Unlikely	Low	Unlikely	Unlikely
Digitaria porrecta	Finger Panic Grass	E1	E	Occurs in NSW and Queensland. In NSW it is found on the North West Slopes and Plains, from near Moree south to Tambar Springs and from Tamworth to Coonabarabran.	Habitat includes native grassland, woodlands or open forest with a grassy understorey, on richer soils.	Low	Unlikely	Low	Unlikely	Unlikely
Diuris tricolor	Painted Diuris	V	~	Sporadically distributed on the western slopes of NSW, extending from south of Narrandera all the way to the far north of NSW.	Grows in sclerophyll forest among grass, often with native Cypress Pine (*Callitris spp.*). It is found in sandy soils, either on flats or small rises. Also recorded from a red earth soil in a Bimble Box community in western NSW. Disturbance regimes are not known, although the species is usually recorded from disturbed habitats.	High	Likely	Moderate	Potential	This species is known in the study region and has potential to occur in the study area. An AoS has been undertaken for this species.
Haloragis exalata subsp. *velutina*	Tall Velvet Sea-berry	V	V	Disjunctly distributed in the central coast, south coast and north-western slopes botanical subdivisions of NSW	Protected and shaded damp situations in riparian habitats.	Low	Unlikely	Low	Unlikely	Unlikely
Homopholis belsonii	Belson's Panic	E1	V	North from the Warialda district and into Queensland	Habitat and ecology poorly known. Grows in dry woodland (e.g. Belah) on poor soils.	Low	Potential	Low	Unlikely	Unlikely
Lepidium aschersonii	Spiny Peppercress	V	V	Not widespread, occurring in the marginal central-western slopes and north-western plains regions of NSW (and potentially the south western plains). A several populations recorded at Narrabri. Also known from the West Wyalong, Barmedman and Temora areas.	Found on ridges of gilgai clays dominated by *Acacia harpophylla* (Brigalow), with *Austrodanthonia* and/or *Austrostipa* species in the understorey. The species grows as a component of the ground flora, in grey loamy clays. Vegetation structure varies from open to dense Brigalow, with sparse grassy understorey and occasional heavy litter.	Low	Potential	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Lepidium monoplocoides	Winged Peppercress	E1	E	Widespread in the semi-arid western plains region of NSW. Recorded in previous ELA survey in Western Pilliga.	Known to occur on seasonally moist to waterlogged sites, on heavy fertile soils. In W Pilliga, it was found in White Cypress Pine - Bulloak - ironbark woodland of the Pilliga area of the Brigalow Belt South Bioregion vegetation and associated with gilgais.	Moderate	Known	Low	Unlikely	Unlikely
Monotaxis macrophylla	Large-leafed Monotaxis	E1	~	Large-leaf Monotaxis is recorded from several highly disjunct populations in NSW: eastern edge of Deua NP (west of Moruya), Bemboka portion of South East Forests National Park, Cobar area (Hermitage Plains), the Tenterfield area, and Woodenbong (near the Queensland border). It is also in Queensland.	Grows on rocky ridges and hillsides. There is a great diversity in the associated vegetation within NSW (less though in Queensland), encompassing coastal heath, arid shrubland, forests and montane heath from almost sea level to 1300 m altitude.	Moderate	Potential	Low	Unlikely	Unlikely
Myriophyllum implicatum		CE	~	This species was previously thought to be extinct in NSW; however the plant was recently discovered in the Pilliga National Park, south of Narrabri. It is known from QLD and is listed as 'Least Concern' under that States Nature Conservation Act (1992) (OEH 2013b).	The species occurs in moist situations, extending away from fresh water. A recent population was found in NSW in a large open partly inundated gilgai depression on cracking clay soil (OEH 2013b).	Low	Unlikely	Low	Unlikely	Unlikely
Philotheca ericifolia		~	V	Upper Hunter Valley and Pilliga to Peak Hill district	Grows chiefly in dry sclerophyll forest and heath on damp sandy flats and gullies	Low	Unlikely	Low	Unlikely	Unlikely
Platyzoma microphyllum	Braid Fern	E1	~	Species records exist in NSW only in the Yetman district. However, the species is widespread across northern Australia, from WA to the NT, eastern Qld and just into central-northern NSW (OEH 2013b).	It grows in sandy or swampy soils, or in clay soils adjacent to streams and lagoons and subject to periodic flooding. It has been recorded in NSW at Bruxner Highway growing as one localised patch in deep sandy soil, with *Leptospermum* species, *Brachyloma daphnoides* and *Lomandra* species (OEH 2013b).	Low	Unlikely	Low	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Polygala linariifolia	Native Milkwort	E1	~	Found north from Copeton Dam and the Warialda area to southern QLD; also found on the NSW north coast near Casino and Kyogle, and there is an isolated population in far western NSW near Weebah Gate, west of Hungerford. This species also occurs in Western Australia.	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.	High	Known	High	Known	This species is known in the study region and is recorded in the study area during previous surveys. An AoS has been undertaken for this species.
Pomaderris queenslandica	Scant Pomaderris	E1	~	Records are widely scattered, but not common in north-east NSW and in Queensland. It is only known from a few locations on the New England Tablelands and North West Slopes, including near Torrington and Coolatai, and also from several locations on the NSW north coast.	The species is found in moist eucalypt forest or sheltered woodlands with a shrubby understorey, and occasionally along creeks.	Moderate	Known	Low	Unlikely	Unlikely
Prasophyllum sp. *Wybong* (C.Phelps ORG 5269)	a leek-orchid	~	CE	Endemic to NSW. It is known from seven populations in eastern NSW near Ilford, Premer, Muswellbrook, Wybong, Yeoval, Inverell and Tenterfield	Known to occur in open eucalypt woodland and grassland	Low	Unlikely	Low	Unlikely	Unlikely
Pterostylis cobarensis	Greenhood Orchid	V	V	It is known chiefly from the Nyngan-Cobar-Bourke district in the far western plains of New South Wales. Recorded districts include Narrabri, Nyngan, Cobar, Nymagee, Mt Gundabooka, Mt Grenfell and Mutawintji National Park. There are also records from the Darling Downs district of Queensland.	The Greenhood Orchid is found in Eucalypt woodlands, open mallee or *Callitris* shrublands on low stony ridges and slopes in skeletal sandy-loam soils.	High	Known	High	Known	This species is known in the study area. An AoS has been undertaken for this species.
Pultenaea setulosa	Stony Bush-pea	~	V	Slopes and tablelands of NSW	Dry sclerophyll forest	Low	Unlikely	Low	Unlikely	Unlikely
Rulingia procumbens		V	V	The species is endemic to NSW and mainly confined to the Dubbo-Mendooran-Gilgandra region, but also in the Pilliga and Nymagee areas.	It grows in sandy sites, often along roadsides. Recorded in *Eucalyptus dealbata* and *E. sideroxylon* communities, *Melaleuca uncinata* scrub, under mallee eucalypts with a *Calytrix tetragona* understorey, and in a recently burnt Ironbark and *Callitris* area. It also occurs in *E. fibrosa* subsp. *nubila, E. dealbata, E. albens* and *Callitris glaucophylla* woodlands north of Dubbo.	High	Known	Moderate	Unlikely	Unlikely

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Scientific name	Common name	TSC Act	EPBC Act	Distribution	Habitat	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in the study area	Likelihood of occurrence in the study area	Potential for impact by proposal
Sida rohlenae	Shrub Sida	E1	~	It has a limited distribution in QLD, the NT, SA and WA. In NSW it has been recorded south of Enngonia, south of Bourke and north-west of Coonamble	It occurs in flood-out areas, creek banks and at the base of rocky hills. NSW specimens have been found along roadsides in hard red loam to sandy-loam soils.	Low	Unlikely	Low	Unlikely	Unlikely
Swainsona murrayana	Slender Darling Pea	V	V	The species is found throughout NSW. It has been recorded in the Jerilderie and Deniliquin areas of the southern Riverine plain, the Hay plain as far north as Willandra National Park, near Broken Hill and in various localities between Dubbo and Moree.	The species has been collected from clay-based soils, ranging from grey, red and brown cracking clays to red-brown earths and loams. It grows in a variety of vegetation types including bladder saltbush, black box and grassland communities on level plains, floodplains and depressions and is often found with Maireana species.	Low	Unlikely	Low	Unlikely	Unlikely
Thesium australe	Austral Toadflax	V	V	Small populations are scattered across eastern NSW, along the coast, and from the Northern to Southern Tablelands. It is also found in Tasmania and Queensland and in eastern Asia.	Austral Toadflax occurs in grassland or grassy woodland and often found in damp sites in association with *Themeda australis* (Kangaroo Grass).	Low	Unlikely	Low	Unlikely	Unlikely
Tylophora linearis	-	V	E	The species is found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes of NSW.	It grows in dry scrub and open forest. Recorded from low-altitude sedimentary flats in dry woodlands of *Eucalyptus fibrosa*, *E. sideroxylon*, *E. albens*, *Callitris endlicheri*, *C. glaucophylla* and *Allocasuarina luehmannii*.	High	Known	High	Known	This species is known in the study area. An AoS has been undertaken for this species.

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Table 20: Endangered Ecological Communities likelihood of occurrence within the north-east Pilliga Forest and study area

Threatened ecological community	TSC Act	EPBC Act	Description	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in study area	Likelihood of occurrence in study area	Potential for impact by the proposed activity
ENDANGERED ECOLOGICAL COMMUNITIES								
TSC: Brigalow within the Brigalow Belt South, Nandewar and Darling Riverine Plains Bioregions EPBC: Brigalow (*Acacia harpophylla* dominant and co-dominant)	E	E	The ecological community is a low woodland or forest community dominated by *Acacia harpophylla* (Brigalow), with pockets of *Casuarina cristata* (Belah) and *Eucalyptus populnea* subsp. *bimbil* (Poplar Box). The canopy tends to be quite dense and the understorey and ground cover are only sparse. It is found in the Brigalow Belt South Bioregion in NSW and as isolated occurrences in the Darling Riverine Plains and Nandewar Bioregions.	Low	Known to occur to on the northern edge of the Pilliga Forest	Not observed within study area	No	Unlikely
Cadellia pentastylis (Ooline) community in the Nandewar and Brigalow Belt South Bioregions	V	~	The Ooline community is an unusual and distinctive forest community with the canopy dominated by the tree *Cadellia pentastylis* (Ooline). Other canopy species include *Eucalyptus albens* (White Box), *E. beyeriana* and *E. melanophloia*, *E. chloroclada* (Dirty Gum), *E. pilligaensis* (Narrow-leaved Grey Box), *E. viridis* (Green Mallee) and *Callitris glaucophylla* (White Cypress Pine). The understorey is made up of a range of shrubs such as wattles and grasses. It is now known from only seven main locations on the North West Slopes in NSW, between Narrabri and the Queensland border, and also in Queensland.	Low	Unlikely, not known within north-east Pilliga Forest	Not observed within study area	No	Unlikely
TSC: Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregion EPBC: Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	E	E	Represents occurrences of one type of semi-arid to humid subtropical woodland where *Eucalyptus coolabah* subsp. *coolabah* (Coolibah) and/or *Eucalyptus largiflorens* (Black Box) are the dominant canopy species and where the understorey tends to be grassy. The structure of the community may vary from tall riparian woodlands to very open 'savanna like' grassy woodlands with a sparse midstorey of shrubs and saplings. The ecological community is associated with the floodplains and drainage areas of the Darling Riverine Plains and the Brigalow Belt South bioregions.	Low	Unlikely, known to occur on the floodplain of the Namoi River	Not observed within study area	No	Unlikely
TSC: Myall Woodlands in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW south western slopes bioregions EPBC: Weeping Myall Woodlands	E	E	Occurs on red-brown earths and heavy textured grey and brown alluvial soils where annual rainfall is in the range 375 and 500 mm. The structure can varies from low woodland and low open woodland to low sparse woodland or open shrubland. The tree layer grows up to a height of about 10 metres and invariably includes *Acacia pendula* (Weeping Myall or Boree) as one of the dominant species or the only tree species present. The understorey includes an open layer of chenopod shrubs and other woody plant species and an open to continuous groundcover of grasses and herbs. The shrub stratum may have been reduced by clearing or heavy grazing. It is scattered across the eastern parts of alluvial plains of the Murray-Darling river system.	Low	Unlikely, known to occur on the Liverpool Plains	Not observed within study area	No	Unlikely
TSC: White Box Yellow Box Blakely's Red Gum Woodland EPBC: White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	E	CE	The community has an overstorey dominated, or was once dominated by *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box) or *E. blakelyi* (Blakely's Red Gum) trees. It is characterised by a species-rich understorey of native tussock grasses, herbs and forbs. In the Nandewar Bioregion, *E. microcarpa* or *E. moluccana* may also be dominant or co-dominant. The tree-cover is generally discontinuous and consists of widely-spaced trees of medium height in which the canopies are clearly separated. The shrub layer can be non-existent. In NSW the community is found from the Queensland border in the north, to the Victorian border in the south along the tablelands and western slopes areas.	Low	Potential, the potential presence of this community in the Pilliga Forest requires further consideration against the final determination based on floristic, structural and soil characteristics	Not observed within study area	No	Unlikely

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Threatened ecological community	TSC Act	EPBC Act	Description	Availability of habitat in the north-east pilliga forest	Likelihood of occurrence in the north-east pilliga forest	Availability of habitat in study area	Likelihood of occurrence in study area	Potential for impact by the proposed activity
Fuzzy Box Woodland on alluvial soils of the south western slopes, Darling Riverine Plains and Brigalow Belt South bioregions	E	~	The community is a tall woodland or open forest usually dominated by *Eucalyptus conica* (Fuzzy Box), which often grows with *E. microcarpa* (Inland Grey Box), *E. melliodora* (Yellow Box) or *Brachychiton populneus* (Kurrajong). *Allocasuarina luehmannii* (Buloke) is common in places. Shrubs are generally sparse and the ground cover moderately dense, but this can change with the season. It is found on the alluvial soils of the South West Slopes, Brigalow Belt South and Darling Riverine Plains Bioregions (mainly in the Dubbo-Narromine-Parkes-Forbes area).	Moderate	Known to occur on the floodplain of Bohena Creek and major tributaries	Not observed within study area	No	Unlikely
TSC: Inland Grey Box Woodland in the Riverina, NSW south western slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions EPBC: Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of south-eastern Australia	E	E	The community is a woodland dominated by *Eucalyptus microcarpa* (Inland Grey Box). It is often found in association with *E. populnea* subsp. *bimbil*, *Callitris glaucophylla* (White Cypress Pine), *Brachychiton populneus* (Kurrajong), *Allocasuarina luehmannii* (Bulloak) or *E. melliodora* (Yellow Box), and sometimes with *E. albens* (White Box). It occurs in landscapes of low-relief such as flat to undulating plains, low slopes and rises and, to a lesser extent, drainage depressions and flats. The ecological community may extend to more elevated hillslopes on the fringes of its range where it intergrades with other woodland or dry sclerophyll forest communities. In NSW the community principally occurs within the Riverina and South West Slopes Bioregions and is also found in portions of the Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions.	Low	Unlikely	Not observed within study area	No	Unlikely
TSC: Native Vegetation on Cracking Clay Soils of the Liverpool Plains EPBC: Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	E	CE	The ecological community is mainly a native grassland community containing a range of small forb and herb species, but can be found with scattered / patchy shrubs and trees. The main grass species include *Austrostipa aristiglumis* (Plains Grass), *Dichanthium sericeum* (Queensland Bluegrass) and *Panicum queenslandicum* (Coolibah Grass). It occurs on flat to low slopes, of no more than 5 percent (or less than 1 degree) inclination. As slope increases, grassy woodlands dominated by trees such as *Acacia pendula* (Weeping Myall), *Eucalyptus coolabah* (Coolabah), *E. populnea* (Poplar Box) or *E. melliodora* (Yellow Box) occur. The ground layer component of these woodlands may be similar to the grassland but the soils will not be the same cracking clays as on the plains.	Low	Unlikely, known to occur on the Liverpool Plains	Not observed within study area	No	Unlikely
TSC: Semi-evergreen Vine Thicket in the Brigalow Belt South and Nandewar Bioregions EPBC: Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	E	E	The community is a low, dense form of dry rainforest generally less than 10 m high, made up of vines and rainforest trees as well as some shrubs. The main canopy is dominated by rainforest species such as *Cassine australis* var. *angustifolia* (Red Olive Plum), *Geijera parvifolia* (Wilga), *Notelaea microcarpa* var. *microcarpa* (Native Olive) and *Ehretia membranifolia* (Peach Bush), with taller eucalypts and cypress pines from surrounding woodland vegetation emerging above the main canopy. *Carissa ovata* (Currant Bush) is often present and typical vines include *Parsonsia eucalyptophylla* (Gargaloo) and *Pandorea pandorana* (Wonga Vine). It has a scattered distribution near Gunnedah, Barraba, Bingara and north of Warialda on the NSW North West Slopes and Plains, and also in Queensland.	Low	Unlikely	Not observed within study area	No	Unlikely
Marsh Club-rush sedgeland in the Darling Riverine Plains Bioregion	CE	~	The community is dominated by *Bolboschoenus fluviatilis* (Marsh Club-rush), which forms dense stands up to 2 m tall. The community is further characterised by an understorey including *Carex appressa* (Tussock Sedge), *Eleocharis plana* (Ribbed Spike Rush), *Lachnagrostis filiformis* (Blown Grass), *Paspalum distichum* (Water Couch) and *Ranunculus undosus* (Swamp Buttercup). It is distinguished from other surrounding communities by a lack of trees and the dominance of *Bolboschoenus fluviatilis* (generally over 40% of the vegetation cover) although the structure may vary depending on past disturbance. The community is associated with grey clay soils usually with a surface layer of organic matter several centimetres thick. The community has a very fragmented distribution and is mainly restricted to the Gwydir wetlands but may occur elsewhere in the Darling Riverine Plains Bioregion.	Low	Unlikely	Not observed within study area	No	Unlikely

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Appendix B: Vegetation survey results

Flora species recorded within the study area

1. Families are group under the headings 1. Pteridophytes, 2. Gymnosperms, 3. Dicotyledons, 4. Monocotyledons.

2. An '*' before species indicates exotic species

3. A sample flora assemblage obtained from a short term survey, such as the present one, cannot be considered comprehensive, but rather indicative of the actual flora assemblage. It can take many years of flora surveys to record all of the plant species occurring within any area, especially species that are only apparent in some seasons.

4. Not all species can be accurately identified to species level due to absence of flowering or fruiting material.

5. Cover Abundance (C-A) + = few, small cover (<5%), r = solitary, small cover (<5%), 1 = numerous (<5%), 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = >75%

6. Species in **bold** are listed under the TSC Act or EPBC Act

Family	Species	Common name	Plot			
			Dewhurst 13-18	Dewhurst 30	Dewhurst 31	Meander
1. Pteridophytes						
Sinopteridaceae	*Cheilanthes sieberi* subsp. *sieberi*	Rock Fern	1	+	+	
2. Gymnosperms						
Cupressaceae	*Callitris endlicheri*	Black Cypress-pine			r	

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Family		Species	Common name	Plot			
				Dewhurst 13-18	Dewhurst 30	Dewhurst 31	Meander
		Callitris glaucophylla	White Cypress-pine	1	1	r	
3. Dicotyledons							
Apiaceae		*Platysace lanceolata*	Lance-leaf Platysace			1	
Apocynaceae		***Tylophora linearis***					r
Asteraceae		*Brachyscome multifida* var. *multifida*	Cut-leaf Daisy	+			
		Calotis cuneifolia	Purple Burr-daisy		r		
		Cassinia arcuata	Sifton Bush, Chinese-shrub	+	+	1	
		Centipeda cunninghamii	Common Sneezeweed	+			
		Epaltes australis	Spreading Nut-heads	+			
		Euchiton sphaericus		+			
	*	*Hypochaeris radicata*	Catsear, False Dandelion	r			
	*	*Sonchus oleraceus*	Common Sow-thistle, Milk-thistle	r			
Cactaceae	*	*Opuntia stricta*	Prickly Pear, Common Pest Pear	+			
Campanulaceae		*Wahlenbergia* sp. (unidentified)	Australian Bluebell	r			
Casuarinaceae		*Allocasuarina luehmannii*	Bulloak	2	1	r	
Chenopodiaceae		*Einadia nutans*	Climbing Saltbush		r		
Clusiaceae		*Hypericum gramineum*	Small St Johns-wort	+			
Dilleniaceae		*Hibbertia obtusifolia*	Guinea-flower			r	
Droseraceae		*Drosera peltata*	Pale Sundew	+			
Ericaceae - Styphelioideae		*Leucopogon muticus*	Blunt Beard-heath	+			
		Lissanthe strigosa	Peach Heath		r	+	
		Melichrus urceolatus	Urn Heath	r	+		

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Family	Species	Common name	Plot			
			Dewhurst 13-18	Dewhurst 30	Dewhurst 31	Meander
Fabaceae Faboideae	*Daviesia acicularis*	Sandplain Bitter-pea			1	
	Glycine clandestina	Twining Glycine	+			
	Pultenaea foliolosa			r	2	
	Templetonia stenophylla	Leafy Templetonia		r		
Fabaceae Mimosoideae	*Acacia caroleae*				1	
	Acacia deanei subsp. *deanei*	Green Wattle, Deane's Wattle	1	+		
	Acacia pravifolia	Coil-pod Wattle		1		
	Acacia spectabilis	Mudgee Wattle	+	r		
Goodeniaceae	*Brunonia australis*	Blue Pincushion	+	+		
	Goodenia cycloptera	Serrated Goodenia		+		
	Goodenia macbarronii		1			
	Goodenia rotundifolia			+	1	
Haloragaceae	*Haloragis heterophylla*	Raspwort	1			
	Haloragis sp. (unidentified)				r	
Myrtaceae	*Eucalyptus crebra*	Narrow-leaved Ironbark	+	2	2	
	Homoranthus flavescens				+	
	Melaleuca uncinata	Broom Honeymyrtle			+	
	Micromyrtus sessilis				r	
Polygalaceae	***Polygala linariifolia***					r
Primulaceae	* *Anagallis arvensis*	Pimpernel	+			
Proteaceae	*Persoonia sericea*				r	
Rubiaceae	*Pomax umbellata*	Pomax	r			

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Family	Species	Common name	Plot			
			Dewhurst 13-18	Dewhurst 30	Dewhurst 31	Meander
Sapindaceae	*Dodonaea heteromorpha*	Propellor Bush		1		
Stackhousiaceae	*Stackhousia muricata*			+		
4. Monocotyledons						
Anthericaceae	*Laxmannia gracilis*	Slender Wire Lily	+	+		
Cyperaceae	*Carex inversa*	Knob Sedge	1			
	Cyperus fulvus	Sticky Sedge	+			
	Fimbristylis dichotoma		1			
	Gahnia aspera	Rough-leaved Saw-sedge	+	1	1	
Juncaceae	*Juncus* sp. (unidentified)	Rush	1			
Lomandraceae	*Lomandra filiformis* subsp. *filiformis*	Wattle Mat-rush			1	
	Lomandra leucocephala subsp. leucocephala	Woolly-head Mat-rush			+	
	Lomandra longifolia	Spiny-headed Mat-rush, Honey Reed, Spike Mat-rush	+			
	Lomandra multiflora	Many-flowered Mat-rush	+	1	1	
	Lomandra multiflora (terete form)	Many-flowered Mat-rush		r		
Orchidaceae	*Caladenia fuscata*	Dusky Fingers	r			
	Cyanicula caerulea	Blue Fairy, Blue Caladenia	r	+	+	
	Pterostylis mutica	Midget Greenhood		+		
	Pterostylis cobarensis	Greenhood Orchid		r		+
Phormiaceae	*Dianella longifolia*	Smooth Flax-lily	+			
	Dianella revoluta	Blue Flax-lily, Spreading Flax-lily	r	r	+	
Poaceae	*Aristida caput-medusae*	Many-headed Wiregrass	+			

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Family	Species	Common name	Plot			
			Dewhurst 13-18	Dewhurst 30	Dewhurst 31	Meander
	Aristida jerichoensis var. *jerichoensis*	Jericho Wiregrass	+	1	2	
	Aristida ramosa	Purple Wiregrass	r		2	
	Aristida sp.	Wiregrass	+			
	Austrodanthonia sp.	Wallaby Grass		+		
	Austrostipa setacea	Corkscrew Grass		1		
	Cymbopogon refractus	Barbed Wire Grass	+			
	Digitaria breviglumis		+			
	Digitaria diffusa		r		+	
	Enteropogon acicularis	Curly Windmill Grass		+		
	Eragrostis brownii	Brown's Lovegrass	+		r	
	Eragrostis lacunaria	Purple Lovegrass	+	+		
	Microlaena stipoides	Meadow Rice-grass, Weeping Grass	+		+	
	Panicum decompositum	Native Millet	2			
	Panicum simile	Two-colour Panic	+	+		
	Paspalidium gracile	Slender Panic	+			

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Biometric Plot Data

Dewhurst 13-18

Stratum	Growth form	Species name	Cover (%)	Height to crown (m)		
				min	avg	max
Upper	M	*Allocasuarina luehmannii*	15	2	10	12
Upper	M	*Callitris glaucophylla*	5	9	10	10
Mid	M	*Allocasuarina luehmannii*	2	2	3	4
Mid	M	*Acacia deanei*	2	2	3	4
Ground	G	*Panicum decompositum*	10		0.3	

Site	NPS	NOS	NMS	NGCG	NGCS	NGCO	Litter	Bare	Cryptogam	EPC	NTH	OR	FL	Site Value	Long	Lat
Dewhurst 13-18	46	5.5	12	20	4	8	72	1	0	0	0	0.5	67	62	764824	6617337

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Dewhurst 30

Stratum	Growth form	Species name	Cover (%)	Height to crown (m)		
				min	avg	max
Upper	T	*Eucalyptus crebra*	15	8	18	20
Upper						
Mid	M	*Allocasuarina luehmannii*	2.5	1	5	10
Mid	M	*Callitris glaucophylla*	5	2	5	10
Ground	S	*Acacia pravifolia*	2		0.5	
Ground	O	*Lomandra multiflora*			0.5	

Site	NPS	NOS	NMS	NGCG	NGCS	NGCO	Litter	Bare	Cryptogam	EPC	NTH	OR	FL	Site Value	Long	Lat
Dewhurst 30	33	6	7.5	0	4	4	84	6	10	0	1	1	109	78	755378	6600368

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Dewhurst 31

Stratum	Growth form	Species name	Cover (%)	Height to crown (m)		
				min	avg	max
Upper	T	*Eucalyptus crebra*	15	6	15	16
Upper						
Mid	M	*Acacia caroleae*	2	1	2	3
Mid						
Ground	S	*Pultenaea foliolosa*	20		1	
Ground	G	*Aristida jerichoensis*	10		0.3	

Site	NPS	NOS	NMS	NGCG	NGCS	NGCO	Litter	Bare	Cryptogam	EPC	NTH	OR	FL	Site Value	Long	Lat
Dewhurst 31	29	13.2	2.7	10	31	6	54	2	0	0	0	1	48	50	754747	6599519

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Appendix C: HBT survey details

ID	Tree_SP	DBH_CM	Less_5CM	5CM_15CM	15CM_30CM	Over_30CM	BASAL	SPOUT	Tree_NO	Easting	Northing
91	stag	80	2	3	0	0	0	0	103	754771	6599517
91	*E. crebra*	40	2	0	0	0	0	0	102	754789	6599542
93	*E. crebra*	40	3	1	0	0	0	0	104	754811	6599543
89	*E. crebra*	40	2	0	0	0	0	0	100	754724	6599547
94	stag	50	3	0	3	0	0	0	105	754814	6599564
90	*E. crebra*	40	2	0	0	0	0	0	101	754768	6599571
96	*E. crebra*	30	1	0	0	0	0	0	109	754609	6599590
98	*E. crebra*	120	0	2	0	0	0	1	111	754560	6599644
99	*E. crebra*	60	3	0	0	0	0	0	112	754551	6599647
67	*E. crebra*	30	2	0	0	0	0	0	70	755353	6600299
66	*E. crebra*	60	3	0	0	0	0	0	69	755393	6600304
64	*E. crebra*	40	0	1	0	1	0	0	67	755401	6600307
65	*E. crebra*	40	3	1	0	0	10	0	68	755396	6600313
63	*E. crebra*	30	0	1	0	0	0	1	66	755428	6600317
62	*E. crebra*	40	1	0	0	1	0	1	65	755425	6600321
61	*E. crebra*	60	5	3	0	0	0	0	64	755430	6600325
407	stag	90	0	2	1	0	0	0	425	755253	6600328
68	*E. crebra*	40	1	0	0	0	0	0	71	755360	6600337

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ID	Tree_SP	DBH_CM	Less_5CM	5CM_15CM	15CM_30CM	Over_30CM	BASAL	SPOUT	Tree_NO	Easting	Northing
70	*E. crebra*	20	2	0	0	0	0	0	73	755377	6600338
69	*E. crebra*	60	4	2	0	0	0	0	72	755376	6600338
70	*E. crebra*	70	2	0	1	1	0	0	74	755390	6600339
71	*E. crebra*	100	4	1	0	0	0	0	75	755426	6600348
75	*E. crebra* dead	50	3	0	1	0	0	1	79	755356	6600357
76	stag	20	1	0	0	0	0	1	81	755349	6600365
73	stag	30	2	1	0	0	0	0	77	755416	6600375

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Appendix D: Anabat detector results

Dewhurst 13 – 18 and 30 - 31: 10 Anabat nights 26 – 28 August 2013

Bat calls were analysed using the program AnalookW (Version 3.8 25 October 2012, written by Chris Corben, www.hoarybat.com). Call identifications were made using regional based guides to the echolocation calls of microbats in New South Wales (Pennay et al. 2004); and south-east Queensland and north-east New South Wales (Reinhold et al. 2001) and the accompanying reference library of over 200 calls from north-eastern NSW. Available: (http://www.forest.nsw.gov.au/research/bats/default.asp).

Bat calls are analysed using species-specific parameters of the call profile such as call shape, characteristic frequency, initial slope and time between calls (Rinehold et al. 2001). To ensure reliable and accurate results the following protocols (adapted from Lloyd et. al. 2006) were followed:

Search phase calls were used in the analysis, rather than cruise phase calls or feeding buzzes (McKenzie et al. 2002).

- Recordings containing less than three pulses were not analysed and these sequences were labeled as short (Law et al. 1999).
- Four categories of confidence in species identification were used (Mills et al. 1996):
    - Definite – identity not in doubt.
    - Probable – low probability of confusion with species of similar calls.
    - Possible – medium to high probability of confusion with species with similar calls.
    - Unidentifiable – calls made by bats which cannot be identified to even a species group.
- *Nyctophilus* spp. are difficult to identify confidently from their calls and no attempt was made to identify this genus to species level (Pennay et al. 2004).
- Sequences not attributed to microbat echolocation calls were labeled as junk or non-bat calls and don't represent microbat activity at the subject site.
- Sequences labelled as low were of poor quality and therefore not able to be identified to any microbat species, they can however be used as an indicator of microbat activity at the subject site.

The calls of *Chalinolobus gouldii, Mormopterus planiceps* (species 4) long penis form (South-eastern Freetail Bat), *Mormopterus planiceps* (species 3) short penis form (Inland Freetail Bat) and *Scotorepens balstoni* can be difficult to separate. Calls were identified as M. sp 4 if the call shape was flat and the frequency was between 26 – 30.5 kHz and as M. sp 3 if the call shape was flat and the frequency was between 31 – 36 kHz. *C. gouldii* was distinguished by alternation in call frequency between pulses. *S. balstoni* was identified by a curved shape to the call, a greater slope to the call compared with M. sp 3 and a frequency of the knee lower than 37 kHz. When no distinguishing characteristics were present calls may have been identified as belonging to either two or three possible species (e.g. C. gouldii / M. sp 3).

Falsistrellus tasmaniensis (Eastern Falsistrelle) was identified and calls were widespread across most subject sites. However all calls were assigned a low certainty level (possible) despite many calls having characteristics that could not be attributed to other species because this species has not been recorded at this location, nor within excess of 50 km despite significant survey effort over time. The nearest

records are from Coolah Tops, 75 km to the south-east. Coolah Tops retains a connection to the Pilliga through the Warrumbungle Range so it is possible that the calls were made by *F. tasmaniensis.* However, due to the paucity of reference calls for this species and other similar species, it is also possible that the calls were made by any of the more common species in the *Scotorepens* genus calling in a way that has not been captured in reference calls (see below).

The calls of *F. tasmaniensis, Scoteanax rueppellii* (Greater Broad-nosed Bat)*, Scotorepens greyii* (Little Broad-nosed Bat) *Scotorepens orion* (Eastern Broad-nosed Bat) and *S*. sp (Central-eastern Broad-nosed Bat) can be difficult to separate in this geographic region as their call frequencies and some other call characteristics overlap falling between 32 and 40 kHz. Calls were only positively identified when defining characteristics were present such as call shape and when the characteristic frequency allowed discrimination of a species. There were a significant number of calls that it was not possible to identify to species and they remain grouped together in groups of two or three potential species depending on recorded characteristics.

The calls of *Miniopterus schreibersii oceanensis* are difficult to separate from *Vespadelus vulturnus* in this geographic region, both falling between 43 and 48 kHz. *M. schreibersii oceanensis* was identified using the following criteria; the pulse shape and time between pulses was irregular, the calls had a downward sweeping tail, the pre-characteristic section was longer with a drop of more than 2 kHz from the knee to the characteristic section.

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 31	26/08/2013	*Miniopterus schreibersii oceanensis*	9	1	7	1
Dewhurst 31	26/08/2013	*Miniopterus schreibersii oceanensis / Vespadelus vulturnus*	1	1	0	0
Dewhurst 31	26/08/2013	*Nyctophilus* sp	1	1	0	0
Dewhurst 31	26/08/2013	*Scotorepens* sp / *Scotorepens greyii / Falsistrellus tasmaniensis*	1	1	0	0
Dewhurst 31	26/08/2013	*Vespadelus vulturnus*	31	18	6	7
Dewhurst 31	26/08/2013	*Vespadelus vulturnus / Miniopterus schreibersii oceanensis*	3	3	0	0
Dewhurst 31	26/08/2013	low	30			
Dewhurst 31	26/08/2013	short	39			
		Total sequences	115			
		Total Id'ed	46			
Dewhurst 31	27/08/2013	*Chalinolobus gouldii*	1	1	0	0
Dewhurst 31	27/08/2013	*Chalinolobus picatus*	1	1	0	0
Dewhurst 31	27/08/2013	*Falsistrellus tasmaniensis*	29	0	29	0
Dewhurst 31	27/08/2013	*Falsistrellus tasmaniensis / Scotorepens orion*	13	13	0	0
Dewhurst 31	27/08/2013	*Miniopterus schreibersii oceanensis*	15	6	3	6
Dewhurst 31	27/08/2013	*Mormopterus* sp4	4	4	0	0

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 31	27/08/2013	*Scotorepens orion / Scotorepens greyii / Falsistrellus tasmaniensis*	1	1	0	0
Dewhurst 31	27/08/2013	*Scotorepens balstoni*	5	5	0	0
Dewhurst 31	27/08/2013	*Scotorepens balstoni / Chalinolobus gouldii*	1	1	0	0
Dewhurst 31	27/08/2013	*Scotorepens orion*	1	1	0	0
Dewhurst 31	27/08/2013	*Scotorepens orion / Falsistrellus tasmaniensis*	1	1	0	0
Dewhurst 31	27/08/2013	*Scotorepens orion/Scoteanax rueppellii*	1	1	0	0
Dewhurst 31	27/08/2013	*Scotorepens orion / Scoteanax rueppellii /Falsistrellus tasmaniensis*	2	2	0	0
Dewhurst 31	27/08/2013	*Vespadelus vulturnus*	24	14	10	0
Dewhurst 31	27/08/2013	*Vespadelus vulturnus / Miniopterus schreibersii oceanensis*	9	9	0	0
Dewhurst 31	27/08/2013	low	37			
Dewhurst 31	27/08/2013	short	36			
		Total sequences	**181**			
		Total Id'ed	**108**			
Dewhurst 31	26/08/2013	*Chalinolobus gouldii*	52	51	0	1
Dewhurst 31	26/08/2013	*Falsistrellus tasmaniensis*	20	0	20	0
Dewhurst 31	26/08/2013	*Falsistrellus tasmaniensis / Scotorepens greyii / Scotorepens* sp	1	1	0	0

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 31	26/08/2013	*Falsistrellus tasmaniensis / Scotorepens orion*	1	1	0	0
Dewhurst 31	26/08/2013	*Falsistrellus tasmaniensis / Scoteanax rueppellii / Scotorepens orion*	1	1	0	0
Dewhurst 31	26/08/2013	*Miniopterus schreibersii oceanensis*	5	4	1	0
Dewhurst 31	26/08/2013	*Nyctophilus* sp	1	0	1	0
Dewhurst 31	26/08/2013	*Scotorepens balstoni*	2	1	0	1
Dewhurst 31	26/08/2013	*Vespadelus vulturnus*	14	14	0	0
Dewhurst 31	26/08/2013	*Vespadelus vulturnus / Miniopterus schreibersii oceanensis*	5	5	0	0
Dewhurst 31	26/08/2013	*Vespadelus vulturnus*	5	0	3	2
Dewhurst 31	26/08/2013	low	11			
Dewhurst 31	26/08/2013	short	12			
		Total sequences	130			
		Total Id'ed	107			
Dewhurst 31	27/08/2013	*Chalinolobus gouldii*	91	87	3	1
Dewhurst 31	27/08/2013	*Chalinolobus gouldii / Scotorepens balstoni*	2	2	0	0
Dewhurst 31	27/08/2013	*Chalinolobus picatus*	3	1	2	
Dewhurst 31	27/08/2013	*Falsistrellus tasmaniensis*	50	0	50	0
Dewhurst 31	27/08/2013	*Falsistrellus tasmaniensis / Scotorepens orion*	1	1	0	0
Dewhurst 31	27/08/2013	*Falsistrellus tasmaniensis /Scotorepens* sp	4	4	0	0

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 31	27/08/2013	*Miniopterus schreibersii oceanensis*	48	45	0	3
Dewhurst 31	27/08/2013	*Mormopterus* sp4	4	3	0	1
Dewhurst 31	27/08/2013	*Nyctophilus* sp	12	12	0	0
Dewhurst 31	27/08/2013	*Scotorepens balstoni*	9	9	0	0
Dewhurst 31	27/08/2013	*Vespadelus vulturnus*	11	10	1	0
Dewhurst 31	27/08/2013	*Vespadelus vulturnus / Miniopterus schreibersii oceanensis*	3	3	0	0
Dewhurst 31	27/08/2013	low	10			
Dewhurst 31	27/08/2013	short	20			
		Total sequences	**268**			
		Total Id'ed	**238**			
Midway 30 & 31	26/08/2013	*Chalinolobus gouldii*	77	72	4	1
Midway 30 & 31	26/08/2013	*Chalinolobus gouldii / Mormopterus sp3*	1	1	0	0
Midway 30 & 31	26/08/2013	*Chalinolobus gouldii / Mormopterus sp4*	1	1	0	0
Midway 30 & 31	26/08/2013	*Chalinolobus gouldii / Scotorepens balstoni*	1	1	0	0
Midway 30 & 31	26/08/2013	*Chalinolobus gouldii / Scotorepens balstoni*	1	1	0	0
Midway 30 & 31	26/08/2013	*Chalinolobus morio*	1	1	0	0
Midway 30 & 31	26/08/2013	*Falsistrellus tasmaniensis*	11	0	11	0
Midway 30 & 31	26/08/2013	*Falsistrellus tasmaniensis / Scotorepens orion*	1	1	0	0

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Midway 30 & 31	26/08/2013	*Miniopterus schreibersii oceanensis / Vespadelus vulturnus*	2	2	0	0
Midway 30 & 31	26/08/2013	*Miniopterus schreibersii oceanensis*	1	0	1	0
Midway 30 & 31	26/08/2013	*Mormopterus* sp3	2	2	0	0
Midway 30 & 31	26/08/2013	*Mormopterus* sp4	5	4	1	0
Midway 30 & 31	26/08/2013	*Mormopterus* sp4 */Chalinolobus gouldii*	1	1	0	0
Midway 30 & 31	26/08/2013	*Mormopterus* sp4/*Mormopterus* sp3	1	1	0	0
Midway 30 & 31	26/08/2013	*Nyctophilus* sp	6	6	0	0
Midway 30 & 31	26/08/2013	*Scotorepens balstoni*	12	12	0	0
Midway 30 & 31	26/08/2013	*Scotorepens greyii / Scotorepens* sp	1	1	0	0
Midway 30 & 31	26/08/2013	*Scotorepens greyii*	1	1	0	0
Midway 30 & 31	26/08/2013	*Scotorepens orion / Scotorepens greyii*	1	1	0	0
Midway 30 & 31	26/08/2013	*Scoteanax rueppellii*	2	0	2	0
Midway 30 & 31	26/08/2013	*Vespadelus vulturnus*	79	74	3	2
Midway 30 & 31	26/08/2013	low	26			
Midway 30 & 31	26/08/2013	short	101			
		Total sequences	**335**			

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
		Total Id'ed	**208**			
Midway 30 & 31	27/08/2013	*Chalinolobus gouldii*	49	44	2	3
Midway 30 & 31	27/08/2013	*Chalinolobus gouldii / Scotorepens balstoni*	1	1	0	0
Midway 30 & 31	27/08/2013	*Chalinolobus morio*	2	2	0	0
Midway 30 & 31	27/08/2013	*Falsistrellus tasmaniensis*	2	0	2	0
Midway 30 & 31	27/08/2013	*Falsistrellus tasmaniensis / Scotorepens greyii*	1	1	0	0
Midway 30 & 31	27/08/2013	*Miniopterus schreibersii oceanensis*	9	6	2	1
Midway 30 & 31	27/08/2013	*Mormopterus* sp4	23	22	0	1
Midway 30 & 31	27/08/2013	*Nyctophilus* sp	1	1	0	0
Midway 30 & 31	27/08/2013	*Saccolaimus flaviventris*	1	1	0	0
Midway 30 & 31	27/08/2013	*Scotorepens balstoni*	9	9	0	0
Midway 30 & 31	27/08/2013	*Scotorepens orion*	1	0	1	0
Midway 30 & 31	27/08/2013	*Tadarida australis*	4	4	0	0
Midway 30 & 31	27/08/2013	*Vespadelus troughtoni / Chalinolobus morio*	1	1	0	0
Midway 30 & 31	27/08/2013	*Vespadelus vulturnus*	29	26	1	2

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Midway 30 & 31	27/08/2013	*Vespadelus vulturnus / Miniopterus schreibersii oceanensis*	4	4	0	0
Midway 30 & 31	27/08/2013	low	32			
Midway 30 & 31	27/08/2013	short	84			
		Total sequences	**253**			
		Total Id'ed	137			
Dewhurst 13-18	28/08/2013	*Nyctophilus* sp	1	1	0	0
Dewhurst 13-18	28/08/2013	*Vespadelus vulturnus*	8	7	1	0
Dewhurst 13-18	28/08/2013	low	3			
Dewhurst 13-18	28/08/2013	short	7			
Dewhurst 13-18	29/08/2013	*Miniopterus schreibersii oceanensis*	1	0	1	0
Dewhurst 13-18	29/08/2013	*Saccolaimus flaviventris*	2	2	0	0
Dewhurst 13-18	29/08/2013	*Tadarida australis*	1	1	0	0
Dewhurst 13-18	29/08/2013	*Vespadelus vulturnus*	9	8	0	1
Dewhurst 13-18	29/08/2013	*Vespadelus vulturnus / Miniopterus schreibersii oceanensis*	1	1	0	0
Dewhurst 13-18	29/08/2013	low	7			

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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 13-18	29/08/2013	short	18			
		Total sequences	**58**			
		Total Id'ed	33			
Dewhurst 30	26/08/2013	*Chalinolobus gouldii*	35	32	1	2
Dewhurst 30	26/08/2013	*Falsistrellus tasmaniensis* / *Scotorepens* sp / *Scotorepens greyii*	1	1	0	0
Dewhurst 30	26/08/2013	*Falsistrellus tasmaniensis*	3	0	3	0
Dewhurst 30	26/08/2013	*Miniopterus schreibersii oceanensis*	5	1	3	1
Dewhurst 30	26/08/2013	*Vespadelus vulturnus*	9	7	2	0
Dewhurst 30	26/08/2013	low	5			
Dewhurst 30	26/08/2013	short	3			
		Total sequences	**61**			
		Total Id'ed	53			
Dewhurst 30	27/08/2013	*Chalinolobus gouldii*	82	82	0	0
Dewhurst 30	27/08/2013	*Falsistrellus tasmaniensis* / *Scotorepens orion* / *Scotorepens greyii*	1	1	0	0
Dewhurst 30	27/08/2013	*Falsistrellus tasmaniensis*	2	0	2	0
Dewhurst 30	27/08/2013	*Miniopterus schreibersii oceanensis*	2	1	1	0
Dewhurst 30	27/08/2013	*Mormopterus* sp3	1	1	0	0
Dewhurst 30	27/08/2013	*Mormopterus* sp4	1	1	0	0
Dewhurst 30	27/08/2013	*Scotorepens balstoni*	1	1	0	0
Dewhurst 30	27/08/2013	*Vespadelus vulturnus*	4	3	0	1

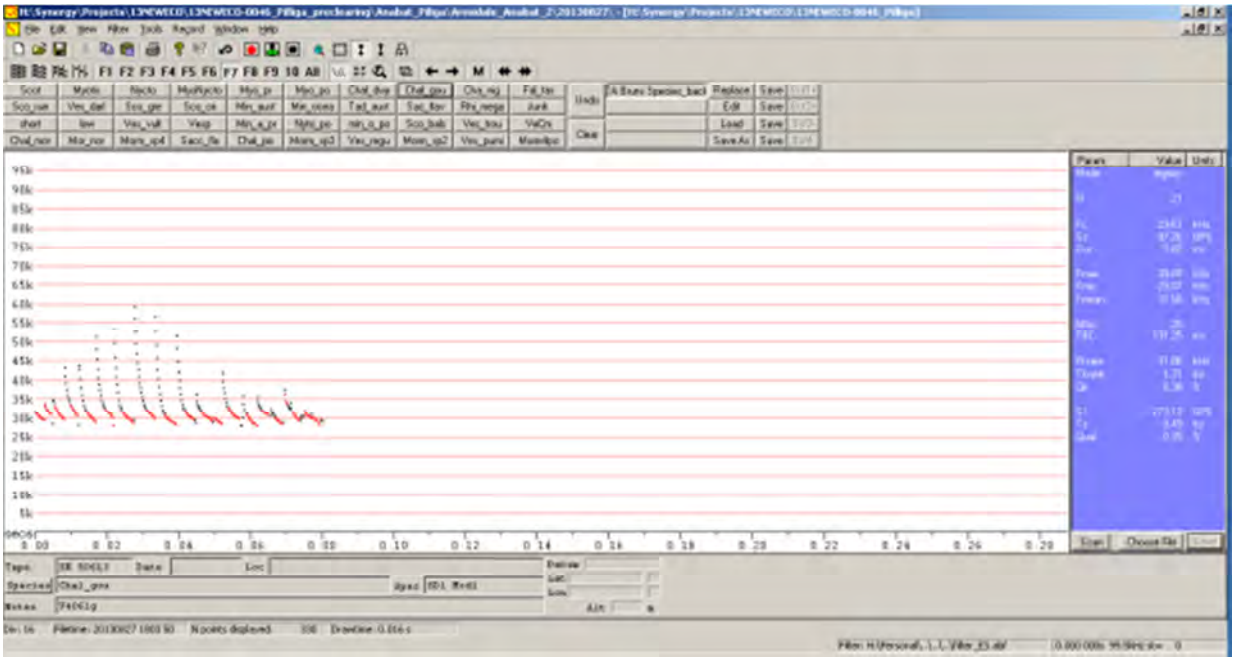
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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 30	27/08/2013	low	2			
Dewhurst 30	27/08/2013	short	6			
		Total sequences	**102**			
		Total Id'ed	94			
Dewhurst 13-18	28/08/2013	*Miniopterus schreibersii oceanensis*	1	0	0	1
Dewhurst 13-18	28/08/2013	*Vespadelus vulturnus*	1	1	0	0
Dewhurst 13-18	28/08/2013	low	2			
Dewhurst 13-18	28/08/2013	short	19			
Dewhurst 13-18	29/08/2013	*Chalinolobus gouldii*	1	1	0	0
Dewhurst 13-18	29/08/2013	*Mormopterus* sp4	1	1	0	0
Dewhurst 13-18	29/08/2013	*Saccolaimus flaviventris*	1	0	0	1
Dewhurst 13-18	29/08/2013	low	1			
Dewhurst 13-18	29/08/2013	short	20			
		Total sequences	**47**			
		Total Id'ed	26			
Dewhurst 30	26/08/2013	*Chalinolobus gouldii*	4	0	1	3
Dewhurst 30	26/08/2013	*Miniopterus schreibersii oceanensis*	7	0	4	3
Dewhurst 30	26/08/2013	*Nyctophilus* sp	7	6	0	1
Dewhurst 30	26/08/2013	*Vespadelus vulturnus*	1	1	0	0

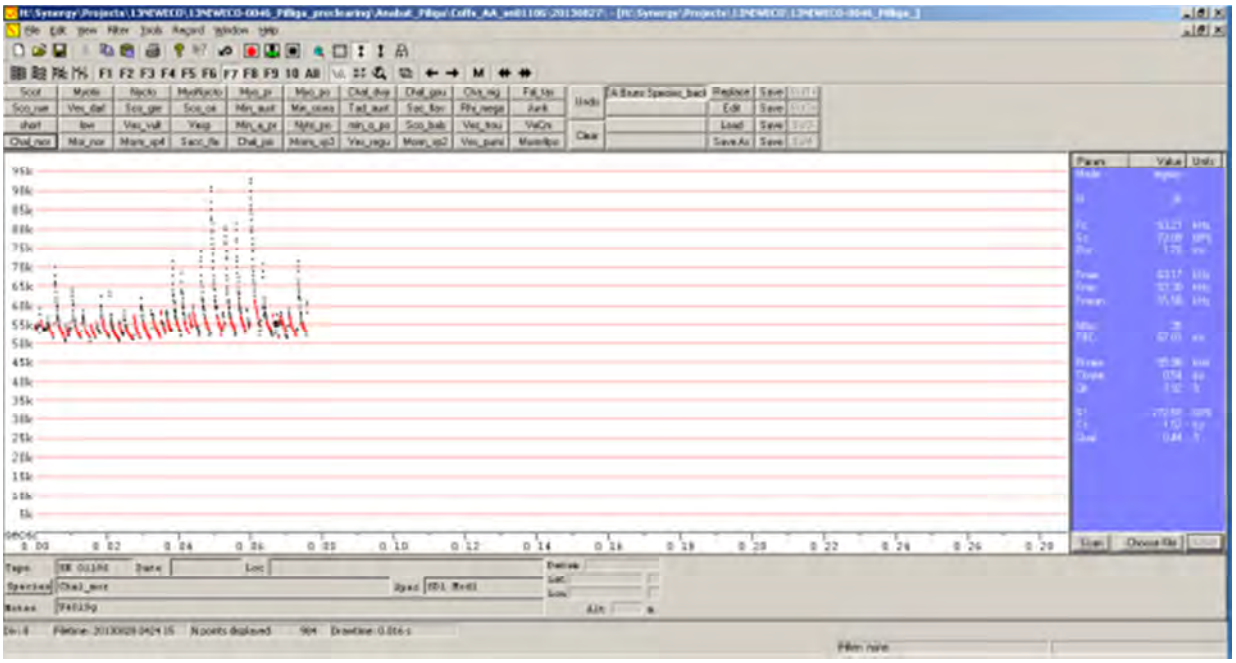
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Site name	Night	Species name	Number of calls	Definite	Possible	Probable
Dewhurst 30	26/08/2013	low	16			
Dewhurst 30	26/08/2013	short	11			
		Total sequences	46			
		Total Id'ed	19			
Dewhurst 30	27/08/2013	*Miniopterus schreibersii oceanensis*	4	1	3	0
Dewhurst 30	27/08/2013	*Mormopterus* sp4	3	2	0	1
Dewhurst 30	27/08/2013	*Nyctophilus* sp	4	1	2	1
Dewhurst 30	27/08/2013	*Scotorepens greyii*	1	0	1	0
Dewhurst 30	27/08/2013	*Vespadelus vulturnus*	3	1	1	1
Dewhurst 30	27/08/2013	low	9			
Dewhurst 30	27/08/2013	short	5			
		Total sequences	**29**			
		Total Id'ed	15			

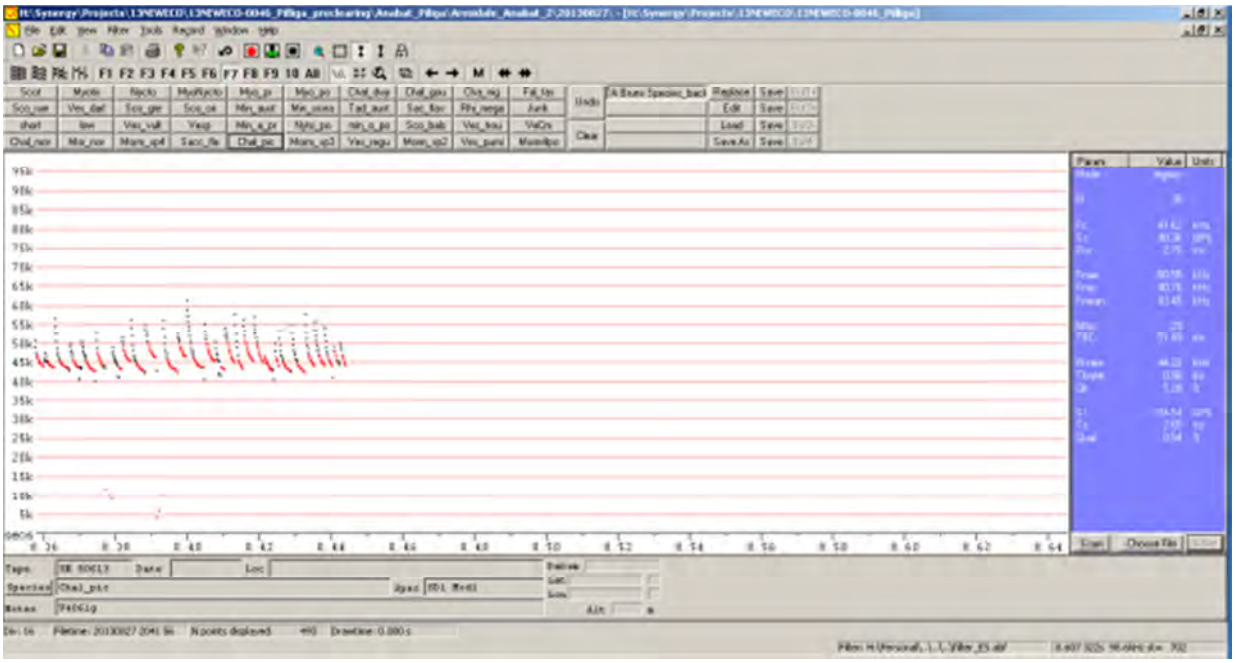
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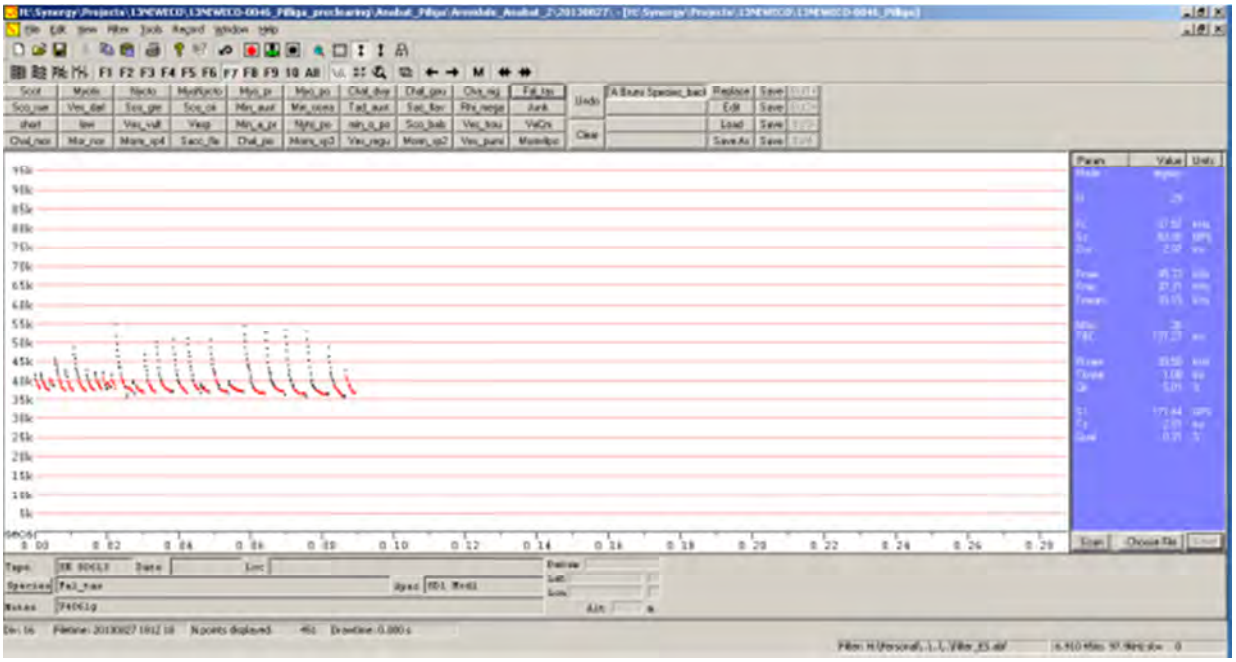
Call profile for *Chalinolobus gouldii* at 18:03 on 27 August 2013.



Call profile for *Chalinolobus morio* at 04:24 on 28 August 2013.

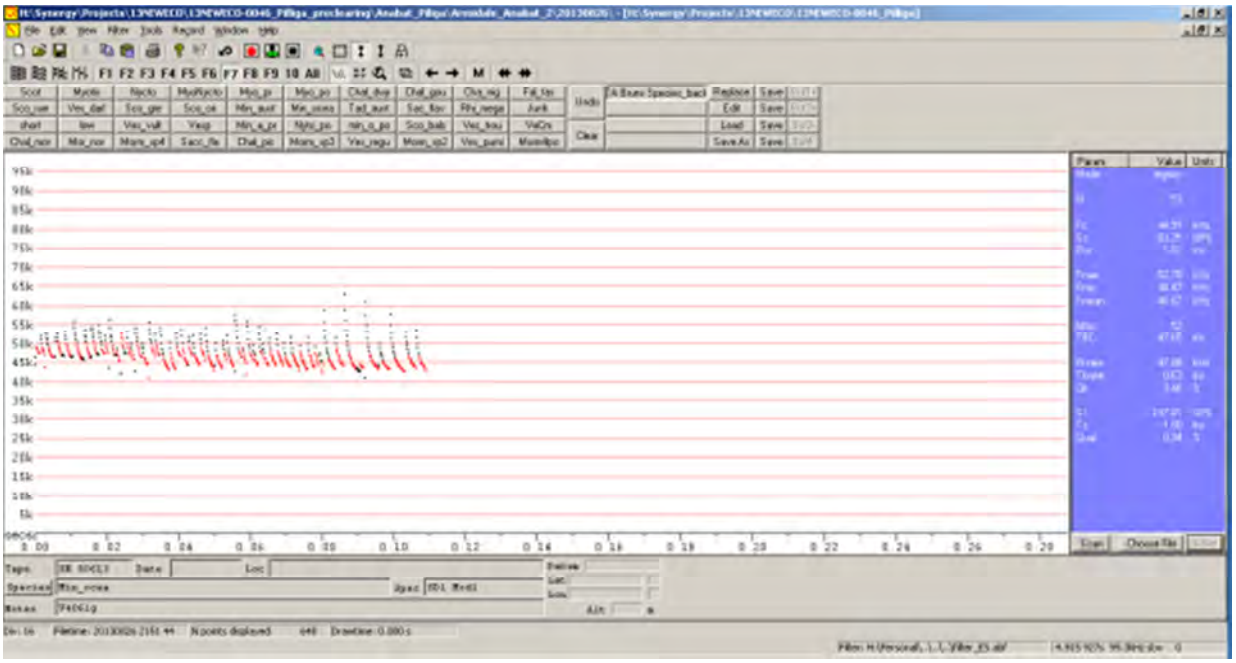


Call profile for *Chalinolobus picatus* at 20:41 on 27 August 2013

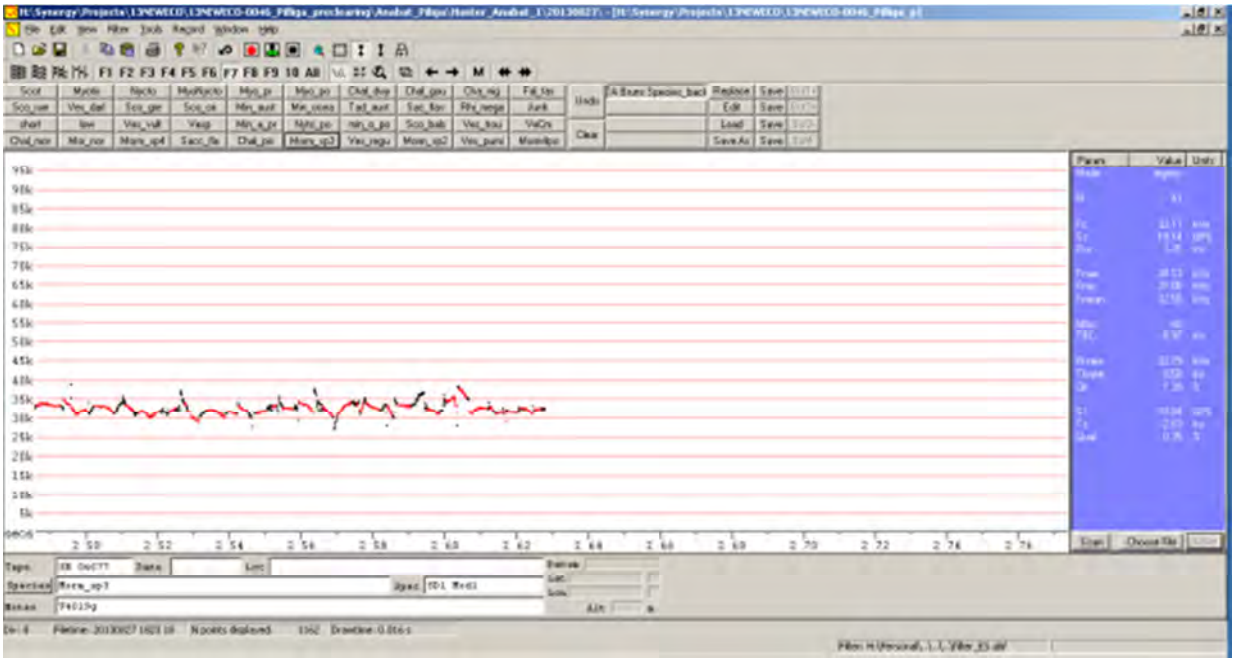


Possible call profile for *Falsistrellus tasmaniensis* at 18:12 on 27 August 2013

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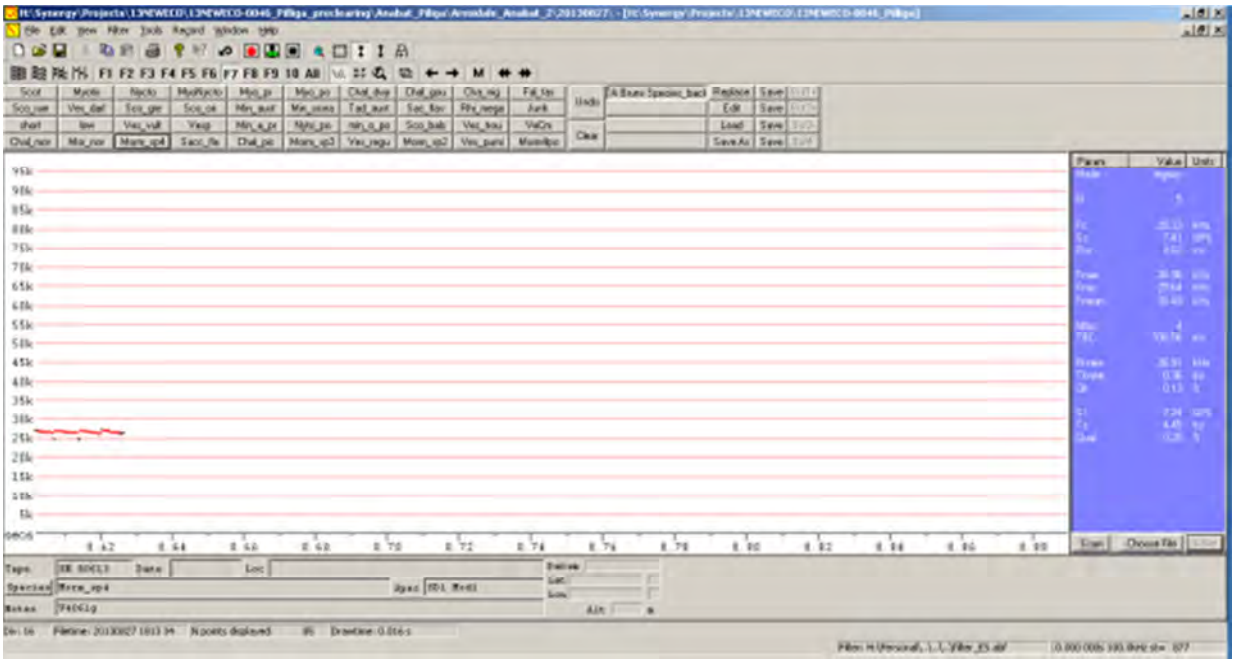


Call profile for *Miniopterus schreibersii oceanensis* at 21:51 on 26 August 2013.

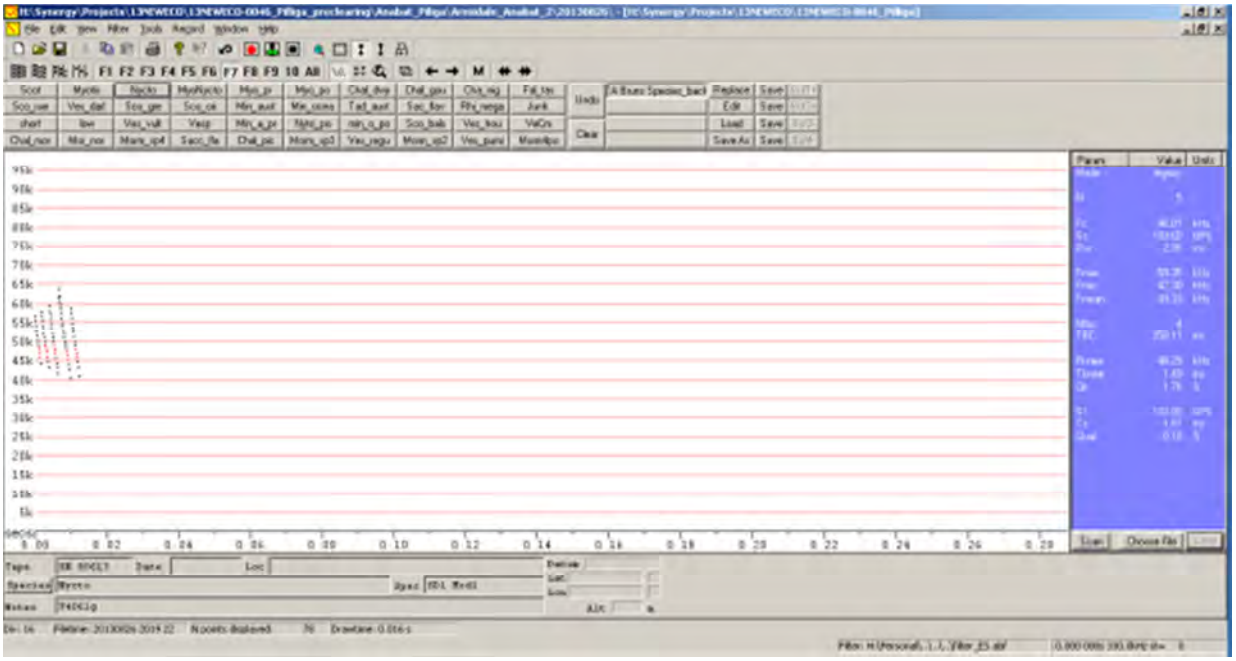


Call profile for *Mormopterus* species 3 at 18:23 on 27 August 2013

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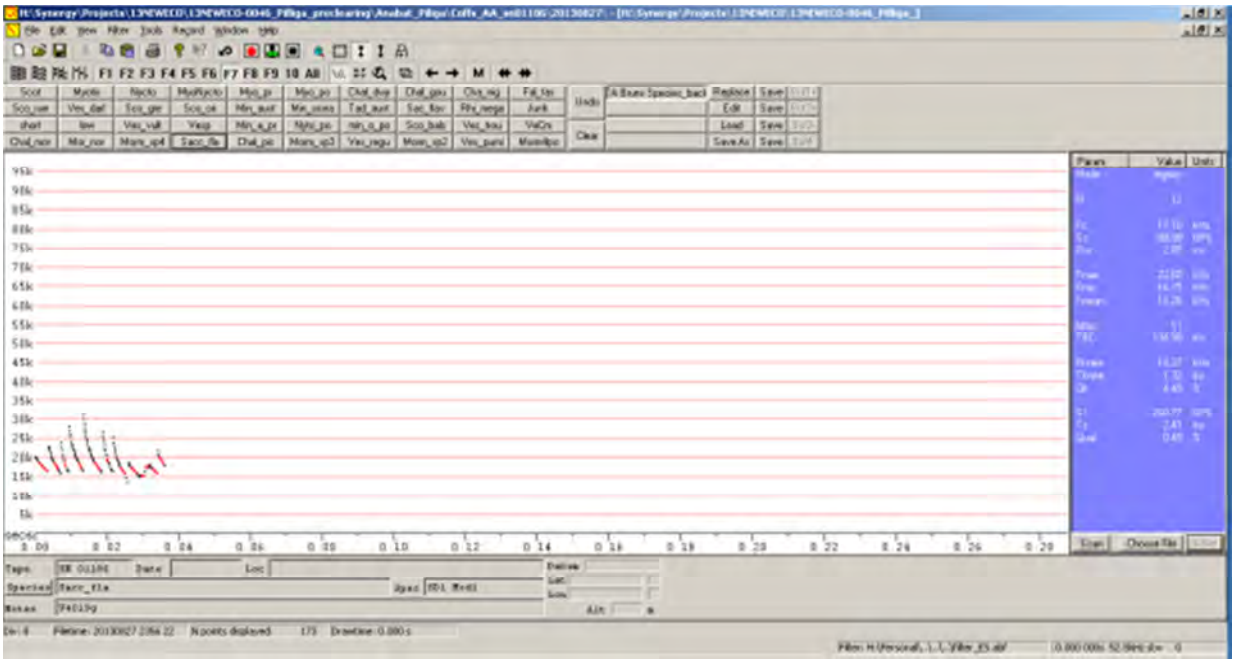


Call profile for *Mormopterus* species 4 at 18:13 on 27 August 2013.

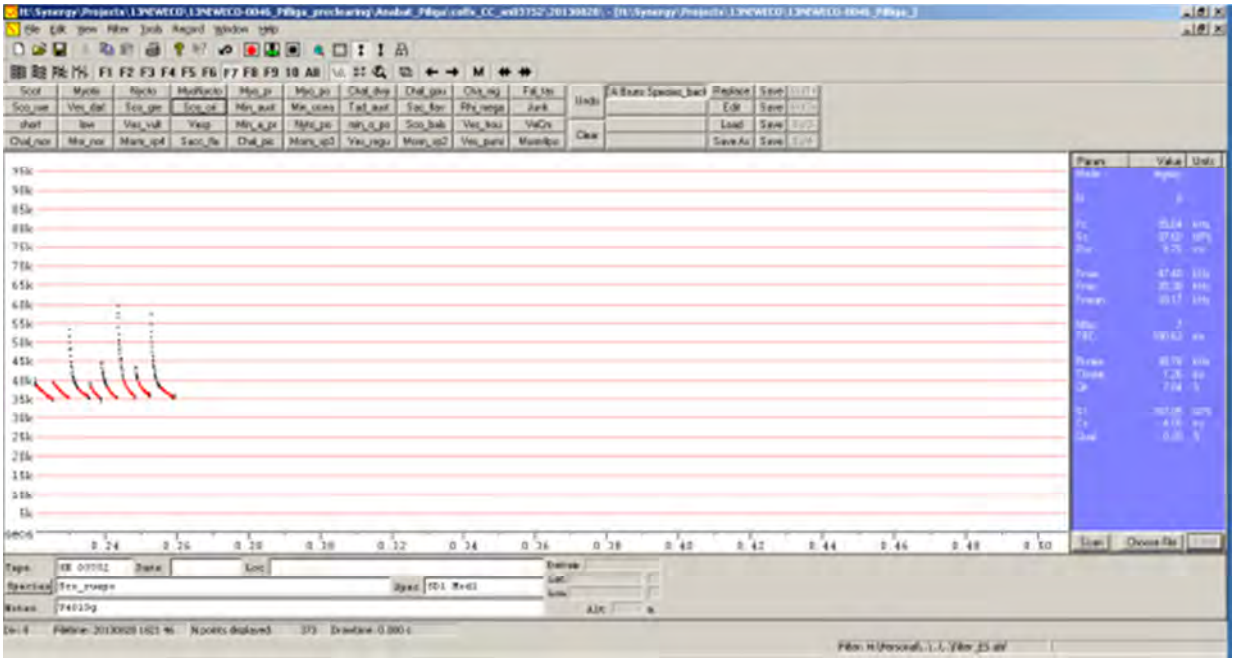


Possible call profile for *Nyctophilus sp.* at 20:19 on 26 August 2013.

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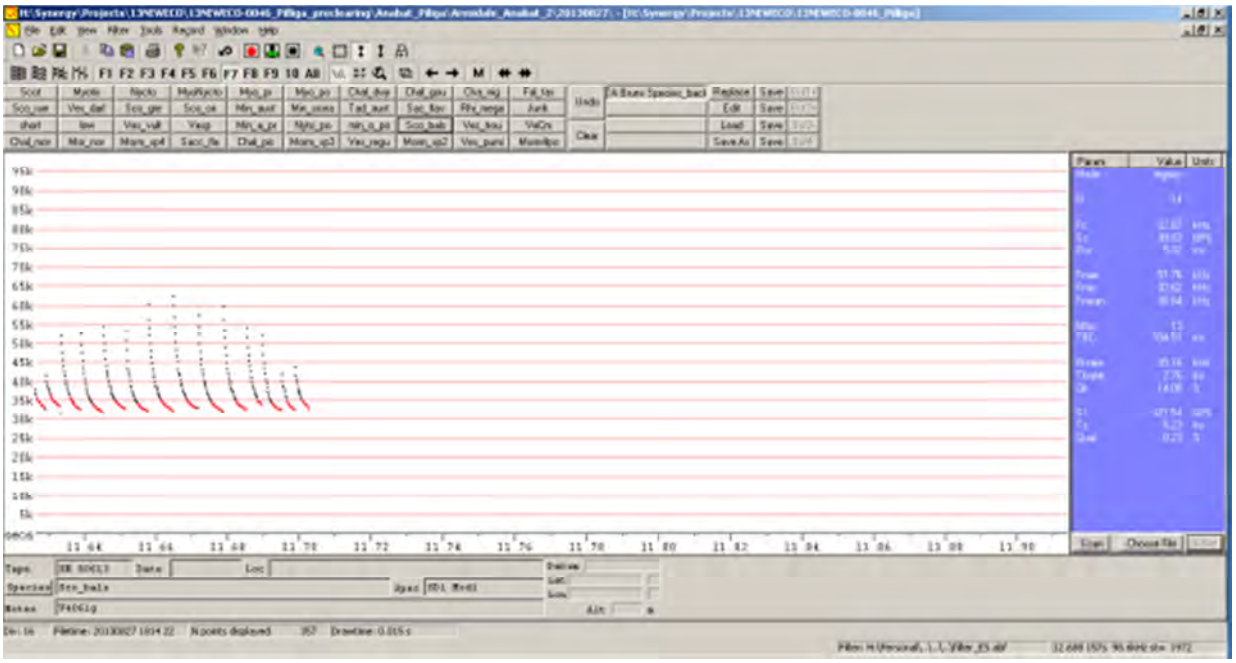


Call profile for *Saccolaimus flaviventrus* at 23:56 on 27 August 2013

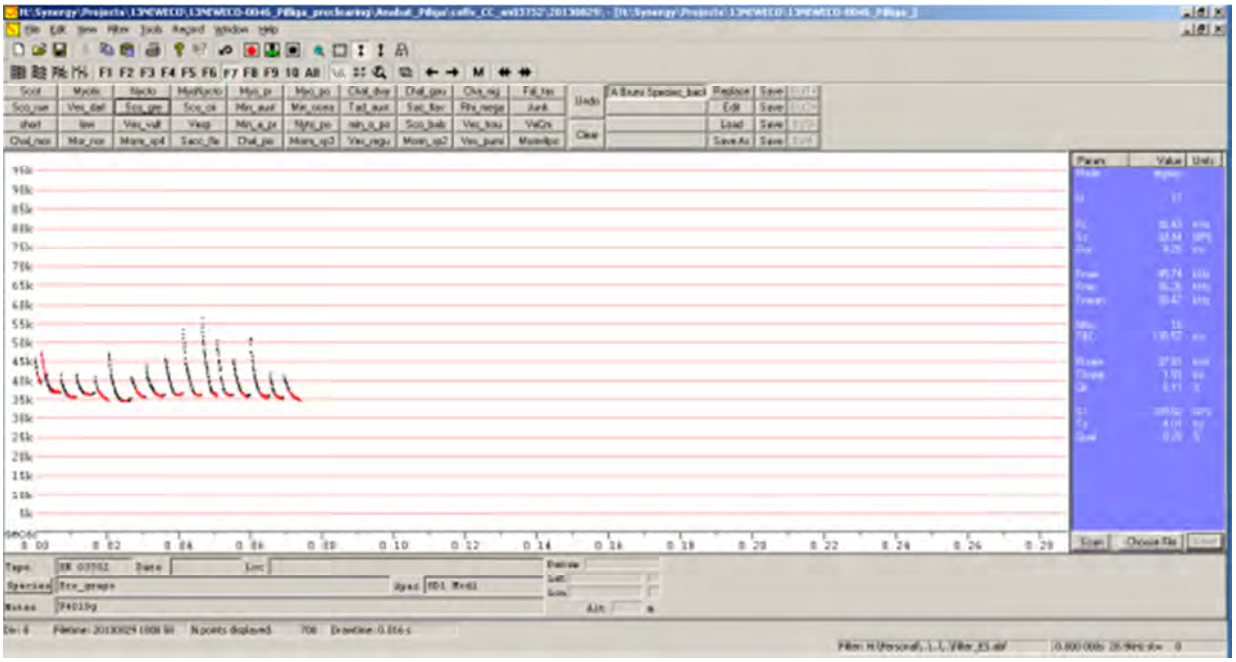


Possible call profile for *Scoteanax rueppellii* at 18:21 on 28 August 2013

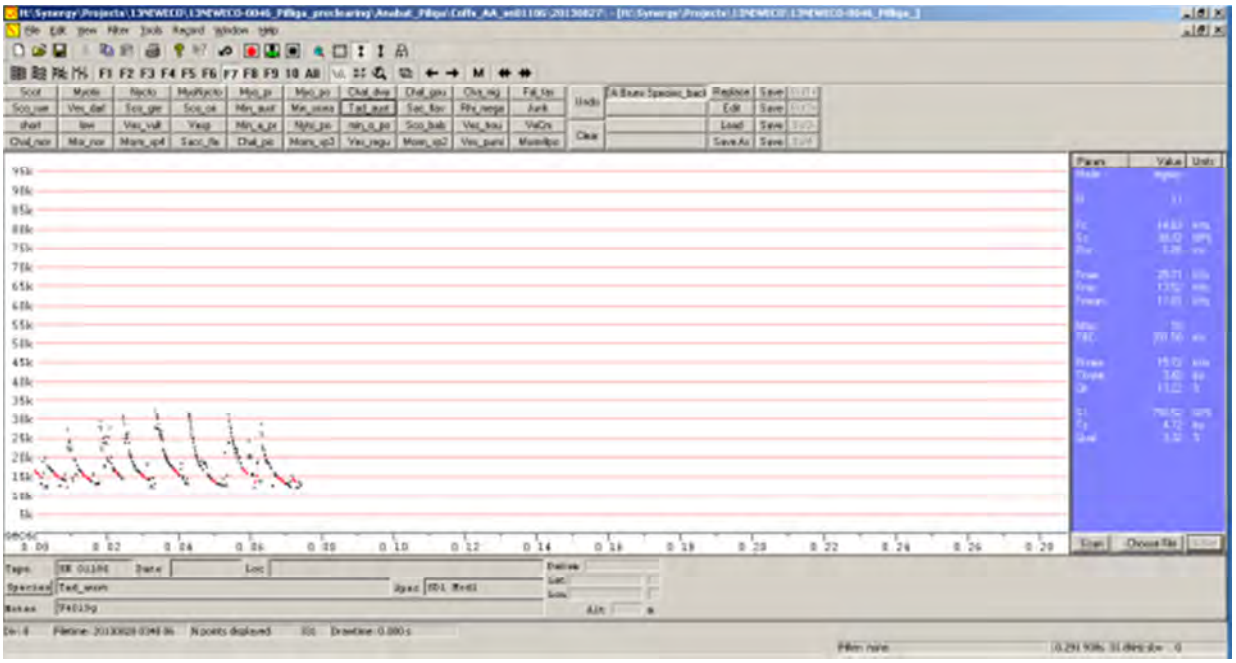
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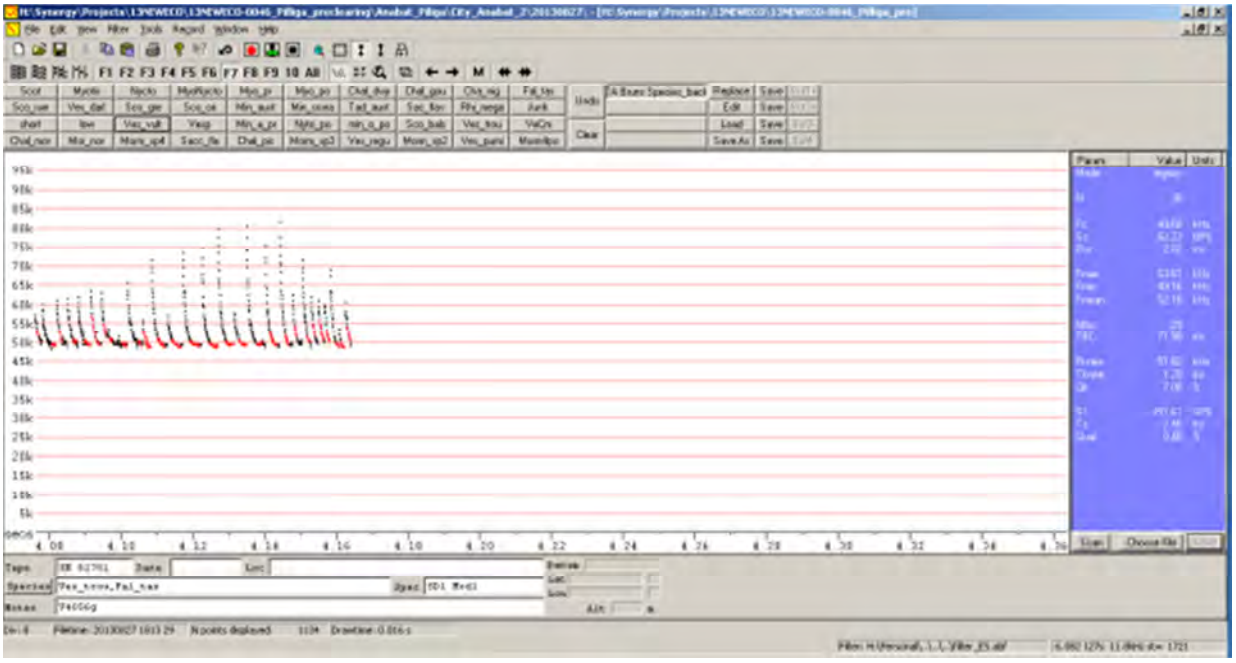
Call profile for *Scotorepens balstoni* at 18:14 on 27 August 2013



Possible call profile for *Scotorepens greyii* at 18:08 on 29 August 2013

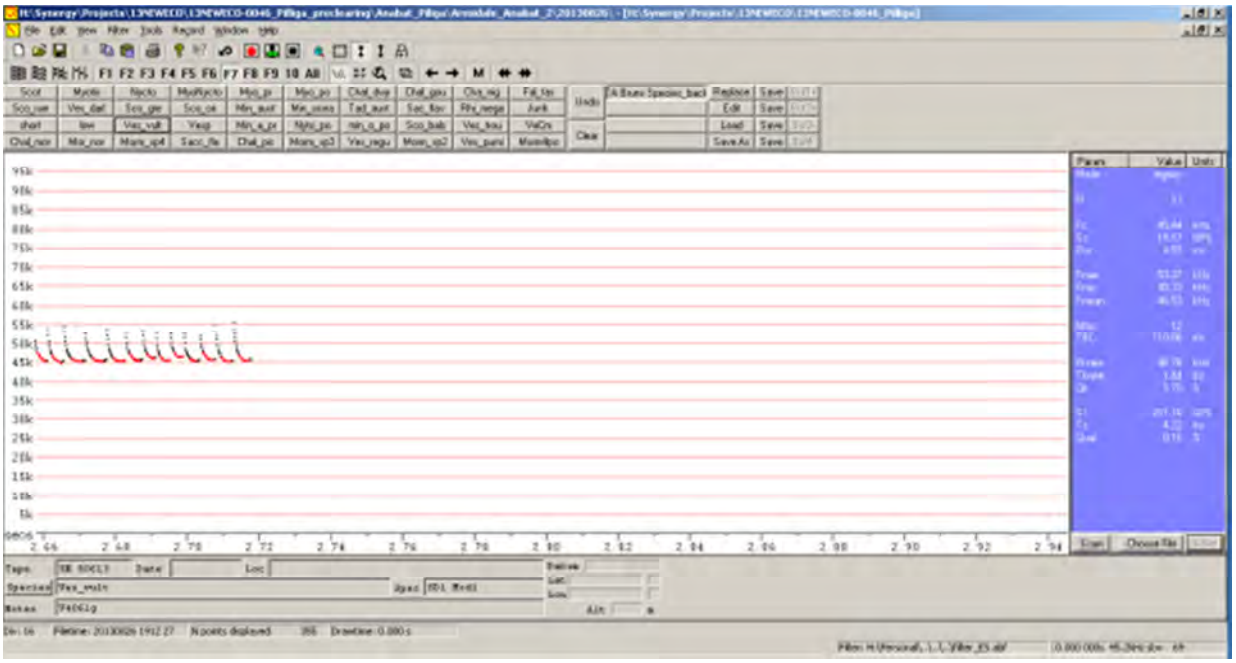


Call profile for *Tadarida australis* at 03:48 on 28 August 2013.



Call profile for *Vespadelus troughtoni* at 18:13 on 27 August 2013.

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Call profile for *Vespadelus vulturnus* at 19:12 on 26 August 2013.

Appendix E: Fauna species list recorded during field surveys

Common name	Scientific name	TSC Act**	EPBC Act**	Dewhurst 30	Dewhurst 31	Dewhurst 13-18	Midway 30 & 31	RPS (2012)	ELA (2010-2013)
AMPHIBIANS									
Broad-palmed Frog	*Litoria latopalmata*	P						X	
Ornate Burrowing Frog	*Platyplectrum ornatum* g	P						X	
Salmon Striped Frog	*Limnodynastes salmini*	P						X	
BIRDS (68 species)									
Australasian Grebe	*Tachybaptus novaehollandiae*	P				X			
Australian King-Parrot	*Alisterus scapularis*	P		X					
Australian Owlet-nightjar#	*Aegotheles cristatus*	P			X			X	
Australian Pelican*	*Pelicanus conspicillatus*	P				X			
Australian Raven	*Corvus coronoides*	P						X	
Australian Ringneck	*Barnardius zonarius*	P		X		X			
Black-faced Cuckoo-shrike#	*Coracina novaehollandiae*	P			X			X	
Black-fronted Dotterel	*Elseyornis melanops*	P				X			
Blue-faced Honeyeater	*Entomyzon cyanotis*							X	
Brown Honeyeater	*Lichmera indistincta*	P						X	
Brown Thornbill	*Acanthiza pusilla*	P		x				X	
Brown-headed Honeyeater	*Melithreptus brevirostris*	P						X	
Buff-rumped Thornbill	*Acanthiza reguloides*	P		X	X	X		X	
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	P		X	X				
Cicadabird	*Coracina tenuirostris*	P						X	
Cockatiel	*Nymphicus hollandicus*	P				X			
Common Bronzewing	*Phaps chalcoptera*	P						X	

Common name	Scientific name	TSC Act**	EPBC Act**	Dewhurst 30	Dewhurst 31	Dewhurst 13-18	Midway 30 & 31	RPS (2012)	ELA (2010-2013)
Dusky Woodswallow	*Artamus cyanopterus*	P			X			X	
Eastern Rosella	*Platycercus eximius*	P		X				X	
Eastern Yellow Robin	*Eopsaltria australis*	P		X	X	X		X	
Emu	*Dromaius novaehollandiae*	P		X	X				
Eurasian Coot	*Fulica atra*	P				x			
Galah	*Eolophus roseicapillus*	P			X	X		X	
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	V		X					
Golden Whistler	*Pachycephala pectoralis*	P		X	X	X			
Grey Butcherbird	*Cracticus torquatus*	P		X	X	X		X	
Grey Fantail	*Rhipidura albiscapa*	P		X	X	X		X	
Grey Shrike-thrush	*Colluricincla harmonica*	P		x		X		X	
Grey Teal	*Anas gracilis*	P				X			
Grey-crowned Babbler	*Pomatostomus temporalis*	V		X				X	
Hardhead	*Aythya australis*	P				X			
Hooded Robin	*Melanodryas cucullata*	V				X			
Inland Thornbill	*Acanthiza apicalis*	P		X					
Jacky Winter	*Microeca fascinans*	P		X				X	
Laughing Kookaburra	*Dacelo novaeguineae*	P						X	
Leaden Flycatcher	*Myiagra rubecula*	P						X	
Little Black Cormorant	*Phalacrocorax sulcirostris*	P				X			
Magpie-lark	*Grallina cyanoleuca*	P						X	
Masked Woodswallow	*Artamus personatus*	P						X	
Mistletoebird	*Dicaeum hirundinaceum*							X	
Noisy Friarbird	*Philemon corniculatus*	P		X	X	X		X	
Noisy Miner	*Manorina melanocephala*	P		X	X			X	
Olive-backed Oriole	*Oriolus sagittatus*	P		X	X	X			
Pacific Black Duck	*Anas superciliosa*	P				X			

Common name	Scientific name	TSC Act**	EPBC Act**	Dewhurst 30	Dewhurst 31	Dewhurst 13-18	Midway 30 & 31	RPS (2012)	ELA (2010-2013)
Pied Cormorant*	*Phalacrocorax varius*	P				X			
Pied Currawong	*Strepera graculina*	P		X	X	X		X	
Rufous Whistler	*Pachycephala rufiventris*	P				X		X	
Silvereye	*Zosterops lateralis*								
Speckled Warbler	*Chthonicola sagittata*	V			X				
Spotted Pardalote	*Pardalotus punctatus*	P		X		X		X	
Striated Pardalote	*Pardalotus striatus*	P		X	X			X	
Striped Honeyeater	*Plectorhyncha lanceolata*	P		X	X				
Superb Fairy-wren	*Malurus cyaneus*	P		x	X	X		X	
Varied Sittella	*Daphoenositta chrysoptera*	VP			X				
Variegated Fairy-wren	*Malurus lamberti*	P			X			X	
Weebill	*Smicrornis brevirostris*	P		X	X	X		X	
Western Gerygone	*Gerygone fusca*	P						X	
White-bellied Sea-eagle*	*Haliaeetus leucogaster*	P	Mar, M			X			
White-browed Babbler	*Pomatostomus superciliosus*	P				X			
White-eared Honeyeater	*Lichenostomus leucotis*	P		X	X	X		X	
White-necked Heron	*Ardea pacifica*	P				X			
White-plumed Honeyeater	*Lichenostomus penicillatus*	P						X	
White-throated Gerygone	*Gerygone albogularis*	P		X		X		X	
White-throated Needletail	*Hirundapus caudacutus*	P	Mar, M					X	
White-throated Treecreeper	*Cormobates leucophaea*	P		X	X	X		X	
Willie Wagtail	*Rhipidura leucophrys*	P		X				X	
Yellow Thornbill	*Acanthiza nana*	P		X	X			X	
Yellow-faced Honeyeater	*Lichenostomus chrysops*	P		X	X	X		X	
MAMMALS (32 species)									
Bristle-faced Free-tailed Bat>	*Mormopterus eleryi*	E						X	

Common name	Scientific name	TSC Act**	EPBC Act**	Dewhurst 30	Dewhurst 31	Dewhurst 13-18	Midway 30 & 31	RPS (2012)	ELA (2010-2013)
Chocolate Wattle Bat	*Chalinolobus morio*	P						X	
Common Brushtail Possum	*Trichosurus vulpecula*	P							R-2-2
Common Bent-wing Bat	*Miniopterus schreibersii**	V		X	X	X	X	X	
Eastern Bentwing Bat	*Miniopterus schreibersii oceanensis*	V		X	X		X		
Eastern Broad-nosed Bat	*Scotorepens orion*	P		X	X		X		
Eastern Cave Bat	*Vespadelus troughtoni*	V					X		
Eastern False Pipistrell	*Falsistrellus tasmaniensis*	V		X	X		X		
Eastern Grey Kangaroo	*Macropus giganteus*	P						X	R-2-2
European Fox	*Vulpes vulpes*	U		X				X	PR-A PR-2-2
Feral Cat	*Felis catus*	U						X	
Gould's Long-eared Bat	*Nyctophilus gouldii*	P		X			X		
Gould's Wattle Bat	*Chalinolobus gouldii*	P		X			X	X	
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V		X			X		
Inland Broad-nosed Bat	*Scotorepens balstoni*	P						X	
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	P		X	X		X		
Little Broad-nosed Bat	*Scotorepens greyii*	P		X	X		X	X	
Little Forest Bat	*Vespadelus vulturnus*	P		X	X	X	X		
Little Pied Bat	*Chalinolobus picatus*	V			X			X	
Orion Broad-nosed Bat	*Scotorepens orion*	P		X			X		
Rat	*Rattus* sp.	?							PR-A
Red-necked Wallaby	*Macropus rufogriseus*	P						X	
Swamp Wallaby	*Wallabia bicolor*	P						X	
Western Broad-nosed Bat	*Scotorepens balstoni*	P			X		X		
White-striped Freetail Bat	*Tadarida australis*	P						X	

Common name	Scientific name	TSC Act**	EPBC Act**	Dewhurst 30	Dewhurst 31	Dewhurst 13-18	Midway 30 & 31	RPS (2012)	ELA (2010-2013)
Yellow-bellied Sheathtail Bat	*Saccolaimus flaviventris*	V				X	X	X	
Yellow-footed Antechinus	*Antechinus flavipes*	P		X					H4-B
	Miniopterus sp.	P			X				
	Mormopterus sp.	P			X		X	X	
	Nyctophilus sp.	P			X		X	X	
	Scotorepens sp.	P		X					
	Vespadelus sp.	P						X	
REPTILES (12 species)									
Beared Dragon	*Pogona barbata*	P						X	
Boulenger's Skink	*Morethia boulengeri*	P						X	H4-A
Eastern Robust Slider	*Lerista punctatovittata*	P						X	
Eastern Spiny-tailed Gecko	*Strophurus williamsi*	P						X	
Eastern Stone Gecko	*Diplodactylus vittatus*	P						X	
Lace Goanna	*Varanus varius*	P						X	
Nobbi Dragon	*Amphibolurus nobbi*	P						X	
Robust Ctenotus	*Ctenotus robustus*	P						X	
Sand Goanna	*Varanus gouldii*	P						X	
Snake-eyed Skink	*Cryptoblepharus virgatus*	P						X	
Timid Slider	*Lerista timida*	P						X	
Tree-base Litter-skink	*Lygisaurus foliorum*	P						X	
Unidentified Skink		P			X				

* not recorded in previous surveys; # call playback Midway 30 & 31, > potentially recorded in the study area, but call could not be confirmed.

** P = protected; U = unprotected; V = vulnerable; M = migratory; Mar = marine

Appendix F: Assessment of significance under the TSC Act

The following appendix provides an assessment of the potential significance of the impacts from the proposed activity on ecological values listed under the TSC Act. The ecological values considered relevant to this assessment are identified in Section 4.2 of this report.

The assessment of impact has been conducted where necessary with consideration to the 7-part test criteria (or assessment of significance), as outlined in the text box below:

7-Part Test Assessment of Significance

1. *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.*
2. *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.*
3. *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,*
4. *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, an*
    - *II. whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed activity, 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*
5. *Whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).*
6. *Whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan.*
7. *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*.

The flora and fauna species have been grouped for the assessment process with other values that contain similar characteristics and those that are likely to be impacted in a similar manner.

The flora and fauna groupings for the assessment of significance for species listed under the TSC act include:

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Flora

- *Diuris tricolor, Polygala linariifolia, Pterostylis cobarensis* and *Tylophora linearis*

Birds

- Parrots:
  - Glossy Black-Cockatoo, Little Lorikeet, Swift Parrot and Turquoise Parrot
- Owls:
  - Barking Owl & Masked Owl
- Birds of prey:
  - Spotted Harrier, Black-breasted Buzzard, Little Eagle and Square-tailed Kite
- Woodland birds – large ground foraging:
  - Bush Stone-curlew
- Woodland birds – ground and mid-storey foraging (passerines):
  - Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin
- Woodland birds – canopy foraging (excluding parrots):
  - Regent Honeyeater, Painted Honeyeater and Black-chinned Honeyeater

Mammals

- Arboreal mammals and Flying Fox*:*
  - Grey-headed Flying Fox and Squirrel Glider
- Ground and log dependent mammals*:*
  - Black-striped Wallaby, Pilliga Mouse and Spotted-tailed Quoll
- Grassy woodland mammals*:*
  - Rufous Bettong
- Predominantly tree-roosting bats*:*
  - Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat
- Predominantly cave-roosting bats*:*
  - Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat

THREATENED FLORA

***Diuris tricolor, Polygala linariifolia, Pterostylis cobarensis* and *Tylophora linearis*.**

Significant impacts for these threatened flora species are assessed on the number of individuals or populations directly impacted by the proposed activity relative to the study area. Considerations are also given to important and critical habitat, as well as likely indirect impacts on potential habitat. No critical habitat under the TSC Act has been declared for these species.

Detailed targeted surveys within the broader north-east Pilliga Forest have identified significant populations of these threatened species. Modelled data predicts the existence of 18,180 *Diuris tricolor,* 122,713 *Polygala* linariifolia, 3,349,724 *Pterostylis cobarensis* and 183,908 *Tylophora linearis* individuals in the Pilliga and Pilliga Outwash CMA subregions (ELA 2012). The removal of one *Polygala linariifolia,* three *Pterostylis cobarensis* and three *Tylophora linearis*, would result in the reduction of less than 0.01% of the predicted population in the two modelled CMA subregions.

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The proposed activity will result in the removal of a very small proportion of potential habitat for these species relative to available habitat across the Pilliga region. Habitat for these species is widespread across the Pilliga region, with significant populations of *Pterostylis cobarensis* and *Tylophora linearis* identified outside of the study area including populations within State Forests, National Parks, Nature Reserves and State Conservation Areas. Therefore, significant impacts to the lifecycle and important habitat to these species are unlikely to result from the proposed activity.

The proposed activity has the potential to increase the spread of weed species through the introduction of plant and/or seed material from vehicles and other equipment or through increased penetration of the forest along new access tracks and other disturbed areas. Weed and fungal invasion has the potential to degrade the habitat of these species and weed species may directly compete with them. To address these potential threats, Santos has prepared a weed management strategy and a comprehensive rehabilitation strategy will be prepared which will address issues of restoration, weed invasion and feral animal invasion over the life of the Program.

Significant impacts on the threatened flora species are considered unlikely given:

- The small extent of impacts from the proposed activity relative to extant populations and available habitat across the study region.
- That available potential habitat will not been significantly reduced to an extent likely to cause a significant decline in the species populations.
- The demonstrated and anticipated rehabilitation of areas of impact.
- Potential indirect impacts, such as weed invasion are being actively managed.

BIRDS

Parrots

The Glossy Black-Cockatoo, Little Lorikeet, Swift Parrot and Turquoise Parrot are considered in this impact assessment. Only the Glossy Black Cockatoo has been recorded in the study area.

The proposed activity could potentially impact on the life cycles of these threatened parrots by reducing the amount of foraging, roosting and breeding habitat available to the species, by increasing mortality rates via vehicle collisions and by spreading weeds. Swift Parrots breed in Tasmania. Thus, only potential foraging and roosting habitat would be reduced by the exploration works for these species. Glossy Black Cockatoos, Little Lorikeets, and Turquoise Parrots forage, roost and potentially breed within the study area.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened parrot species. However, this loss is considered relatively minor in the context of similar habitats within the study region, constituting up to 0.01% of available habitat for the threatened parrot species.

The disturbance from the proposed activity is considered unlikely to isolate larger areas of potential habitat or impact on important habitat for the threatened parrot species. This is especially true given the highly mobile nature of these parrots. Swift Parrots are able to migrate large distances from their breeding habitats in southern NSW to northern NSW, and from Tasmania to northern NSW, respectively. Glossy Black Cockatoos, Little Lorikeets, and Turquoise Parrots also move distances to access their foraging resources, although Little Lorikeets have been found to be less nomadic during breeding periods (DoE 2013b).

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The scale of the fragmentation in relation to the total area of potential habitat and individual fragments of habitat within the study region is considered relatively minor in relation to these highly mobile species. In addition, following the construction of linear infrastructure for the proposed activity, vegetation above the buried gathering system (ground and shrub layers) would be largely rehabilitated, reducing the width of the disturbed habitat between undisturbed habitat fragments and thus, limiting the level of habitat fragmentation.

Although HBTs will be impacted by the proposed activity, the scale of loss in the context of the HBTs available in the study region is not significant based on the extent of habitat present. In addition, no critical habitat, recovery plans or threat abatement plans exist or are relevant for the Glossy Black-Cockatoo, Little Lorikeet, Swift Parrot or Turquoise Parrot in the study area.

The proposed activity is unlikely to constitute a significant impact on the threatened parrot species given that the extent of the proposed activity:

- Has been designed to minimise the total area of habitat to be impacted
- Would only remove a small proportion of the total area of habitat available to these species
- Would not isolate or significantly fragment areas of potential habitat given the highly mobile nature of these species

On the basis of the above considerations, it is unlikely that the activities will result in a significant impact on the survival of the Glossy Black-Cockatoo, Little Lorikeet, Swift Parrot or Turquoise Parrot.

Owls

The Barking Owl and Masked Owl are considered in this impact assessment. These species predominately inhabit woodland and/or dry eucalypt forest where there are suitable hollow-bearing trees for nesting. They both have large home ranges (up to 2,000 ha of Barking Owl and 1,000 ha for Masked Owl) and use a variety of habitats to forage, including closed forest and more open areas.

Neither species was recorded within the study area, however the proposed activity may potentially impact on the life cycles of the two owl species by reducing the amount of potential foraging and roosting habitat for both species and breeding habitat for Barking Owl available. The Pilliga Forest, particularly the western Pilliga, is a stronghold of the Barking Owl which supports the largest remaining population of the species in NSW (NPWS 2003; Kavanagh and Stanton 2009).

The proposed activity will results in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened owl species. This loss is considered relatively minor in the context of similar habitat within the study region, constituting up to 0.01% of available habitat for the threatened owl species.

The greatest concern resulting from the proposed activity is the potential removal of breeding habitat (HBTs) for the Barking Owl and whether breeding pairs are present or near vegetation to be removed. The direct impact to potential breeding habitat for the Barking Owl is 2.44 ha. Barking Owls nest in areas that are less disturbed than surrounding areas, and are highly susceptible to disturbance during the breeding season. If breeding sites are disturbed, this could lead to the abandonment of the breeding site by a nesting pair of birds. Barking Owls predominately use large Red Gum and Narrow-leafed Ironbark HBTs for nesting, but can use large dead ringbarked trees (Kavanagh and Stanton 2009). Masked Owls are unlikely to use the study area to breed as this species roosts and breeds in moist eucalypt forested gullies (DoE 2013b).

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A number of measures have been implemented to minimise the impact area. The activities have been designed and micro-sited to minimise the number of HBTs which would be removed. As such, it is unlikely that the activities would significantly impact Masked Owls. For this species, only foraging habitat would be lost. This removal of foraging habitat would not represent a significant loss to Masked Owls, as the species is highly mobile with the ability to hunt over areas of between 500 and 1000 ha, and the total impact areas are much less than the species' territory.

A recovery plan has been prepared for Large Forest Owls (DECC 2006) and the Barking Owl (NPWS 2003). The proposed activity is consistent with the objectives of these recovery plans. In addition, the proposed activities are not inconsistent with the objectives of the threat abatement plan relevant to the species.

The actions proposed will result in the operation of the key threatening processes "Clearing of native vegetation" and "Loss of hollow-bearing trees".

2.44 ha of remnant vegetation would be cleared as a result of the proposed activity including a maximum of 25 HBTs. No Barking Owls were identified during the current study, and no known breeding sites are likely to be affected by the proposed activity. The scale of these impacts in the context of the habitat and HBTs available within the study region is considered relatively minor. In consideration of the above, the proposed activity is unlikely to constitute a significant impact on the Barking Owl as it:

- Has been designed to minimise the total area of foraging and roosting habitat to be impacted including the number of HBTs to be removed
- Would only impact upon foraging and roosting habitat, which is widespread within the study area and the study region, and as such constitutes the removal of only a very minor proportion of this habitat
- Would not isolate areas of potential habitat from currently interconnecting areas of potential habitat for these highly mobile species

Birds of prey

The Spotted Harrier, Black-breasted Buzzard, Little Eagle and Square-tailed Kite are considered in this impact assessment. These species are found in a range of woodland, forest and open habitats, however, all have been associated with some form of riparian habitat, such as timbered watercourses or inland wetlands that can be used for breeding or foraging.

None of these species have been recorded within the study area. However, the activities could potentially impact on the life cycles of the bird of prey species by reducing the amount of potential foraging, breeding or roosting habitat available to these species. All of the birds of prey are highly mobile species that have extensive home ranges. Black-breasted Buzzard, Spotted Harrier, and Square-tailed Kite have been identified as species that are negatively impacted by land clearing.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (primarily foraging habitat) for the Spotted Harrier, Black-breasted Buzzard, Little Eagle and Square-tailed Kite. This loss is considered relatively minor in the context of similar habitats within the Study region constituting up to 0.01% of available habitat for the birds of prey.

No impacts to riparian habitats or timbered watercourses are expected as a result of the proposed activity. As the habitat most frequently used by birds of prey would be predominately avoided, the majority of these birds would also be less likely to be impacted by indirect disturbance from noise or traffic, and by habitat degradation through weed invasion. In addition, indirect impacts have and will

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been minimised through appropriate controls, best-practice construction techniques, rehabilitation of disturbed areas and weed control programs.

With consideration to the above, the proposed activity is considered unlikely to constitute a significant impact on the Black-breasted Buzzard, Little Eagle, Spotted Harrier and Square-tailed Kite as it:

- Would not impact on the most important habitat areas for these species (riparian habitats and timbered watercourses).
- Has been designed to minimise the total area of foraging and roosting habitat to be impacted.
- Would only remove a small proportion of the total area of habitat available to these species in the study region.
- Would not isolate areas of potential habitat from currently interconnecting areas of potential habitat for these highly mobile species.

Woodland birds – large ground foraging

The Bush Stone-curlew is considered in this impact assessment. The Bush Stone-curlew inhabits open forests and woodlands with a sparse grassy groundlayer and fallen timber.

The Bush Stone-curlew has not been recorded within the study area. However, the proposed activity could potentially impact on the life cycle of this threatened woodland bird by reducing the amount of foraging, roosting and breeding habitat available to the species. Bush Stone-curlews forage and potentially breed across the study region.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for the Bush Stone-curlew. This loss is considered relatively minor in the context of similar habitat within the study region, constituting up to 0.01% of available habitat for this threatened woodland bird.

Areas of habitat that would not be removed could be indirectly impacted by disturbance to the point that Bush Stone-curlews could avoid these areas of potential habitat. Indirect impacts could include noise, edge effects, increased traffic volumes, and incursion of weeds that effectively reduces the foraging resources of the species. The implementation of mitigation and management measures for the proposed activity is considered sufficient in reducing these indirect impacts. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, weed and feral animal control programs.

A recovery plan has been prepared for the Bush Stone-curlew (NPWS 2006) which has the overall objective of managing at least five populations of the species across NSW to ensure they are secure and consistently increasing in both extent of occurrence and area of occupancy. The proposed activity is being conducted in a manner than is not inconsistent with the objectives of the recovery plan. In addition, the activities are not inconsistent with the objectives of the threat abatement plans relevant to the species.

It is considered unlikely that the proposed activity will constitute a significant impact on the Bush Stone Curlew as:

- The woodland areas which would be impacted by the activities are widespread within the study region. Therefore, the impact area is not considered to be of high importance for the species. In addition, no critical habitat has been declared by the Director General for the Bush Stone Curlew.

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- The proposed activity has been designed to minimise the total area of foraging and roosting habitat to be impacted.
- The implementation of mitigation measures is considered sufficient to manage the threat of indirect impacts.

Woodland birds – ground and mid-storey foraging (passerines)

The Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin are considered in this impact assessment. These species inhabit a range of woodland habitats associated with the proposed activity. The habitats also range in structural density and complexity.

Only the Grey-crowned Babbler, Speckled Warbler, Varied Sittella and Hooded Robin have been recorded within the study area.

The proposed activity could potentially impact on the life cycles of these woodland birds by reducing the amount of foraging, sheltering and breeding habitat available to the species. Scarlet Robins do not breed in the area. Diamond Firetails, Gilbert's Whistlers, Grey-crowned Babblers, Hooded Robins, Speckled Warblers, and Varied Sittellas forage and potentially breed across the areas impacted by the proposed activity. These species have also been identified as species that are negatively impacted by land clearing, with Diamond Firetails, Gilbert's Whistler, and Speckled Warblers also negatively impacted by inappropriate fire regimes (and therefore habitat loss) (Biosis 2002).

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened ground and mid-storey foraging woodland birds. This loss is considered relatively minor in the context of similar habitat within the study region, constituting up to 0.01% of available habitat for these threatened birds.

The proposed activity would not involve impacts upon the riparian corridors in the study region, thus retaining riparian woodland habitats, which are considered to represent the habitat most frequently used by these species for foraging and/or breeding and roosting. The woodland areas away from the riparian corridors, which would be impacted by the activities, are widespread within the study region. As such the small area to be impacted by the proposed activity is not considered to be of high importance for ground and mid-storey foraging woodland birds.

In addition, no critical habitat has been declared by the Director General for Diamond Firetails, Gilbert's Whistlers, Grey-crowned Babblers, Hooded Robins, Scarlet Robins, Speckled Warblers, or Varied Sittellas.

Many of the ground and mid-storey foraging woodland birds require remnants of minimum sizes. Diamond Firetails appear unable to persist in areas which lack remnants larger than 200 ha. Hooded Robins appear unable to survive in remnants smaller than 100-200 ha. Scarlet Robins are less common in isolated patches of 30 ha or less where there is no tree cover within 200 m and less than 20% cover within 1 km. Speckled Warblers require remnants larger than 100 ha in size (NSW Scientific Committee 2001a). Isolation of populations in small remnants increases vulnerability to local extinction as a result of stochastic events and can decrease their genetic viability in the long term.

Nevertheless, the design of the proposed activity is considered unlikely to isolate large areas of potential habitat from one another. While some species, such as Grey-crowned Babblers which have laborious flight, may be unable to fly across well pads, vegetation surrounding these sites would be

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retained and allow for these species to move between the study areas. Vegetation above any linear infrastructure would be rehabilitated, reducing the width of the disturbed habitat type and thus, reducing the level of fragmentation.

Areas of habitat that would not be removed could be indirectly impacted by disturbance to the point that ground and mid-storey foraging woodland birds could avoid these areas of potential habitat. Habitats fragmented by new access roads, or well pads, would experience increased edge effects, including increased traffic volumes, which ground and mid-storey foraging woodland birds could avoid. Weeds could invade remaining areas of habitat reducing the foraging resources of Diamond Firetail, Gilbert's Whistler, and Speckled Warbler, which amongst other food resources, feed on native grasses, vegetative material and seeds. However, the implementation of mitigation and management measures for the proposed activity is considered sufficient in reducing these indirect impacts. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, weed and feral animal control programs. Furthermore, the proposed activity is not inconsistent with the objectives of any threat abatement plan relevant to ground and mid-storey foraging woodland species.

In conclusion, the proposed activity is unlikely to constitute a significant impact on, Grey-crowned Babbler, Diamond Firetail, Gilbert's Whistler, Scarlet Robin, Speckled Warbler, Varied Sittella and Hooded Robin as the proposed activity:

- Would not involve impacts upon the riparian corridors in the study region.
- Has been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted.
- Would only remove a minor proportion of the total area of habitat available to these species. In addition, the activities will retain significant proportions of grassy woodland habitats in the study region.
- Is unlikely to isolate or reduce areas of potential habitat from interconnecting areas of similar habitat to the point that thresholds for remnants of minimum sizes for these species are met.

Woodland birds – canopy foraging (excluding parrots)

The Black-chinned Honeyeater, Regent Honeyeater and Painted Honeyeater are considered in this impact assessment. The Black-chinned Honeyeater occupies mostly upper levels of drier open forests or woodlands dominated by box and ironbark eucalypts, especially Mugga Ironbark, White Box, Inland Grey Box, Yellow Box and Forest Red Gum. The Painted Honeyeater inhabits Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests. The Regent Honeyeater inhabits dry open forest and woodland, particularly Box-Ironbark woodland, and riparian forests of *Casuarina cunninghamiana* (River Oak).

None of these species have been recorded within the study area. However, the proposed activity could potentially impact on the life cycles of Black-chinned, Painted, and Regent Honeyeaters by reducing the amount of foraging, roosting and breeding habitat available to the species. Regent Honeyeaters are not considered likely to breed in the study region. Black-chinned and Painted Honeyeaters forage, roost and breed across the study region. All three of the species have been identified as species that are negatively impacted by land clearing (and therefore habitat loss) (Biosis 2002).

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for the threatened canopy feeding woodland birds. This loss is considered relatively minor in the context of similar habitat within the study region, constituting up to 0.01% of available habitat for these threatened woodland birds.

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The proposed activity would avoid riparian vegetation communities, thus retaining grassy woodland habitats used by Black-chinned, Painted, and Regent Honeyeaters. The woodland areas which would be impacted by the proposed activity are widespread within the study region and the locality. As such the small area to be impacted by the proposed activity is not considered to be of high importance for the canopy foraging woodland birds. In addition, no critical habitat has been declared for the Black-chinned, Painted, or Regent Honeyeaters.

The proposed activity could also impact on the life cycles of Black-chinned Honeyeaters through decreases in the sizes of intact habitat. Similar to some ground and mid-storey foraging woodland birds, Black-chinned Honeyeater does not persist in remnants less than 200 ha in area (NSW Scientific Committee 2001b). However, while locally nomadic, they tend to forage in home ranges of around 5 ha (OEH 2013b).

The proposed activity would also retain the majority of vegetation representing foraging, roosting and/or breeding habitat for these species. Thus, the remaining habitat remnants would not be completely fragmented from other remnants. Adjacent patches would together form larger patches of vegetation that Black-chinned, Painted, and Regent Honeyeaters would be able to use, provided these species did not avoid areas degraded by noise and light disturbance.

Areas of habitat that would not be removed could be indirectly impacted by disturbance to the point that Black-chinned, Painted and Regent Honeyeaters could avoid these areas of potential habitat. However, the implementation of mitigation and management measures for the proposed activity is considered sufficient in reducing these indirect impacts. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, weed and feral animal control programs.

Furthermore, the proposed activity is not inconsistent with the objectives of any threat abatement plan relevant to these species, nor the recovery plan prepared for the Regent Honeyeater (DNRE 1999), which has the overall objective of ensuring the species persists in the wild and is down-listed from endangered to vulnerable.

The proposed activity is unlikely to constitute a significant impact on the Black-chinned, Painted, or Regent Honeyeaters as the proposed activity:

- Has been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted.
- Would only remove a minor proportion of the total area of habitat available to these species within the study region.
- Would not isolate areas of potential habitat from currently interconnecting areas of habitat or reduce intact habitat to the point that Black-chinned, Painted, and Regent Honeyeaters can no longer persist.

MAMMALS

Arboreal mammals and megabats:

The Grey-headed Flying Fox and Squirrel Glider are considered in this impact assessment. The Squirrel Glider inhabits mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest with a shrubby or *Acacia* midstorey. Grey-headed Flying-foxes forage over a range of habitats, and Squirrel Gliders occur in a number of open Eucalypt woodland communities supporting preferred feed trees and habitat elements such as tree hollows and a shrub mid-storey layer in the case of Squirrel Gliders (OEH 2013b).

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These species have not been recorded within the study area, however Squirrel Glider was recently potentially recorded through hair sampling by ELA within 10 km of the study area (habitat different to that found in the study area). The proposed activity could impact on the life cycles of Grey-headed Flying-foxes and Squirrel Gliders by reducing the amount of foraging, roosting and breeding habitat available to the species, or degrading their habitat. Grey-headed Flying-foxes do not roost or breed in the study area, but may use it to forage, while Squirrel Gliders forage and potentially breed across the study areas. The potential habitats of these species would be reduced directly through the clearing of vegetation, including, HBTs that could be used by Squirrel Gliders to breed and shelter. No critical habitat has been declared for these species.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for these threatened arboreal mammal and megabat species. This loss is considered relatively minor in the context of similar habitats within the study region constituting up to 0.01% of available habitat for these species.

While the proposed activity would result in the removal of some habitat, the activities have sought to avoid riparian vegetation communities (e.g. Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box) with high densities of HBTs, thus retaining the majority of hollows in this area for Squirrel Gliders, and foraging habitat for Grey-headed Flying-foxes. Other habitat elements such as logs would be stockpiled and redistributed during rehabilitation works, or would be relocated to surrounding areas.

Areas of habitat that would not be removed could be indirectly reduced/affected by fragmentation and disturbance (i.e. habitat could be degraded) impacting on Grey-headed Flying-foxes and Squirrel Gliders.

Many of the disturbances that could potentially result from the proposed activity are listed as key threats to Grey-headed Flying Foxes and Squirrel Gliders, such as the loss and modification of habitat. Furthermore, disturbance to roosting sites, unregulated shooting, and electrocution on powerlines are listed as key threats to Grey-headed Flying Fox. Fragmentation of habitat, loss of hollow-bearing trees and flowering understorey and mid-storey shrubs are key threats to Squirrel Glider (OEH 2013b).

The implementation of mitigation and management measures for the proposed activity is considered sufficient in reducing these indirect impacts and disturbances outlined above. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation, fauna friendly fencing (in accordance with Santos' Fencing Standard). and weed and feral animal control initiatives. Furthermore, the proposed activity is not inconsistent with the objectives of any recovery plans and threat abatement plans relevant to these species.

In consideration of the above, the proposed activity is not likely to have a significant impact on Grey-headed Flying-foxes and Squirrel Gliders in the study area.

Ground and log dependent mammals:

The mid-storey and log dependent mammals considered in this impact assessment are the Black-striped Wallaby, Pilliga Mouse and Spotted-tailed Quoll.

It is important to note that the Pilliga Mouse is now considered a southern population of the widespread *Pseudomys delicatulus* (Delicate Mouse) based on genetic analyses, morphological studies and recent surveys which revealed a continuous distribution of the Delicate Mouse to the Pilliga region (Breed and Ford 2007; Ford 2008, as cited in SEWPaC 2011). It is important to note

that this taxonomic change has not yet been formally recognised; hence this assessment considers the Pilliga Mouse as currently listed.

The Black-striped Wallaby prefers habitat characterised by dense woody or shrubby vegetation within three metres of the ground. This dense vegetation must occur near a more open, grassy area to provide suitable feeding habitat. The Pilliga Mouse is restricted to an isolated area of low-nutrient deep sand which has long been recognised as supporting a distinctive vegetation community (Pilliga Scrub), but may forage outside this vegetation type. The Spotted-tailed Quoll is found in a variety of habitats, including sclerophyll forest and woodlands, coastal heathlands and rainforests. No critical habitat has been declared for these species.

Of these species, the Black-striped Wallaby and Pilliga Mouse have been recorded within the study region.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (primarily foraging and sheltering) for Black-striped Wallaby, Pilliga Mouse and Spotted-tailed Quoll. No breeding habitat for the Pilliga Mouse will be impacted as a result of the proposed activity. This loss is considered relatively minor in the context of similar habitats within the study region, constituting up to 0.01% of available habitat for these species.

Areas of habitat that would not be removed could be indirectly reduced/affected by fragmentation and disturbance (i.e. habitat could be degraded) impacting on these species and/or creating barrier effects at the local level for Pilliga Mice. Black-striped Wallabies are mobile with home ranges of 90 ha and Spotted-tailed Quolls are highly mobile with ranges between 2,000 and 5,000 ha.

Following construction, linear infrastructure will be partially rehabilitated, reducing the width of the disturbed habitat and thus any level of fragmentation. Furthermore, habitat connectivity would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study region, limiting any fragmentation impact on the Pilliga Mouse.

Many of the disturbances that could potentially result from the proposed activity are listed as key threats to the ground and log dependent mammals. Clearing and fragmentation of habitat and degradation of habitat (through grazing, weeds, collection of firewood, or inappropriate levels of Broombush harvesting) are listed as key threats to these species. Inappropriate fire regimes affecting habitat elements and predation by introduced animals including cats, foxes, and dogs are key threats to Black-striped Wallabies and Pilliga Mice. Deliberate or accidental killing by poisoning or shooting/trapping are threats to Black-striped Wallabies and Spotted-tailed Quolls. Further, risk of local extinction because populations are small and isolated is a key threat to Black-striped Wallaby. Competition from House Mice is a key threat to Pilliga Mice. Competition with introduced predators such as cats and foxes is a key threat to Spotted-tailed Quoll (OEH 2013b).

The implementation of mitigation and management measures for the proposed activity is considered sufficient in reducing these indirect impacts and disturbances outlined above. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation, and weed and feral animal control initiatives. Furthermore, the proposed activity is not inconsistent with the objectives of the threat abatement plans relevant to these mid-storey and log dependent mammals.

In respect to the above, it is considered that the explorative activities will not have a significant impact on the Black-striped Wallaby, Pilliga Mouse and Spotted-tailed Quoll in the study area.

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Grassy woodland mammals:

The grassy woodland mammal considered in this impact assessment is the Rufous Bettong. This species inhabits a variety of forests from tall, moist eucalypt forest to open woodland, with a sparse or tussock grass understorey. No critical habitat has been declared for this species.

This species has not been recorded in the study area, however the activities could impact on the life cycle of Rufous Bettongs by reducing the amount of foraging, sheltering and breeding habitat (clearing of vegetation) available to the species, or degrading its habitat. The species is highly mobile, requiring large areas of habitat with foraging movements recorded as 2 to 4.5 km a night.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat (foraging, breeding or roosting/sheltering) for the Rufous Bettong. This loss is considered relatively minor in the context of similar habitats within the study region, constituting up to 0.01 % of available habitat for this species.

The woodland areas which would be impacted by the proposed activity are widespread within the study region. As such the small area to be impacted by the proposed activity is not considered to be of high importance for the Rufous Bettong. In addition, habitat elements within impacted areas such as logs would be stockpiled and redistributed during partial rehabilitation works, or would be relocated to surrounding areas.

Habitat connectivity for the Rufous Bettong would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area. This greatly mitigates against a number of disturbances (such as fragmentation and degradation of foraging habitat due to weeds or introduced predators) that would otherwise impact species that are restricted in range and not highly mobile. In addition, the implementation of mitigation and management measures for the proposed activity is considered sufficient in reducing these disturbances. Such measures include appropriate traffic controls, best-practice construction techniques, rehabilitation of disturbed areas, minimisation of fragmentation, and weed and feral animal control initiatives.

In consideration of the above, it is unlikely that the explorative activities will have a significant impact on the Rufous Bettong in the study area.

Predominantly tree-roosting bats:

The predominantly tree-roosting bats considered in this impact assessment are the Yellow-bellied Sheathtail-bat and South-eastern Long-eared Bat. Only the Yellow-bellied Sheathtail-bat has been recorded within the vicinity of the study area.

The Yellow-bellied Sheathtail-bat roosts singly or in groups of up to six, in tree hollows and buildings. The South-eastern Long-eared Bat inhabits a variety of vegetation types, including mallee, Bulloak and box eucalypt dominated communities. The South-eastern Long-eared Bat roosts in tree hollows, crevices, and under loose bark. No critical habitat has been determined for either species.

Both species of bat are likely to forage, roost and breed in the area, with the Yellow-bellied Sheathtail-bats migrating to the southern parts of Australia during late summer or autumn months. The Pilliga area is considered a strong-hold for the South-eastern Long-eared Bats (Churchill 1998). The proposed activity largely avoids vegetation communities with high densities of hollows (primarily the Pilliga Box – Poplar Box – White Cypress, Rough-barked Apple and Fuzzy Box vegetation types), retaining areas with higher densities of potential roosting and breeding sites for both species.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential habitat

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(foraging, breeding or roosting/sheltering) for the two bat species. This loss is considered relatively minor in the context of similar habitats within the study region, constituting up to 0.01% of available habitat for these species.

Indirect impacts on these bat species, including disturbance from noise and or light could add to the impacts associated with habitat loss and or modification. It is possible that South-eastern Long-eared Bats would avoid areas of noise disturbance while foraging. Yellow-bellied Sheathtail-bats are considered less likely to be affected by noise as the species forages aerially, above the canopy. However, bats of many species have been found roosting in areas disturbed by noise (Schaub et al. 2008); thus, it is unlikely that these bat species would be disturbed by noise while roosting. In addition, indirect impacts have largely been minimised through appropriate management controls and best-practice construction techniques. Following construction, linear infrastructure will be partially rehabilitated, reducing the width of the disturbed habitat and thus any level of fragmentation. Weed spread would be controlled to limit the potential for habitat degradation and therefore limit impacts on habitat containing bat prey. More importantly, noise would largely be kept to a minimum and constant, rather than intermittent.

The proposed activity is unlikely to constitute a significant impact on the Yellow-bellied Sheathtail-bat or the South-eastern Long-eared Bat as:

- It avoids impacts on the most important habitat areas for these species (large alluvial woodland areas and riparian habitats containing roosting sites).
- It has been designed to minimise the total area of foraging, roosting and breeding habitat to be impacted including the number of hollow bearing trees to be removed.
- It would only remove a small proportion of the total area of habitat available to these species.
- Indirect disturbances have / will be adequately managed to mitigate potential impacts relating to noise, light, and habitat degradation.

Predominantly cave-roosting bats:

The Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat and Little Pied Bat are considered in this impact assessment. Only the Little Pied Bat, Eastern Bentwing-bat and Eastern Cave Bat have been recorded within the study region.

The Eastern Bentwing-bat occupies a range of forested environments (including wet and dry sclerophyll forests). The Eastern Cave Bat is usually found in dry open forest and woodland, near cliffs or rocky overhangs. The Large-eared Pied Bat is found in well-timbered areas containing gullies in dry open forest and woodland close to caves or other roost sites. The Little-Pied Bat occurs in dry open forest, open woodland, mulga woodlands, chenopod shrublands, cypress-pine forest, mallee, Bimbil box. No critical habitat has been declared for these species.

The proposed activity could potentially impact on the life cycles of the bat species by reducing the amount of foraging and roosting and breeding habitat available for the Little Pied Bat and the amount of foraging habitat for the Eastern Bentwing-bats, Eastern Cave Bats and Large-eared Pied Bats. However, these species are predominantly cave-roosting and breeding (Churchill 1998) and since the proposed activity does not impact on caves, it is predominantly foraging habitat that would be reduced by the activities. An exception exists for the Little Pied Bat that can also use tree hollows for roosting.

The proposed activity will result in the removal and/or modification of up to 2.44 ha of potential foraging habitat for these four bats. This loss is considered relatively minor in the context of similar habitats within the study region, constituting up to 0.01% of available habitat for these species. The

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small area to be impacted by the proposed activity compared to the available habitat is not considered to be of high importance for the bat species.

Retention of vegetation outside the impact areas would continue to support these bat species in the study region. Furthermore, the proposed activity has been designed to be located in areas with lower densities of HBTs and away from prime foraging habitat such as near water sources.

The proposed activity could impact the predominantly cave-roosting species through decreases in the sizes of intact habitat. Little Pied Bats, when roosting in trees, have been found to maintain roosts within 200 m of each other. Eastern Cave Bats have been recorded using only 33 ha over 5 consecutive days (Churchill 1998). Eastern Bentwing Bat, Eastern Cave Bat and Little Pied Bat could also be impacted through the potential increases in the numbers of introduced predators as a result of the proposed activity. These species are threatened by predation by cats and foxes.

Further, indirect impacts on these bat species, including disturbance from noise and or light could add to the impacts associated with foraging habitat loss and / or modification. However, overseas studies on bats that listen for their prey in addition to using echolocation have found that these bats avoid areas with noise disturbance while foraging (Schaub et al. 2008). It is possible that Large-eared Pied Bats forage in a similar manner to the bat species investigated as they forage under the canopy and close to the ground. As such, it is possible that Large-eared Pied Bats would avoid areas of noise disturbance while foraging. Eastern Bentwing-bats, Eastern Cave Bats and Little Pied Bats are considered less likely to be affected by noise as these species forage aerially, above or within the canopy, or catch their prey from water.

Following construction, linear infrastructure will be partially rehabilitated, reducing the level of habitat fragmentation and maintaining a suitable size of intact foraging habitat for the bat species. Weed spread would be controlled to limit the potential for habitat degradation and therefore limit impacts on habitat containing bat prey. More importantly, noise would largely be kept to a minimum and constant, rather than intermittent.

The proposed activity is unlikely to constitute a significant impact on the Eastern Bentwing-bat, Eastern Cave Bat, Large-eared Pied Bat, or the Little Pied Bat as the proposed activity:

- Largely does not impact breeding / roosting habitat as no caves fall within the study area.
- Has been designed to minimise the total area of foraging habitat to be impacted.
- Would only remove a small proportion of the total area of habitat available to these species in the study region.
- Has been designed and managed in a way to limit the impact of indirect impacts.
- Would not isolate areas of potential foraging habitat from currently interconnecting areas of potential habitat for these species.

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Appendix G: Assessment of Significance under the EPBC Act

This section provides an assessment of the potential significance of impacts from the proposed activity on Matters of National Environmental Significance (MNES). The EPBC Act Administrative Guidelines on Significance set out 'Significant Impact Criteria' that are to be used to assist in determining whether a proposed action is likely to have a significant impact on matters of national environmental significance.

MNES considered relevant to this assessment include:

- Flora

Pterostylis cobarensis and *Tylophora linearis*

- Mammals

Spotted-tailed Quoll, South-eastern Long-eared Bat, Large-eared Pied Bat, Grey-headed Flying-fox, and Pilliga Mouse

- Birds

Regent Honeyeater and Swift Parrot

- Migratory species

Regent Honeyeater, White-bellied Sea Eagle, White-throated Needletail, Rainbow Bee-eater, Fork-tailed Swift

FLORA

***Pterostylis cobarensis* (Cobar Greenhood Orchid) - Vulnerable**

Pterostylis cobarensis is a terrestrial orchid. The species is known chiefly from the Nyngan-Cobar-Bourke district in the far western plains of NSW. Its presence has been recorded in districts including Narrabri, Nyngan, Cobar, Nymagee, Mt Gundabooka, Mt Grenfel and Mutawintji National Park.

Within the study area, *P. cobarensis* has been recorded within Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest. Detailed targeted surveys within the study area and study region area have identified populations of *Pterostylis cobarensis*. Three individuals were recorded at the Dewhurst 30 subject site.

The species flowers from September to November (generally October). Vegetative reproduction is not common in this group of Greenhoods, but some species may form more than one dropper annually. Plants are deciduous and die back to the large, underground tubers after seed release. New rosettes are produced following soaking autumn and winter rains. Pollination of the species is by the males of small gnats which are attracted to the flower by some pseudosexual perfume. *Pterostylis cobarensis* occurs as frequent to abundant plants in usually very localised populations (OEH 2013b).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

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Detailed targeted surveys for *Pterostylis cobarensis* have been undertaken both within the study area and across the broader Pilliga to model the population in this area (ELA 2012). From these studies it has been estimated that the total population of *Pterostylis cobarensis* within the Pilliga and Pilliga Outwash CMA subregions is 349, 724 (ELA 2012). The removal of three individuals at the Dewhurst 30 subject site constitutes a <0.01% loss of individuals from the modelled population.

The proposed activity will impact on approximately 2.44 ha of vegetation that may include some areas that support potential habitat for this species. The total amount of potential habitat likely to be impacted by the proposed activity constitutes less than 0.01% of the total habitat within the study region. Given the relatively small scale of impacts to this species, it is unlikely that the proposed activity would lead to a long-term decrease in the population of *P. cobarensis* in the study area.

Reduce the area of occupancy of an important population

The proposed activity is likely to reduce the potential habitat for *P. cobarensis* through the clearing of approximately 2.44 ha of vegetation which represents potential habitat for this species.

The majority of vegetation representing potential habitat for *P. cobarensis* will be retained as part of the proposed activity. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for *P. cobarensis* in the study area and an even smaller portion (0.01%) of potential habitat within the study region; hence the proposed activity is unlikely to reduce the area of occupancy of this species.

Fragment an existing important population into two or more populations

P. cobarensis has the potential to be impacted on by habitat fragmentation where pollination (by small gnats) or seed dispersal (largely wind and seed fall) is interrupted. Fragmentation associated with the proposed activity is considered unlikely to alter pollination or seed dispersal pathways associated with the lifecycle of *P. cobarensis* and are therefore considered unlikely to fragment an existing important population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of *P. cobarensis* could include areas that are necessary for dispersal, for the long-term maintenance of the species or to maintain genetic diversity.

Potential habitat for *P. cobarensis* is extensive both within the study area and broader study region. The loss of less than 0.01% of the total habitat within the study region is considered unlikely to be critical to the survival of this species.

Disrupt the breeding cycle of an important population

The breeding cycle of *P. cobarensis* could potentially be disrupted through the loss of habitat or the displacement of pollinators through fragmentation. The loss of less than 0.01% of potential habitat across the study region and minor fragmentation affects associated with the proposed activity are considered unlikely to disrupt the breeding cycle of this species.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential habitat for this species which equates to 0.01% of the total potential habitat of this species within the study region.

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The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study area.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive weed species such as *Eragrostis curvula* (African Lovegrass) and *Hyparrhenia hirta* (Coolatai Grass) have the potential to invade into suitable habitat for *P. cobarensis* from disturbance associated with the proposed activity. Weed and fungal invasion has the potential to degrade the habitat of this species and weed species may directly compete with the species.

Santos implements pest plant procedures to ensure the rapid and progressive rehabilitation of the study area on completion of construction works for temporary impacts (e.g. flow lines) and over the life of the proposed activity for longer term impacts (e.g. wells).

Introduce disease that may cause the species to decline, or

Phytophthora cinnamomi (Cinnamon Fungus) is a microscopic soil-borne plant pathogen that can invade and destroy the root systems of susceptible native and introduced plant species. As rainfall is one of the key factors influencing the distribution of *P. cinnamomi*, the pathogen is generally restricted to coastal NSW. As such, the risk of infection of *P. cinnamomi* in the study area is considered lower than that in coastal sites.

Machinery utilised for construction and operation of the proposed activity may carry the spores of *P. cinnamomi* if they have been working in coastal areas which are known to be infected by the pathogen. However, all construction machinery and vehicles would be inspected and thoroughly cleaned prior to entry to site in accordance with the mitigation measures outlined in **Section 6.1**

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The loss of potential habitat is less than 0.01% within the study region.
- The regional extent of suitable habitat is sufficient that the proposed activity will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.
- The proposed activity will not disrupt the breeding cycle of the species as vegetation patches would not be separated by distances that would interfere with the pollination of the species (by males of small gnats).
- Weed management procedures will be implemented within the study area.

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***Tylophora linearis* - Endangered**

Tylophora linearis is a slender, almost hairless twiner. The species is known only from NSW and Queensland. In NSW, it is found in the Barraba, Mendooran, Temora and West Wyalong districts in the northern and central western slopes. Records include Crow Mountain near Barraba, Goonoo, Pilliga West, Cumbil, and Eura State Forests, Coolbaggie Nature Reserve, Goobang National Park, and Beni Conservation Area. The species grows in dry scrub and open forest. It has been recorded from low-altitude sedimentary flats in dry woodlands of *Eucalyptus fibrosa*, *E. sideroxylon*, *E. albens*, *Callitris endlicheri*, *C. glaucophylla* and *Allocasuarina luehmannii*. It also grows in association with *Acacia hakeoides*, *A. lineata*, *Melaleuca uncinata*, *Myoporum* species and *Casuarina* species. The species flowers in spring, with flowers recorded in November or May with fruiting probably 2 to 3 months later. Where the species occurs, it has been recorded in very low abundances (OEH 2013b).

Within the study area, *T. linearis* has been recorded within Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest.

Detailed targeted surveys within the study area and broader study region have identified large populations of *T.linearis.*

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

Detailed targeted surveys for *T. linearis* have been undertaken both within the study area and across the broader Pilliga region to model the population in this area (ELA 2012). Modelled data predicts the existence of 183, 908 *Tylophora linearis* individuals in the Pilliga and Pilliga Outwash CMA subregions (ELA 2012). The removal of three individuals from the subject site would result in the loss of less than 0.01% of the population in these CMA subregions.

The proposed activity will impact on approximately 2.44 ha of vegetation that may include some areas that support potential habitat for this species. The total amount of potential habitat likely to be impacted by the proposed activity constitutes less than 0.01% of the total habitat within the study region. Given the relatively small scale of impacts to this species, it is unlikely that the proposed activity would lead to a long-term decrease in the population of *T. linearis* in the study region.

Reduce the area of occupancy of the species

The proposed activity is likely to reduce the potential habitat for *T. linearis* through the clearing of approximately 2.44 ha of vegetation which represents potential habitat for this species.

The majority of vegetation representing potential habitat for *T. linearis* will be retained as part of the proposed activity. The amount of habitat that would be directly impacted comprises only a small portion (0.01%) of potential habitat for *T. linearis* in the study region; hence the proposed activity is unlikely to reduce the area of occupancy of this species.

Fragment an existing population into two or more populations

T. linearis has the potential to be impacted on by habitat fragmentation where pollination (assumed to be insect pollinated, Forster et al. 2004) or seed dispersal (seed fall and wind) is interrupted. Fragmentation associated with the proposed activity is considered unlikely to alter pollination or seed dispersal pathways associated with the lifecycle of *T. linearis* and are therefore considered unlikely to fragment an existing population into two or more populations

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Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of *T. linearis* could include areas that are necessary for dispersal, for the long-term maintenance of the species or to maintain genetic diversity.

Potential habitat for *T. linearis* is extensive both within the study area and broader Pilliga region. The loss of less than 0.01% of the total habitat within the study region is considered unlikely to be critical to the survival of this species.

Disrupt the breeding cycle of a population

The breeding cycle of *T. linearis* could potentially be disrupted through the loss of habitat or the displacement of pollinators through fragmentation. The loss of less than 0.01% of potential habitat across the study region and minor fragmentation affects associated with the proposed activity are considered unlikely to disrupt the breeding cycle of this species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential habitat for this species which equates to less than 0.01% of the total modelled population of this species within the study region

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study region.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

Invasive weed species such as *Eragrostis curvula* (African Lovegrass) and *Hyparrhenia hirta* (Coolatai Grass) have the potential to invade into suitable habitat for *T. linearis* from disturbance associated with the proposed activity. Weed and fungal invasion has the potential to degrade the habitat of this species and weed species may directly compete with the species.

Santos implements pest plant procedures to ensure the rapid and progressive rehabilitation of the study area on completion of construction works for temporary impacts (e.g. flow lines) and over the life of the proposed activity for longer term impacts (e.g. wells).

Introduce disease that may cause the species to decline, or

Phytophthora cinnamomi (Cinnamon Fungus) is a microscopic soil-borne plant pathogen that can invade and destroy the root systems of susceptible native and introduced plant species. As rainfall is one of the key factors influencing the distribution of *P. cinnamomi*, the pathogen is generally restricted to coastal NSW. As such, the risk of infection of *P. cinnamomi* in the study area is considered lower than that in coastal sites.

Machinery utilised for construction and operation of the proposed activity may carry the spores of *P. cinnamomi* if they have been working in coastal areas which are known to be infected by the

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pathogen. However, all construction machinery and vehicles would be inspected and thoroughly cleaned prior to entry to site in accordance with the mitigation measures outlined in **Section 6.1**.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The small extent of impacts from the proposed activity relative to available habitat in the landscape.
- The regional extent of suitable habitat types is sufficient that the proposed activity will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.
- The proposed activity will not disrupt the breeding cycle of the species as vegetation patches would not be separated by distances that would interfere with the pollination of the species.
- Weed management procedures will be implemented within the study area.

MAMMALS

***Dasyurus maculatus* (Spotted-tailed Quoll) - Endangered**

The Spotted-tailed or Tiger Quoll occupies a range of environments within a disjunct distribution along the east coast of Australia, extending from south-eastern Queensland through NSW and Victoria to Tasmania. The species is found in a variety of habitats, including sclerophyll forest and woodlands, coastal heathlands and rainforests. Occasional sightings are made in open country, grazing lands, rocky outcrops and other treeless areas (DoE 2013b). This species feeds on a wide variety of birds, reptiles, mammals and invertebrates and uses several 'latrines' within its territory for defecation (OEH 2013b). It is essentially terrestrial, but is also an agile climber (OEH 2013b). Nesting occurs in rock shelters, hollow logs, caves or tree hollows and they use numerous dens within the home range. Estimates of home ranges vary from 800 ha to 20 km^2 and individuals may move several kilometres in a night (NPWS 1999).

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

The proposed activity could lead to a long-term decrease in the size of a population of Spotted-tailed Quolls if it significantly reduced or degraded foraging, sheltering and breeding habitat available to the species, contributed to the direct mortality of the species, or led to an increase in introduced predators such as cats and foxes which would compete with the species for foraging resources.

The species was not observed during field surveys and there are no existing records for the species within the study area. Previous records of Spotted-tailed Quoll in the Pilliga are sparse, with a record in the Pilliga Nature Reserve from 2006 and three records adjacent to the Pilliga forests (OEH 2013a). One record is from the Warrumbungles from 2008 and two records are south-east of the Pilliga forests from 1994 and 2004.While the species occurs more frequently in coastal areas, there are scattered

records for Spotted-tailed Quolls west of the study area along the Barwon River. Therefore it is considered that the species has the potential to occur in the study area.

The proposed activity will lead to the loss of approximately 2.44 ha of potential habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

As such, it is considered unlikely that the proposed activity would lead to a long-term decrease in the size of a population of Spotted-tailed Quolls.

Reduce the area of occupancy of the species

The area of occupancy for Spotted-tailed Quolls would be reduced if significant amounts of foraging, sheltering and breeding habitat were lost in the study region, or if habitats were degraded to the point that the species avoided degraded areas and could not move through the study region to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study region, hence the proposed activity is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing population into two or more populations

Spotted-tailed Quolls are capable of large movements, and numerous records have been made for overnight movements of several kilometres for the species (NPWS 1999; Belcher et al. 2008). The proposed activity is unlikely to create barriers to movement of this species. Habitat connectivity will be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study region, allowing any potential populations to move across the wider landscape. Thus, it is unlikely that the proposed activity would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is critical to the survival of the species includes foraging, sheltering and breeding habitat. While all habitat types would be important to the species, Spotted-tailed Quolls would likely be able to withstand some level of impact to its habitat. The levels tolerated would depend on the amount and quality of foraging, sheltering and breeding habitat impacted, the time they were impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the area/Namoi CMA region.

The potential habitat proposed to be removed by the action constitutes less than 0.01% of the available habitat within the study region and is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of a population

The proposed activity could impact on or disrupt the breeding cycle of Spotted-tailed Quolls if it impacted on breeding habitat directly, disturbed the species during the breeding season, or reduced/degraded foraging resources used during the breeding season.

There is potential for the study area to be used for breeding by this species. The study area contains habitat elements necessary for breeding, including hollows and fallen logs; however this species has not been detected during field surveys.

As the species has not been detected within the study area and due to the relatively small scale of the impacts of the proposed activity, it is considered unlikely that the proposed activity will disrupt the breeding cycle of a population.

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Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study region.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

Invasive species that are harmful to the Spotted-tailed Quolls such as cats and foxes are already established in the study region. The proposed activity is unlikely to exacerbate the impacts of invasive species or lead to increased competition for Spotted-tailed Quolls for resources.

Introduce disease that may cause the species to decline, or

Spotted-tailed Quolls are susceptible to the spread of epidemics, such as a parasitic protozoan, by cats (NPWS 1999). However, cat populations are already well established in the study region.

Interfere with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The species has some potential to occur within the study area, however, it is most common in coastal areas.
- The proposed activity will disturb a very small proportion (<0.01%) of available habitat within the study region.
- The species is very mobile, able to utilise a variety of habitats within the landscape and is known to travel several kilometres a night.
- The regional extent of suitable foraging habitat types is sufficient that the development will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

***Nyctophilus corbeni* (South-eastern Long-eared Bat) - Vulnerable**

Overall, the distribution of the South-eastern Long-eared Bat coincides approximately with the Murray Darling Basin (DoE 2013b). It is common in the Pilliga region (OEH 2013b). The species inhabits a variety of vegetation types, including mallee, *Allocasuarina luehmannii* (Bull-oak) and box-eucalypt dominated communities, but it is distinctly more common in box/ironbark/cypress-pine vegetation that occurs in a north-south belt along the western slopes and plains of NSW and southern Queensland (OEH 2013b). The species roosts in tree hollows, crevices, and under loose bark. It is a slow flying

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agile bat, using the understorey to hunt non-flying prey, especially caterpillars and beetles, and will even hunt on the ground. Movement patterns are not well known, although roost sites have been recorded as an average of 1.89 ± 1.61 km (range 0.34–7.06 km) from the capture point of bats (Schulz and Lumsden 2010). It appears the species requires large, intact areas of habitat to persist (Turbill *et al.* 2008).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

Nyctophilus species were recorded using anabat recorders during the current study, although identification between species on the basis of anabat recordings is not conclusive. A number of previous surveys have also detected the species near the study area, with a large number of individuals recorded (NPWS 2000, NPA 2002, Ecotone 2009). The Atlas of NSW Wildlife records show the species' presence throughout the study region, and NSW OEH considers the Pilliga region to be a distinct stronghold for this species.

As the South-eastern Long-eared Bat is known to occur in the study region and has its core distribution centred on the Pilliga region, it is likely that South-eastern Long-eared Bat populations within the study area would be defined as an important population under the EPBC Act.

The proposed activity will lead to the loss of approximately 2.44 ha of habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

As the proposed activity represents a small proportion of the available habitat in the study region, the proportion of hollow-bearing trees to be removed is also likely to be low. As such it is considered unlikely that the proposed activity would lead to a long-term decrease in the size of a population of South-eastern Long-eared Bat.

Reduce the area of occupancy of an important population

The area of occupancy for South-eastern Long-eared Bats would be reduced if significant amounts of foraging, roosting and breeding habitat were lost in the study region, or if habitats were degraded to the point that the species avoided or could not cross degraded areas and could not move through the study region to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study region hence the proposed activity is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing important population into two or more populations

South-eastern Long-eared Bats can travel 3 kilometres in a foraging excursion (Churchill 2008). As the species is highly mobile over the distances involved with the proposed impacts, the proposed activity will not create barriers in relation to the foraging activities of the species.

This species locates prey via echolocation and "passive listening". The effectiveness of these prey detection mechanisms may be impacted by noise associated with the construction and/or operation of the proposed activity. However, noise impacts will be highly localised and large areas of habitat will remain undisturbed. Should the South-eastern Long-eared Bat avoid areas of habitat degraded by noise, individuals of this species would be able to traverse these areas to undisturbed patches within the study region.

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Habitat connectivity will be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study region, allowing any potential populations to move across the wider landscape. Thus, it is unlikely that the proposed activity would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of South-eastern Long-eared Bats includes foraging, roosting and breeding habitat. While all habitat types would be important to the species, South-eastern Long-eared Bats would likely be able to withstand some level of impact to its habitat.

The proposed activity would retain the majority of foraging, roosting and breeding habitat in the study region for South-eastern Long-eared Bats, with only a small proportion (0.01%) of habitat impacted in the study region. Thus, the foraging, roosting and breeding habitat lost or degraded is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of an important population

The proposed activity could impact on or disrupt the breeding cycle of South-eastern Long-eared Bats if it impacted on breeding habitat directly, or reduced/degraded foraging resources used during the breeding season.

The proposed activity would impact on foraging and breeding habitat, and reduce/degrade foraging resources indirectly through habitat fragmentation. However, the area directly impacted represents a small proportion available in the study region with the majority of breeding and foraging habitat retained in the study region. South-eastern Long-eared Bats would be able to use undisturbed habitat to complete their life cycles.

As such, the proposed activity is unlikely to disrupt the breeding cycle of the South-eastern Long-eared Bat.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study region.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the South-eastern Long-eared Bat such as cats and foxes are already established in the study region. The proposed activity is unlikely to exacerbate the impacts of invasive species or lead to increased competition for South-eastern Long-eared Bats for resources.

Introduce disease that may cause the species to decline, or

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Disease is not listed as a threat to this species. The proposed activity would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The species is highly mobile and will be able to move across disturbed areas into nearby undisturbed locations.
- The regional extent of suitable habitat is sufficient that the proposed activity will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.
- The regional extent of suitable roosting and breeding habitat is sufficient that the proposed activity will not result in the substantial disruption of elements of this species' breeding cycle.

***Chalinolobus dwyeri* (Large-eared Pied Bat) - Vulnerable**

The Large-eared Pied Bat is an insectivorous bat distributed from Shoalwater Bay in Queensland through to Ulladulla in NSW. This species tends to occur in small populations of around 50 individuals, particularly around sandstone escarpments and cliff lines. Important populations for this species occur in the Hunter Valley, Sydney Basin and Southern Tablelands of NSW. There are scattered records from the New England Tablelands and North West Slopes.

The relatively short, broad wing combined with the low weight per unit area of wing suggests that the species is manoeuvrable and forages below the canopy (OEH 2013b; DoE 2013b). The preferred breeding habitat for the species are caves (near their entrances), crevices in cliffs, old mine workings and in the disused, bottle-shaped mud nests of the *Hirundo ariel* (Fairy Martin). The species has been known to use hollow-bearing trees as roost sites (DoE 2013b). Females have been recorded raising young in maternity roosts (c. 20-40 females) from November through to January in roof domes in sandstone caves. They remain loyal to the same cave over many years (OEH 2013b). Breeding females have recently been recorded in sandstone caves at Coonabarabran, NSW (DoE 2013b).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

The species was not observed during field surveys and there are no existing records for the species within the study area. However, previous surveys have detected the species near the study area in Pilliga East State Forest (NPWS 2000; NPA 2002). The closest records according to the Atlas of NSW Wildlife are approximately 10 km to the south in Pilliga Nature Reserve and 25 km to the north east near Mt Kaputar National Park. Thus, the species has the potential to occur in the study area. This potential predominantly relates to foraging habitat, as preferred breeding habitat for this species (i.e. caves) is not known from within the study area.

As the species has not been recorded in the study area and preferred breeding habitat is not known to occur, it is considered unlikely that an 'important population' of Large-eared Pied Bat occurs within

the study area. Therefore the proposed activity is unlikely to lead to a long-term decrease in the size of an important population.

Reduce the area of occupancy of an important population

As an 'important population' of Large-eared Pied Bats is considered unlikely to occur within the study area, the proposed activity is unlikely to reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

As an 'important population' of Large-eared Pied Bats is considered unlikely to occur within the study area, the proposed activity is unlikely to fragment an existing important population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of Large-eared Pied Bats includes foraging, roosting and breeding habitat. Breeding habitat is critical to the survival of the species as the species roosts in caves and these are limited. Any impacts to breeding habitat could potentially threaten the survival of the species.

Unlike breeding habitat, Large-eared Pied Bats would likely be able to withstand some level of impact to foraging and roosting habitat

The proposed activity would retain the majority of foraging and roosting and breeding habitat in the study region for the Large-eared Pied Bat, with only a small proportion (0.01%) of habitat impacted in the study region. Thus, the foraging and roosting habitat lost or degraded is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of an important population

As an 'important population' of Large-eared Pied Bats is considered unlikely to occur within the study area, the proposed activity is unlikely to disrupt the breeding cycle of an important population.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential foraging and roosting habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study region.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the Large-eared Pied Bat such as cats and foxes are already established in the study region. The proposed activity is unlikely to exacerbate the impacts of invasive species or lead to increased competition for South-eastern Long-eared Bats for resources.

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Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed activity would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The species is highly mobile and will be able to move from disturbed areas into nearby undisturbed locations.
- The regional extent of suitable foraging habitat types is sufficient that the proposed activity is unlikely to result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.
- The proposed activity will not disrupt the breeding cycle of the species as no breeding areas are known within the study area, and no caves or sandstone outcrops (breeding habitat) will be impacted by the proposed activity.

***Pteropus poliocephalus* (Grey-headed Flying-fox) – Vulnerable**

The Grey-headed Flying-fox occurs primarily along the eastern coastal plain from Bundaberg in Queensland, through NSW and south to eastern Victoria. A colony has also established in Melbourne (FFG SAC 2001). Small numbers may occur as far west as Warrnambool (Menkhorst 1995). Regular movements are made over the Great Dividing Range to the western slopes of NSW and Queensland.

This species is a canopy-feeding frugivore, blossom-eater and nectarivore of rainforests, open forests, woodlands, *Melaleuca* swamps and *Banksia* woodlands. As such, it plays an important ecosystem function by providing a means of seed dispersal and pollination for many indigenous tree species (Eby 1996; Pallin 2000). Grey-headed Flying-foxes also feed on introduced trees including commercial fruit crops

Grey-headed Flying-foxes congregate in large numbers at roosting sites (camps) that may be found in rainforest patches, *Melaleuca* stands, mangroves, riparian woodland or modified vegetation in urban areas. Individuals generally exhibit a high fidelity to traditional camps and return annually to give birth and rear offspring (Lunney and Moon 1997; Augee and Ford 1999). They forage opportunistically, often at distances up to 30 km from camps, and occasionally up to 60-70 km per night, in response to patchy food resources (Augee and Ford 1999; Tidemann 1999.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

The Grey-headed Flying-fox was not recorded within the study area during field surveys however a number of previous surveys have detected the species near the study area and the Atlas of NSW Wildlife records show the species' presence throughout the study region.

Grey-headed Flying-foxes forage over a range of habitats. The proposed activity will lead to the loss of approximately 2.44 ha of habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

As the proposed activity represents a small proportion of the available habitat in the study region, the proportion of hollow-bearing trees to be removed is also likely to be low. As such it is considered unlikely that the proposed activity would lead to a long-term decrease in the size of a population of Grey-headed Flying-fox.

Reduce the area of occupancy of an important population

The area of occupancy for the Grey-headed Flying-fox would be reduced if significant amounts of foraging habitat were lost in the study region, or if habitats were degraded to the point that the species avoided or could not cross degraded areas and could not move through the study region to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study region hence the proposed activity is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing important population into two or more populations

Grey-headed Flying-fox can travel up to 50 kilometres in a foraging excursion. As the species is highly mobile over the distances involved with the proposed impacts, the proposed activity will not create barriers in relation to the foraging activities of the species.

No roosting habitat will be impacted for the Grey-headed Flying-fox as a result of this proposal.

Habitat connectivity will be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study region, allowing any potential populations to move across the wider landscape. Thus, it is unlikely that the proposed activity would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of Grey-headed Flying-fox includes foraging, roosting and breeding habitat. The proposed activity would impact on 2.44 ha of potential foraging habitat for the species. No roosting habitat will be impacted as a result of this proposal.

Considering only a small proportion (0.01%) of foraging habitat for the Grey-headed Flying-fox will be impacted in the NGDP area, it is considered that the proposed activity is unlikely to adversely affect habitat critical to the survival of the species.

Disrupt the breeding cycle of an important population

The proposed activity would not impact on breeding habitat for the Grey-headed Flying-fox. As such, the proposed activity is unlikely to disrupt 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

The proposed activity will lead to the loss of approximately 2.44 ha of potential habitat for this species, which equates to less than 0.01% of the available habitat within the study region.

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The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing potential habitat for the species would be retained in the study region.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

Invasive species that are harmful to the Grey-headed Flying-fox such as cats and foxes are already established in the study region. The proposed activity is unlikely to exacerbate the impacts of invasive species or lead to increased competition for Grey-headed Flying-fox for resources.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed activity would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The species is highly mobile and will be able to move from disturbed areas into nearby undisturbed locations.
- The regional extent of suitable foraging habitat types is sufficient that the proposed activity is unlikely to result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.
- The proposed activity will not disrupt the breeding cycle of the species as no breeding areas are known within the study area or be impacted by the proposed activity.

***Pseudomys pilligaensis* (Pilliga Mouse) - Vulnerable**

It is important to note that the Pilliga Mouse is now considered a southern population of the widespread *Pseudomys delicatulus* (Delicate Mouse) based on genetic analyses, morphological studies and recent surveys which revealed a continuous distribution of the Delicate Mouse to the Pilliga region (Breed and Ford 2007; Ford 2008, as cited in SEWPaC 2011). It is important to note that this taxonomic change has not yet been formally recognised under the EPBC Act (SEWPaC 2011), hence this assessment considers the Pilliga Mouse as currently listed.

The Pilliga Mouse is restricted to the Pilliga region of New South Wales, where low-nutrient deep sand supports a distinctive vegetation type (Pilliga Scrub). The Pilliga Mouse is very sparsely distributed and appears to prefer areas with a light ground cover. Recent studies indicate that the Pilliga Mouse is found in greatest abundance in recently burnt moist gullies, areas dominated by broombush and areas containing an understorey of *Acacia burrowii* (Kurricabah) with a *Corymbia trachyphloia* (Brown Bloodwood) overstorey (Paull 2009). Consistent features of the latter two habitats are a relatively

high plant species richness, a moderate to high low shrub cover; and a moist groundcover of plants, litter and fungi. Consistent features of gully habitat are an extensive cover by low grasses and sedges, with little shrub cover and large areas of ash-covered ground. Some evidence exists of marked population fluctuations by this species. It is nocturnal and appears to live in burrows (OEH 2013b).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of an important population of a species

The species was not recorded within the study area however is known to occur more broadly in the study region. It is unlikely that the study area supports part of an important population of Pilliga Mouse given that lack of suitable breeding habitat available.

The proposed activity will lead to the loss of approximately 2.44 ha of potential dispersing habitat for this species. This loss is considered relatively minor in the context of similar habitats within the study region, constituting less than 0.01% of available dispersing habitat for this species.

As the proposed activity represents a small proportion of the available habitat in the study region, it is considered unlikely that the proposed activity would lead to a long-term decrease in the size of a population of Pilliga Mouse.

Reduce the area of occupancy of an important population

The area of occupancy for Pilliga Mouse would be reduced if significant amounts of dispersing, foraging and breeding habitat were lost in the study region, or if habitats were degraded to the point that the species avoided or could not cross degraded areas and could not move through the study region to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study region, hence the proposed activity is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing important population into two or more populations

The home range sizes of the Pilliga Mouse are not well documented, although Tokushima and Jarman (2008) measured average movement distances of 40 m (range 0–181 m) for recaptured individuals. They did not discount that larger movement patterns could occur. Indeed, Paull (2002) noted that the species can experience marked population fluctuations in response to environmental changes caused by fire or rain. There are also seasonal fluctuations in Pilliga Mouse numbers, with the cooler autumn and winter months showing a time of population congregation for this species and the warmer spring and summer months a time for dispersal, indicating that the species has the ability to move some distances.

Patches will only be separated from other adjacent patches by road and flow line corridors, which will be approximately 10 m on average during construction, and up to 5 m following construction. The extent to which habitat fragmentation may impact on Pilliga Mouse habitat is not fully understood, however it is recognised that clearing associated with the proposed activity could represent a real or perceived barrier to movement.

A fragmentation analysis was undertaken as part of the assessment for the NSW Coal seam Gas exploration appraisal program (ELA 2013b). Based on the results of this analysis, twelve out of twenty

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five movement pathways between modelled breeding and foraging habitat will be potentially impacted by the Program, however no potential movement pathways are proposed to be impacted by the proposed activity. All of the movement pathways are currently impacted by forestry roads. The species is known to undergo seasonal congregations and dispersals (NPA 2002) suggesting that the species has the ability to move significant distances and is currently doing so within an environment currently bisected by much higher number of existing roads, trails and drainage lines than proposed as part of this action. In this way, the proposed activity is not expected to introduce new fragmentation effects; however, they may contribute to existing impacts in some areas of habitat in the short term until natural regeneration occurs along the flow lines following installation.

Given that the Pilliga Mouse persists in habitat that is already fragmented by roads and tracks due to a long history of forestry activities and that they are known to be able to disperse over some distances, the proposed activity is considered unlikely to fragment an important population of the Pilliga Mouse.

Adversely affect habitat critical to the survival of a species

Habitat that is critical to the survival of Pilliga Mouse includes foraging and breeding habitat.

The proposed activity would retain the majority of foraging and breeding habitat in the study region for Pilliga Mouse, with only a small proportion (0.01%) of dispersing habitat impacted in the study region. Thus, the habitat lost or degraded is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of an important population

When assessing the potential for impacts to the breeding cycle of the Pilliga Mouse, it is necessary to consider impacts to areas of breeding habitat and the size of the species' home range. Broombush was previously defined as the preferred breeding habitat for the Pilliga Mouse (Paull 2009). Recent surveys undertaken in the study region (e.g. NICE and CUCCLG 2012) indicate that breeding habitat for the Pilliga Mouse potentially occurs in a broader range of vegetation associations than previously thought. Vegetation associations within the Pilliga Forest where Pilliga Mouse has previously been recorded are generally characterised by a high diversity, moderate density, low (<1 m) sclerophyllous shrubby layer. These characteristics are widespread within the study region and more broadly across the eastern, southern and central Pilliga Forest. As the proposed activity is not likely to impact on breeding habitat, the breeding cycle of the Pilliga Mouse is unlikely to be disrupted.

Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of habitat for this species, which equates to 0.01% of the potential dispersing habitat within the study region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. No breeding habitat for the Pilliga Mouse will be impacted and the majority of vegetation representing potential habitat for the species would be retained in the study region.

Therefore, it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat

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Invasive species that are harmful to the Pilliga Mouse such as house mice, cats and foxes are already established in the study region. The proposed activity is unlikely to exacerbate the impacts of invasive species or lead to increased competition for Pilliga Mouse for resources.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed activity would be unlikely to introduce a disease that may cause this species to decline.

Interfere substantially with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on this species for the following reasons:

- No breeding habitat for the Pilliga Mouse will be impacted and the majority of vegetation representing potential foraging habitat for the species would be retained in the study region.
- The proposed activity will lead to the loss of a very small proportion (less than 0.1%) of available dispersing habitat within the study region.
- The regional extent of suitable foraging habitat types is sufficient that the proposed activity will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

BIRDS

***Anthochaera phrygia* (Regent Honeyeater) – Endangered**

The Regent Honeyeater mainly inhabits temperate woodlands and open forests of the inland slopes of south-east Australia, particularly Box-Ironbark woodland, and riparian forests of River Sheoak. Birds are also found in drier coastal woodlands and forests in some years. There are three known key breeding regions: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. In NSW the distribution is very patchy and mainly confined to the two main breeding areas and surrounding fragmented woodlands, although other potential breeding sites, close to the study area, include the Warrumbungles National Park and Pilliga Nature Reserve (NPWS 1999a). The species is known to make large scale nomadic movements across the landscape, which is thought to coincide with flowering times of different eucalypt species on which they feed (SEWPAC 2013).

There are no existing records for the species within the study area and the Regent Honeyeater was not identified during surveys. The species has been recorded nearby with two records in the Pilliga Nature Reserve, and one in Pilliga East State Forest. Breeding behaviour has been recorded in the Pilliga Nature Reserve; however the important Bundarra-Barraba breeding area is located 150 km to the east. It is considered likely that the species would utilise habitats present in the study area for foraging on occasion.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

The proposed activity could lead to a long-term decrease in the size of a population of Regent Honeyeaters if it significantly reduced or degraded foraging, roosting and breeding habitat available to the species, or contributed to the direct mortality of the species.

The proposed activity will lead to the loss of approximately 36 ha of potential foraging/roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study area and much less in Namoi CMA region. The loss of potential foraging/roosting habitat will occur in small areas across the landscape for the well leases and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As such, it is considered unlikely that the proposed activity would lead to a long-term decrease in the size of a population of the Regent Honeyeater.

Reduce the area of occupancy of the species

The area of occupancy for Regent Honeyeaters could be reduced if significant amounts of foraging and roosting habitat were lost in the study area, or if habitats were degraded to the point that the species avoided degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the study region, hence the proposed activity is considered unlikely to reduce the area of occupancy of the species.

Fragment an existing population into two or more populations

The proposed activity could potentially fragment foraging/roosting habitat. Regent Honeyeaters are nomadic and can make large regional movements across their range. Regent Honeyeaters would be able to traverse the length and width of the study area to access potential foraging resources despite the potential fragmentation caused by the proposed activity. Habitat connectivity would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing an existing population to move across the wider landscape. Thus, it is unlikely that the proposed activity would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat critical to the survival of the species includes breeding habitat, and foraging/roosting habitat. Breeding habitat is critical to the survival of the species as Regent Honeyeaters only use a small number of specific areas to breed. Any impacts to breeding habitat could threaten the survival of the species. Unlike breeding habitat, Regent Honeyeaters would likely be able to withstand minor impacts to foraging/roosting habitat, i.e. not all habitat representing foraging/roosting habitat is critical to the survival of the species. The levels tolerated would depend on the amount and quality of foraging/roosting habitat impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the study area and study region.

There are three known key breeding regions remaining for the species: north-east Victoria (Chiltern-Albury), and in NSW at Capertee Valley and the Bundarra-Barraba region. The species has also been recorded displaying breeding behaviour in Pilliga Nature Reserve and Warrumbungles National Park (NPWS 1999a), located to the south of the study area. The study area is not a known key breeding area for the species, and thus the proposed activity would not directly impact on breeding habitat.

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The foraging/roosting habitat proposed to be removed by the action constitutes less than 0.1% of the available habitat within the study region and is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of a population

The proposed activity could impact on or disrupt the breeding cycle of the Regent Honeyeater if it impacted on breeding habitat directly, or reduced/degraded foraging resources used during the breeding season. The study area is not a known key breeding area for the species, and thus the proposed activity would not directly impact on breeding habitat.

The vegetation type impacted by the proposed activity is not considered to contain profusely flowering winter-flowering species and as such the study area is considered to only represent transient foraging/roosting habitat which is unlikely to be considered a significant foraging resource for the Regent Honeyeater during breeding.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential foraging/roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study area region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing foraging/roosting habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is unlikely that the proposed activity would result in the introduction of invasive species that would impact on Regent Honeyeater in the study area. The species suffers from competition from larger aggressive honeyeaters, particularly Noisy Miners, Noisy Friarbirds and Red Wattlebirds. However, the proposed activity is unlikely to lead to an increase in the incidence of these species in the study area.

Introduce disease that may cause the species to decline, or

Disease is not listed as a threat to this species. The proposed activity would be unlikely to introduce a disease that may cause this species to decline.

Interfere with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the Regent Honeyeater for the following reasons:

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- The proposed activity will disturb a very small proportion (<0.1%) of available foraging/roosting habitat within the study region- the species is highly mobile and thus able to utilise areas across the landscape.
- The proposed activity will not disrupt the breeding cycle of the species as important breeding habitat will not be impacted.
- The regional extent of suitable foraging habitat types is sufficient that the proposed activity will not result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline.

***Lathamus discolour* (Swift Parrot) – Endangered**

The Swift Parrot is a wide-ranging, highly mobile species which is endemic to south-eastern Australia (SEWPAC 2013). It is known to use habitat within the Namoi CMA region (OEH 2013b). Swift Parrots breeds in Tasmania during spring and summer, migrating in the autumn and winter months to south-eastern Australia from Victoria and the eastern parts of South Australia to south-east Queensland. In NSW this species mostly occurs on the coast and south west slopes.

On the mainland birds occur in areas where eucalypts are flowering profusely or where there is abundant lerp (from sap-sucking bugs) infestations (OEH 2013b). Favoured feed trees include winter flowering species such as *Eucalyptus robusta* (Swamp Mahogany), *Corymbia maculata* (Spotted Gum), *C. gummifera* (Red Bloodwood), *E. sideroxylon* (Mugga Ironbark), and *E. albens* (White Box). Commonly used lerp infested trees include *E. microcarpa* (Inland Grey Box), *E. moluccana* (Grey Box) and *E. pilularis* (Blackbutt). Following winter they return to Tasmania where they breed from September to January.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

Lead to a long-term decrease in the size of a population

There are no existing records for the species within the study area. The closest records according to the Atlas of NSW Wildlife are approximately 24 km to the east in Boggabri and 55 km to the south east near Gunnedah. The vegetation type impacted by the proposed activity is not considered to contain profusely flowering winter-flowering species and as such the study area is considered to only represent transient foraging habitat.

The proposed activity will lead to the loss of approximately 2.44 ha of potential foraging habitat for this species, which equates to less than 0.1% of the available habitat within the study region. The loss of habitat will occur in small areas across the landscape for the well pads and linear corridors for the flow lines which generally follow existing tracks and infrastructure. Up to 40% of clearing associated with the well pads and 60% of clearing associated with the flowlines and water and gas gathering systems will be rehabilitated.

As such, it is considered unlikely that the proposed activity would lead to a long-term decrease in the size of a population of the Swift Parrot

Reduce the area of occupancy of the species

The area of occupancy for Swift Parrots could be reduced if significant amounts of foraging/roosting habitat were lost in the study area, or if habitats were degraded to the point that the species avoided degraded areas and could not move through the study area to undisturbed areas.

The loss of habitat through clearing is small relative to the amount of habitat retained in the study area and the study region, hence the proposed activity is considered unlikely to reduce the area of occupancy of the species

Fragment an existing population into two or more populations

The proposed activity could potentially fragment foraging/roosting habitat. Swift Parrots are migratory and can make large movements across their range. Swift Parrots would be able to traverse the length and width of the study area to access potential foraging resources despite the potential fragmentation caused by the proposed activity. Habitat connectivity would be maintained at a regional level, with contiguous vegetation and habitat connectivity retained around the study area, allowing an existing population to move across the wider landscape. Thus, it is unlikely that the proposed activity would fragment an existing population into two or more populations.

Adversely affect habitat critical to the survival of a species

Habitat that is necessary to the survival of the species includes breeding habitat, and foraging and roosting habitat. Breeding habitat is critical to the survival of the species as Swift Parrots only breed in Tasmania. Any impacts to breeding habitat could threaten the survival of the species. Unlike breeding habitat, Swift Parrots would likely be able to withstand some level of impact to foraging/roosting habitat, i.e. not all habitat representing foraging/roosting habitat is critical to the survival of the species.

The levels tolerated would depend on the amount and quality of foraging/roosting habitat impacted, the location of the habitat in the landscape, and the amount of habitat remaining in the study area and study region.

The foraging/roosting habitat proposed to be removed by the action constitutes less than 0.1% of the available habitat within the study region and is unlikely to be critical to the survival of the species.

Disrupt the breeding cycle of a population

The study area is not used as a breeding area for the species, and thus the proposed activity would not directly impact on breeding habitat. The species would not use the study area as foraging habitat during the breeding season as it remains in Tasmania during its breeding season (spring and summer months), only migrating to mainland Australia during its non-breeding season (autumn and winter months). Thus, the proposed activity is unlikely to disrupt the breeding cycle of the species.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The proposed activity will lead to the loss of approximately 2.44 ha of potential foraging/roosting habitat for this species, which equates to less than 0.1% of the available habitat within the study region.

The amount of habitat directly removed is unlikely to be on the scale that would result in a decline of the species. The majority of vegetation representing foraging/roosting habitat for the species would be retained in the study area.

Therefore it is unlikely that the proposed activity will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

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Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

It is unlikely that the proposed activity would result in the introduction of invasive species that would impact on Swift Parrots in the study area.

Introduce disease that may cause the species to decline, or

A disease that could potentially infect Swift Parrots is beak and feather disease. However, the proposed activity would be unlikely to introduce a disease that may cause this species to decline, given the disease is transmitted by other birds of the same species.

Interfere with the recovery of the species.

In consideration of the above factors, the proposed activity is unlikely to substantially interfere with the recovery of the species.

Conclusion

The proposed activity is not considered likely to have a significant impact on the species for the following reasons:

- The species is not known to occur in the study area.
- The proposed activity will disturb a very small proportion (<0.1%) of available foraging/roosting habitat within the study region - the species is highly mobile and thus able to utilise areas across the landscape.
- The vegetation within the study area is not considered to represent core foraging habitat.
- The species' migratory route will not be affected by the proposed activity.
- The proposed activity will not disrupt the breeding cycle of the species as it breeds exclusively in Tasmania.

MIGRATORY SPECIES

***Anthochaera phrygia* (Regent Honeyeater) – Migratory**

Regent Honeyeater is listed as an endangered and migratory species under the EPBC Act. A description of the species and distribution in NSW is provided in under the endangered species assessment above.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed activity would remove potential foraging and roosting habitat within the study area. No breeding habitat representing important habitat would be impacted.

The majority of vegetation representing foraging and roosting habitat for the species would be retained in the study region. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for Regent Honeyeaters throughout the study region. This species could also access vegetation outside of the study area as it is capable of making large regional movements in the order of hundreds of kilometres.

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Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

It is unlikely that the proposed activity would result in the introduction of invasive species that would impact on Regent Honeyeater in the study area. The species suffers from competition from larger aggressive honeyeaters, particularly Noisy Miners, Noisy Friarbirds and Red Wattlebirds. However, the proposed activity is unlikely to lead to an increase in the incidence of these species in the study area.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The species is not known to breed in the study area, although it has been recorded displaying breeding behaviour to the south of the study area in Pilliga Nature Reserve. The study area could be potentially be used as a foraging resource during the species' breeding period and thus the proposed activity could potentially disrupt the lifecycle of Regent Honeyeater. However, only a small proportion of the foraging habitat in the study region will be removed. Regent Honeyeaters would be able to continue using these resources within and outside of the study area. Thus, the proposed activity is unlikely to seriously disrupt the lifecycle of a Regent Honeyeater population.

***Haliaeetus leucogaster* (White-bellied Sea Eagle) - Migratory**

The White-bellied Sea-Eagle is found in coastal habitats (especially those close to the sea-shore) and around near-coastal wetlands in tropical and temperate regions of mainland Australia and its offshore islands. The habitats occupied by the sea-eagle are characterised by the presence of large areas of open water (larger rivers, swamps, lakes, the sea).

While the species is mostly coastal in its distribution, White-bellied Sea-Eagles may travel inland along major rivers. Birds also occasionally visit inland lakes, rivers or reservoirs that occur outside of the usual distribution of the species (DoE 2013bb).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The study area could provide occasional foraging habitat for the species following heavy rainfall periods (within the riparian areas that are within close proximity of the study area), but would be unlikely to provide permanent foraging or breeding habitat for the species as the breeding territories of White-bellied Sea Eagles are typically located close to bodies of water which are absent from the study area.

The proposed activity avoids the main riparian area in proximity to the study area and would not substantially modify potential foraging habitat for White-bellied Sea Eagles.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

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The proposed activity would not result in the establishment of an invasive species that is harmful to White-bellied Sea Eagles.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The study area does not provide breeding habitat for the species. The species could potentially be present in the study area opportunistically following rain periods, however there is more optimal habitat located to the north and east of the study area along the Namoi River. The proposed activity will not impact on any riparian areas or riparian vegetation. The proposed activity is therefore unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of White-bellied Sea Eagles.

***Hirundapus caudacutus* (White-throated Needletail) - Migratory**

The White-throated Needletail is listed as a migratory species under the EPBC Act, and is included in the Japan-Australia Migratory Bird Agreement, the China-Australia Migratory Bird Agreement, and the Republic of Korea-Australia Migratory Bird Agreement (DoE 2013b).

In Australia, the White-throated Needletail is almost exclusively aerial, from heights of less than 1 m up to more than 1000 m above the ground. Because they are aerial, it has been stated that conventional habitat descriptions are inapplicable, but there are, nevertheless, certain preferences exhibited by the species. Although they occur over most types of habitat, they are probably recorded most often above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy, but they are less commonly recorded flying above woodland. They also commonly occur over heathland, but less often over treeless areas, such as grassland or swamps. When flying above farmland, they are more often recorded above partly cleared pasture, plantations or remnant vegetation at the edge of paddocks. In coastal areas, they are sometimes seen flying over sandy beaches or mudflats, and often around coastal cliffs and other areas with prominent updraughts, such as ridges and sand-dunes (DoE 2013b).

During the non-breeding season in Australia, the White-throated Needletail has been recorded eating a wide variety of insects, including beetles, cicadas, flying ants, bees, wasps, flies, termites, moths, locusts and grasshoppers. The White-throated Needletail almost always forage aerially, at heights up to 'cloud level' though usually much lower (DoE 2013b).

The species has been recorded roosting in trees in forests and woodlands, both among dense foliage in the canopy or in hollows. It has been suggested that they also sometimes roost aerially (DoE 2013b).

The species breeds in wooded lowlands and sparsely vegetated hills, as well as mountains covered with coniferous forests in Asia, from central and south-eastern Siberia and Mongolia, east to the Maritime Territories of Russia, Sakhalin and the Kuril Islands and south to northern Japan and north-eastern China (DoE 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

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Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed activity would remove vegetation above which White-throated Needletail could use to forage. The amount of vegetation that would be directly impacted comprises only a small portion of vegetation in the study region with the majority of vegetation in the study region to be retained. The proposed activity is considered unlikely to constitute important habitat for the White-throated Needletail and is unlikely to substantially modify, destroy or isolate areas of important habitat.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

The proposed activity would not result in the establishment of an invasive species that is harmful to White-throated Needletails.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

White-throated Needletails do not breed in Australia. The removal of vegetation in the study area would be unlikely to affect the species, which forages aerially over a range of habitats. Therefore the proposed activity is unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of White-throated Needletail.

***Apus pacificus* (Fork-tailed Swift) - Migratory**

The Fork-tailed Swift is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities. They mostly occur over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. They are also found at treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes (DoE 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed activity would remove vegetation above which Fork-tailed Swifts could potentially forage. However, the majority of vegetation in the study region would be retained. The amount of vegetation that would be directly impacted comprises only a small portion of vegetation throughout the study area and an even smaller portion of vegetation within the Namoi CMA region. The proposed activity is considered unlikely to constitute important habitat for the Fork-tailed Swift and is unlikely to substantially modify, destroy or isolate areas of important habitat.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

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The proposed activity would not result in the establishment of an invasive species that is harmful to Fork-tailed Swifts.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

Fork-tailed Swifts do not breed in Australia. The removal of vegetation in the study area would be unlikely to affect the species, which forages aerially over a range of habitats including cleared areas. Therefore the proposed activity is unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of Fork-tailed Swift.

***Merops ornatus* (Rainbow Bee-eater) – Migratory**

The Rainbow Bee-eater is listed as a migratory species under the EPBC Act (DoE 2013b).

In Australia, the Rainbow Bee-eater mainly occurs in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation. It usually occurs in open, cleared or lightly-timbered areas that are often, but not always, located in proximity to permanent water. It also occurs in inland and coastal sand dune systems, and in mangroves in northern Australia, and has been recorded in various other habitat types including heathland, sedgeland, vine forest and vine thicket, and on beaches (DoE 2013b).

The Rainbow Bee-eater mainly feeds on insects, and will occasionally take other animal items including earthworms, spiders and tadpoles. The insect component of the diet mainly consists of bees and wasps, but also includes various other insects such as beetles, moths, butterflies, damselflies, dragonflies, flies, ants and bugs. The Rainbow Bee-eater captures most of its prey in flight, although it also takes food items from the ground and from foliage, and has occasionally been seen to snatch items from below the surface of rivers and dams (DoE 2013b).

The Rainbow Bee-eater breeds in socially monogamous pairs that are sometimes assisted by a varying number of auxiliary birds or 'helpers' that are usually male. The nests are typically concentrated together in loose colonies, although in some instances pairs will nest solitarily. The nest is located in an enlarged chamber at the end of long burrow or tunnel that is excavated, by both sexes, in flat or sloping ground, in the banks of rivers, creeks or dams, in roadside cuttings, in the walls of gravel pits or quarries, in mounds of gravel, or in cliff-faces. Nesting areas are often re-used, and banding studies indicate that at least some migrant birds return to the same nesting area each year. However, pairs usually excavate a new nesting burrow for each breeding season (DoE 2013b).

The movement patterns of the Rainbow Bee-eater are complex, and are not fully understood. Populations that breed in southern Australia are migratory. However, populations that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year. Regarding populations that breed in southern Australia, these move north to northern Australia, Papua New Guinea and eastern Indonesia after breeding and remain there for the duration of the Australian winter. Populations of the Rainbow Bee-eater gather together and assemble into flocks before migration. The migrating flocks, which can consist of tens to hundreds or thousands of birds, often fly high above the ground when on passage (DoE 2013b).

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will meet any of the following criteria:

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Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

The proposed activity would remove foraging, roosting and potential breeding habitat for the Rainbow Bee-eater. However, the majority of vegetation in the study region representing foraging, roosting and potential breeding habitat for Rainbow Bee-eater would be retained. The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for Rainbow Bee-eater throughout the study area and an even smaller portion of potential habitat within the Namoi CMA region.

The proposed activity is considered unlikely to substantially modify, destroy or isolate areas of important habitat.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species, or

The proposed activity would not result in the establishment of an invasive species that is harmful to Rainbow Bee-eater.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.

The proposed activity would remove foraging, roosting and potential breeding habitat for the Rainbow Bee-eater. However, the majority of vegetation representing foraging, roosting and breeding habitat in the study region that could be used by Rainbow Bee-eater would be retained.

The amount of habitat that would be directly impacted comprises only a small portion of potential habitat for Rainbow Bee-eater throughout the study region and an even smaller portion of potential habitat within the Namoi CMA region. The species could also access vegetation outside of the study area. Thus, the proposed activity is considered unlikely to seriously disrupt the lifecycle of a Rainbow Bee-eater population.

Conclusion

The proposed activity is considered unlikely to have a significant impact on any of these migratory species as the regional extent of suitable habitat types is sufficient that the proposed activity is unlikely to result in the modification, removal or availability of habitat to the extent that it is likely to significantly impact on the species causing decline. Furthermore the proposed activity is unlikely to result in an invasive species becoming established, nor seriously disrupt the lifecycle of any migratory species.

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Appendix H: Survey effort compared to recommended survey guidelines (DEC 2004)

Survey guidelines	ELA survey effort	RPS survey effort
Small mammals: *Pseudomys pilligaensis* (Pilliga Mouse), *Cercartetus nanus* (Eastern Pygmy-possum) and *Petaurus norfolcensis* (Squirrel Glider).		
Guidelines for sampling small mammals (DEC 2004): • Elliott trapping: Elliott A terrestrial trapping 100 trap nights per stratification unit (i.e. 25 Elliott traps over four nights). Trap lines spaced between 20 m and 50 m apart. Arboreal Elliott trapping 24 trap nights per stratification unit (i.e. 6 Elliott traps over four nights). Trapping intensity should be increased with decreased abundance. Traps should be checked every morning and should contain materials that allow the animal to keep warm. • Hair tubes: transects of 10 tubes in each stratification unit. Minimum 4 days and nights. Hair samples to be analysed by specialist. • Pitfall trapping: Minimum 24 trap nights over minimum three to four nights. Trap consists of 28 cm diameter and 40 cm deep (20 L bucket). Place rock/wood and dirt/leaves in pit to provide refuge. Objects that float should be used as refuge in case of heavy rains. Drift fencing 5 m either side of hole of 30 cm height with the lower 5 cm buried in soil, supported by steel pegs and of a material which resists small mammals climbing.	This survey: Two transects of six arboreal Elliott A traps (Eastern Pygmy Possum) and two transects of six arboreal Elliott B traps (Squirrel Glider) over three to four nights. Total effort 42 Elliott A arboreal trap nights and 48 Elliott B arboreal trap nights. Remote cameras: 9 cameras positioned facing arboreal Elliott traps for four nights. Total effort 36 trap nights. ELA 2013: 10 small (30 mm diameter) terrestrial hairtubes over 19 nights, baited with oats, peanut butter and honey. Total effort 140 trap nights. Two further small mammal trapping sites within 2 km of study area. However, both sites are in a different habitat type to the study area. Opportunistic surveys for small mammals were also undertaken.	262 Elliott A terrestrial trap nights; 34 Elliott E terrestrial trap nights; 57 pitfall trap nights. Dispersal habitat for Pilliga Mouse.
Medium mammals: *Dasyurus maculatus* (Spotted-tailed Quoll), *Aepyprymnus rufescens* (Ruffous Bettong) and *Macropus dorsalis* (Black-striped Wallaby).		

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Survey guidelines	ELA survey effort	RPS survey effort
Guidelines for sampling medium mammals (DEC 2004): • Hair tubes: transects of 10 tubes in each stratification unit. Minimum 4 days and nights. Hair samples to be analysed by specialist. • Elliott trapping: Elliott B terrestrial trapping 100 trap nights per stratification unit (i.e. 25 Elliott traps over four nights). Trap lines spaced between 20 m and 50 m apart. Trapping intensity should be increased with decreased abundance. Traps should be checked every morning and should contain materials that allow the animal to keep warm. Large Elliott traps are not appropriate for Spotted-tailed Quolls. Cage traps require 24 trap nights over 3-4 consecutive nights. • Tracks, scats and scratches searches: at least a 30 minute search in appropriate habitat, combined with other searching techniques. • Spotlighting: 2 x 1 hour and 1 km up to 200 ha of stratification unit, walking approximately 1 km per hour on 2 separate nights.	This survey: Fifty terrestrial Elliott B traps over four nights (25 traps at two sites), baited with oats, peanut butter and honey. At each site, traps were set in two line transects spaced approximately 50 m apart, with each trap approximately 10-15 m apart. Total effort: 200 trap nights Spotlighting: two people over five separate nights. On each night, spotlighting was conducted on foot for approximately 20 minutes. ELA 2013: A transect of 40 large (90 mm diameter) hair tubes baited with fish to attract Spotted-tailed Quoll over 25 nights. Transect runs through habitat similar to study area. Total effort 600 trap nights. Opportunistic surveys for medium mammals were also undertaken.	150 hair funnel trap nights. 17 terrestrial Elliott B trap nights Spotlight searches for nocturnal fauna including dedicated listening periods for fauna vocalisations, were carried out over two nights for 1.5 hours. 3 remote cameras with 44 remote cameras survey nights. Opportunistic surveys for Spotted-tailed Quoll were also undertaken.
Large forest birds: *Ninox connivens* (Barking Owl) and *Tyto novaehollandiae* (Masked Owl)		
Guidelines for sampling owls (DEC 2004): • Call playback: sites should be separated by 800 metres – 1km, and each site should have the playback session repeated at least five visits per site (Barking Owl) or eight visits per site (Masked Owl) on different nights. • Day habitat search: Search habitat for pellets, and likely hollows • Stag-watching: observing potential roost hollows for 30mins prior to sunset and 60mins following sunset.	ELA 2013: Call playback: within a 1 km radius of the study area for Dewhurst 30 & 31 over five nights. Call playback started with five minutes of listening and five to ten minutes of spotlighting. This was followed by broadcasting a call for 5 minutes using a loudspeaker followed by another five minutes of listening. Recorded calls of Barking Owl and Masked Owl were broadcast. This was then followed by a further 5 – 10 mins of listening for a response and then 5 – 10 minutes of spotlighting. Hollow-bearing trees examined for hollow	No targeted large forest owl surveys were undertaken.

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Survey guidelines	ELA survey effort	RPS survey effort
	size. Opportunistic surveys for large forest birds were also undertaken.	
Burhinus grallarius (Bush Stone-curlew)		
Guidelines for sampling Bush Stone-curlew (DEC 2004): • Call playback: sites should be 2-4km apart and conducted during the breeding season. • Day habitat search: flushing of Bush Stone-curlews by walking through potential habitat. • Spotlighting: by foot or from a vehicle driven in first gear.	ELA 2013: Call playback: within a 1 km radius of the study area for Dewhurst 31 & 31 over five nights. Recorded call of Bush Stone-curlew was broadcast over a loudspeaker for approximately 5 mins; this was then followed by a further 5 – 10 mins of listening for a response. Opportunistic surveys for Bush Stone-curlew were also undertaken.	No targeted surveys for Bush Stone-curlew were undertaken.
Diurnal Birds including migratory species: *Anthochaera phrygia* (Regent Honeyeater), *Ardeotis australis* (Australian Bustard), *Calyptorhynchus lathami* (Glossy Black-Cockatoo), *Chthonicola sagittata* (Speckled Warbler), *Circus assimilis* (Spotted Harrier), *Daphoenositta chrysoptera* (Varied Sittella), *Falco hypoleucos* (Grey Falcon), *Glossopsitta pusilla* (Little Lorikeet), *Grantiella picta* (Painted Honeyeater), *Hamirostra melanosternon* (Black-breasted Buzzard), *Hieraaetus morphnoides* (Little Eagle), *Lathamus discolor* (Swift Parrot), *Lophoictinia isura* (Square-tailed Kite), *Melanodryas cucullata* (Hooded Robin), *Melithreptus gularis gularis* (Black-chinned Honeyeater), *Neophema pulchella* (Turquoise Parrot), *Pachycephala inornata* (Gilbert's Whistler), *Petroica boodang* (Scarlet Robin), *Polytelis swainsonii* (Superb Parrot), *Pomatostomus temporalis temporalis* (Grey-crowned Babbler) and *Stagonopleura guttata* (Diamond Firetail).		
Guidelines for sampling diurnal birds (DEC 2004): • area search methods, where observers walk around an area of pre-determined size for a pre-determined length of time. A 1 ha (200m x 500m) 20-minute search is the most common method. • point count methods, where observations are made from a series of pre-determined points for pre-determined lengths of time. By recording the bird's distance from the point, density estimates can also be made. Guidelines for sampling migratory birds (DEC 2004): • Specific guidelines for surveying diurnal birds have not been listed in the DEC guidelines but a few methods for consideration are discussed. The suggested minimum effort is an area search using a species-time curve approach. Using this approach, a survey session will cease when no additional species are identified within a set time period. The area search must be repeated in each stratification	Three sites were surveyed during an AM (first four hours of light) and PM (last four hours of light) survey period by two ELA ecologists. Each survey consisted of an initial 20 minute census recording all bird calls and observations. If new species are added to the list in the last 5 minute period of the survey, an extra five minutes of survey is undertaken. This method was repeated to make a species-time curve until no new species were identified. Opportunistic surveys for diurnal birds were also undertaken.	2 sites with 1 AM and 1 PM survey at each site. Total effort: 2 hours. Opportunistic surveys were also undertaken at all sites.

Survey guidelines	ELA survey effort	RPS survey effort
unit. Can either undertake an area search or point count method: • Area search: observers walk around a predetermined size for a pre-determined length of time. A 1 ha 20 minute search is the most common method. • Point count: observations are made from a series of pre-determined points for pre-determined lengths of time. By recording the bird's distance from the point, density estimates can also be made. A suggested method is 10 minute observations recorded at 0-5m, 5m-10m, 10m- 20m, 20m-30m, 30m-50m and >50m.		
Reptiles: *Hoplocephalus bitorquatus* (Pale-headed Snake)		
Guidelines for sampling nocturnal reptiles (DEC 2004): • Stream search: 2 person hours per 200 m of stream during the evening (November to March). • Nocturnal spotlighting of tree trunks and other habitat: 30 minute search on two separate nights, targeting specific habitat (November to March). • Active searching for hibernating individuals during cooler months (can look under bark, however other species from the *Hoplocephalus* genus exhibit prolonged overwinter sequestration and this is potential also for the Pale-headed Snake (Webb & Shine 1997a, b; Fitzgerald et al. 2002; Fitzgerald et al. 2010). • Other sampling techniques for reptiles are not appropriate for Pale-headed Snake.	No additional Pale-headed Snake surveys were undertaken.	38 snake funnel trap nights. Active searches of the area to identify potential habitat for Pale-headed Snake. Survey techniques included: • diurnal searches for sheltering or basking reptiles as well as indirect evidence e.g. tracks, scratches etc. • rock, log and debris rolling • spotlight surveys for nocturnally active species
Bats: *Nyctophilus corbeni* (South-eastern Long-eared Bat), *Chalinolobus dwyeri* (Large-eared Pied Bat), *Chalinolobus picatus* (Little Pied Bat), *Miniopterus schreibersii oceanensis* (Eastern Bentwing-bat), *Saccolaimus flaviventris* (Yellow-bellied Sheathtail-bat), *Vespadelus troughtoni* (Eastern Cave Bat) and *Pteropus poliocephalus* (Grey-headed Flying-fox).		
Guidelines for sampling bats (DEC 2004): Harp trapping: four trap nights over two consecutive nights Anabat detector: Two sound activated recording devices utilised for the entire night (a minimum of four hours), starting at dusk for two nights. A combination of trapping and echolocation call recording as the most efficient approach for bat inventory surveys.	Harp traps: four traps over two consecutive nights. Traps were assembled just prior to dusk and checked each morning before 0930 hrs. Any bats caught were identified to the lowest taxonomic level possible. Total effort: eight trap nights. Anabat detectors: Six units over two consecutive nights placed in flyways that were likely to be used by bats. On each night of survey the Anabats were turned on	An Anabat detection unit was placed for one to two nights in suitable flyways located adjacent to the survey sites. Positioning was focused on natural flyways below the canopy, which typically provide an abundance of microbat foraging resources. No targeted mistnet or harp trapping was undertaken.

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Survey guidelines	ELA survey effort	RPS survey effort
	time-delayed recording prior to dusk and then turned off the following morning by 0930 hrs.	

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Appendix 5

Air Quality Impact Assessment

ACOUSTICS AND AIR

DEWHURST PILOT EXPANSION

AIR QUALITY IMPACT ASSESSMENT

REPORT NO. 13258
VERSION C

OCTOBER 2013

PREPARED FOR

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WILKINSON MURRAY

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Wilkinson Murray is an independent firm established in 1962, originally as Carr & Wilkinson. In 1976 Barry Murray joined founding partner Roger Wilkinson and the firm adopted the name which remains today. From a successful operation in Australia, Wilkinson Murray expanded its reach into Asia by opening a Hong Kong office early in 2006. 2010 saw the introduction of our Queensland office and 2011 the introduction of our Orange office to service a growing client base in these regions. From these offices, Wilkinson Murray services the entire Asia-Pacific region.

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GLOSSARY OF TERMS

Air Pollutant – Any substance in air that could, in high enough concentration, harm man, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of airborne matter capable of being airborne.

Air Pollution – The presence of contaminants or pollutant substances in the air that interfere with human health or welfare, or produce other harmful environmental effects.

Carbon Monoxide (CO) – A colourless, odourless, poisonous gas, produced by incomplete burning of carbon-based fuels, including gasoline, oil and wood. Carbon monoxide is also produced from incomplete combustion of many natural and synthetic products. For instance, cigarette smoke contains carbon monoxide. When carbon monoxide gets into the body, the carbon monoxide combines with chemicals in the blood and prevents the blood from bringing oxygen to cells, tissues and organs. The body's parts need oxygen for energy, so high-level exposures to carbon monoxide can cause serious health effects, with death possible from massive exposures.

Concentration – The relative amount of a substance mixed with another substance. Examples are 5 ppm of carbon monoxide in air and 1 mg/l of iron in water.

Emission – Release of pollutants into the air from a source. We say sources emit pollutants.

Emission Factor – The relationship between the amount of pollution produced and the amount of raw material processed. For example, an emission factor for a blast furnace making iron would be the number of pounds of particulates per ton of raw materials.

Emission Inventory – A listing, by source, of the amount of air pollutants discharged into the atmosphere of a community; used to establish emission standards.

Flow Rate – The rate, expressed in gallons -or litres-per-hour, at which a fluid escapes from a hole or fissure in a tank. Such measurements are also made of liquid waste, effluent, and surface water movement.

Fugitive Emissions – Emissions not caught by a capture system.

Nitric Oxide (NO) – A gas formed by combustion under high temperature and high pressure in an internal combustion engine. NO is converted by sunlight and photochemical processes in ambient air to nitrogen oxide. NO is a precursor of ground-level ozone pollution, or smog.

Nitrogen Dioxide (NO_2) – The result of nitric oxide combining with oxygen in the atmosphere; major component of photochemical smog.

Nitrogen Oxides (NO_x) – A criteria air pollutant. Nitrogen oxides are produced from burning fuels, including gasoline and coal. Nitrogen oxides are smog formers, which react with volatile organic compounds to form smog. Nitrogen oxides are also major components of acid rain.

Particulates; Particulate Matter (PM10) – PM10 is a measure of particles in the atmosphere with a diameter of less than 10 or equal to a nominal 10 micrometers. A criteria air pollutant. Particulate matter includes dust, soot and other tiny bits of solid materials that are released into and move around in the air. Particulates are produced by many sources, including burning of diesel fuels by trucks and buses, incineration of garbage, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steel making, mining operations, agricultural burning (field and slash burning), and operation of fireplaces and woodstoves. Particulate pollution can cause eye, nose and throat irritation and other health problems.

Parts Per Billion (ppb)/Parts Per Million (ppm) – Units commonly used to express contamination ratios, as in establishing the maximum permissible amount of a contaminant in water, land, or air.

Point Source – A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g. a pipe, ditch, ship, ore pit, factory smokestack.

Source – Any place or object from which pollutants are released.

Stack – A chimney, smokestack, or vertical pipe that discharges used air.

1 INTRODUCTION

Santos NSW (Eastern) Pty Ltd (a wholly owned subsidiary of Santos Limited) (Santos) is seeking consent for the expansion of operations at two petroleum exploration pilots, referred to as Dewhurst 13-18H and Dewhurst 26-31. Works at Dewhurst 13-18H involves redrilling three existing wells to convert single horizontal wells to triple-stacked horizontal wells, while works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas.

Wilkinson Murray Pty Limited (WM) has been commissioned by RPS Australia to conduct an air quality assessment of the proposed activity.

Director General Requirements have been issued for the proposed activity and required the following with regards to air quality:

***"Air Quality** - including a quantitative assessment of potential:*

- *construction and operational impacts, with a particular focus on dust emissions including PM10 emissions and the dust generation from transport;*
- *risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal, including risk of environmental harm and risk to human health and amenity;*
- *cumulative impacts associated with existing emission sources as well as any currently approved developments or proposed future developments;*
- *flaring and/or venting; and*
- *monitoring and management measures, including real-time air quality monitoring;"*

2 PROJECT BACKGROUND

The proposed activity involves the expansion of operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operation of both pilots for up to three years. Works at Dewhurst 13-18H involve re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells. Works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas to expand the proposed pilot from four to six wells.

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The NSW Department of Primary Industries (DPI) approved construction, drilling and operation of Dewhurst 13, 14, 15, 16H, 17H and 18H on 21 July 2009 following an REF assessment under Part 5 of the EP&A Act. The wells operated for a short period in 2011.

Dewhurst 26-29 is a proposed four well pilot which was approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) on 16 August 2013 following a REF assessment under Part 5 of the EP&A Act. Dewhurst 26-29 is scheduled to be drilled in Q3 2013.

More specifically, the proposed activity includes:

Site preparation

- establishing two 10 metre wide service corridors between Beehive Road and the Dewhurst 30 and 31 lease areas (including clearing of approximately 0.2 hectares of vegetation)
- constructing access roads within the two service corridors at Dewhurst 30 and 31
- establishing the Dewhurst 30 and Dewhurst 31 lease areas each up to approximately one hectare in size (including approximately two hectares of vegetation clearing)
- removing the existing water gathering system and electrical cable connecting Dewhurst 13, 14 and Dewhurst 15 wells
- preparing the sites and establishing necessary equipment, temporary structures and facilities on the existing well leases Dewhurst 16H, 17H and 18H and on the new lease areas Dewhurst 30 and 31 to enable drilling.

Drilling

- drilling an additional two horizontals from existing casing within Dewhurst 16H, 17H and 18H to convert each well from a single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley coal seams
- drilling one vertical (Dewhurst 30) and one triple-stacked horizontal (Dewhurst 31) well to target coal seams within the Maules Creek Formation.

Surface and subsurface facility construction

- preparing the site on the existing well lease Dewhurst 14 to enable installation of a gas flare and water balance tank
- constructing a new gas and water gathering system connecting all the wells within the Dewhurst 13-18H Pilot to the existing Dewhurst 14 well lease area (including clearing of approximately 0.24 hectares of disturbed vegetation)
- extending the existing water and gas gathering system for Dewhurst 26-29 within the service corridors to Dewhurst 30 and 31
- installing surface and sub-surface infrastructure within the lease areas to connect the wells to

the Dewhurst 13-18H and Dewhurst 26-31 gas and water gathering system

- installing a gas flare and water balance tank at the existing Dewhurst 14 lease area and a gas flare at the Dewhurst 28 lease area.

Operation

- operating the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot for up to three years from the commencement of operations at each pilot respectively
- managing the water and gas produced during operation
- undertaking occasional maintenance of the pilots.

Post operation

- on completion of operations, suspending the wells and ancillary infrastructure or decommissioning them and rehabilitating the well leases.

Flaring of methane gas has the potential to generate air pollutants which can result in adverse affects on nearby sensitive receptors. This report focuses on the emissions and potential impacts associated with the construction and operation of the pilot wells at both sites, and flaring as part of the Dewhurst 13-18H pilot and Dewhurst 26-31 Pilot

Potential air emissions associated with works from the proposed activity would include dust generated during establishment of the well lease, emissions from vehicle movements to and from the site and emissions associated with the operation of the flare and wells on the site.

It should be noted that there may be flaring of gas during drilling, although this will be highly unlikely. There will be a flare and vent tank on site during construction for emergency use only. Given the improbable nature of this occurrence this has not been assessed.

Additionally there may be fugitive emissions of gas. Fugitive emissions are likely to be very small. To safeguard against fugitive emissions there will be sensors at transitional points across the well head and pipe network that will detect changes in pressure levels and trigger investigation and repair in the event of a leak.

Air emissions generated by the proposed development would include particulate matter, carbon monoxide, oxides of nitrogen and minor contributions of other pollutants. These pollutants generally dissipate with distance from the source and are therefore unlikely to affect nearest sensitive receptors given the separation distances to these receptors, as discussed in the following chapter.

3 LOCAL SETTING

The proposed activity is located between approximately 25km and 44km south of Narrabri and 32km west-northwest of Boggabri in the Pilliga Forest of NSW (see **Figure 3-1**). The surrounding land use consists of predominately forested land (State forest) with some existing coal seam gas (CSG) infrastructure and grazing land at Dewhurst 13-18H Pilot. In the wider vicinity, the land use is generally composed of rural activities.

A number of residential properties have been identified located in the vicinity of the proposed flare location (see **Figure 3-1**). These properties have been selected to represent sensitive receptors for this assessment and are most likely to be affected by the potential impacts from the proposed activity. RR4 (the closest residence) is currently under lease to Santos till December 2015. Due to the surrounding State forests, the sensitive receivers identified for Dewhurst 13-18H are also the nearest for Dewhurst 26-31.

Figure 3-1 Project Location (Dewhurst 13-18H and Dewhurst 26-31)

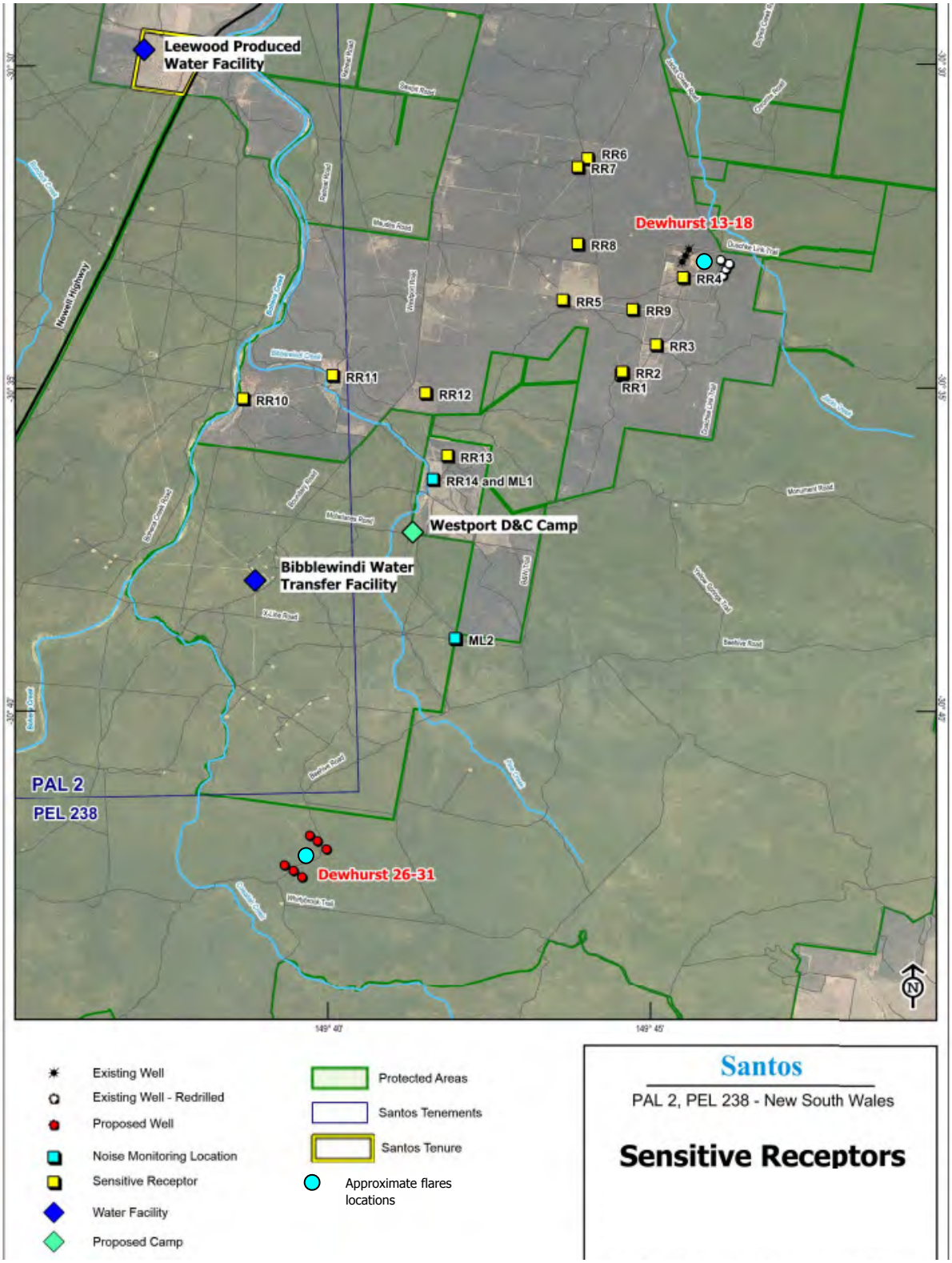
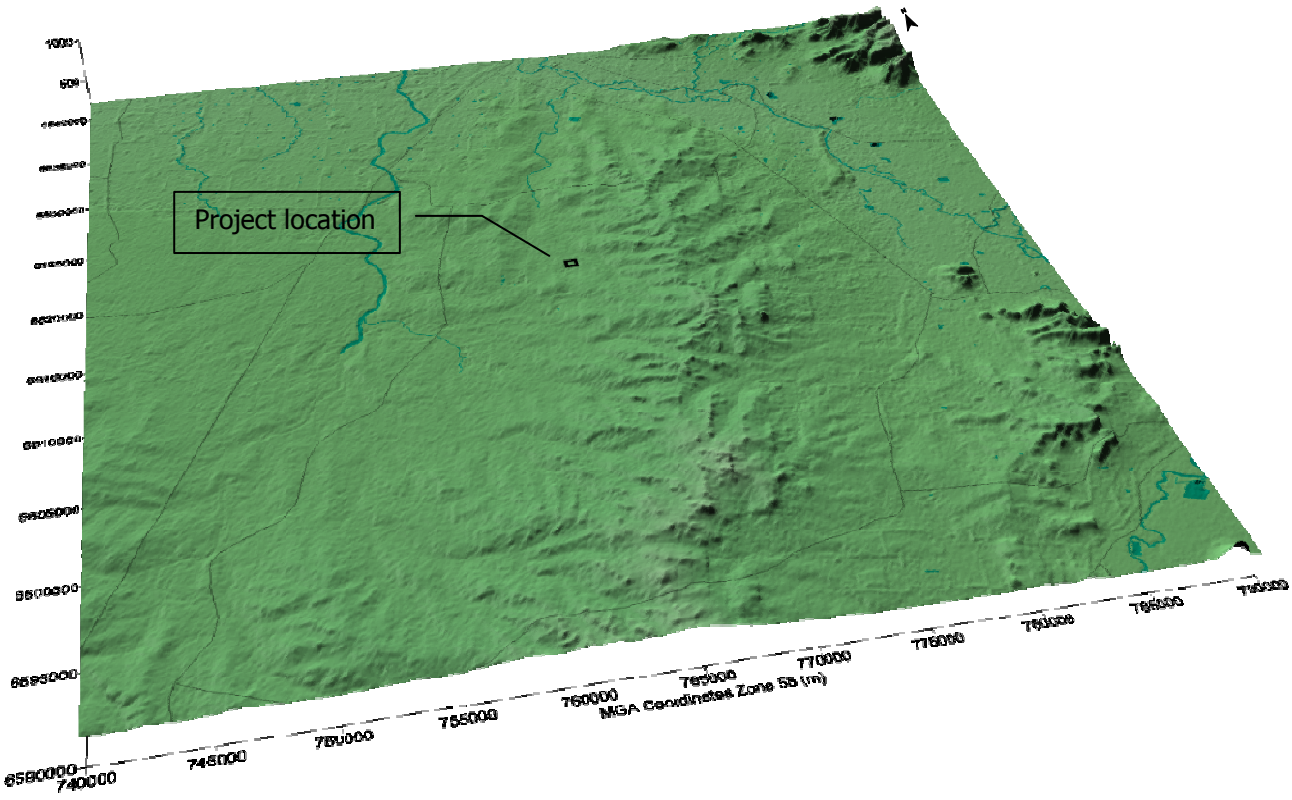


Figure 3-2 presents a three-dimensional representation of the topography in the vicinity of the proposed activity. The terrain is gently undulating to the east and south of the proposed activity, and becomes generally flatter to the northwest.

Figure 3-2 Topography surrounding Project Location



4 AIR QUALITY ASSESSMENT CRITERIA

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. This section identifies the relevant air quality criteria that are applicable to the proposed activity. The air quality goals that are relevant to this study are sourced from the NSW EPA document "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (**NSW DEC, 2005**).

Emissions of carbon monoxide (CO) and nitrogen dioxide (NO_2) can be expected from the combustion and flaring of the CSG.

CO enters the bloodstream and reduces oxygen delivery to the body's organs and tissues, and can impair health due to prolonged exposure at high levels. CO is an odourless gas formed from the partial oxidation of carbon-containing compounds, commonly as a result of incomplete or inefficient combustion of fuels containing carbon. CO in the atmosphere is relatively unstable and reacts with oxygen to form carbon dioxide and ozone.

NO_2 can irritate the lungs and lower resistance to respiratory infections such as influenza. NO_2 belongs to a family of reactive gases called nitrogen oxides (NOx). These gases form when fuel is burned at high temperatures, mainly from motor vehicles, power stations and industrial boilers.

The air quality goals for the relevant criteria pollutants relate to the total pollutant burden in the air and not just the pollutants from the proposed activity, as such, consideration of background pollutant levels is required when using these goals to assess potential impacts. **Table 4-1** shows the impact criteria applied in this assessment.

Table 4-1 NSW EPA Air Quality Impact Assessment Criteria

Pollutant	Averaging Period	Impact	Criterion
Total suspended particulates (TSP)	Annual	Total	90µg/m³
Particulate matter ≤10micrometers (PM10)	Annual	Total	30µg/m³
	24-hour	Incremental	50µg/m³
Deposited dust (DD)	Annual	Total	2g/m²/month
	Annual	Incremental	4g/m²/month
Nitrogen dioxide (NO_2)	1-hour	Total	246µg/m³
Carbon monoxide (CO)	15-minute	Total	100mg/m³
	1-hour	Total	30mg/m³
	8-hour	Total	10mg/m³

Source: NSW DEC, 2005

5 EXISTING ENVIRONMENT

5.1 Local Climate

Long-term climatic data from the Bureau of Meteorology (BoM) weather station at Narrabri West Post Office (Site No. 053030) is used to characterise the local climate in the area of study.

Table 5-1 and **Figure 3-1** present a summary of data from Narrabri West Post Office (Narrabri) collected approximately from 1962 to present.

The data indicates that January is the hottest month with mean maximum temperature of 33.8ºC and July is the coldest month with mean minimum temperature of 3.7ºC.

Humidity levels exhibit variability and seasonal flux across the year. Mean 9am humidity levels range from 57% in October to 84% in June at Narrabri. Mean 3pm humidity levels vary from 37% in October and December to 52% in June.

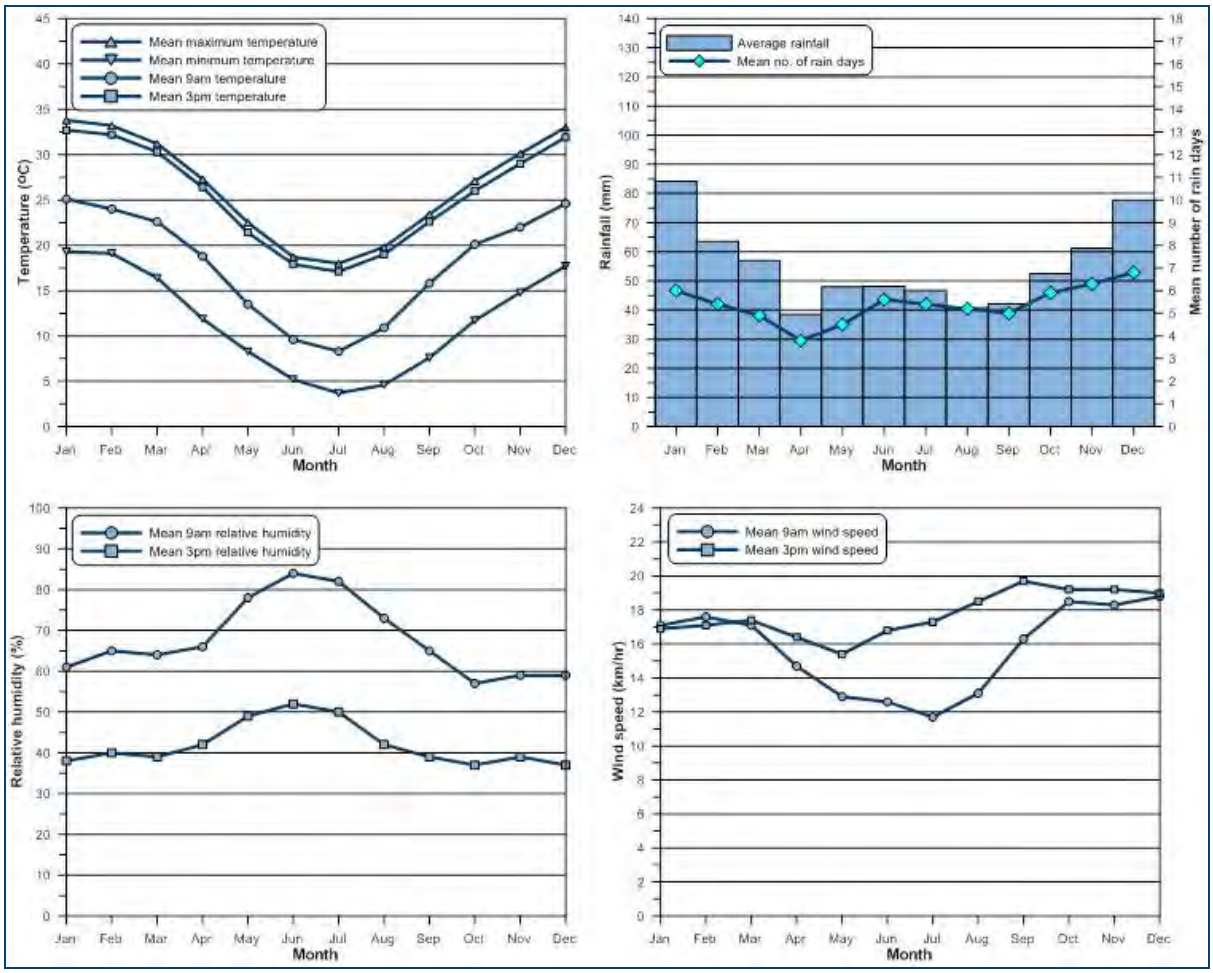
Rainfall generally peaks during the summer months and declines during winter. The data indicates that January is the wettest month with an average rainfall of 84.2mm over 3.7 days at Narrabri. April is the driest month at Narrabri with average rainfalls of 38.6mm over 2.3 days.

Wind speeds at these stations indicate that the colder months tend to have a greater spread between the 9am and 3pm conditions compared to the warmer months. At Narrabri, mean 9am wind speeds range from 11.7km/h in July to 18.8km/h in December and mean 3pm wind speeds range from 15.4km/h in May to 19.7km/h in September.

Table 5-1 Monthly Climate Statistics Summary – Narrabri West Post Office

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Mean max. temperature (ºC)	33.8	33.2	31.2	27.3	22.5	18.7	18.0	19.8	23.4	27.1	30.1	33.0
Mean min. temperature (ºC)	19.3	19.1	16.4	11.9	8.3	5.2	3.7	4.6	7.6	11.7	14.8	17.7
Rainfall												
Rainfall (mm)	84.2	63.6	57.0	38.6	48.0	48.1	46.8	40.7	42.1	52.5	61.2	77.8
Mean No. of rain days (≥1mm)	6.0	5.4	4.9	3.8	4.5	5.6	5.4	5.2	5.0	5.9	6.3	6.8
9am conditions												
Mean temperature (ºC)	25.1	24.0	22.6	18.8	13.5	9.6	8.3	10.9	15.8	20.1	22.0	24.6
Mean relative humidity (%)	61	65	64	66	78	84	82	73	65	57	59	59
Mean wind speed (km/h)	17.1	17.6	17.1	14.7	12.9	12.6	11.7	13.1	16.3	18.5	18.3	18.8
3pm conditions												
Mean temperature (ºC)	32.7	32.2	30.3	26.4	21.4	17.9	17.1	19.0	22.6	26.0	29.0	31.9
Mean relative humidity (%)	38	40	39	42	49	52	50	42	39	37	39	37
Mean wind speed (km/h)	16.9	17.1	17.4	16.4	15.4	16.8	17.3	18.5	19.7	19.2	19.2	19.0

Figure 5-1 Monthly Climate Statistics Summary – Narrabri West Post Office



5.2 Local Meteorology

Suitable local site representative meteorological data for the proposed activity area and its wider surroundings were not available at the time of writing this report. To generate the representative local meteorological data required for this assessment, the meteorological component of The Air Pollution Model (TAPM) was used in accordance with the applicable EPA guidelines (**NSW DEC, 2005**).

TAPM is an incompressible, non-hydrostatic, primitive equation prognostic model with a terrain-following vertical coordinate for three-dimensional simulations. It predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

The TAPM modelling incorporated data assimilation of observations from the BoM weather station at Narrabri Airport (Site No. 054038) which provides the best contemporary hourly data available in the region. The 2008 calendar year was selected for dispersion modelling based on a long-term meteorological analysis for the area which indicated that conditions during 2008 most represented the long-term conditions of the area.

Figure 5-2 presents the annual and seasonal windroses (generated from TAPM output) for the proposed activity location. On an annual basis, winds from the southeast and east-southeast are most frequent with a spread of winds from the other directions.

The summer wind distribution pattern indicates the winds from the east-southeast are most predominant with a portion of winds from the southeast. Autumn shares a similar wind distribution to the annual windrose with winds from the southeast quadrant most common. In winter, winds tend to mainly occur from the southeast and range to the west-southwest. During spring, winds are varied and predominantly occur from east-southeast and north with a lesser portion of winds from the north-northeast and southeast.

Table 5-2 presents a summary of the stability class distribution from the TAPM generated data. This distribution (Class A to Class F) is a measure of the turbulence of the atmosphere with Class A associated with highly unstable or turbulent conditions and Class F related to stable conditions, typically at night. The relatively high frequency of Class E and Class F combined (40.1%) suggests that emissions will disperse slowly for a fair portion of time.

Table 5-2 Stability Class Distribution (TAPM 2008)

Stability Class	Frequency of Stability Class Occurrence (%)
A	3.0
B	11.7
C	15.7
D	29.5
E	12.2
F	27.9

Figure 5-2 Annual & Seasonal Windroses for Dewhurst



5.3 Local Air Quality

5.3.1 Particulate Matter

Suitable site-specific air quality monitoring data are not available to quantify the existing ambient levels at the site. Background ambient monitoring data obtained from the Tamworth NSW EPA monitoring site that measures PM_{10} concentration using a Tapered Element Oscillating Microbalance (TEOM) were analysed and used to characterise the ambient air quality.

The location of this monitoring site is approximately 132km southeast of the proposed activity. Due to the presence of human activity, including residential areas, traffic, major highways and industry, the Tamworth monitoring location is likely to experience higher levels of pollutants than the areas in the vicinity of the site, which is largely rural and undeveloped. Therefore the use of the Tamworth data to represent local air quality is likely to be conservative as it may overestimate the likely levels of air pollutants.

A summary of the annual average PM_{10} monitoring data collected during 2010-2012 at the Tamworth monitoring site is presented in **Table 5-3**. The monitoring data show the annual average PM_{10} concentrations at this monitoring site are below the 30µg/m³ criterion. As a conservative measure the maximum annual average value of 15.9µg/m³ is applied to represent background levels for the proposed activity.

Table 5-3 Summary of Annual PM10 Concentrations from Tamworth NSW EPA Monitoring Site (µg/m³)

Year	PM_{10} Concentration
2010	12.0
2011	13.1
2012	15.9

There are no readily available site specific TSP and deposited dust monitoring data for the proposed activity. The NSW EPA monitoring site does not measure these components; however estimates of the background levels for the site are required to assess the impacts per the criteria presented in **Section 4**.

Estimates of the annual average background total suspended particulates (TSP) concentrations can be determined from a relationship with measured PM_{10} concentrations. This relationship assumes that 40% of the TSP is PM_{10}, and was developed as part of a review of ambient monitoring data collected by co-located TSP and PM_{10} monitors in Hunter Valley (**NSW Minerals Council, 2000**).

Applying this relationship to the annual average PM_{10} concentration of 15.9µg/m³ from the Tamworth monitor estimates an annual average TSP concentration of the order of 39.7µg/m³.

To estimate annual average dust deposition levels, a similar process to the method used to estimate TSP concentrations is applied. This approach assumes that a TSP concentration of 90µg/m^3 will have an equivalent dust deposition value of 4g/m²/month.

This relationship indicates a background annual average dust deposition of 1.8g/m²/month for the area surrounding the proposed activity.

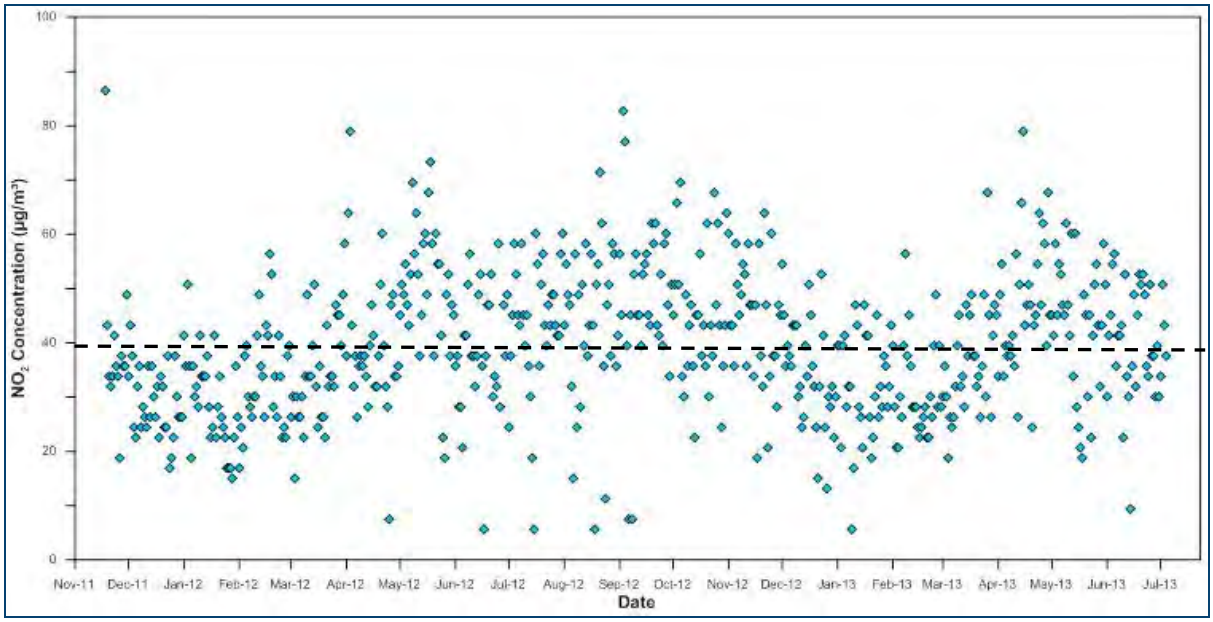
5.3.2 Nitrogen dioxide

Suitable site-specific NO_2 data was not available to quantify the existing ambient levels at the site. Background ambient NO_2 data obtained from the closest suitable site at Muswellbrook NSW EPA monitoring site (approximately 215km from Narrabri). Due to the presence of human activity, including residential areas, traffic, major highways and industry, the Muswellbrook monitoring location is likely to experience higher levels of NO_2 pollutants than the areas in the vicinity of the site, which is largely rural and undeveloped. Therefore the use of the Muswellbrook data to represent local ambient NO_2 levels is likely to be conservative as it may overestimate the likely levels of air pollutants.

Figure 5-3 presents the maximum daily 1-hour average NO_2 concentrations from the Muswellbrook NSW EPA monitoring sites from November 2011 to July 2013. The reviewed monitoring data indicate that there were no exceedances of the NSW EPA 1-hour average goal of 246µg/m³ during this period at the monitor.

The data in **Figure 5-3** indicate that levels of NO_2 are relatively low compared to the criterion level and show a seasonal fluctuation.

Figure 5-3 Daily 1-hour Maximum NO_2 Concentrations – Muswellbrook



The maximum 1-hour background NO_2 levels measured at Muswellbrook during November 2011 to July 2013 is 86.48µg/m³ (1 hour average); with the average being 40 µg/m³ (1 hour average).

5.3.3 Carbon Monoxide

Suitable site-specific CO data was not available to quantify the existing ambient levels at the site. The NSW EPA monitoring sites at Tamworth or Muswellbrook do not record ambient concentrations of CO. Combustion activities are the cause of CO emissions and spatially there is very little such activity in the area apart from power generation, motor vehicles and wood heaters. Therefore, ambient concentrations of CO are expected to be low (ie <0.02 µg/m³ (8hour average)) which is consistent with NO_2 monitoring results.

6 APPROACH TO ASSESSMENT

6.1 Emission Estimation

6.1.1 Construction

For the construction phase of the proposed activity, minor works would be required including; the levelling of the drill pad, the installation of additional surface facilities and equipment, excavation of a cellar pit, drilling and surface clearing.

During the construction phase of the proposed activity, air emissions generated would generally comprise of particulate matter associated with the earthworks. Other emissions would occur from the exhaust of plant equipment required for the construction phase, these emissions are generally considered to be too low to generate any significant pollutant concentrations in the vicinity of the proposed activity and have not been assessed further in this study.

The activities associated with the vehicle travel on unsealed surfaces, drilling, excavation and wind erosion are identified as the significant sources of particulate matter generation. Dust emission estimates from the construction operations have been made using emission factors developed both locally and by the US EPA.

Table 6-1 and **Table 6-2** presents the estimated TSP emissions for the construction phase associated with the Dewhurst 30/31 and Dewhurst 13-18H, respectively. Further details regarding each of the emissions estimation techniques applied to estimate the TSP emissions are provided in **Appendix A**.

Table 6-1 Estimated Emissions for Construction Operations – Dewhurst 30/31

Activity	TSP emissions (kg/year)
Travel to site	5,043
Travel between Dewhurst 30 and Dewhurst 31	470
Excavating material	2
Drilling	4
Wind erosion of exposed areas	12,334
Total	**17,854**

Table 6-2 Estimated Emissions for Construction Operations – Dewhurst 13-18H

Activity	TSP emissions (kg/year)
Travel to site	4,827
Travel between Dewhurst 13-18H and Dewhurst 30/31	588
Excavating material	3
Drilling	5
Wind erosion of exposed areas	7,604
Total	**13,027**

These estimated emissions consider that the construction phase would occur for a full year, whereas it is proposed to take approximately 5-6 months. The impact due to these activities is difficult to accurately quantify due to the short sporadic periods of dust generating activity that may occur over the construction time frame. The sources are considered temporary in nature and would be confined to the construction period.

Given that the activities would occur for a limited period, it is unlikely that there would be any significant or prolonged impact off-site.

It should also be noted that as a conservative approach, no consideration of dust controls have been applied to the estimation of dust emissions during activities. The Project includes a limited period of construction activity and would have limited capacity to influence air quality to any significant degree.

6.1.2 Operation phase

For the operation phase, air emissions associated with the flare operation were calculated based on the flare exhaust flow rate and estimated stack concentrations.

It is noted that in addition to CO and NO_2 formation, a small amount of particulate matter (<10µg diameter, referred to as PM_{10}) may be generated from the combustion operation. Considering the surrounding activities in the local area, it is unlikely that the proposed flare operation will make any significant contribution to an increase in the PM_{10} level in the surrounding areas during operation and therefore has not been investigated in this assessment.

Typically, NOx emissions emitted from flares consist for the larger part (>95%) of nitrogen monoxide (NO) and for a small part (<5%) of NO_2. After emission from the stack, NO is converted to NO_2 through oxidation with atmospheric ozone (O_3) (**Janssen et al, 1988**). The rate of this reaction is governed by the level of ozone in the air, air dispersion and other meteorological factors such as temperature. The reaction are complicated and most pronounced in urban areas with high ozone and other levels of pollution which do not generally arise in this situation.

The modelled stack parameters and emission rate of the Dewhurst 14 and Dewhurst 28 flare units included in the modelling is presented in **Table 6-3** and **Table 6-4,** respectively.

Table 6-3 Stack Parameters & Estimated Emissions for the Dewhurst 14 Flare

Parameter	Value	Units
Stack height	4.5	m
Stack diameter	0.3	m
Exit velocity	21.93	m/s
Exit temperature	750	ºC
Gas flow rate*	5.81	Am^3/s
Gas flow rate**	1.55	Nm^3/s
NO_2 emission rate	0.008	g/s
CO emission rate	0.19	g/s

* A - Actual **N - Nominal 0 ºC

Table 6-4 Stack Parameters & Estimated Emissions for the Dewhurst 28 Flare

Parameter	Value	Units
Stack height	4	m
Stack diameter	0.3	m
Exit velocity	13.16	m/s
Exit temperature	750	ºC
Gas flow rate*	3.48	Am^3/s
Gas flow rate**	0.93	Nm^3/s
NO_2 emission rate	0.0048	g/s
CO emission rate	0.12	g/s

* A - Actual **N - Nominal 0 ºC

6.1.3 NO_x to NO_2 conversion

For this assessment, the NO_x to NO_2 was estimated using an empirical equation for estimating the oxidation rate of NO in power plant plumes as outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**) and developed by **Janssen et al. (1988)**. This method consists of calculating the ratio of NO_2 to NO_x as determined by the atmospheric conditions and distance from the maximum recorded level to the source.

As per this method, a Level 1 assessment was carried out adding maximum prediction and maximum background concentrations to predict the total impact of NO_2. The predicted maximum impacts were recorded approximately 0.26km from the source during summer. Using this distance the ratio of NO_2 to NO_x at receptors due to the flare operations was calculated to be approximately 3%.

6.2 Modelling methodology

The AUSPLUME dispersion model in conjunction with a TAPM generated meteorological data file (described in **Section 5.2**) provides predictions of the ground level concentrations of pollutants based on the emission estimation provided in **Section 6.1**.

Sources modelled for the operational scenario were modelled as point sources. **Appendix B** provides a sample of AUSPLUME output file.

7 ANALYSIS OF MODELLING RESULTS

7.1 Construction Impacts

This section presents the predicted impacts on air quality arising from dust emissions generated during the construction process for each relevant dust metric. **Figure 7-1** to **Figure 7-4** and **Figure 7-5** to **Figure 7-8** presents isopleths of the spatial distribution of predicted incremental impacts over the modelling domain for maximum 24-hour average PM_{10}, annual average PM_{10}, TSP and deposited dust levels for construction activities occurring at Dewhurst 13-18H and Dewhurst 30/31, respectively.

Table 7-1 presents the predicted incremental and total impacts at each of the sensitive receptor locations due to construction activities.

Table 7-1 Predicted Incremental & Total Concentrations at Sensitive Receptors – Construction Activities

Receptor ID	PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental Impact				**Total Impact**		
	24-hour Average	**Annual Average**	**Annual Average**	**Annual Average**	**Annual Average**	**Annual Average**	**Annual Average**
	Air Quality Impact Criteria						
	50	**-**	**-**	**2**	**30**	**90**	**4**
RR1	0.15	0.01	0.02	<0.01	15.91	39.72	1.80
RR2	0.15	0.02	0.02	0.01	15.92	39.72	1.81
RR3	0.23	0.02	0.03	0.01	15.92	39.73	1.81
RR4	1.65	0.13	0.20	0.12	16.03	39.90	1.92
RR5	0.25	0.04	0.06	0.02	15.94	39.76	1.82
RR6	0.25	0.04	0.05	0.02	15.94	39.75	1.82
RR7	0.25	0.05	0.06	0.03	15.95	39.76	1.83
RR8	0.21	0.04	0.05	0.02	15.94	39.75	1.82
RR9	0.32	0.05	0.05	0.02	15.94	39.75	1.82
RR10	0.04	<0.01	<0.01	<0.01	15.90	39.70	1.80
RR11	0.05	0.01	0.01	<0.01	15.91	39.71	1.80
RR12	0.06	0.01	0.01	<0.01	15.91	39.71	1.80
RR13	0.05	0.01	0.01	<0.01	15.91	39.71	1.80
RR14	0.05	0.01	0.01	<0.01	15.91	39.71	1.80

The predicted results show minimal incremental impacts during the construction period at the sensitive receptors. Therefore, it is unlikely that the existing PM_{10}, TSP or dust deposition levels at any sensitive receptor will significantly change during this time.

The estimated background levels in **Section 5.3** were added to the predicted incremental levels to assess potential total impacts at the sensitive receptors. The predicted total results for PM_{10}, TSP and dust deposition are also below the relevant NSW EPA criteria at the sensitive receptors.

The predicted dust levels at the sensitive receptors due to activities occurring at Dewhurst 30/31 indicate negligible levels of impact (see **Figure 7-5** to **Figure 7-8**). This is largely due to the low level of dust generation due to construction activities and the large spatial displacement between the construction activities and the sensitive receptors.

Additionally the impact on the nearby sensitive receptors is likely to be lower than predicted due to the vegetation between the site and receptors. Studies have shown that significant vegetation barriers can reduce dust emissions by up to 30% (**Warren, 1973**). The modelling completed for this assessment has not taken into account any mitigation from the vegetation buffer.

Figure 7-1 Predicted Maximum 24-hour Average Incremental PM_{10} Concentrations (µg/m³) – Dewhurst 13-18H

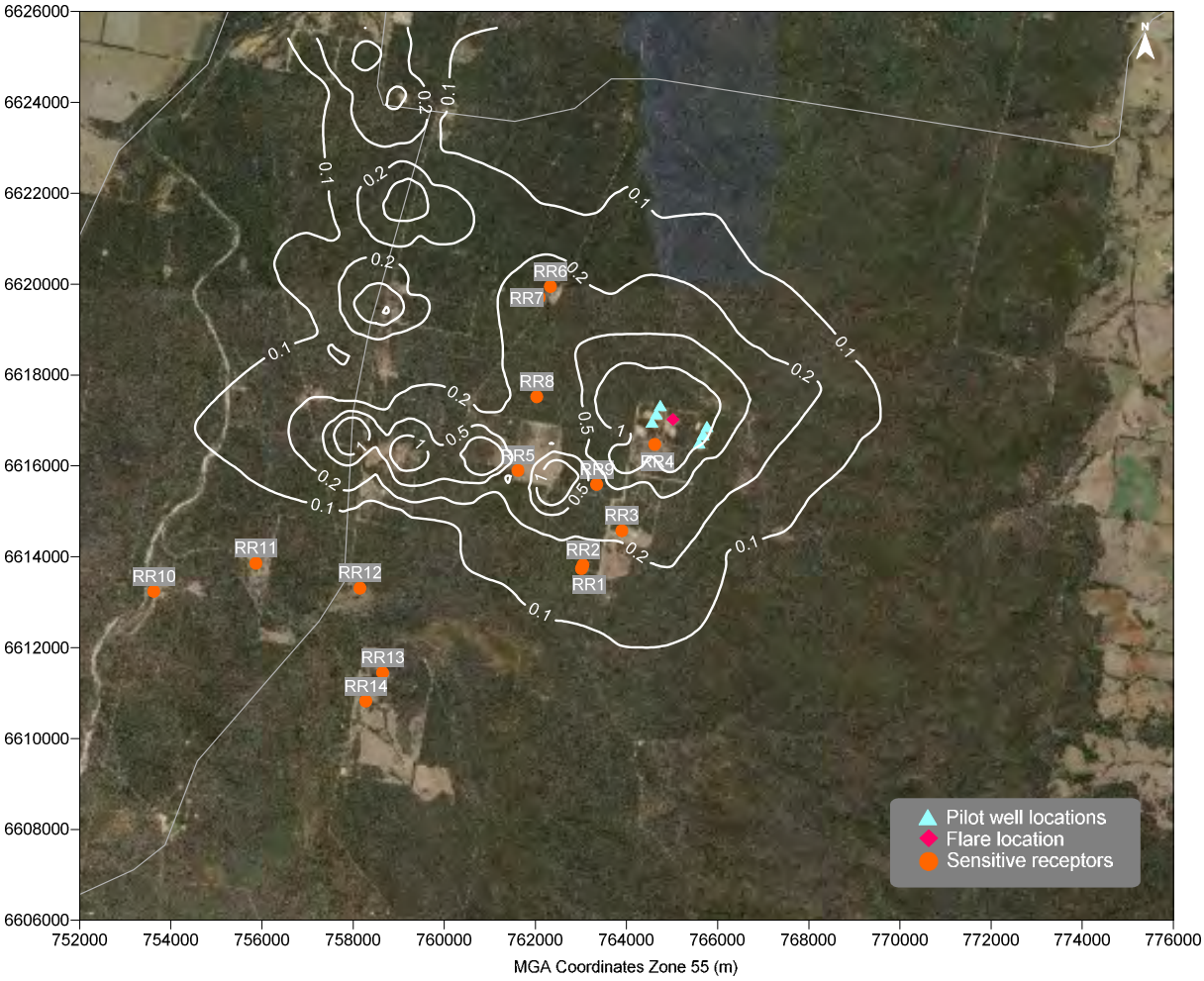


Figure 7-2 Predicted Annual Average Incremental PM_{10} Concentrations (µg/m³) – Dewhurst 13-18H

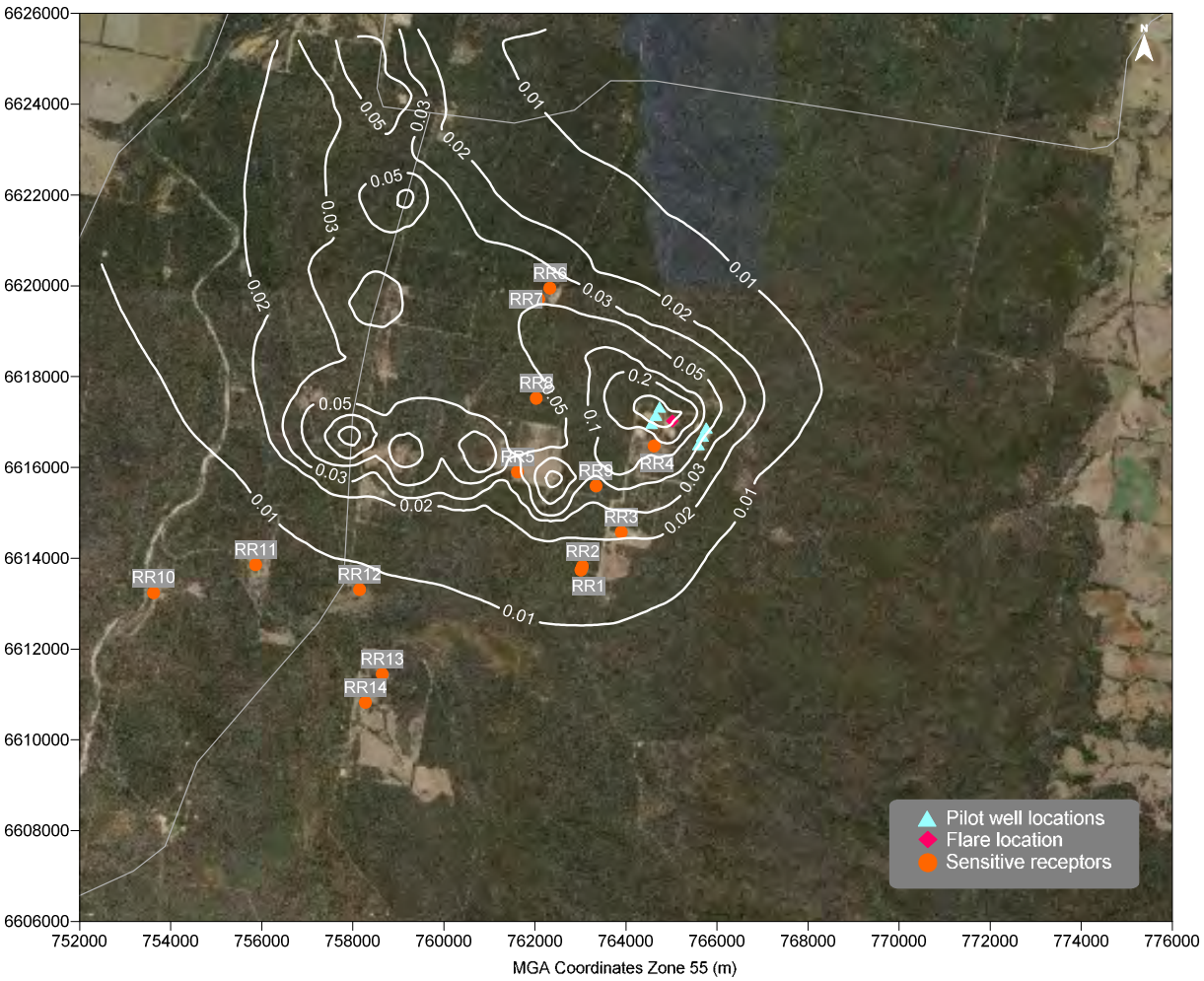


Figure 7-3 Predicted Annual Average Incremental TSP Concentrations (µg/m³)– Dewhurst 13-18H

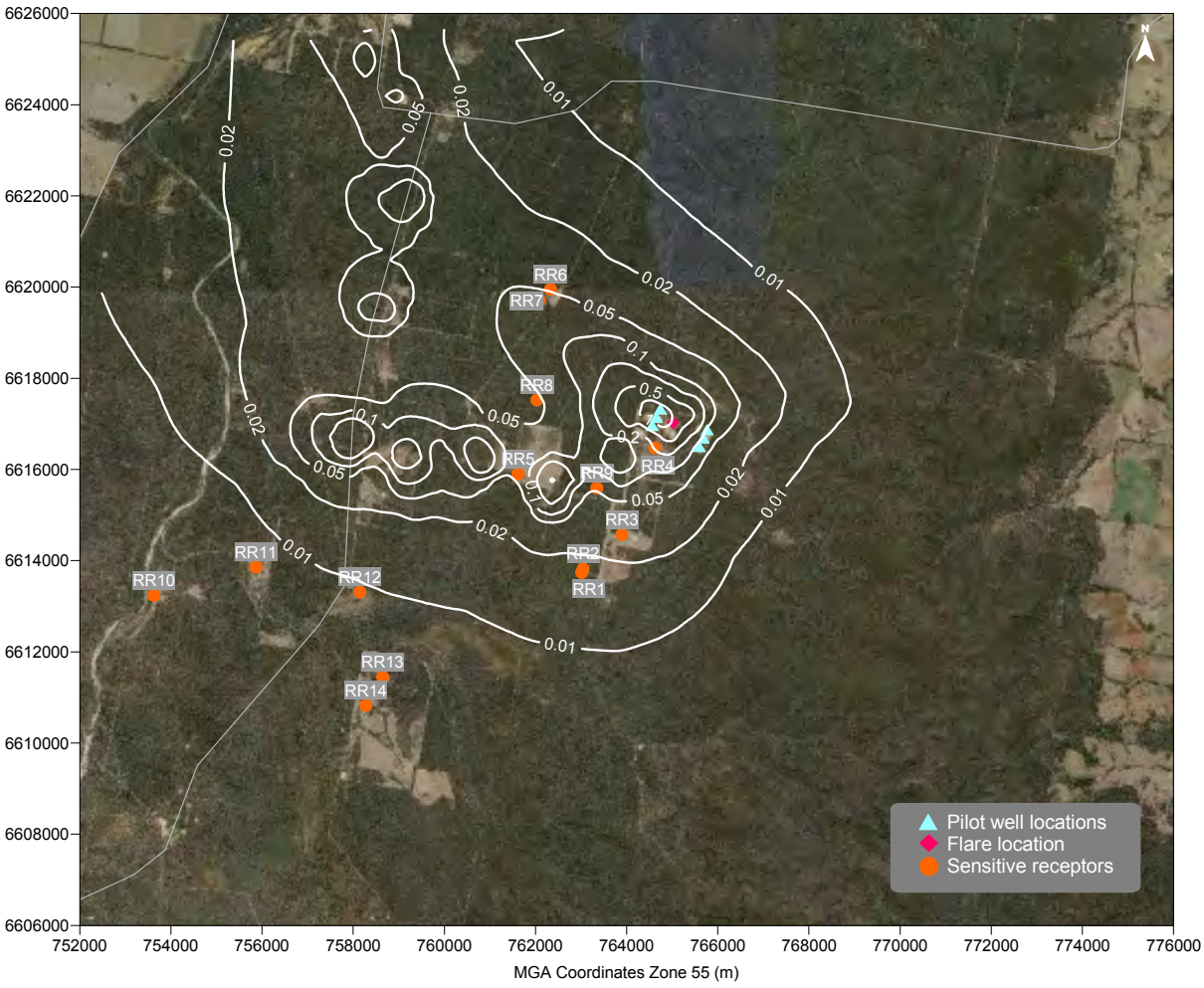


Figure 7-4 Predicted Annual Average Incremental Dust Deposition Levels (g/m²/month) – Dewhurst 13-18H

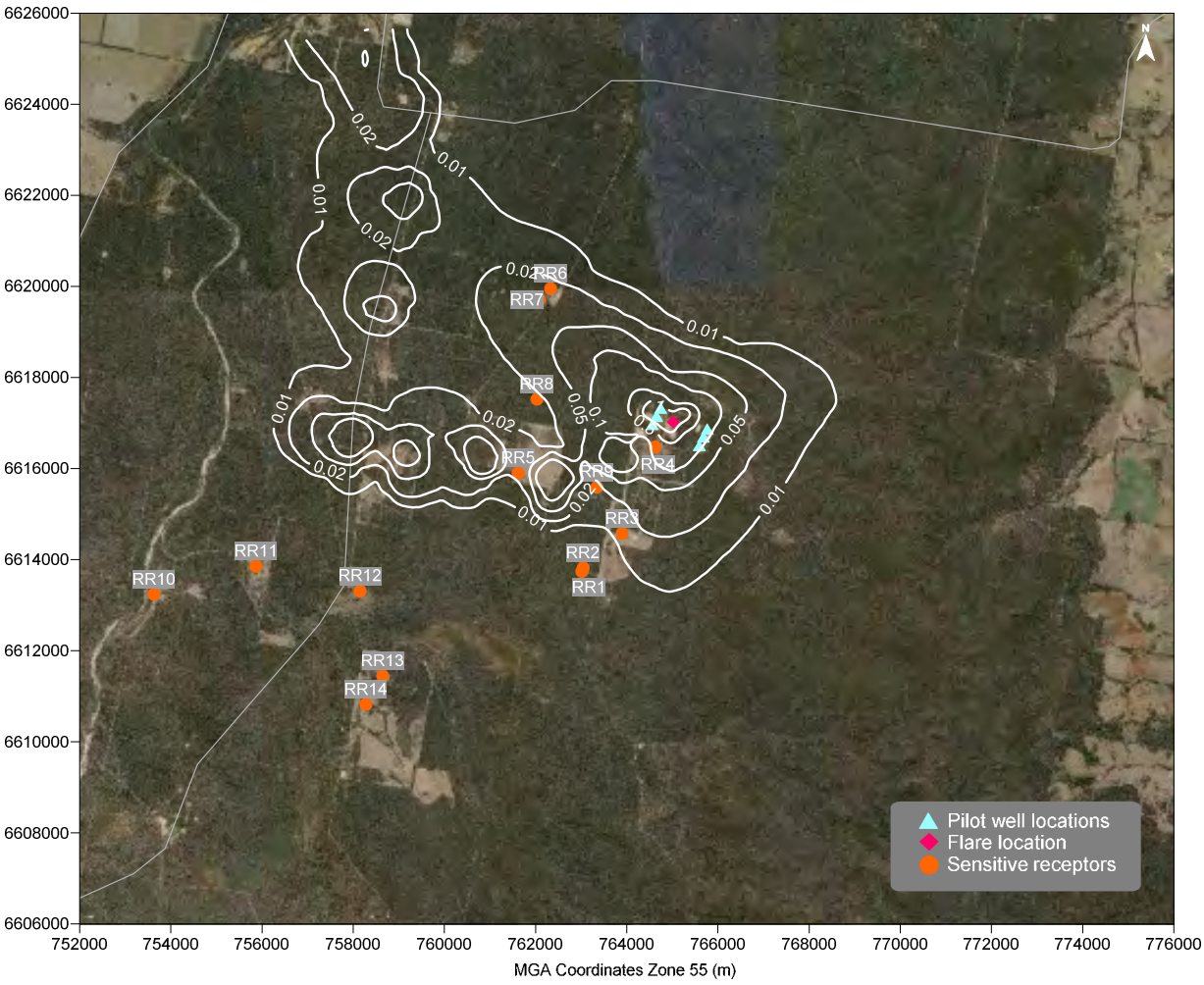


Figure 7-5 Predicted Maximum 24-hour Average Incremental PM_{10} Concentrations (µg/m³) – Dewhurst 30/31

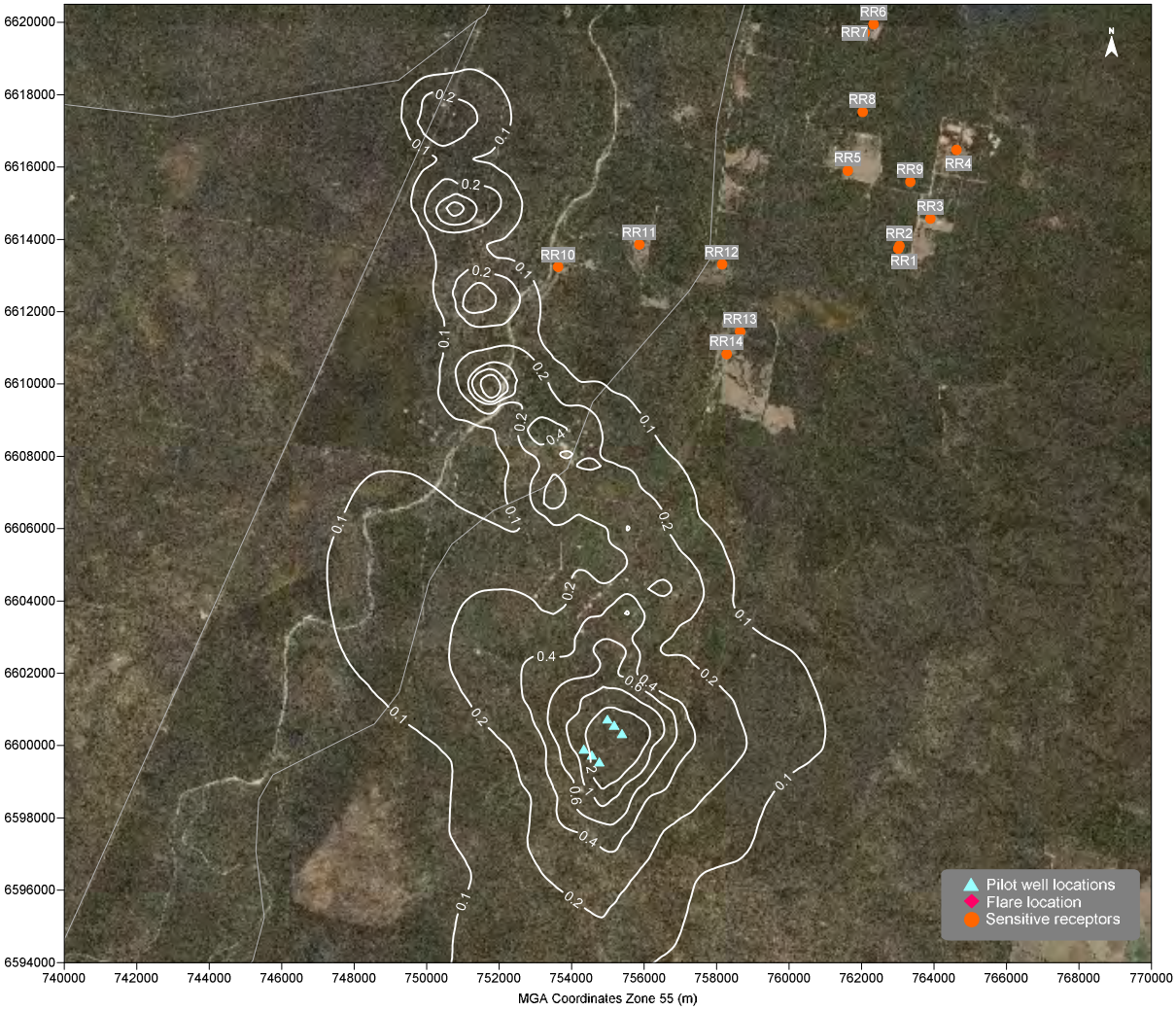


Figure 7-6 Predicted Annual Average Incremental PM_{10} Concentrations (µg/m³) – Dewhurst 30/31

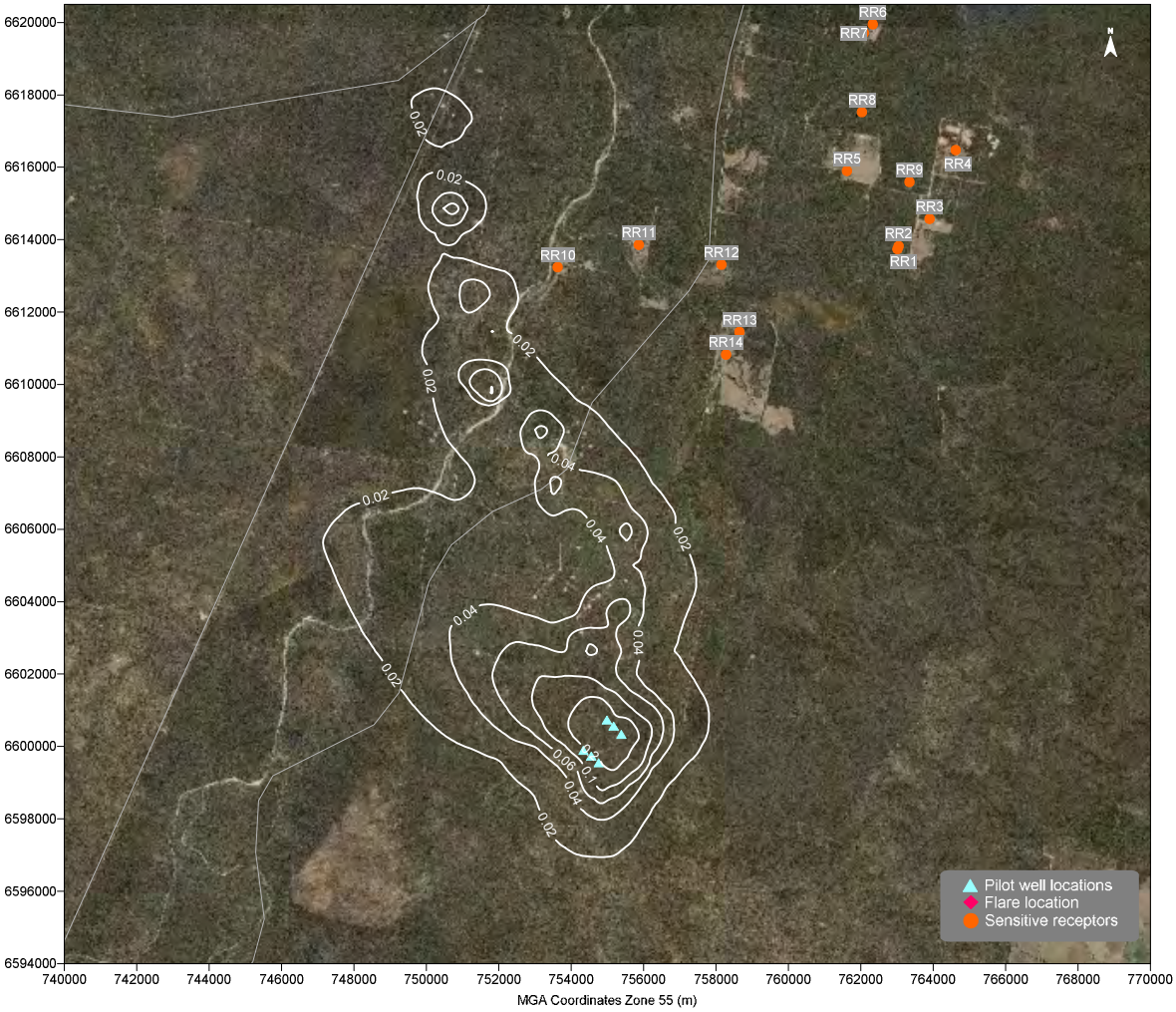


Figure 7-7 Predicted Annual Average Incremental TSP Concentrations (µg/m³)– Dewhurst 30/31

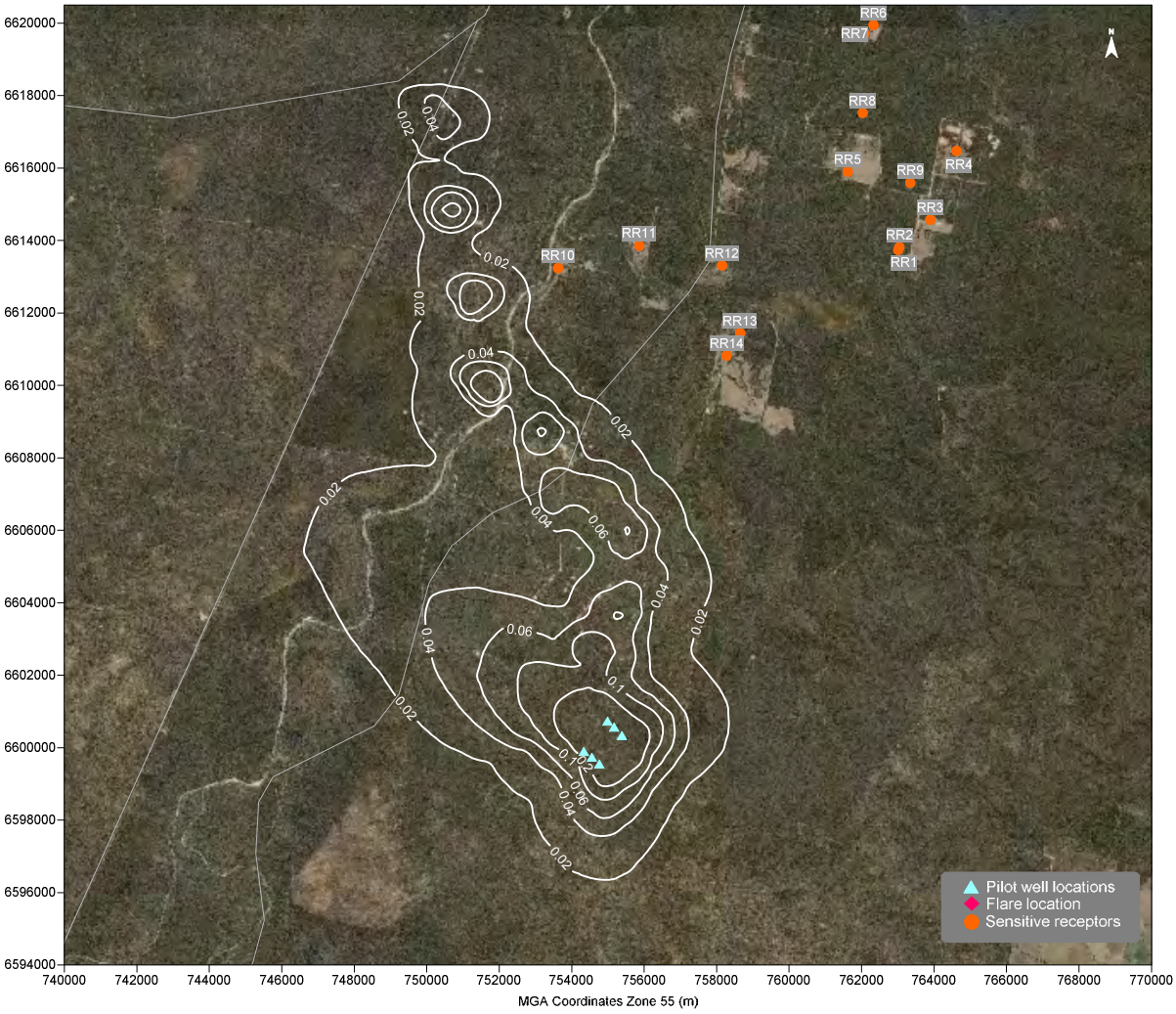
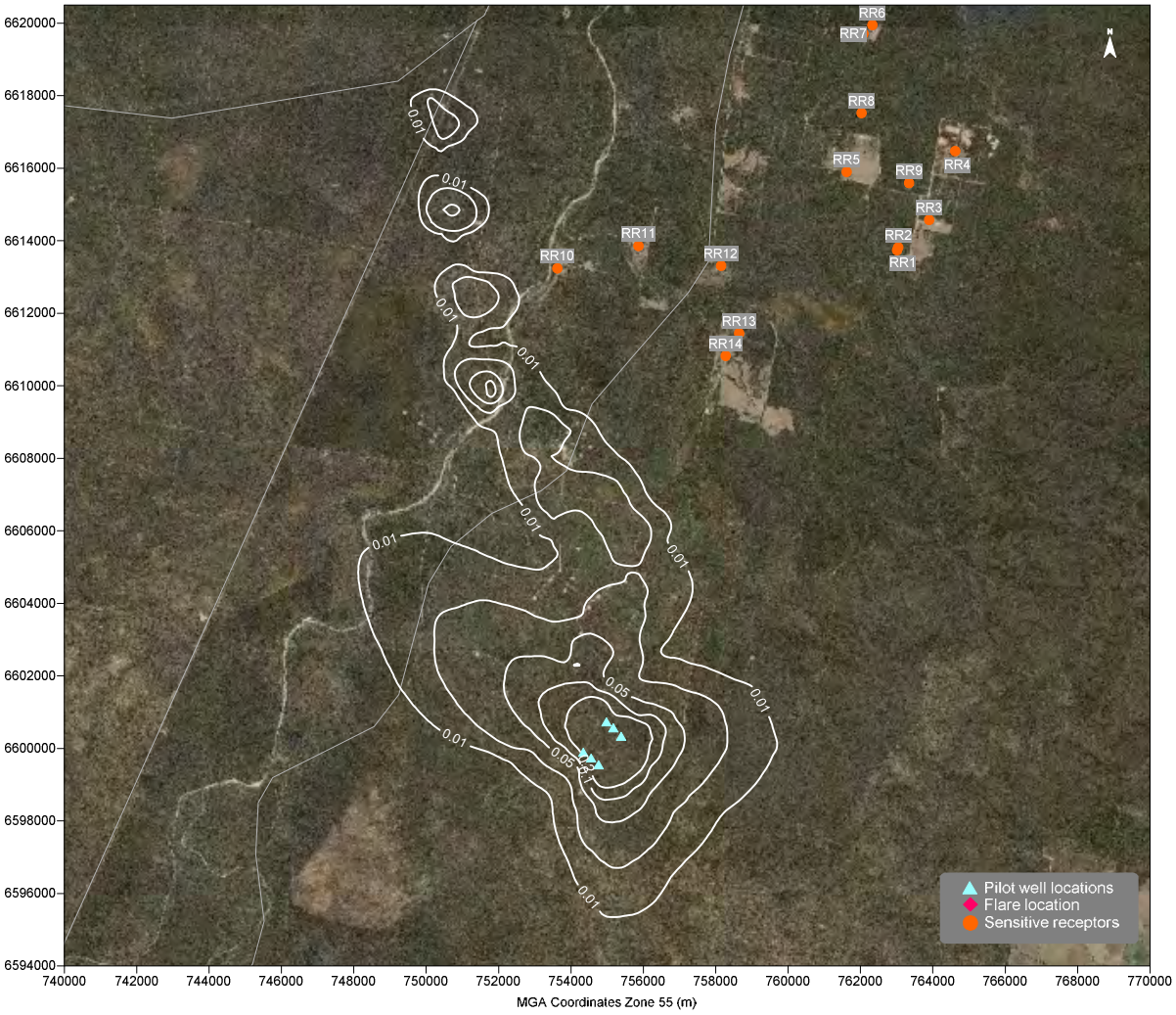


Figure 7-8 Predicted Annual Average Incremental Dust Deposition Levels (g/m²/month) – Dewhurst 30/31



7.2 Operational impacts from Dewhurst 14 and Dewhurst 28 Flares

The spatial distribution of the dispersion model predictions for NO_2 and CO are presented as contour plots in **Figure 7-9 to Figure 7-12** for the operation of the flares at Dewhurst 14 and Dewhurst 28. Each of the sensitive receptors was assessed individually as discrete receptors with the results presented in tabular form for the privately owned receptors.

Analysis of the predicted NO_2 and CO impacts presented in **Figure 7-9** to **Figure 7-12** shows minimal impact at all sensitive receptors.

Table 7-2 presents the predicted incremental NO_2 and CO impacts from the proposed flare operations at Dewhurst 14 at the surrounding sensitive receptors. It can be observed from **Table 7-2** that predicted incremental impacts from the proposed operation are low.

With the addition of the maximum 1-hour background NO_2 levels measured at Muswellbrook during November 2011 to July 2013 of 86.48µg/m³, the total predicted impact at the sensitive receptors would remain below the respective criterion level.

It is noted that site specific CO monitoring is not available for this assessment. However comparison of the predicted incremental CO concentrations with the NSW EPA criteria for CO shows that the proposed activity contribution would be significantly below the criteria. It is unlikely that existing background levels of CO would be approaching the criteria levels, which would result in any exceedance.

Therefore the maximum impacts due to the proposed Dewhurst 14 flare operation would not exceed the NSW EPA criteria for NO_2 and CO in surrounding areas, even at the nearest sensitive receiver (RR4), located within one kilometre of the flare.

Table 7-2 Predicted Incremental Concentrations at Sensitive Receptors – Operation of the Dewhurst 14 Flare and 28 Flare

Receptor ID	NO_2		CO	
	1-hour Average	**15-minute Average**	**1-hour Average**	**8-hour Average**
	Air Quality Impact Criteria (µg/m³)			
#	**246**	**100**	**30**	**10**
RR1	0.0987	0.00309	0.00234	0.00155
RR2	0.1015	0.00318	0.00241	0.00159
RR3	0.1408	0.00441	0.00334	0.00221
RR4	0.2426	0.00760	0.00576	0.00380
RR5	0.0884	0.00277	0.00210	0.00138
RR6	0.0776	0.00243	0.00184	0.00122
RR7	0.0846	0.00265	0.00201	0.00133
RR8	0.1051	0.00329	0.00250	0.00165
RR9	0.1553	0.00487	0.00369	0.00243
RR10	0.0287	0.00090	0.00068	0.00045
RR11	0.0366	0.00115	0.00087	0.00057
RR12	0.0373	0.00117	0.00089	0.00058
RR13	0.0326	0.00102	0.00077	0.00051
RR14	0.0305	0.00095	0.00072	0.00048

Figure 7-9 Predicted Incremental 1-hour Average NO_2 Concentrations (µg/m³) from operation of the Dewhurst 14 and Dewhurst 28 Flares

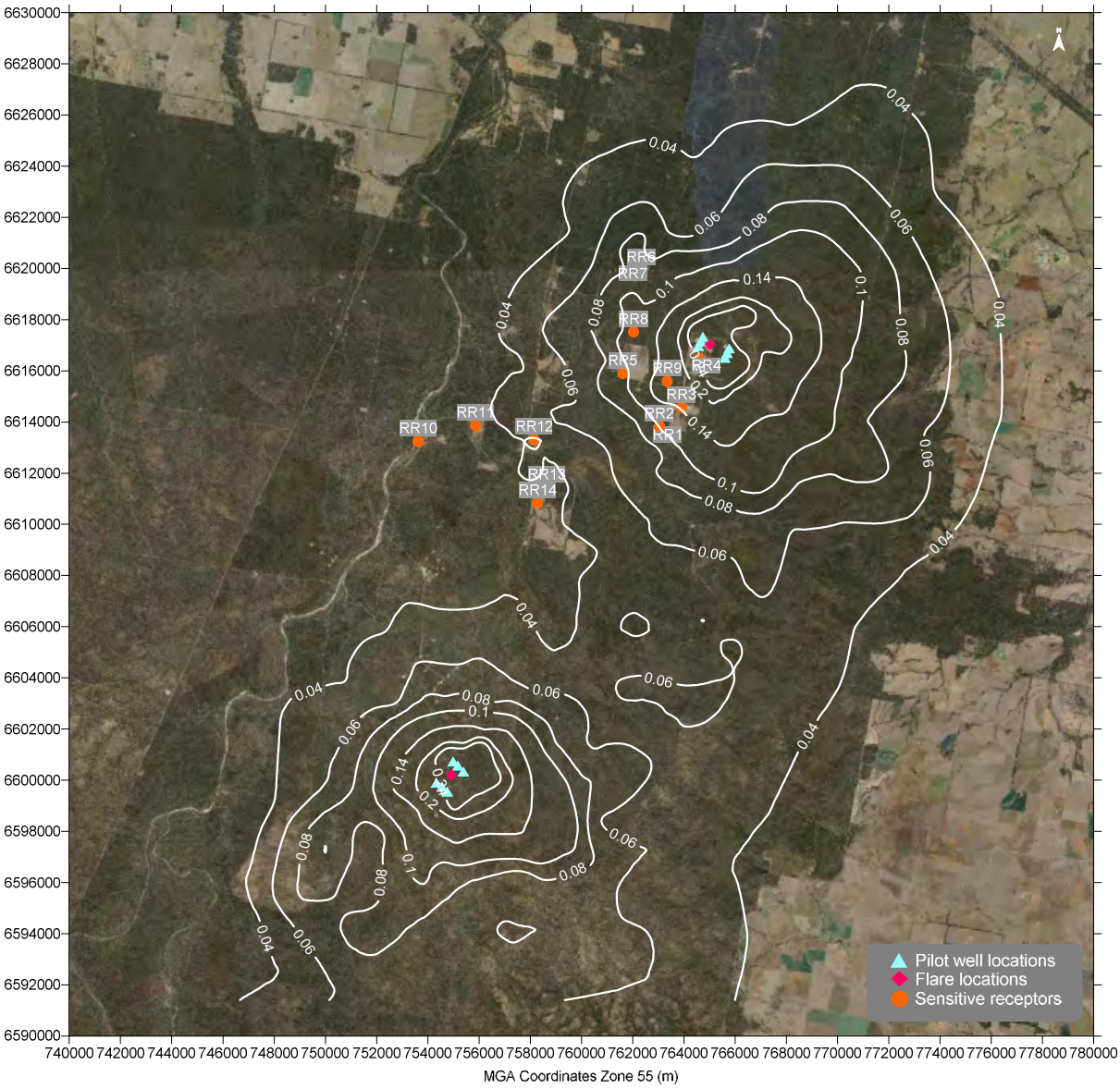


Figure 7-10 Predicted Incremental 15-minute Average CO Concentrations (mg/m³) from operation of the Dewhurst 14 and Dewhurst 28 Flares.

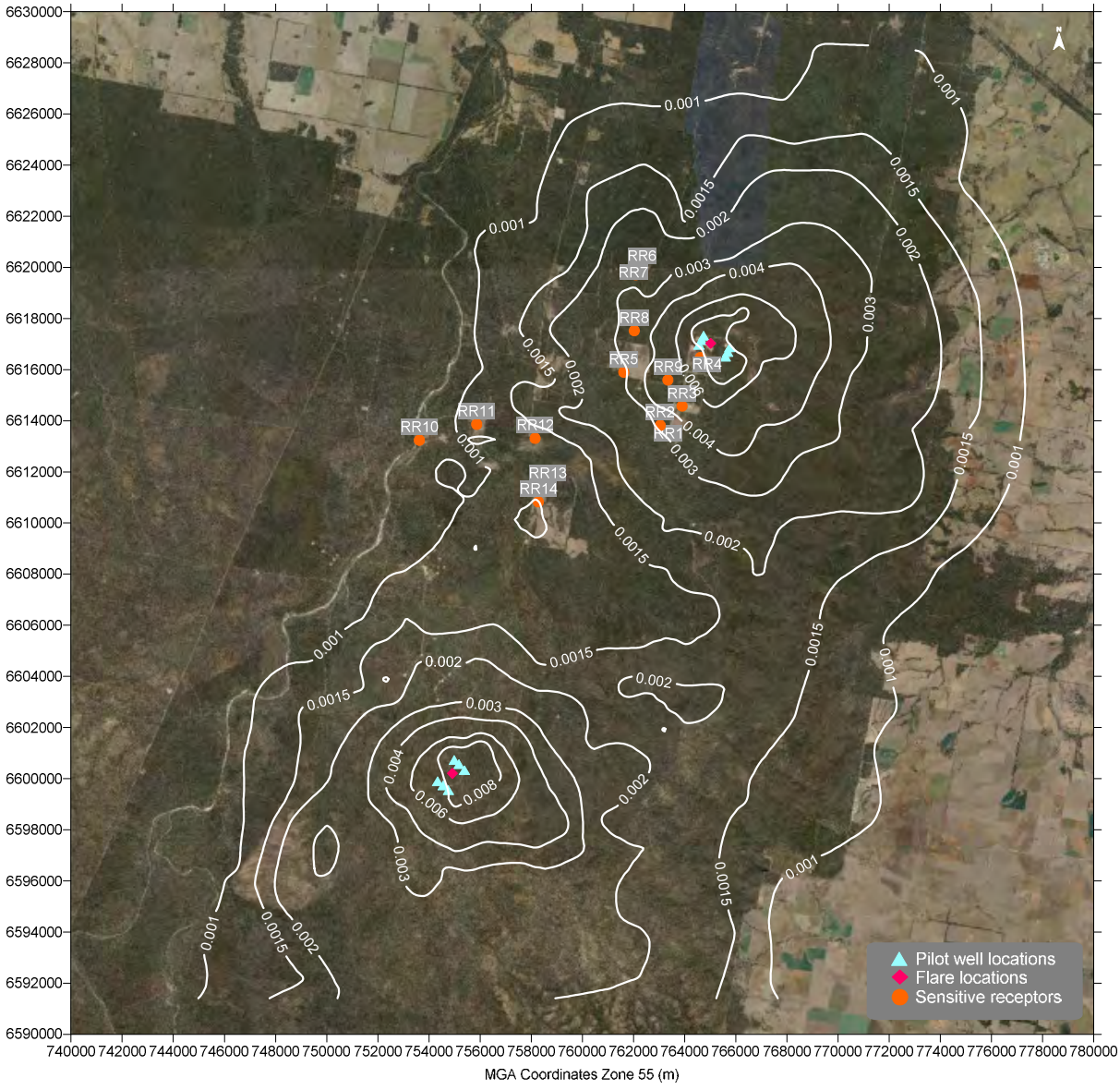


Figure 7-11 Predicted Incremental 1-hour Average CO Concentrations (mg/m³) from operation of the Dewhurst 14 and Dewhurst 28 Flares.

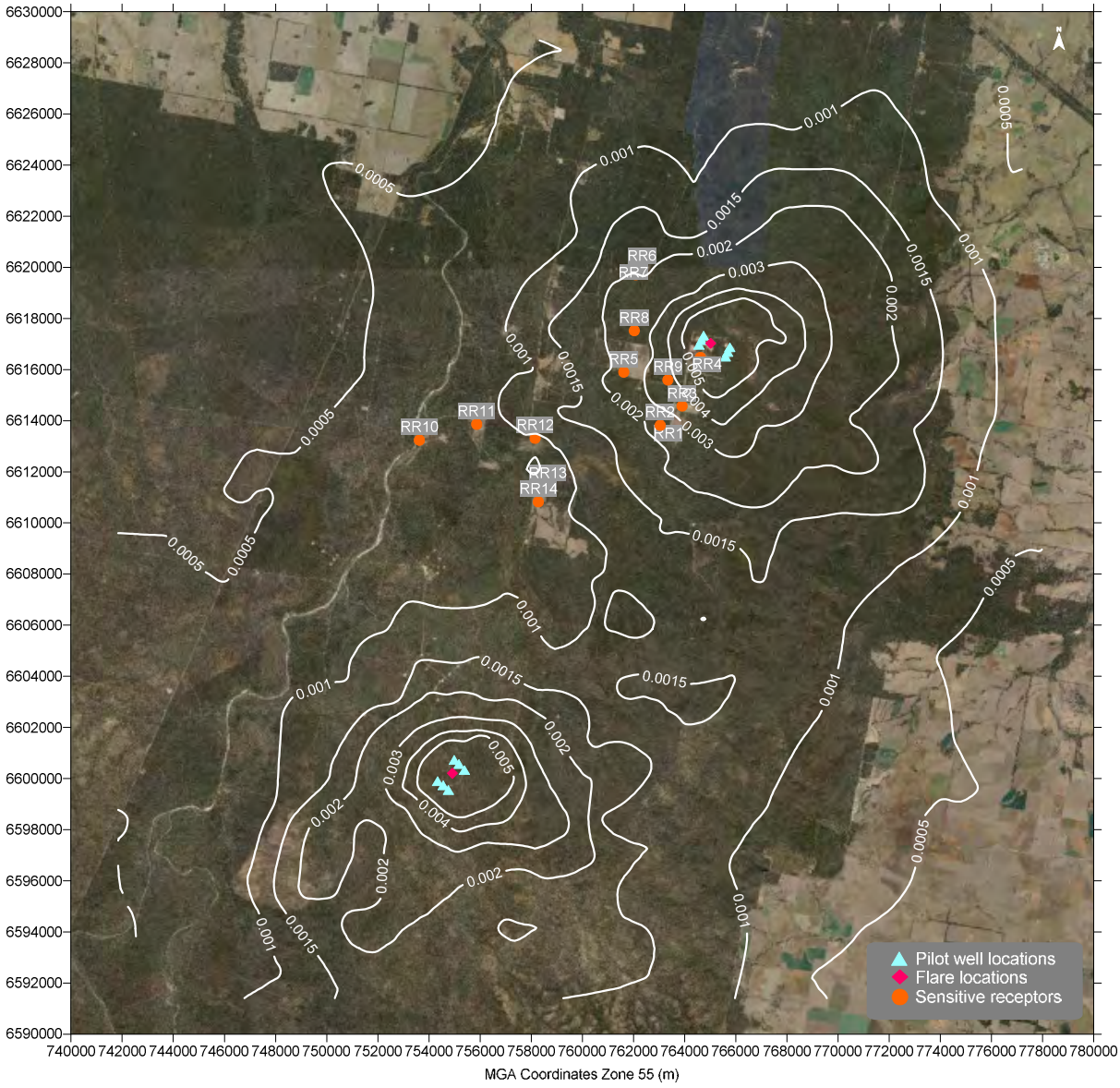
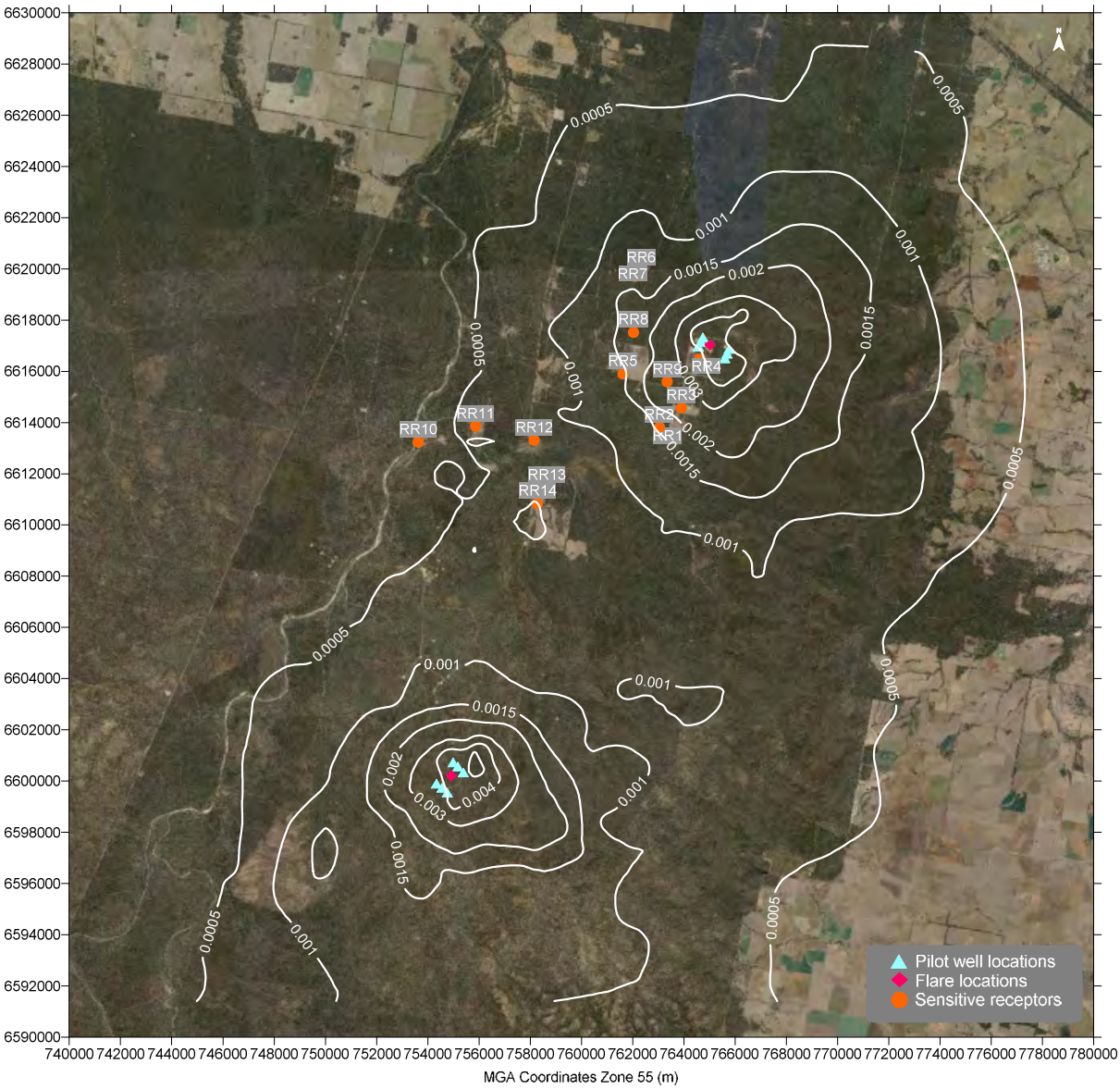


Figure 7-12 Predicted Incremental 8-hour Average CO Concentrations (mg/m³) from operation of the Dewhurst 14 and Dewhurst 28 Flares.



7.2.1 Consideration of Potential Cumulative Impacts

Analysis of the predicted incremental NO_2 and CO impacts for the proposed activity shows minimal impact at all sensitive receptors due to low incremental pollutant levels from the proposed flares.

It is noted that in the vicinity of the proposed activity there are potentially other sources of NO_2 and CO emissions originating from on-site plant equipment, site vehicles, small generators and other flaring operations. These sources are unlikely to generate significant amounts of NO_2 and CO and would be located away from the nearby sensitive receptors to allow sufficient dilution.

Cumulative emissions from flaring and Wilga Park Power Station are insignificant. The reasons for the insignificant cumulative impact are due to the fact that the sources of air emission relating to the proposed activity i.e. Dewhurst 14 and Dewhurst 28 flares have:

- low incremental pollutant levels from the proposed flares; and
- there are large distances between all the different sources.

The other operating flares would emit at similar rates to the proposed flare. Based on the predicted very low incremental levels for the proposed flare, very large distances between the flares and sensitive receivers, and the conservative nature of the assessment approach, it would be unlikely for any potential cumulative impacts to occur at the sensitive receptors. For example:

- Wilga Park Power Station is approximately 38 km north of Dewhurst 28 and 23 km northwest of Dewhurst 14;
- the Bibblewindi flare is approximately 8 km northwest of Dewhurst 28 and approximately 13 km southwest of Dewhurst 14; and
- the proposed Tintsfield flare is approximately 35 km north of Dewhurst flare and approximately 23 km northwest of Dewhurst 14 flare.

8 MITIGATION MEASURES

The site activities will generate dust, therefore it is prudent to take reasonable and practicable measures to prevent or minimise dust emissions into the surrounding environment.

The primary dust sources identified from the proposed activity are:

- Wind-blown dust from exposed areas; and
- Dust generated by construction and operational activities.

Table 8-1 summarises the following procedures proposed to minimise dust emissions from the primary dust sources.

Table 8-1 Dust Mitigation Measures

Source	Control Procedure
Exposed areas	• Restrict ground disturbance to the minimum area practically possible. • Rehabilitate exposed areas as soon as practicable. • Dust will be suppressed as required by spraying water along the access tracks and lease areas
Vehicle activities	• Limit vehicle speeds. • Covering loose, dust generating material loads, travelling to and from the site.

9 CONCLUSIONS

This assessment has examined the potential air quality impacts of the proposed construction activities at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operating a gas flares at Dewhurst 14 and Dewhurst 28 lease area.

The study predicts that the additional air quality impacts arising from the proposed Project would be minor at the surrounding sensitive receptors.

The predicted change in air quality is unlikely to be detectable and the results show that levels would be well below the relevant criteria for the pollutants assessed.

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[*http://www.bom.gov.au/climate/averages*]

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"Technical Paper – Particulate Matter and Mining Interim Report".

SPCC (1983)

"Air Pollution from Coal Mining and Related Developments", State Pollution Control Commission.

US EPA (1985 and updates)

"Compilation of Air Pollutant Emission Factors", AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711. Note this reference is now a web-based document.

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"Green Space for Air Pollution Control". Technical Report N.50. School of Forest Resources, North Carolina State University, Rayleigh. July 1973.

APPENDIX A

EMISSION INVENTORY

Construction Operations

Hauling on unpaved roads

Emissions from unpaved roads are dependent on the silt content of the road and the gross weight of the vehicles. TSP emissions for this activity have assumed that a no control of dust emissions from this activity as a conservative measure. The following equation developed by US EPA (**USEPA, 1985 and updates**) estimates the amount TSP emissions from the activity.

$$EF = \left(\frac{0.4536}{1.6093} \times \left(\frac{s}{12}\right)^{0.7} \times 4.9 \times \left(M \times \frac{1.1023}{3}\right)^{0.45}\right) \frac{kg}{VKT}$$

Where:

S = Silt content = 10%

M = Vehicle gross weight = 30 tonnes

Material extraction

Emissions from this activity are dependent on wind speed and the moisture content of the material. The following equation developed by US EPA (**USEPA, 1985 and updates**) estimates the amount TSP emissions from the activity.

$$EF = k \times 0.0016 \times \left(\left(\frac{U}{2.2}\right)^{1.3} \Big/ \left(\frac{M}{2}\right)^{1.4}\right) \frac{kg}{tonne}$$

Where

k = Particulate size specific factor for batch loading operations (k_{TSP} = 0.74)

U = Wind speed (m/s)

M = Moisture content of loading material = 2%

Drilling

TSP emissions from the drilling operations are estimated using emission factors developed by US EPA (**USEPA, 1985 and updates**). An emission factor of 0.59kg/hole for the drilling operation is applied. This emission factor is applicable for equipment with no dust suppression.

Wind erosion

Emissions from stockpiles and exposed areas occur due to wind erosion. The emission factor developed by State Pollution Control Commission (SPCC) (**SPCC, 1983**) allows an estimation of the total TSP generated due to wind erosion. An emission factor of 0.4 kg/ha/hour was applied in estimating the TSP emissions due to the wind erosion and has assumed that no control of dust emission from these operations would be applied.

DEWHURST 30/31

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 6	Units
Travel to site	1,382	386	trips/year	3.6	kg/VKT	30.0	km/return trip	10.0	% silt content	30	Ave GMV (tonnes)		% Control
Travel to site	129	36	trips/year	3.6	kg/VKT	1.6	km/return trip	10.0	% silt content	30	Ave GMV (tonnes)		% Control
Excavating material	1	324	tonnes/year	0.002	kg/t	1.54	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %				
Drilling	1	2	holes/year	0.59	kg/hole								% Control
Wind erosion of exposed areas	3,379	3.5	ha	0.40	kg/ha/hour	2,400	hours						% Control
Total TSP emissions (kg/yr)	**4,892**												

DEWHUSRT 13-18H

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 6	Units
Travel to site	1,058	296	trips/year	3.6	kg/VKT	40.0	km/return trip	10.0	% silt content	30	Ave GMV (tonnes)		% Control
Travel to site	129	36	trips/year	3.6	kg/VKT	46.0	km/return trip	10.0	% silt content	30	Ave GMV (tonnes)		% Control
Excavating material	1	324	tonnes/year	0.002	kg/t	1.54	average of (wind speed/2.2)^1.3 in m/s	2	moisture content in %				
Drilling	1	2	holes/year	0.59	kg/hole								% Control
Wind erosion of exposed areas	1,667	2.2	ha	0.40	kg/ha/hour	1,920	hours						% Control
Total TSP emissions (kg/yr)	**2,855**												

APPENDIX B

SAMPLE OF *AUSPLUME* OUTPUT FILE

1

Dust

Concentration or deposition	Concentration
Emission rate units	grams/second
Concentration units	microgram/m3
Units conversion factor	1.00E+06
Constant background concentration	0.00E+00
Terrain effects	Egan method
Plume depletion due to dry removal mechanisms included.	
Smooth stability class changes?	No
Other stability class adjustments ("urban modes")	None
Ignore building wake effects?	Yes
Decay coefficient (unless overridden by met. file)	0.000
Anemometer height	10 m
Roughness height at the wind vane site	0.500 m

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high	Pasquill-Gifford
Vertical dispersion curves for sources <100m high	Pasquill-Gifford
Horizontal dispersion curves for sources >100m high	Briggs Rural
Vertical dispersion curves for sources >100m high	Briggs Rural
Enhance horizontal plume spreads for buoyancy?	Yes
Enhance vertical plume spreads for buoyancy?	Yes
Adjust horizontal P-G formulae for roughness height?	Yes
Adjust vertical P-G formulae for roughness height?	Yes
Roughness height	0.400m
Adjustment for wind directional shear	None

PLUME RISE OPTIONS

Gradual plume rise?	Yes
Stack-tip downwash included?	Yes
Building downwash algorithm:	Schulman-Scire method.
Entrainment coeff. for neutral & stable lapse rates	0.60,0.60
Partial penetration of elevated inversions?	No
Disregard temp. gradients in the hourly met. file?	No

and in the absence of boundary-layer potential temperature gradients
given by the hourly met. file, a value from the following table
(in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIMES
24 hours
average over all hours

AUSPLUME Input File : Dust concentration

SOURCE GROUPS

Group No.	Members						
1	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19		
2	20	21	22	23	24	25	26
	27	28	29	30	31	32	33
	34	35	36	37	38		
3	39	40	41	42	43	44	45
	46	47	48	49	50	51	52
	53	54	55	56	57		

1

AUSPLUME Input File : Dust concentration

SOURCE CHARACTERISTICS

VOLUME SOURCE: 1

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
754450	6619746	256m	2m	10m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
1.0000	1.0	2.50

VOLUME SOURCE: 2

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
755053	6618712	255m	2m	10m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
1.0000	1.0	2.50

VOLUME SOURCE: 3

X(m)	Y(m)	Ground Elevation	Height	Hor. spread	Vert. spread
755196	6617708	255m	2m	10m	2m

(Constant) emission rate = 1.00E+00 grams/second

Hourly multiplicative factors will be used with
this emission factor.

Particle Mass fraction	Particle Size (micron)	Particle Density (g/cm3)
1.0000	1.0	2.50

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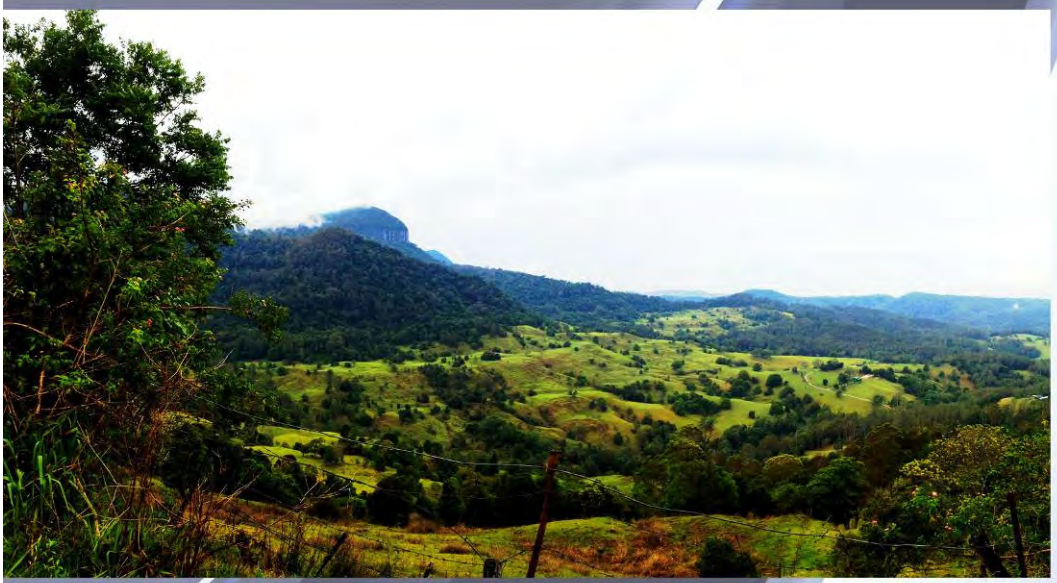
Appendix 6

Noise Assessment

NOISE MEASUREMENT SERVICES

Noise Assessment Report
Dewhurst Pilot Expansion
Santos Limited
Pilliga State Forest
Narrabri NSW

Report No 2462 R5 29 October 2013





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Revision No	Issue Date	Revision Description	Checked By	Issued By
0	05/09/2013	Draft Report for Review	BT	MD
1	30/09/2013	Revisions to text re Client review and Editorial changes	BT	MT
2	14/10/2013	Further client comments and text changes	MT	MT
3	21/10/2013	Further client comments and text changes	BT	MT
4	24/10/2013	Change to project description	BT	MT
5	29/10/2013	Change to travel route	BT	MT

Copy No(s)	Rev No	Destination
1pdf	5	RPS Australia East
2	5	Noise Measurement Services

REPORT FOR **RPS Australia East** *on behalf of* **Santos**

CONTACT **Katharine Bond, Belinda Lewis**

Signed



Dr Bob Thorne
(Principal)

DISCLAIMER
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 and following Client review. 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 has been commissioned by RPS Australia East, consulting to Santos NSW (Eastern) Pty Ltd, to complete an environmental noise assessment for the Dewhurst Pilot Expansion Environmental Impact Statement (EIS). The Dewhurst Pilot Expansion includes the drilling and construction of additional horizontal wells at the existing Dewhurst 13 - 18H Pilot, drilling and construction of the Dewhurst 30 and 31 wells and the operation of the Dewhurst Pilots (the proposed activity). The scope of the assessment includes:

- Establishing the existing background sound levels in the vicinity of the proposed Dewhurst Pilots;
- Establishing the environmental noise criteria that would apply to the drilling, construction and operation of the proposed activities;
- Predicting the environmental noise levels due to the construction and operation of the proposed activities at noise sensitive receivers (residences), including drilling and the cumulative operation of the wells, and associated traffic noise;
- Assessing the noise related impacts, if any, at noise sensitive receivers (residences); and
- Propose measures to mitigate noise where required, reasonable and feasible.
- Commentary on cumulative impacts of the proposed activities.

The noise assessment required in the Director General's Environmental Assessment Requirements (DGRs) dated 22 July 2013 includes consideration of:

- Construction, operational and transport noise impacts;
- offsite road noise impacts; and
- reasonable and feasible mitigation measures, including evidence that there are no such measures available other than those proposed, and
- monitoring and management measures.

This report applies the Intrusive noise criterion and sleep disturbance criterion under the *NSW Industrial Noise Policy (INP).* The Rating Background Level plus 5 dB(A) and is established as 35d(A) or 35 dB L_{Aeq}. The duration of works associated with the construction of a pilot is in the order of weeks. 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 (ICNG)*. Road noise is assessed in accordance with the *NSW Road Noise Policy (RNP)*.

The timing of construction/drilling activities will be staggered so that only one pilot will be drilled at a time; the pilots will then operate concurrently. The pilot wells to the south are treated separately to the north as they are not considered to have a cumulative impact on the noise sensitive receptors.

Conclusions

Noise impacts are confined to the local area surrounding each pilot. Other pilots within the E&A Program that will operate concurrently are all located at distances that would not create a cumulative impact. During drilling, a maximum of two drilling rigs will be in operation, including a smaller workover rig. The E&A Program ensures that the two drill rigs will operate at sufficient distances to eliminate any cumulative noise impacts. These exceedances are isolated to the most proximate receivers to particular wells and there is no cumulative effect as such.

It is concluded that:

Construction

- The drilling stages will be in exceedance, principally at night, at receivers N-R3 and N-R9 in circumstances where adverse weather conditions will enhance noise propagation, but any audible activity or exceedance will be of short duration.
- The impact at these residences may be reduced by management or design.
- Monitoring is required during construction to validate noise modelling, as a management measure to control noise.

Operation

- The operation of the pilot wells should not exceed compliance levels at any of the residences identified in this assessment, with the exception of residence N-R4, which is currently leased by Santos.
- Consideration should be given to modification of the dwelling (N-R4), to enhance its acoustic performance, prior to the surrender of the lease, should a continuation of the lease not be possible. The modification should be based on actual sound measurements at the time in order to determine the degree of mitigation required. Monitoring is required during operation (prior to expiry of lease) to validate noise modelling predictions (particularly at N-R4) as a management measure to control noise.
- The only means by which noise will be reduced at the façade is to reduce it at source. If there is a possibility of localised noise treatments to the Pilot these should be explored. Such mitigation measures include acoustic screening by barrier design or enclosure, and/or modification to plant.

Transport

- The overall noise levels produced by road traffic on the Newell Highway will not measurably increase due to the addition of construction and worker traffic;
- Incidental vehicle movements on the non-highway road network will be measurable but will not exceed criteria;
- Increase in overall noise levels due to traffic movements is minor;
- The nature of the additional traffic is similar to the nature of existing traffic flows on the Highways; and
- The increase in overall traffic noise (existing plus operational vehicles, or operation vehicles considered in isolation) is within the criteria established under the *RNP or INP.*

It is concluded therefore that in general the construction and operation of the proposed activity can meet the requirements of the NSW Industrial Noise Policy, the NSW Road Noise Policy, the Interim Construction Noise Guideline and the EPA Environmental Criteria for Road Traffic Noise.

References

- 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), DECC January 2000,
- Interim Construction Noise Guideline, DECC 2009
- Environmental Criteria for Road Traffic Noise (ECRTN), EPA/DECC, May 1999,
- NSW Environmental Noise Control Manual or ENCM (DEC Ref. 94/31),
- NSW Roads and Maritime Services Road Noise Policy (RNP), DECCW March 2011,
- Environmental Noise Management, Noise Guide for Local Government (DEC Ref.2004/59).
- *Dewhurst Gas Exploration Pilot Expansion, Narrabri, Traffic and Transport Assessment - GTA Consultants* 2013
- *Dewhurst Exploration and Appraisal Activities – PEL 238, Gunnedah Basin NSW – Request for DGRs supporting documents* RPS Australia East Pty Ltd 2013

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), LAeq

Commonly called the "LAeq" 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.

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. Introduction

1.1 Proposed activity location

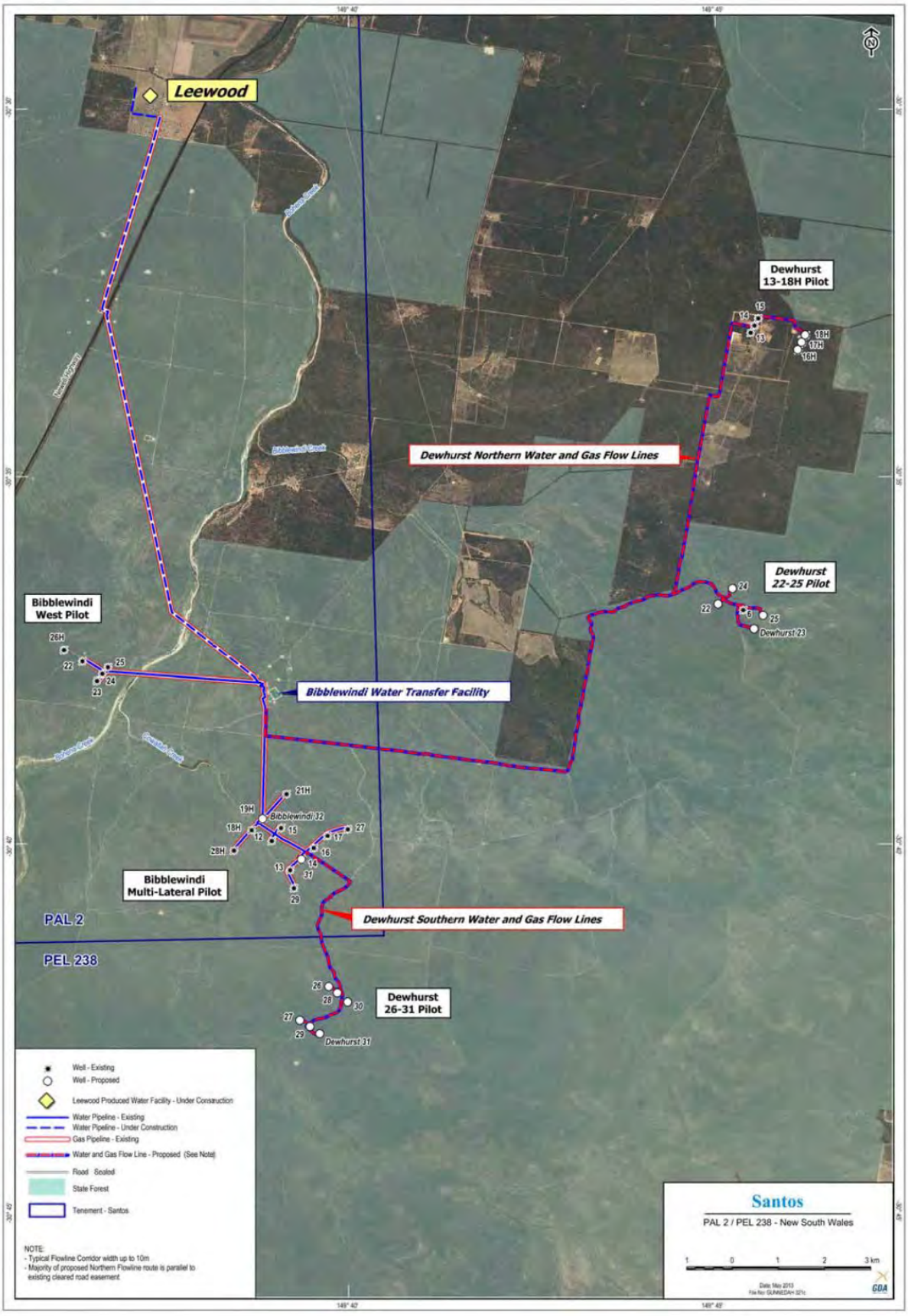
Noise Measurement Services Pty Ltd has been commissioned by RPS Australia East, consulting to Santos NSW (Eastern) Pty Ltd, to complete an environmental noise assessment for the Dewhurst Pilot Expansion Environmental Impact Statement (EIS). Santos NSW (Eastern) Pty Ltd (Santos), as the coal seam gas (CSG) operator of Petroleum Exploration Lease (PEL) 238, is seeking consent for the Dewhurst Gas Exploration Pilot Expansion (proposed activity).

The proposed activity will occur at two pilot sites:

- The existing Dewhurst 13-18H Pilot, located on freehold land and Crown Land road reserve, approximately 25 kilometres south of Narrabri;
- The proposed Dewhurst 26-31 Pilot, located in the Pilliga East State Forest, approximately 44 kilometres south of Narrabri.

The proposed well locations are illustrated in **Plate 1.1.1**. The gathering system operational works for the wells is calculated as part of the overall noise emissions. The information of this Report is referenced to our previous reports for the Dewhurst 6, 22 - 25 and 13 – 18 pilot wells (NMS Report 2228 series) and Bibblewindi Multi-Lateral Pilot (NMS Report 2422).

Plate 1.1.1: Location of Dewhurst Pilots.



1.2 Proposed activity Description

This Report considers the noise emissions from CSG well construction and operation of the two pilot wells. The scope of works in this Report includes predicting the environmental noise levels due to the construction and operation of the proposed activities potentially heard at noise sensitive receivers (residences) from drilling and the cumulative operation of the wells, and from traffic noise related to these activities.

The proposed activity involves the expansion of operations at the Dewhurst 13-18H and Dewhurst 26-31 pilots, and operation of both pilots for up to three years. Works at Dewhurst 13-18H involve re-entering three existing wells to convert single horizontal wells to triple-stacked horizontal wells. Works at Dewhurst 26-31 involve the construction of two additional wells on new lease areas to expand the proposed pilot from four to six wells.

The Dewhurst 13-18H Pilot is an existing pilot well set that comprises three vertical wells (Dewhurst 13, 14 and 15) and three single horizontal wells (16H, 17H and 18H). The NSW Department of Primary Industries (DPI) approved construction, drilling and operation of Dewhurst 13, 14, 15, 16H, 17H and 18H on 21 July 2009 following an REF assessment under Part 5 of the EP&A Act. The wells operated for a short period in 2011.

Dewhurst 26-29 is a proposed four well pilot which was approved by the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) on 16 August 2013 following a REF assessment under Part 5 of the EP&A Act. Dewhurst 26-29 is scheduled to be drilled in Q3 2013.

More specifically, the proposed activity includes:

Site preparation

- establishing two 10 metre wide service corridors between Beehive Road and the Dewhurst 30 and 31 lease areas (including clearing of approximately 0.2 hectares of vegetation)
- constructing access roads within the two service corridors at Dewhurst 30 and 31
- establishing the Dewhurst 30 and Dewhurst 31 lease areas each up to approximately one hectare in size (including approximately two hectares of vegetation clearing)
- removing the existing water gathering system and electrical cable connecting Dewhurst 13, 14 and Dewhurst 15 wells
- preparing the sites and establishing necessary equipment, temporary structures and facilities on the existing well leases Dewhurst 16H, 17H and 18H and on the new lease areas Dewhurst 30 and 31 to enable drilling.

Drilling

- drilling an additional two horizontals from existing casing within Dewhurst 16H, 17H and 18H to convert each well from a single horizontal to a triple-stacked horizontal well targeting the Bohena, Namoi and Rutley coal seams
- drilling one vertical (Dewhurst 30) and one triple-stacked horizontal (Dewhurst 31) well to target coal seams within the Maules Creek Formation.

Surface and subsurface facility construction

- preparing the site on the existing well lease Dewhurst 14 to enable installation of a gas flare and water balance tank
- constructing a new gas and water gathering system connecting all the wells within the Dewhurst 13-18H Pilot to the existing Dewhurst 14 well lease area (including clearing of approximately 0.24 hectares of disturbed vegetation)
- extending the existing water and gas gathering system for Dewhurst 26-29 within the service corridors to Dewhurst 30 and 31
- installing surface and sub-surface infrastructure within the lease areas to connect the wells to the Dewhurst 13-18H and Dewhurst 26-31 gas and water gathering system
- installing a gas flare and water balance tank at the existing Dewhurst 14 lease area and a gas flare at the Dewhurst 28 lease area.

Operation

- operating the Dewhurst 13-18H Pilot and Dewhurst 26-31 Pilot for up to three years from the commencement of operations at each pilot respectively
- managing the water and gas produced during operation
- undertaking occasional maintenance of the pilots.

Post operation

- on completion of operations, suspending the wells and ancillary infrastructure or decommissioning them and rehabilitating the well leases.

1.2.1 Timing and Duration of Activities

On-site activities are expected to take approximately 3 months with the main phases of work identified in Table 1.2.5.1 and 1.2.5.2. The timing of the construction/drilling activities will be staggered so that only one pilot well will be drilled at one time, although there is a possibility of a "workover" rig running at the same time as the principal drilling rig in another location.

Table 1.2.5.1: Duration of on-site activities at Dewhurst 13-18H

Activity	Approximate Duration	12hr or 24 hr [1]
Site Preparation	30 days	12
Drilling* and workover (Dewhurst 16, 17, 18)	65 days	24
** drilling and cementing as a stand-alone process*	*3 – 7 days within the above time*	*24*
Surface facilities (gathering system)	65 days	24
Operation of pilot (Dewhurst 13-18H)	Up to 3 years	24

1. 12 hr refers to daytime operations, equivalent to "standard working hours" under the ICNG; 24 hr refers to continuous or 24hr activities. In emergencies, wells could be visited 24 hours

Table 1.2.5.1: Duration of on-site activities and Dewhurst 30 and 31

Activity	Approximate Duration	12hr or 24 hr [1]
Site Preparation (Dewhurst 30 and 31)	20 days	12
Drilling* and workover	60 days	24
** drilling and cementing as a stand-alone process*	*3 – 7 days within the above time*	*24*
Surface facilities	60 days	24
Operation of pilot (Dewhurst 26-31)	Up to 3 years	24

1. 12 hr refers to daytime operations, equivalent to "standard working hours" under the ICNG; 24 hr refers to continuous or 24hr activities. In emergencies, wells could be visited 24 hours

Drilling activities will take place between May and August 2014. The maximum number of people on-site at any one time is expected to be 20 staff during drilling. Crews will be located at the Westport drillers' camp and travel to site daily. Work will be 24 hours. The maximum number of vehicle movements is expected to be approximately between 10 and 20 per day (10 during drilling and completion, and 20 for short periods when equipment is delivered to site), generally within the hours of 7:00am and 6:00pm.

1.3 Existing Environment - Sensitive Receptors

Nine noise sensitive receptors (i.e. residences N-R1 to N-R9) are within 5km of the Dewhurst 13-18H Pilot, as shown in **Plate 1.3.1**. The location of the Dewhurst 13-18H Pilot is shown on **Plate 1.3.1**. The location of the residences (noise sensitive receptors) and modelling receivers (where different) in this report are given in **Table 1.3.1** by latitude and longitude.

Five noise sensitive receptors (i.e. residences S-R1 to S-R5) are outside of 10km (within 15km) of the Dewhurst 26-31 Pilot, as shown in Plate 1.3.2. The location of the Dewhurst 26-31 Pilot is shown on Plate 1.3.1. The location of the residences and modelling receivers in this report are given in Table 1.3.2 by latitude and longitude.

Table 1.3.1: Residential Locations within 5km of Dewhurst 13-18H Pilot (exact locations vary slightly in model)

Location	Degrees East	Degrees South
N-R1 (centre of group of residences)	149° 44' 32.9"	30° 34' 48.7"
N-R2	149° 44' 34.5"	30° 34' 46.5"
N-R3	149° 45' 5.4"	30° 34' 19.6"
N-R4[1]	149° 45' 31"	30° 33' 18"
N-R5 (centre of group of residences)	149° 43' 39"	30° 33' 39"
N-R6	149° 44' 2"	30° 31' 27"
N-R7	149° 43' 53"	30° 31' 35"
N-R8	149° 43' 53"	30° 32' 46"
N-R9 (centre of group of residences)	149° 44' 44"	30° 33' 47.6"

1 Note this is leased by Santos; it will not be occupied during construction phase, but is considered to be a sensitive receiver during operation phase as its lease expires in December 2015, prior to the expiry of 3 years.

Plate 1.3.1: Residences (R1-R9) and Dewhurst 13-18H pilot well locations

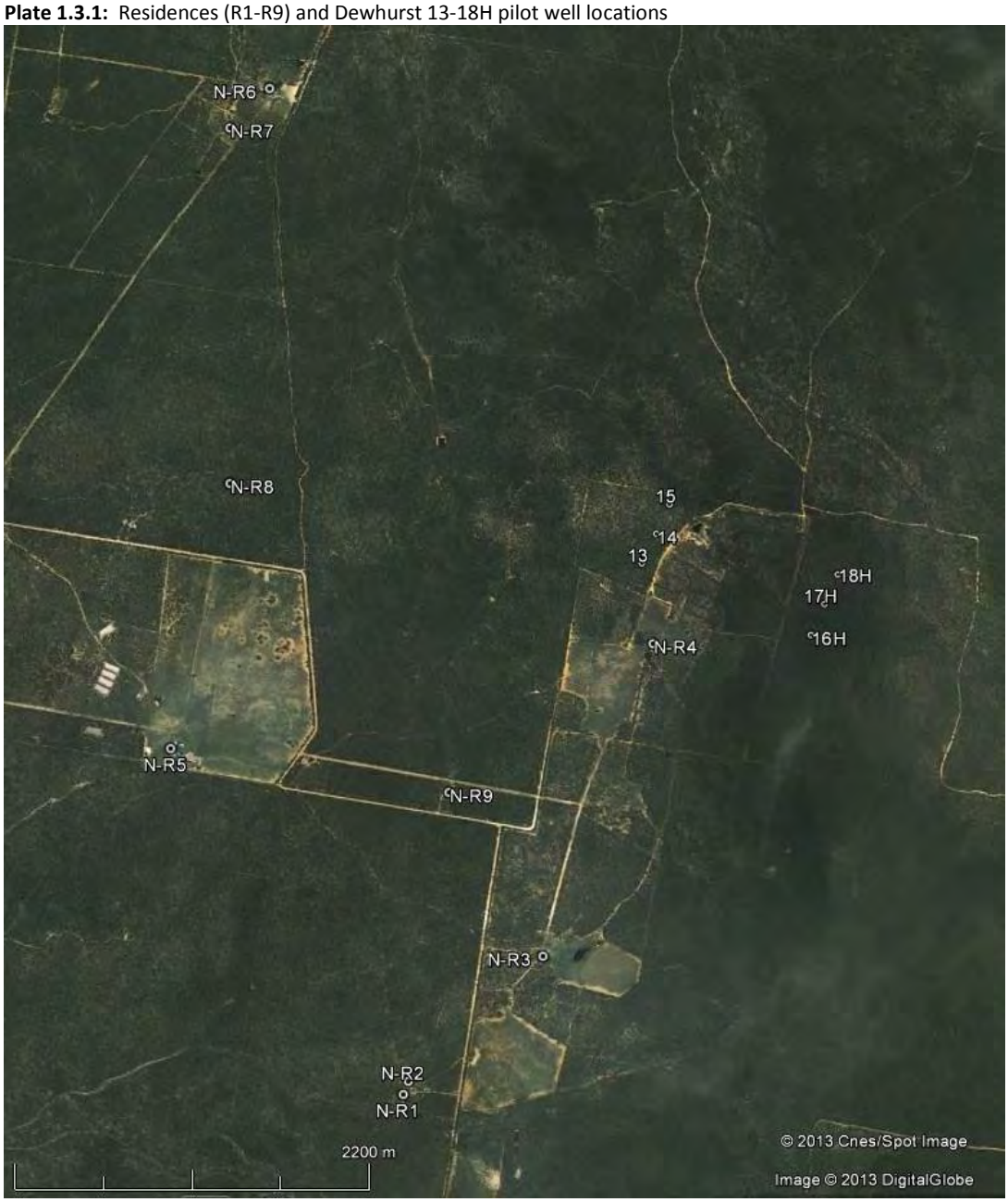


Table 1.3.2: Residential Locations within 15km of Dewhurst 26-31 Pilot (none are known to the south)

Location	Degrees East	Degrees South
S-R1	149°44'33.23"	30°34'47.97"
S-R2	149°44'34.39"	30°34'45.35"
S-R3	149°45'5.73"	30°34'20.21"
S-R4	149°45'30.98"	30°33'18.02"
S-R5	149°43'38.99"	30°33'39.02"

Plate 1.3.2: Residences (S-R1 to S-R5) and Dewhurst 26-31 pilot well locations



1.4 Noise Assessment Method

The basic concept of determining whether or not the noise from the construction activities at Dewhurst 13-18H and 26-31 is likely to cause intrusive noise impacts is to compare the existing background and ambient sound levels to the expected noise levels from the proposed activities. The operational noise assessment was conducted in accordance with the *NSW Industrial Noise Policy* (INP) published by the NSW Environmental Protection Agency (EPA) in 2000. Further, detailed consideration of criteria is set out in **Section 3**.

The determination compared the background sound levels calculated to the INP (the average of the minimum sound levels without the proposed activities) to the measured sound level at a potentially affected sensitive residence when the proposed activities are being carried out. Operational noise levels were calculated to potentially affected residences. Noise modelling was undertaken for different scenarios, including different 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 proposed activities 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, animals, rural activity and 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 referred to as the source noise only (i.e. without the contribution of background noise).

The measured ambient sound levels are detailed in **Section 2**. We conclude that, in the absence of insects and winds the background sound levels are below 30 dB(A). This level constitutes the minimum Rating Background Level (RBL) considered in NSW under the INP (EPA 2000) and other policies/guidelines that refer to the determination of background noise levels detailed in the INP.

An RBL of 30 dB(A) 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, being measured at 1metre from a façade) as per Table 2.1 of the INP. It is measured as the time-average (LAeq) sound level over 15 minutes.

Road Noise

The Road Noise Criterion for traffic on local roads is determined as 55 dB(A), measured as the time-average LAeq sound level over 1 hour.

2. Ambient Noise Monitoring

2.1 Noise monitoring locations

In order to establish the existing noise environment within and adjacent to the proposed activity 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 proposed activity area broadly identified in **Plate 2.2.1**. In addition, two monitoring locations (ML3 and ML4) just to the north of the proposed activity area are included as these give representative rural noise levels for June 2012. The measurement locations are shown in **Plate 2.1.1**. 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 to ML4. ML1 and ML4 are located close to residences.



The following **photographs** illustrate the various sound measurement locations for the survey.

Photo 2.1.1: View of noise logger location ML1 including weather station and residential dwelling behind



Photo 2.1.2: View of noise logger ML2



Photo 2.1.3: View of noise logger ML3 (June 2012 Survey).



Photo 2.1.4: 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 a current calibration certificate.

2.3 Meteorological data

Weather data for the area was sourced from the Bureau of Meteorology's Narrabri Airport weather station (**Annex B**), which provides overall wind speed and direction over four full year periods. Additionally, during the monitoring weather data was recorded to ensure compliance with the INP. 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 **Figure 2.3.1**. All the 15 minutes samples are displayed in 6-hour blocks. The noise data is unaffected by adverse weather.

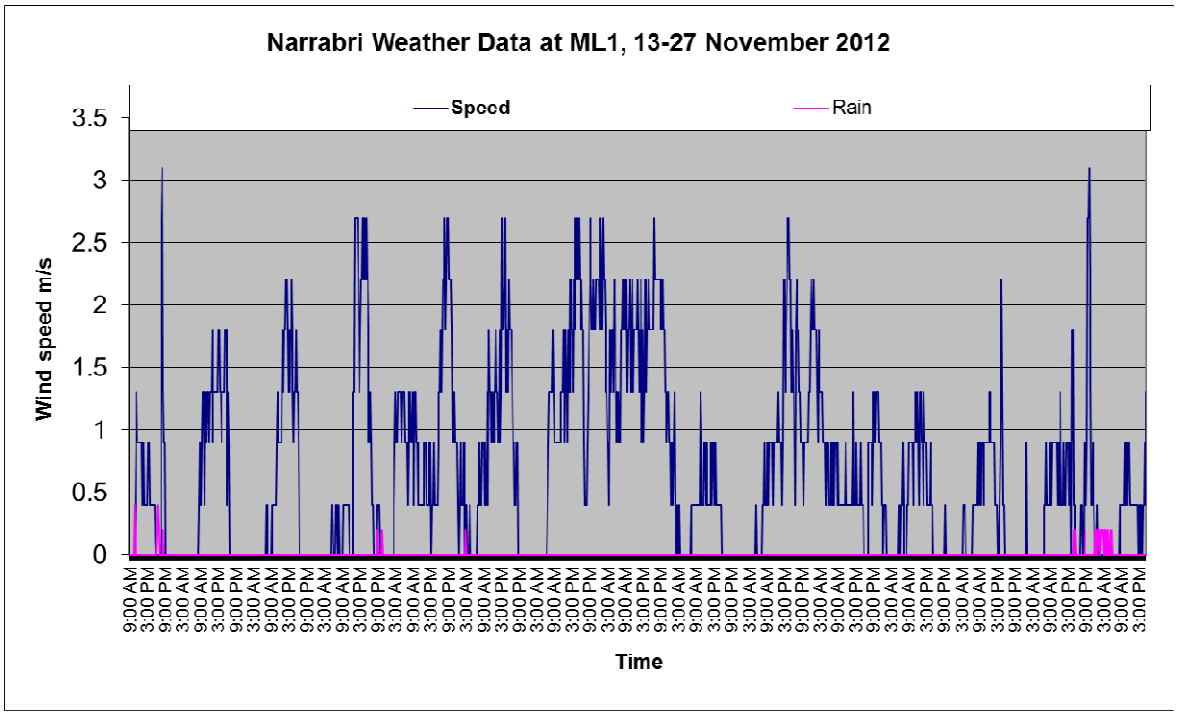


Figure 2.3.1: Weather data at Narrabri during the monitoring in November 2012

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 INP, 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. The results of the noise monitoring were processed in accordance with the procedures contained in the INP.

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 derived background levels are presented in **Tables 2.5.1 to 2.5.4**, in the following section '2.5 Rating Background Noise Levels'.

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 INP are presented in Tables 2.5.1 to 2.5.4. The levels were measured in continuous 15 minute intervals in June and November 2012. MLs 1 and 2 were measured from 14th to 27th November 2012. The data is correlated to 15-minute wind and rain data. There were no events (rain or average wind speeds above 5m/s) requiring data to be excluded.

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.

Table 2.5.1: Background noise levels at Residence (ML1); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
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**

Consequently, the Rating Background Level is determined from the RBL values of Table 2.5.1 (ML1)

Day = 32 dB(A)

Evening = 33 dB(A)

Night = 35 dB(A)

However, the noise levels at this site are influenced by noise from the nearby residences and may be considered to be affected by local noise. In considering whether these levels should be applied to the present proposed activities, consideration needs to be made of the levels at the other measurement locations, MLs 2 to 4, as set out in **Tables 2.5.2 to 2.5.4** following.

Table 2.5.2: Background noise levels background location (ML2); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
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**

The time of the year in which MLs 3 and 4 were measured may be more indicative of levels for the currently proposed construction (drilling activities) than that for MLs 1 and 2, being measured in June and activities being proposed for May to August 2014.

Table 2.5.3: Background (2012) noise levels in rural area to north of proposed activity area (ML3); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
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 2.5.4: Background (2012) noise levels at residential property, rural locale north of the proposed activity area (ML4); RBL (Median LA90)

	Day dB(A)	Evening dB(A)	Night dB(A)
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**

In each of the surveys at ML2, ML3, and ML4, the Rating Background Level was found to be below 30dB(A). The levels were somewhat below the levels recorded at ML1. It would be safer and more conservative to design to the lower levels, recorded at MLs 2 to 4 inclusive, as compliance with these lower levels would insure compliance at ML1 whereas compliance with ML1 levels would not ensure compliance at MLs 2 to 4. That said, under the INP, where the rating background level is found to be less than 30dB(A) the RBL is set to 30dB(A). In consideration of the factors discussed above, this is the RBL applied in this assessment.

2.6 Ambient L_{Aeq} Noise Levels

The L_{Aeq} sound levels calculated to the procedure under the INP are presented in the following **Tables 2.6.1 to 2.6.4.** The levels were measured in continuous 15 minute intervals from 14th to 27th November 2012. Days affected by rain or high winds (average wind gusts over 5m/s) were excluded from assessment, where possible.

Table 2.6.1: Ambient LAeq noise levels at residence (ML1)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
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 LAeq	**47**	**56**	**51**	**54**

Table 2.6.2: Ambient LAeq noise levels background location (ML2)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
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 LAeq	**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; numerous days were excluded due to weather conditions being outside of tolerances for the INP.

The time of the year in which ML3 and ML4 were measured may be more indicative of levels for the currently proposed construction (drilling activities), being measured in June and activities being proposed for May to August 2014.

Table 2.6.3: Ambient LAeq 2012 noise levels at residential property, rural locale north of the proposed activity area (ML3)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
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 LAeq	**48**	**37**	**47**	**39**

Table 2.6.4: Ambient LAeq 2012 noise levels at rural property boundary north of the proposed activity area (ML4)

	Day dB(A)	Evening dB(A)	Daytime dB(A)	Night dB(A)
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 LAeq	**43**	**31**	**42**	**33**

Consequently, the Ambient LAeq Level is determined from the lowest LAeq values of Tables 2.6.2 to 2.6.4

Day = 42 dB(A)

Evening = 31 dB(A)

Night = 33 dB(A)

3. Noise Assessment Criteria

3.1 Operational noise criteria

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), EPA 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),
- NSW Roads and Maritime Services Road Noise Policy (RNP) March 2011
- Environmental Noise Management, Noise Guide for Local Government (DEC Ref.2004/59).

Noise generated within by construction activities, operational plant, truck movements, loading/unloading activities, mechanical services associated with site buildings, are assessed in accordance with the INP guidelines. Noise of this type 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(A). 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. Based on an RBL of 30dB(A), the intrusiveness criterion is 35dB(A) for this assessment.

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.

Table 3.3: Amenity criteria from INP

Table 2.1. Amenity criteria

Recommended L_{Aeq} noise levels from industrial noise sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A) *(see Note 8 in Section 2.2.1)*	
(see Notes in Section 2.2.1)			**Acceptable** *(See Note 11)*	**Recommended Maximum** *(See Note 11)*
Residence	Rural	Day	50	55
		Evening	45	50
		Night	40	45
	Suburban	Day	55	60
		Evening	45	50
		Night	40	45
	Urban	Day	60	65
		Evening	50	55
		Night	45	50
	Urban/Industrial Interface – for existing situations only	Day	65	70
		Evening	55	60
		Night	50	55

Notes to above table:

"Note 8" advises: The LAeq noise level for a specific period represents the LAeq level calculated or measured over the applicable day, evening or night period except where otherwise stated

"Note 11" advises: The acceptable and recommended maximum LAeq noise levels can provide a guide to the negotiation process set out in Section 8 [of the INP].

3.4 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).

3.5 Sound character

The character of the sound emissions from the site construction, drilling, and pilot well operation is different to that of 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(A) is more appropriate. In this report it is not assumed that any activity will exhibit obvious tonal or impulsive components at any noise sensitive receptor; it may be considered appropriate to undertake testing and resolve any such issue as it arises through management means.

3.6 Interim Construction Noise Guideline

The proposed activity is considered a mining project for the purpose of this noise assessment. In accordance with the recommendations in the *Interim Construction Noise Guideline (ICNG)*, the construction activities for mining projects are normally assessed under the INP, and in accordance with this requirement the operational noise criteria presented previously will also apply to construction works associated with the proposed activity. However it is noted that 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 the assessment guidelines detailed in the Interim Construction Noise Guideline (ICNG, DECC 2009) may be appropriate. 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) as required under the INP.

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.

3.7 Road Traffic Noise – Road Noise Policy

The *NSW Road Noise Policy* (RNP) came into effect on 1 July 2011 and aims to identify strategies that address the issue of road traffic noise from new traffic-generating developments. It also defines criteria to be used in assessing the impact of such noise, based on protecting amenity and wellbeing. Although it is not mandatory to achieve the noise assessment criteria in the RNP, proponents of a proposed activity will need to provide justification if it is not considered feasible or reasonable to achieve them.

The application fits the general character of the situation set out in Section 2.2.2 of the RNP – *Principal haulage routes along public roads.* In this section the noise criteria is set out for a route that is not served by an arterial route (although the highways are by definition arterial they are also subject to lower traffic flows than normal arterial routes). Table 3 of the RNP sets out the criteria to be applied; see **Tables 3.8.1 and 3.8.2** following.

Table 3.7.1 – Table 3 of the RNP

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq, (15\ hour)}$ 55 (external)	$L_{Aeq, (9\ hour)}$ 50 (external)
	2. Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq, (15\ hour)}$ 60 (external)	$L_{Aeq, (9\ hour)}$ 55 (external)
Local roads	4. Existing residences affected by noise from **new** local road corridors 5. Existing residences affected by noise from **redevelopment** of existing local roads 6. Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{Aeq, (1\ hour)}$ 55 (external)	$L_{Aeq, (1\ hour)}$ 50 (external)

It is noted that special criteria apply under the RNP for particular uses such as schools and hospitals (internal and external).

In addition to the criteria set out in **Table 3.8.1** above, any increase in noise levels for sensitive uses of more than 12dB(A) for the day/evening or night periods will require mitigation to be considered. This is known as the "relative increase criteria", see **Table 3.8.2** following.

Table 3.7.2 – Relative increase criteria for residential land uses (Table 6 of the RNP)

Road category	Type of project/development	Total traffic noise level increase – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.– 7 a.m.)
Freeway/arterial/ sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq, (15\ hour)}$ + 12 dB (external)	Existing traffic $L_{Aeq, (9\ hour)}$ + 12 dB (external)

In summary the noise criteria for road traffic noise are:

- Major Roads 60dB(A) $L_{Aeq,\ 15\ hour}$ or relative increase of no more than 12dB(A), $L_{Aeq,\ 15\ hour}$ on existing traffic noise levels
- Minor Roads 55dB(A) $L_{Aeq,\ 1\ hour}$

Note: The 15hr period is from 7am to 10pm (i.e. day and evening). Vehicles associated with the proposed activity will preferably only travel during recommended standard construction hours (as discussed in section 3.6).

4. 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 Services 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 **Annex C**. The noise model is based on an assessed flat topography as the land is effectively flat between the pilot wells and the nearest residences.

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 **Annex B**), the occurrence of F class or greater temperature inversions is approximately 20% 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%. Modelling, in calm conditions, with a 3m/s breeze blowing towards the nearest residences, and in inversion conditions, was conducted as part of this assessment.

4.3 Potential impacts

All construction activities and operational plant are assumed to be running continuously. Predictions are made for 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 proposed activity 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

Sound Power levels for site clearing and well drilling are derived from measurements previously undertaken by Noise Measurement Services and presented in **Annex A1**. It may be that a specific rig, measured by Wilkinson Murray, is employed, and information from those surveys are also set out in **Annex A1** (for cross reference purposes). Sound Power Levels for pilot well operation (including flares) have been obtained from third party sources, **Annex A2**, due to the actual pilot wells not being available to NMS for measurement. While NMS is not in a position to validate the levels at this stage, part of the management measures to control noise is to undertake measurements upon commencement of operations. Note: The residence indicated by N-R4 is currently leased by Santos and is therefore not considered to be a sensitive receptor for drilling activities. The residence is considered a sensitive receptor for Pilot Operation as the lease expires in December 2015.

4.3.1 Potential Impacts – Construction

The modelling assumptions, visual contours and calculated results for each scenario are set out in Annex D, and the results assessed against criteria are set out in the tables below. The 'worst case' or 'enhanced' assessments for noise from the drilling rig (or from similar noisy plant and machinery such as excavators) are given in Table 4.3.1.1. The weather conditions in the Table 4.3.1.2 relate to 'calm' conditions where there is no breeze blowing towards a residence; and 'enhanced' conditions when there is a 3 m/s breeze blowing towards a residence. It is expected that the "calm" conditions will occur more frequently than the "enhanced" conditions, and are referred to as "most likely" and "worst case" accordingly.

Table 4.3.1.1: Predicted 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) dB(A)						
		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 4.3.1.2: Dewhurst 16H drilling operations:
Noise 'Scenario 1 Most Likely' Predicted Levels (LAeq) and 'Scenario 2 - Worst case' as Dewhurst 16H is the closest well to the northern receptors. Sound levels are rounded and calculated to 5 metres from the façade ('free-field')

Residence	Distance from site (km)	Scenario 1 'Most Likely' dB(A)	Scenario 2 'Worst Case' dB(A)
N-R1	3.6	22	32
N-R2	3.5	22	31
N-R3	2.5	29	39
N-R4	0.5	N/A*	N/A*
N-R5	3.1	20	30
N-R6	3.7	17	26
N-R7	3.7	17	26
N-R8	2.6	22	32
N-R9	1.8	30	40
Plant		Drilling 16H	Drilling 16H
Weather		Calm	Enhanced

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary
*The residence indicated by N-R4 is currently leased by Santos.

Table 4.3.1.3: Dewhurst 30, drilling operations:
Scenarios 3 to 6 'Most Likely' predicted operating levels (LAeq), worst case scenarios as Dewhurst 30 is the closest well to the southern receptors. Scenarios 5 and 6 include wells 26-29. Sound levels are rounded and calculated at the residential façade

Residence	Distance from site (km)	Scenario 3 'Most Likely' dB(A)	Scenario 4 'Worst Case' dB(A)	Scenario 5 'Most Likely' dB(A)	Scenario 6 'Worst Case' dB(A)
S-R1	13.1	<15	<15	<15	<15
S-R2	13.6	<15	<15	<15	<15
S-R3	13.2	<15	<15	<15	<15
S-R4	11.6	<15	<15	<15	<15
S-R5	10.9	<15	<15	<15	15
Plant		Drilling 30	Drilling 30	Drilling 30, 26-29 running	Drilling 30, 26-29 running
Weather		Calm	Enhanced	Calm	Enhanced

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Assessment of Intrusive Noise

Tables 4.3.1.4 A and B present an assessment of the INP guideline values for Intrusive Noise with respect to the potential noise sources as they affect the residences. The criterion is 35dB LAeq.

Table 4.3.1.4A: Dewhurst 13-18H: Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance from site (km)	Scenario 1 'Most Likely' dB(A)	Scenario 2 'Worst Case' dB(A)
N-R1	3.6	Pass	Pass
N-R2	3.5	Pass	Pass
N-R3	2.5	Pass	+4#
N-R4	0.5	N/A*	N/A*
N-R5	3.1	Pass	Pass
N-R6	3.7	Pass	Pass
N-R7	3.7	Pass	Pass
N-R8	2.6	Pass	Pass
N-R9	1.8	Pass	+5#
Plant		Drilling 16H	Drilling 16H
Weather		Calm	Enhanced

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary
*The residence indicated by N-R4 is currently leased by Santos
Compliant with daytime levels under the ICNG (i.e. RBL + 10) but not night-time (i.e. RBL +5), using RBL of 30dB(A). If ML1 levels were employed the predicted levels would be compliant at night.

Table 4.3.1.4B: Dewhurst 26-31:
Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level. Scenarios 3 to 6 'Most Likely' Predicted Levels (LAeq), worst case scenarios as Dewhurst 30 is the closest well to the southern receptors. Scenarios 5 and 6 include wells 26-29. Sound levels are rounded and calculated at the residential façade

Residence	Distance from site (km)	Scenario 3 'Most Likely' dB(A)	Scenario 4 'Worst case' dB(A)	Scenario 5 'Most likely' dB(A)	Scenario 6 'Worst Case' dB(A)
S-R1	13.1	Pass	Pass	Pass	Pass
S-R2	13.6	Pass	Pass	Pass	Pass
S-R3	13.2	Pass	Pass	Pass	Pass
S-R4	11.6	Pass	Pass	Pass	Pass
S-R5	10.9	Pass	Pass	Pass	Pass
Plant		Drilling 30	Drilling 30	Drilling 30, 26-29 running	Drilling 30, 26-29 running
Weather		Calm	Enhanced	Calm	Enhanced

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Sleep Amenity

Tables 4.3.1.5 A and B present an assessment of the INP guideline values for Sleep Amenity (measured outdoors) with respect to the potential noise sources as they affect the residences. The criterion is 40dB(A) LAeq.

Table 4.3.1.5A: Dewhurst 13-18H: Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level. Scenario 1 represents the 'Most Likely' case and Scenario 2 represents the 'Worst Case'.

Residence	Distance from site (km)	Scenario 1 'Most Likely' dB(A)	Scenario 2 'Worst case' dB(A)
N-R1	3.6	Pass	Pass
N-R2	3.5	Pass	Pass
N-R3	2.5	Pass	Pass
N-R4	0.5	N/A*	N/A*
N-R5	3.1	Pass	Pass
N-R6	3.7	Pass	Pass
N-R7	3.7	Pass	Pass
N-R8	2.6	Pass	Pass
N-R9	1.8	Pass	= Potential Exceedance
Plant		Drilling 16H	Drilling 16H
Weather		Calm	Enhanced

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

Table 4.3.1.5B: Dewhurst 26-31:
Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level. Scenarios 3 to 6 'Most Likely' Predicted Levels (LAeq), worst case scenarios as Dewhurst 30 is the closest well to the southern receptors. Scenarios 5 and 6 include wells 26-29. Sound levels are rounded and calculated at the residential façade

Residence	Distance from site (km)	Scenario 3 'Most Likely' dB(A)	Scenario 4 'Worst Case' dB(A)	Scenario 5 'Most Likely' dB(A)	Scenario 6 'Worst case' dB(A)
S-R1	13.1	Pass	Pass	Pass	Pass
S-R2	13.6	Pass	Pass	Pass	Pass
S-R3	13.2	Pass	Pass	Pass	Pass
S-R4	11.6	Pass	Pass	Pass	Pass
S-R5	10.9	Pass	Pass	Pass	Pass
Plant		Drilling 30	Drilling 30	Drilling 30, 26-29 running	Drilling 30, 26-29 running
Weather		Calm	Enhanced	Calm	Enhanced

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

In conclusion it is found that the noise levels during the construction phase are within the assessment criteria at all residences, with the exception of N-R4, which is currently leased by Santos and is unoccupied, and N-R3 and N-R9 *in certain circumstances.* Receivers N-R3 and N-R9 will experience noise above criteria in conditions where propagation of noise is enhanced (by wind and temperature); the conditions are most likely found at night.

As the noise levels are for a relatively short period (the re-drilling of wells 16H, 17H and 18H), there is potential for the noise to be managed to ensure nuisance is avoided. Strategies could include:

- Avoid drilling during inversion conditions (which will be likely at night in the late autumn, winter, and early spring periods);
- Ensuring the noise levels are not causing undue concern at the residence, through community liaison, and assessing practices should there be a concern;
- Monitoring is undertaken during construction to validate noise modelling, as a management measure to control noise.
- Due to the temporary nature of the works, it may be feasible to upgrade the acoustic performance of the residence, but the cost of capital works should be balanced with the reasonable long term acoustic needs of the dwelling (it being expected that the operation of the wells will be compliant with criteria), and the transience of the activities. Depending on manner of usage of the dwellings, some acoustic treatments may be non-feasible due to factors out of the applicant's control (for example where occupants insist on open windows, upgrades to glazing would be rendered redundant);
- Noise mitigation to the mud-pump (the main source of noise) will reduce further any audible sound.

4.3.2 Potential Impacts – Operation

Noise predictions have been made for well operation to the nearest identified residential receptors to the Dewhurst wells. The different types of operational plant referenced in the predictions are described in **Annexures A1 and A2**. The modelling assumptions, visual contours and calculated results for each scenario are set out in **Annex D**, and the results assessed against criteria are set out in the tables below. The distances of the fourteen nearest residential receptors to the source locations are shown in the predictions tables, **Table 4.3.2.1 and 4.3.2.2.** Note that the inversion is stability 'F' and calculated as a temperature gradient of 3.0 °C/100m, 10°C ambient, 50% relative humidity. All residential receptors were

modelled at a height of 1.8 m above ground level.

The noise criterion to be achieved is established as the Intrusive Noise Criterion under the INP. This is the Rating Background Level plus 5 dB(A) and is established as L_{Aeq} 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 4.3.2.1** gives the predicted time-average L_{Aeq} sound levels at the facades of the residences.

Table 4.3.2.1: Predicted façade noise levels from at each receptor for individual wells in operation.

Receptor	Height	Noise Level dB(A)											
	(m)	D13	D14	D15	D16H	D17H	D18H	D26	D27	D28	D29	D30	D31
N-R1	1.5	16	15	14	15	15	14	<0	<0	<0	<0	<0	<0
N-R2	1.5	16	15	15	15	15	14	<0	<0	<0	<0	<0	<0
N-R3	1.5	20	19	18	19	19	18	<0	<0	<0	<0	<0	<0
N-R4	1.5	35	33	31	30	29	27	<0	<0	<0	<0	<0	<0
N-R5	1.5	17	17	16	14	14	14	<0	<0	<0	<0	<0	<0
N-R6	1.5	15	16	16	13	13	13	<0	<0	<0	<0	<0	<0
N-R7	1.5	15	16	16	13	13	13	<0	<0	<0	<0	<0	<0
N-R8	1.5	19	19	19	15	15	15	<0	<0	<0	<0	<0	<0
N-R9	1.5	23	22	21	20	19	19	<0	<0	<0	<0	<0	<0
S-R1	1.5	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0	<0
S-R2	1.5	5	5	4	4	4	3	<0	<0	<0	<0	<0	<0
S-R3	1.5	7	7	7	6	6	6	<0	<0	<0	<0	<0	<0
S-R4	1.5	6	6	6	6	6	5	<0	<0	<0	<0	<0	<0
S-R5	1.5	5	5	5	5	5	4	<0	<0	<0	<0	<0	<0

4.3.3 Cumulative Impacts – Operation

The cumulative noise emissions from the operation of the new Dewhurst pilot wells together, including under temperature inversion conditions, are set out in **Tables 4.3.3.1 and 4.3.3.2** following. The pilots to the south are presented separately from the pilots to the north as they are not considered to have any measureable cumulative impact on the receivers. The duration of noise from pilot well is taken as being '24/7' and is calculated on a 15-minute or 1-hour basis. The calculation scenarios 7 to 12 are for the pilots operating with no ancillary noise considered.

Table 4.3.3.1: Dewhurst 13-18H:

Scenarios 7 to 9 Noise 'Most Likely', 'Worst Case' and 'Inversion' 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 from site (km)	Scenario 7 'Most Likely' dB(A)	Scenario 8 'Worst Case' dB(A)	Scenario 9 'Inversion' dB(A)
N-R1	3.6	20	27	21
N-R2	3.5	20	27	21
N-R3	2.5	24	30	25
N-R4*	0.5	37*	41*	38*
N-R5	3.1	20	28	21
N-R6	3.7	19	27	20
N-R7	3.7	19	27	20
N-R8	2.6	22	30	23
N-R9	1.8	26	33	27
Plant		13-18H Running	13-18H Running	13-18H Running
Weather		Calm	Enhanced	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary
* The residence N-R4 is considered a sensitive receptor for Pilot Operation due to the lease expiring in December 2015.

Table 4.3.3.2: Dewhurst 26-31:
Scenarios 10 to 12 - Noise 'Most Likely', 'Worst case' and 'Inversion' Predicted Levels (LAeq), Noise Criteria, and Distances to Residences. Sound levels are rounded and calculated at the residential façade

Residence	Distance from site (km)	Scenario 10 'Most Likely' dB(A)	Scenario 11 'Worst Case' dB(A)	Scenario 12 'Inversion' dB(A)
S-R1	13.1	<15	<15	<15
S-R2	13.6	<15	<15	<15
S-R3	13.2	<15	<15	<15
S-R4	11.6	<15	<15	<15
S-R5	10.9	<15	15	<15
Plant		26-31 Running	26-31 Running	26-31 Running
Weather		Calm	Enhanced	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

INP Intrusiveness Assessment (Wells)

Tables 4.3.3.3 and 4.3.3.4 present an assessment of the INP guideline values for Intrusive Noise with respect to the potential noise sources as they affect the residences. The criterion is 35 LAeq. The pilots to the south are treated separately to the north as they are not considered to have a cumulative impact on the receivers. The duration of noise from pilot well is taken as being '24/7' and is calculated on a 15-minute or 1-hour basis.

Table 4.3.3.3: Dewhurst 13-18H:
Scenarios 13 to 15 Noise 'Most Likely', 'Worst Case' and 'Inversion' Predicted Levels for Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance from site (km)	Scenario 13 dB(A)	Scenario 14 dB(A)	Scenario 15 dB(A)
N-R1	3.6	Pass	Pass	Pass
N-R2	3.5	Pass	Pass	Pass
N-R3	2.5	Pass	Pass	Pass
N-R4*	0.5	+2*	+6*	+3*
N-R5	3.1	Pass	Pass	Pass
N-R6	3.7	Pass	Pass	Pass
N-R7	3.7	Pass	Pass	Pass
N-R8	2.6	Pass	Pass	Pass
N-R9	1.8	Pass	Pass	Pass
Plant		13-18H Running	13-18H Running	13-18H Running
Weather		Calm	Enhanced	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary
* The residence N-R4 is considered a sensitive receptor for Pilot Operation due to the lease expiring in December 2015. If ML1 levels were employed the predicted levels would be compliant at night.

Table 4.3.3.4: Dewhurst 26-31:
Scenarios 16 to 18 Noise 'Most Likely', 'Worst Case' and 'Inversion' Predicted Levels for Compliance with Intrusive Noise Guideline of 35 dB(A) LAeq façade level

Residence	Distance from site (km)	Scenario 16 dB(A)	Scenario 17 dB(A)	Scenario 18 dB(A)
S-R1	13.1	Pass	Pass	Pass
S-R2	13.6	Pass	Pass	Pass
S-R3	13.2	Pass	Pass	Pass
S-R4	11.6	Pass	Pass	Pass
S-R5	10.9	Pass	Pass	Pass
Plant		26-31 Running	26-31 Running	26-31 Running
Weather		Calm	Enhanced	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

INP Sleep Amenity (Wells)

Tables 4.3.3.5 and 4.3.3.6 present an assessment of the INP guideline values for Sleep Amenity (measured outdoors) with respect to the potential noise sources as they affect the residences. The criterion is 40 LAeq. The pilot wells to the south are treated separately to the north as they are not considered to have a cumulative impact on the noise sensitive receptors (i.e. the occupied residences). The duration of noise from pilot well is taken as being '24/7' and is calculated on a 15-minute or 1-hour basis.

Table 4.3.3.5: Dewhurst 13-18H:
Scenarios 19 to 21 Noise 'Most Likely', 'Worst Case' and 'Inversion' Predicted Levels for Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance from site (km)	Scenario 19 'Most Likely' dB(A)	Scenario 20 'Worst Case' dB(A)	Scenario 21 'Inversion' dB(A)
N-R1	3.6	Pass	Pass	Pass
N-R2	3.5	Pass	Pass	Pass
N-R3	2.5	Pass	Pass	Pass
N-R4*	0.5	Pass*	+1*	Pass*
N-R5	3.1	Pass	Pass	Pass
N-R6	3.7	Pass	Pass	Pass
N-R7	3.7	Pass	Pass	Pass
N-R8	2.6	Pass	Pass	Pass
N-R9	1.8	Pass	Pass	Pass
Plant		13-18H Running	13-18H Running	13-18H Running
Weather		Calm	Enhanced	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

* If ML1 levels were employed the predicted levels would be close to compliant at night.

Table 4.3.3.6: Dewhurst 26-31:
Scenarios 22 to 24 Noise 'Most Likely', 'Worst Case' and 'Inversion' Predicted Levels for Compliance with Amenity (sleep) Guideline of 40 dB(A) LAeq façade level

Residence	Distance from site (km)	Scenario 22 'Most likely' dB(A)	Scenario 23 'Worst Case' dB(A)	Scenario 24 'Inversion' dB(A)
S-R1	13.1	Pass	Pass	Pass
S-R2	13.6	Pass	Pass	Pass
S-R3	13.2	Pass	Pass	Pass
S-R4	11.6	Pass	Pass	Pass
S-R5	10.9	Pass	Pass	Pass
Plant		26-31 Running	26-31 Running	26-31 Running
Weather		Calm	Enhanced	Inversion

Note: 'Distance' is the distance in kilometres from the site to the relevant residence; distances from individual pilots to residences will vary

In conclusion it is found that the noise levels during the operation phase are within the assessment criteria at all residences, with the exception of N-R4, which is currently leased by Santos and is unoccupied. The lease that Santos

has over Receiver N-R4 is due to expire in December 2015 and may revert to its owners. On this basis is assessed as a sensitive receiver and is potentially non-compliant.

4.3.4 Mitigation and Management of Noise from Wells

There is potential for the noise to be managed to ensure nuisance is avoided. Strategies could include:

- Monitoring at residence N-R4 during operation (prior to expiry of lease) to validate noise modelling predictions and operational activity noise.
- It may be feasible to upgrade the acoustic performance within an affected residence, with the cost of capital works balanced with the reasonable long term acoustic needs of the dwelling. As the criteria at the façade is the greater exceedance, design to reduce noise by 6dB(A) would be ideal and would resolve issues of potential sleep disturbance.
- That said, the only means by which noise will be reduced at the façade is to reduce it at source. If there is a possibility of localised noise treatments to the Pilot these should be explored. Such mitigation measures include acoustic screening by barrier design or enclosure, and/or modification to plant.
- Alternatively, acoustic treatment to the dwelling, to reduce levels from outside to inside by 6dB(A) (often obtained through window treatments and mild wall treatments) is a reasonable alternative, if it is acceptable to the residents.

4.4 Road Traffic Noise

4.4.1 Vehicle Volumes – Existing

The current traffic flows on the Newell highway are given by Narrabri Council as 1860 vehicles per day with 40% of these being heavy vehicles; this is understood to be a peak period ADT. 18 hour traffic flows (from 6:00am to 12:00 midnight) are 92% of 24 hour traffic flows. NSW RTA sources gave an average of 1465 vehicles per day; this is understood to be a low period ADT. In absolute terms the heavy vehicle content is expected to range between 586 and 744 vehicles per day. 140 vehicles are observed per hour between 8:00am and 4:00pm. There are currently negligible traffic volumes on X-Line Road, Tighes Gully Road, Beehive Road and Westport Road.

4.4.2 Traffic Noise Discussion

The proposed activities contemplate the addition of traffic to:

- the Newell Highway,
- X-Line Road,
- Tighes Gully Road,
- Garlands Road,
- Boundary Road,
- Westport Road, and
- Killara Road

to access the Dewhurst 13-18H Pilot and the Dewhurst 26-31 Pilot.

Santos advises that access to Dewhurst 13-18H Pilot will be via X-Line Road, Garlands Road, Boundary Road, Killara Road, and an unnamed road. Access to Dewhurst 26-31 Pilot will be via X-Line Road, Tighes Gully Road, and Beehive Road, see **Plate 4.4.2.1**.

Traffic from the Westport Drillers Camp will access Dewhurst 13-18H via MacFarlanes Road, joing Garlands Road. It will access Dewhurst 26-31 by connecting to Tighes Gully Road via Bibblewindi Creek Road and Middle Road, see **Plate 4.4.2.1**.

Plate 4.4.2.1 Vehicle access to sites

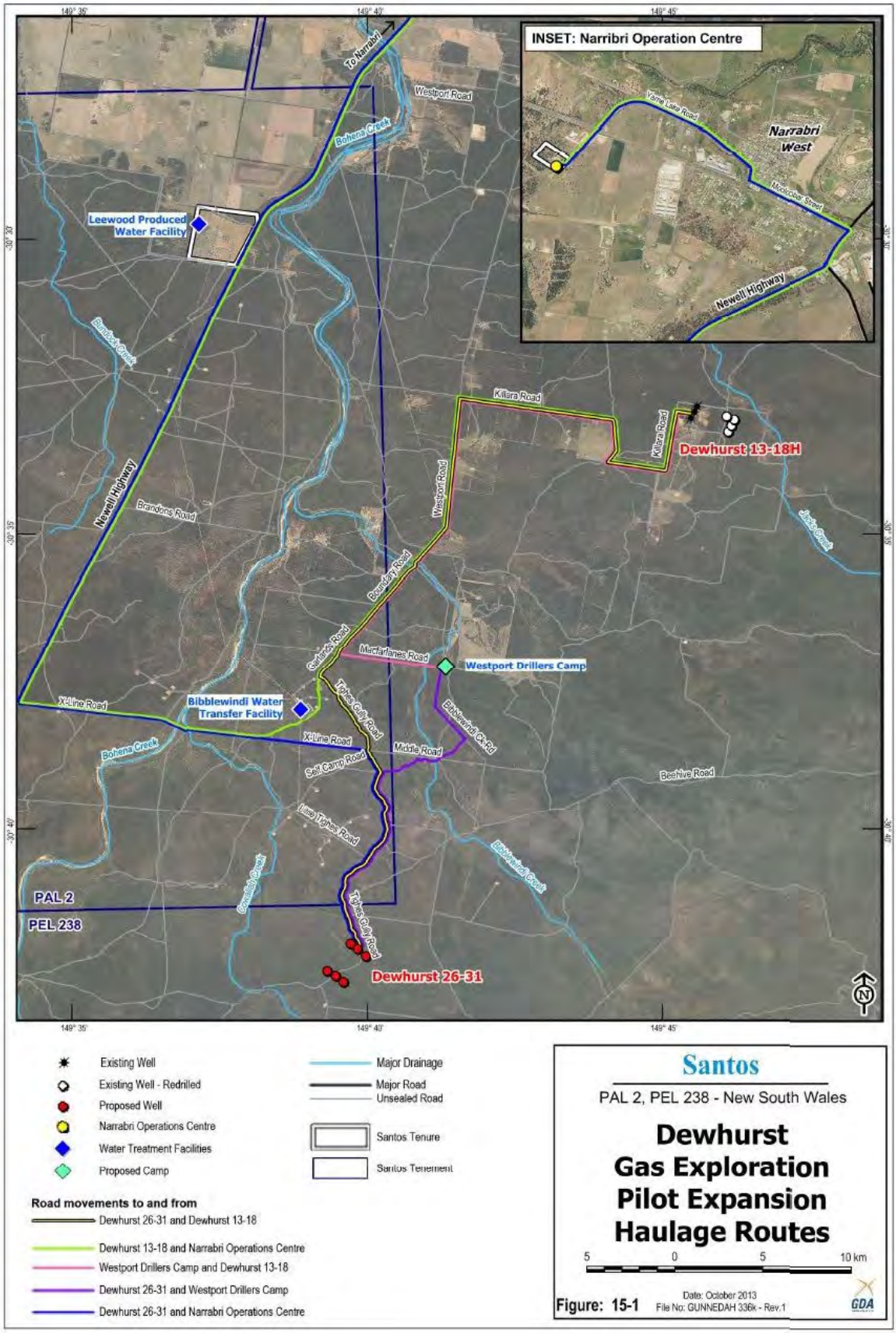


Table 4.4.2.1 Overall Estimated Construction Traffic Volumes (Table 4.1 of GTA Consultants' Report)

Table 4.1: Estimated Daily Construction and Worker Vehicles

Site	Construction Activity	Estimated Duration	Construction Vehicles	Worker Vehicles	Total Vehicles	Total Trips
Dewhurst 13-18H	Site Preparation	0 days	0	0	**0**	**0**
	Delivery of Drilling Equipment	3 days	15	8 [1]	**23**	**46**
	Drilling	18 days	1	8 [1]	**9**	**18**
	Removal of Drilling Equipment	3 days	18	8 [1]	**26**	**52**
	Delivery of Gathering System Equipment	1 day	8	3	**11**	**22**
	Gathering System	7 days	0	3	**3**	**6**
	Delivery of Surface Facilities Equipment	1 day	3	3	**6**	**12**
	Surface Facilities	21 days	0	3	**3**	**6**
Dewhurst 30-31	Site Preparation	7 days	3	1	**4**	**8**
	Delivery of Drilling Equipment	3 days	19	8 [1]	**27**	**54**
	Drilling	25 days	1	8 [1]	**9**	**18**
	Removal of Drilling Equipment	3 days	18	8 [1]	**26**	**52**
	Delivery of Gathering System Equipment	1 day	3	3	**6**	**12**
	Gathering System	7 days	0	3	**3**	**6**
	Delivery of Surface Facilities Equipment	1 day	3	3	**6**	**12**
	Surface Facilities	21 days	0	3	**3**	**6**

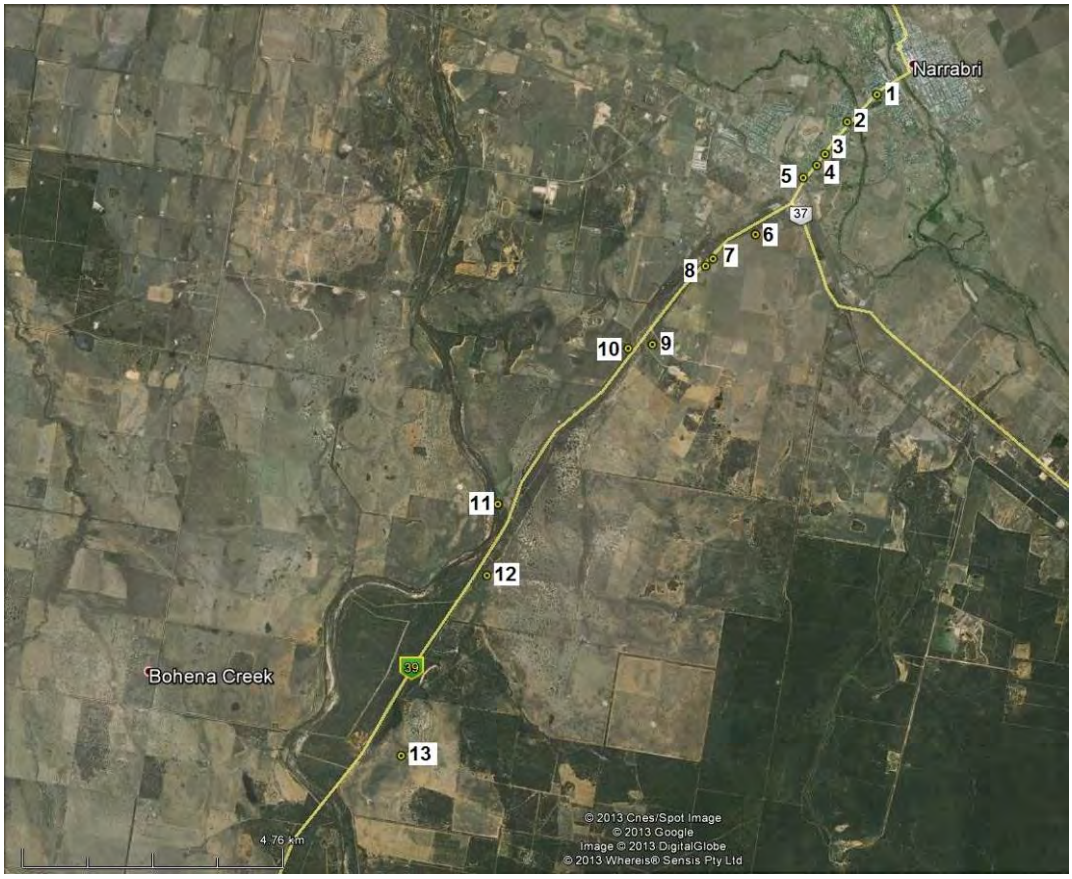
[1] Vehicles associated with transportation of workers by bus and delivery of meals to workers at the works site.

Newell Highway

Peak traffic flows on the Newell Highway will occur for a short period when heavy vehicles and staff will travel along the highway from Narrabri to the site. An approximate additional traffic flow is, at its highest, 66 vehicle trips per day but otherwise 24-25 vehicle trips per day and then less than 5 in any given hour. For the balance of the time no more than 1 vehicle movement per day is expected on the Newell Highway during operation.

In terms of the cumulative effects on nearby sensitive uses, a number of dwellings adjacent to the highways have been identified. It is not confirmed that these are all dwellings, or if they are permanently occupied where they are confirmed to be dwellings, but by treating them all as occupied dwellings the intent is to demonstrate the impact on sensitive uses at varying distances (up to 600m from the Highways, in accordance with the RNP). **Plate 4.4.2.2** shows the position of these dwellings.

Plate 4.4.2.2 Potentially Affected Residences (Newell Highway)



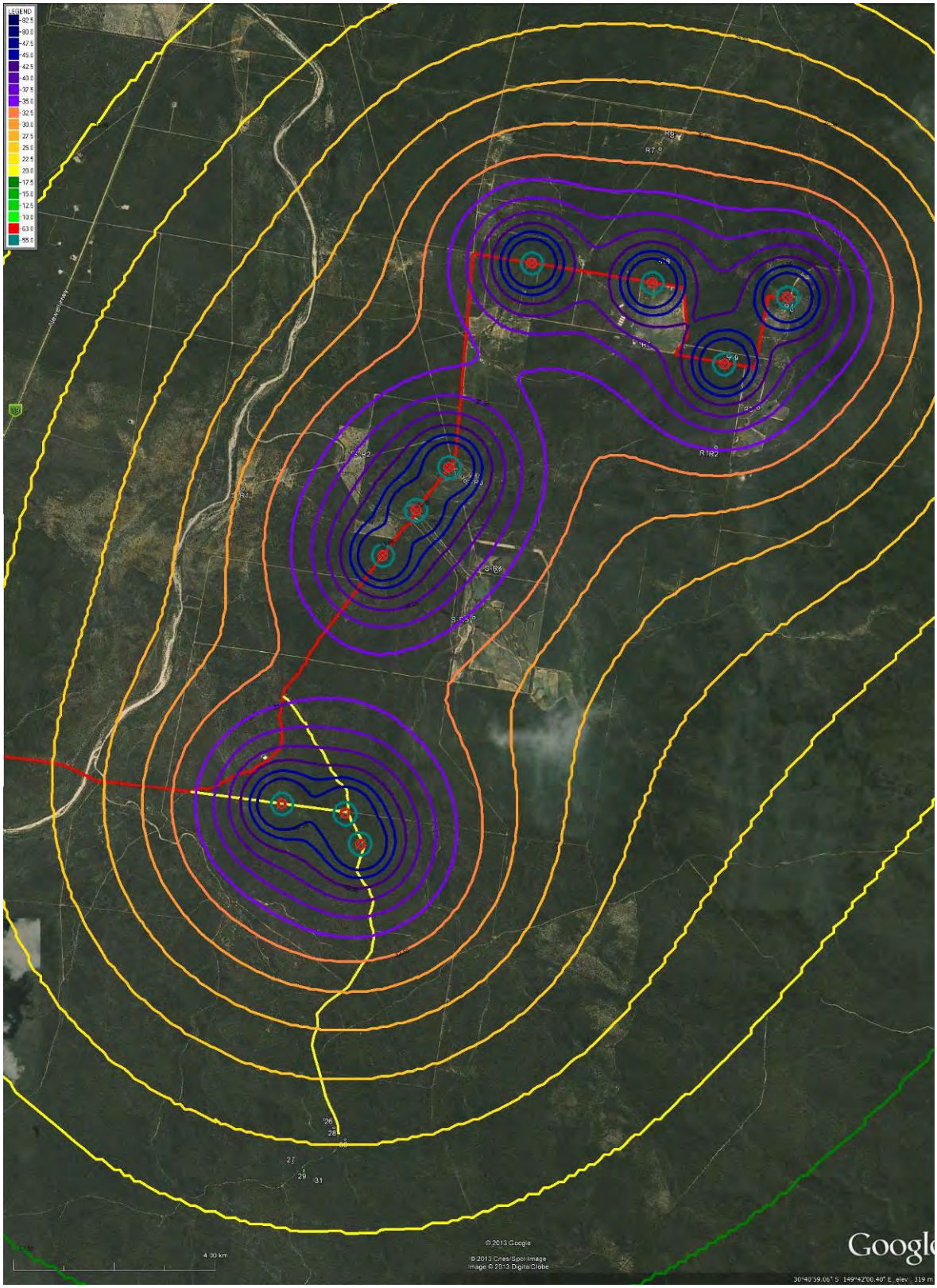
Noise levels associated with the increase in traffic due to the proposed activity are minimal with all construction vehicles and equipment to be delivered during the beginning of the construction works and collected upon completion. Between these times, equipment will remain on site.

The predicted increase in traffic noise over existing levels on the Newell Highway is calculated as at or below 0.1 dB(A) for each of receivers 1 through 13, during peak traffic flows, and will be below the *RNP relative increase* criterion of existing $L_{Aeq,\ 15hr}$ +12dB(A) (external). The contribution of peak vehicle movements is negligible (i.e. makes no measureable difference, at 0.1dB(A) increase), and during operation will be below this. Noise levels are currently predicted to be at or below the *RNP Table 3 noise limits* and the addition of traffic from this activity will not affect that. Road impacts are therefore considered negligible during construction and will meet the *RNP.* During operation, traffic volumes would be less and would still be considered negligible. The nature of the additional traffic is similar to the nature of existing traffic flows on the Highway.

Local Roads

Local traffic on X-Line Road, Tighes Gully Road, Garlands Road, Boundary Road, Westport Road, and Killara Road (as well as MacFarlanes Road, Bibblewindi Creek Road, Middle Road, and unnamed roads) will include vehicles on shift rotations, and these will be minimal but regular during the construction (maximum of approximately 19 movements per day). Traffic flows are below those able to be employed under the CoRTN model, and accordingly an environmental model has been created using a nominal truck in the vicinity of the closest sensitive receptors along the route. **Plate 4.4.2.3** shows noise contours from the trucks along each vehicle access route (for principle access to Dewhurst 13-18H and Dewhurst 26-31).

Plate 4.4.2.3 Noise contours (dB(A), Lmax) from trucks along access routes to Dewhurst 13-18H and Dewhurst 26-31 Pilots.



Levels have been calculated on the basis of an maximum pass-by noise level, corrected to $L_{Aeq,\ 1hr}$ (compared to the RNP criteria, in **Table 4.4.2.2** following. Predicted noise levels are below the local road criterion under the *RNP* (55dB(A) ($L_{Aeq,\ 1hr}$) and are also below the *INP* criterion of 35dB(A) ($L_{Aeq,\ 1hr}$) for the majority of residences.

Table 4.4.2.2 Nominal truck noise levels at Receivers N-R1 to N-R9 and S-R1 to S-R5, levels in dB(A) (free field); calm scenario. Sound levels are rounded and calculated at the residential façade

Residence	Distance from noise source (m)	Predicted levels dB(A), Lmax	Predicted levels dB(A), 1 hr (single passby)	Predicted levels dB(A), 1 hr (two passes-by)	RNP Criterion dB(A), 1 hr	Pass
N-R1	1750	35	18	21	55	Yes
N-R2	1650	35	18	21	55	Yes
N-R3	1100	40	23	26	55	Yes
N-R4*	280	53*	36*	39*	55*	Yes*
N-R5	810	39	22	25	55	Yes
N-R6	2900	31	14	17	55	Yes
N-R7	2660	32	14	17	55	Yes
N-R8	470	48	31	34	55	Yes
N-R9	140	59	42	45	55	Yes
S-R1	6150	23	13	16	55	Yes
S-R2	7000	25	20	23	55	Yes
S-R3	6980	27	33	36	55	Yes
S-R4	5620	26	19	22	55	Yes
S-R5	4850	26	19	22	55	Yes

Note: 'Distance' is the distance in meters from the receptor to the closest noise source.

Conclusions

Accordingly it is concluded that-

- The overall noise levels produced by road traffic on the Newell Highway will not measurably increase due to the addition of construction and worker traffic.
- The nature of the additional traffic is similar to the nature of existing traffic flows on the Highways.
- Incidental vehicle movements on the non-highway road network will be measurable but will not exceed criteria.
- Increase in overall noise levels due to traffic movements is minor.
- The increase in overall traffic noise (existing plus operational vehicles, or operation vehicles considered in isolation) is within the criteria established under the *RNP or INP.*

5. Conclusions

The chief noise criteria to be achieved are the Intrusive noise criterion and sleep disturbance criterion under the INP. The Rating Background Level plus 5 dB(A) 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 (for each well). 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.*

As demonstrated in Section 4, all sound levels calculated in the noise modelling process are within the noise criteria set out in the INP, with the exception of construction of three locations under adverse weather conditions (one of those locations being leased by Santos during the construction period), and one location (N-R4) under all conditions during operations.

Noise impacts are confined to the local area surrounding each pilot. Other pilots within the E&A program that will operate concurrently are all located at distances that would not create a cumulative impact during operation. During construction, a maximum of two drilling rigs will be in operation, including a smaller workover rig. The E&A Program ensures that the two drill rigs will operate at sufficient distances to eliminate any cumulative noise impacts.

In summary it is concluded

Construction

- The drilling stages will be in exceedance, principally at night, at receivers N-R3 and N-R9 in circumstances where adverse weather conditions will enhance noise propagation, but any audible activity or exceedance will be of short duration.
- The impact at these residences may be reduced by management or design.
- Monitoring is required during construction to validate noise modelling, as a management measure to control noise.

Operation

- The operation of the pilot wells should not exceed compliance levels at any of the residences identified in this assessment, with the exception of residence N-R4, which is currently leased by Santos to December 2015.
- Consideration should be given to modification of the dwelling (N-R4), to enhance its acoustic performance, prior to the surrender of the lease, should a continuation of the lease not be possible. The modification should be based on actual sound measurements at the time in order to determine the degree of mitigation required. Monitoring is required during operation (prior to expiry of lease) to validate noise modelling predictions (particularly at N-R4) as a management measure to control noise.
- The only means by which noise will be reduced at the façade is to reduce it at source. If there is a possibility of localised noise treatments to the Pilot these should be explored. Such mitigation measures include acoustic screening by barrier design or enclosure, and/or modification to plant.

Transport

- The overall noise levels produced by road traffic on the Newell Highway will not measurably increase due to the addition of construction and worker traffic;

- Incidental vehicle movements on the non-highway road network will be measurable but will not exceed criteria;
- Increase in overall noise levels due to traffic movements is minor;
- The nature of the additional traffic is similar to the nature of existing traffic flows on the Highways; and
- The increase in overall traffic noise (existing plus operational vehicles, or operation vehicles considered in isolation) is within the criteria established under the *RNP or INP.*

It is concluded therefore that in general the construction and operation of the proposed activity can meet the requirements of the NSW Industrial Noise Policy, the NSW Road Noise Policy, the Interim Construction Noise Guideline and the EPA Environmental Criteria for Road Traffic Noise.

5.1 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 should include:

- Consultation with owners and occupiers of potentially affected noise sensitive receptors;
- Monitoring of noise impacts;
- Implementation of feasible and reasonable work practices if required; and
- Complaint management and response.

Noise generated by the proposed activity is unlikely to be audible at any residential receivers, with the exception of N-R4, due to its remote location. Users of the Forest, such as bushwalkers, picnickers and Forestry NSW staff, may be affected by noise and vibration during the works. Forestry NSW, the private landowner at Dewhurst 13-18H and the next two nearest sensitive receivers will be notified prior to the proposed activity commencing. This will include details of the timing and duration of noise generating activities.

During construction, feasible and reasonable work practices will be implemented with the aim to achieve L_{Aeq} 40dB(A) noise levels during recommended standard constructions hours and L_{Aeq} 35 dB(A) outside of standard working hours outside of these times. 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 commencement of drilling and cementing activities to confirm actual noise levels from construction activities. Monitoring is also required at residence N-R4 during operation (prior to expiry of lease) to validate noise modelling predictions for operational activity noise levels.

In the unlikely event that noise levels exceed L_{Aeq} 40dB(A) during standard working hours or L_{Aeq} 35 dB(A) outside of standard working hours at any noise sensitive receptor, feasible and reasonable work practices should 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; and
- reducing throttle setting and turning off equipment when not in use.

In the unlikely event of a noise complaint, the source of the noise will be investigated. Where necessary, it is recommended that Santos will 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.

During operation, in the event that the residence located 500 metres south of the Dewhurst 13-18H Pilot (N-R4) is to be re-occupied, monitoring will be undertaken to confirm operational noise levels at this location. If noise monitoring determines that levels are above noise criteria, an agreement will be negotiated with the landowner, or further feasible and reasonable mitigation measures will be implemented to reduce noise levels.

ANNEX A1: 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 for the determination of sound power levels (as distinct from propagation of noise as detailed in **Section 4**) 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 A1** 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 A2**.

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	Front	72	64	47	38	32	27	<10
	case	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	Front	72	64	47	38	32	27	<10
	case	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	Front	72	66	50	40	35	30	<10
	case	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	Front	63	57	39	31	26	22	<10
	case	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.

A drilling rig that may be utilised within the proposed activity 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 for the RPS Group on behalf of Santos Ltd.

Figure 2-1 Indicative EDA Rig 1 Layout

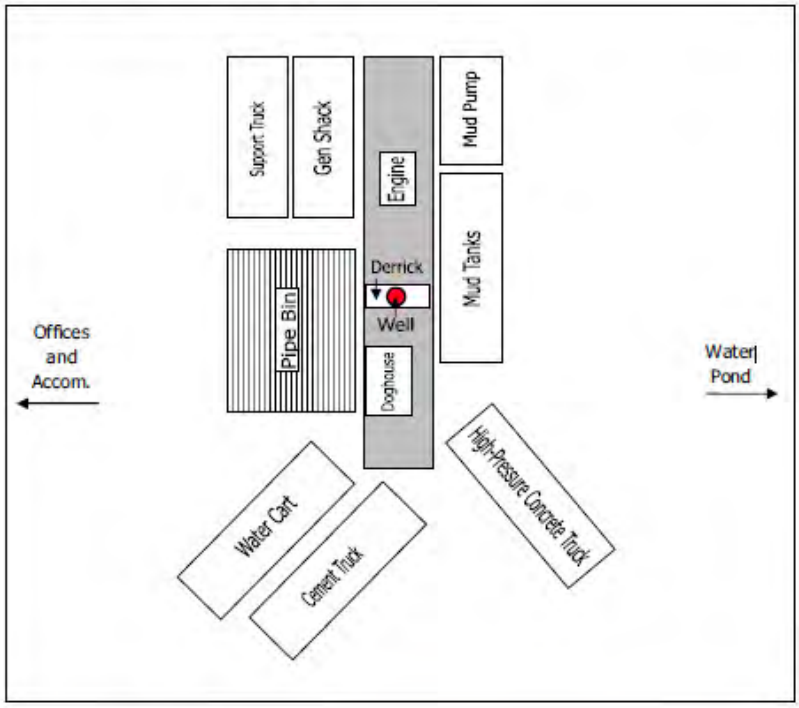


Figure 2-2 EDA Rig 1



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(A) below drilling noise levels. Running casing was 2-5 dB(A) below drilling. Cementing casing was similarly 2-5 dB(A) 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

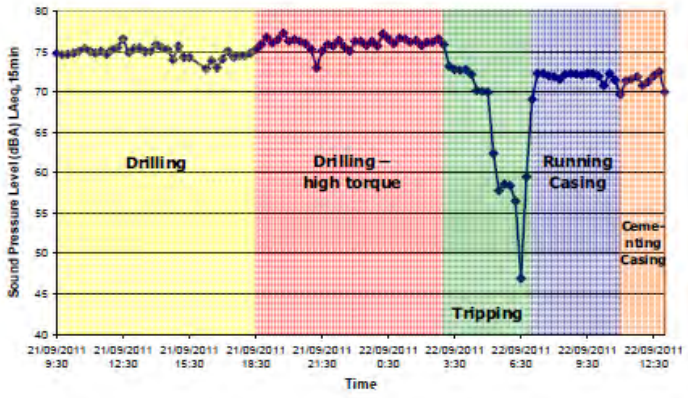


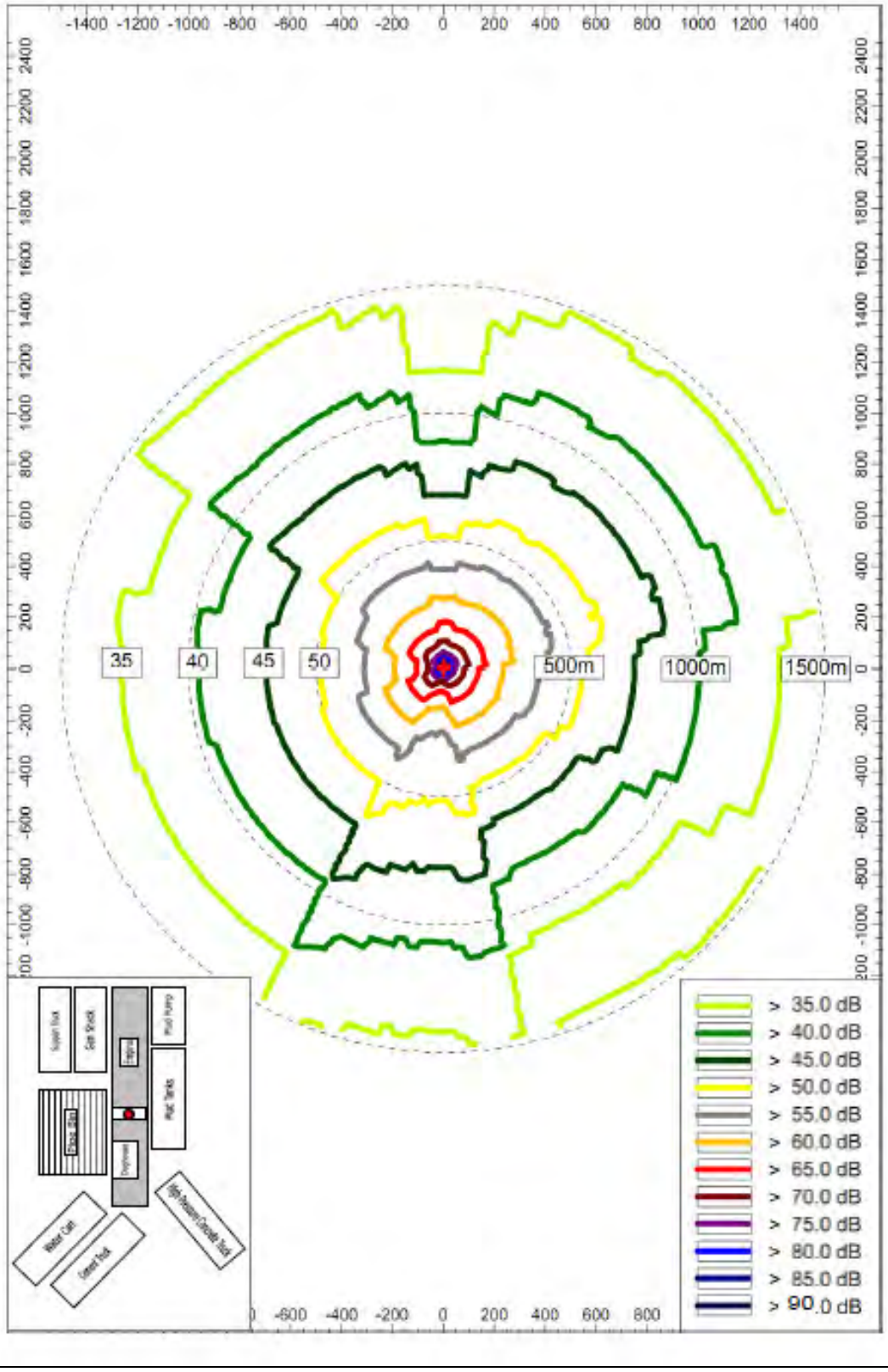
Table 3-1 presents the sound power levels for each plant item. Note that many of these sources radiate over significant areas and thus cannot be equated by point sources in the near field (less than 20m). Determination of the sound power levels has considered the radiated area of these sources. Near 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 A2: CSG 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 or tonal (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 sound emissions from different plant will vary depending on the item chosen. For example, the generator-type referenced for this report has a nominal sound level rating of 85 dBA at one metre. The level of 85 dB(A) at 1 metre is 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 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

Noise Mitigation measures

Noise mitigation measures, if necessary, may include screening (barrier walls, enclosures) or direct modification to the plant (normally to the exhaust system). However, all generator systems have specific noise mitigation designs and are installed in accordance with the manufacturer's instructions.

ANNEX B: 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 2002-2006 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.

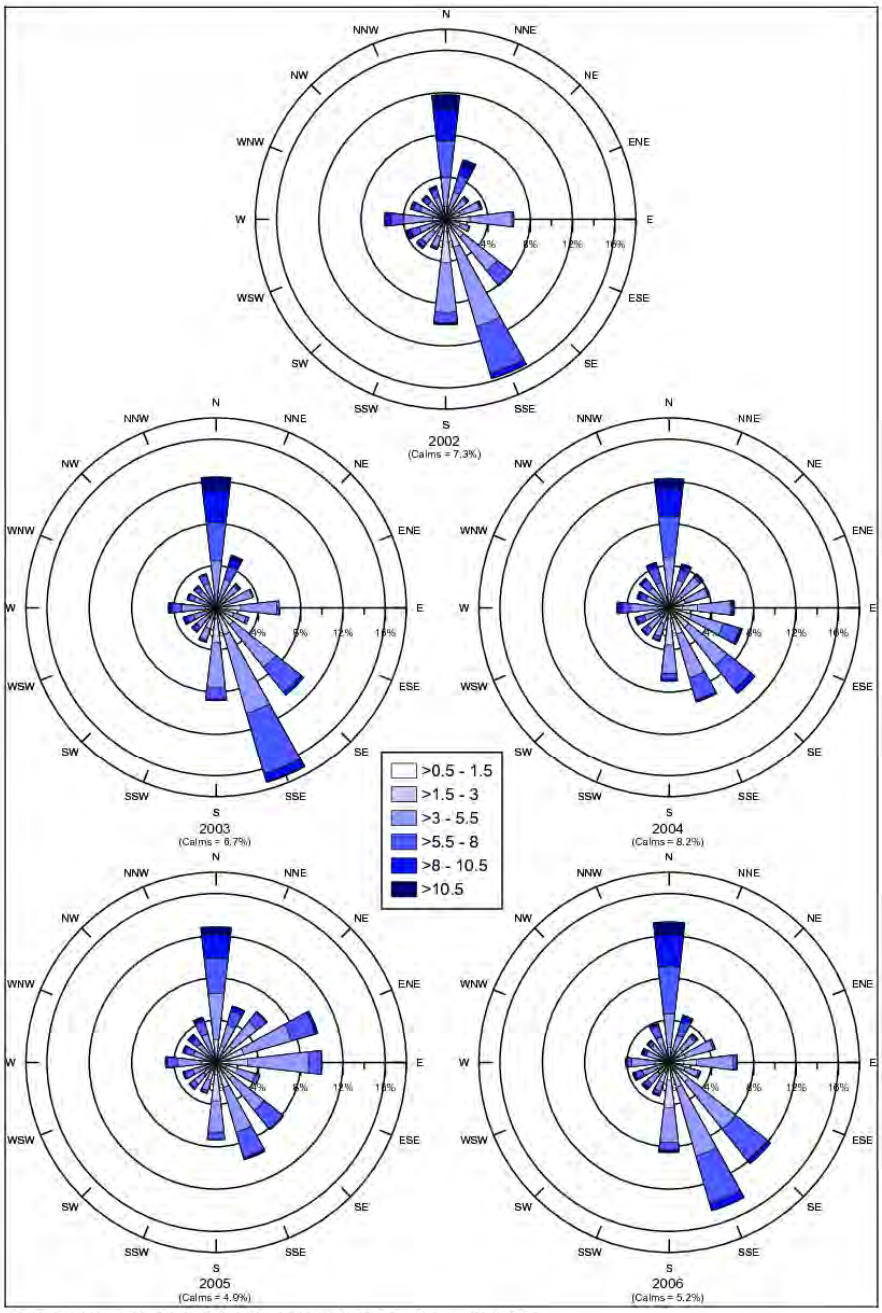
The seasonal variation in wind behaviour at the Narrabri Airport AWS is also presented following as **Figure C2** from the Heggies Report. The seasonal wind roses indicate the following:

- 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 INP) 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.

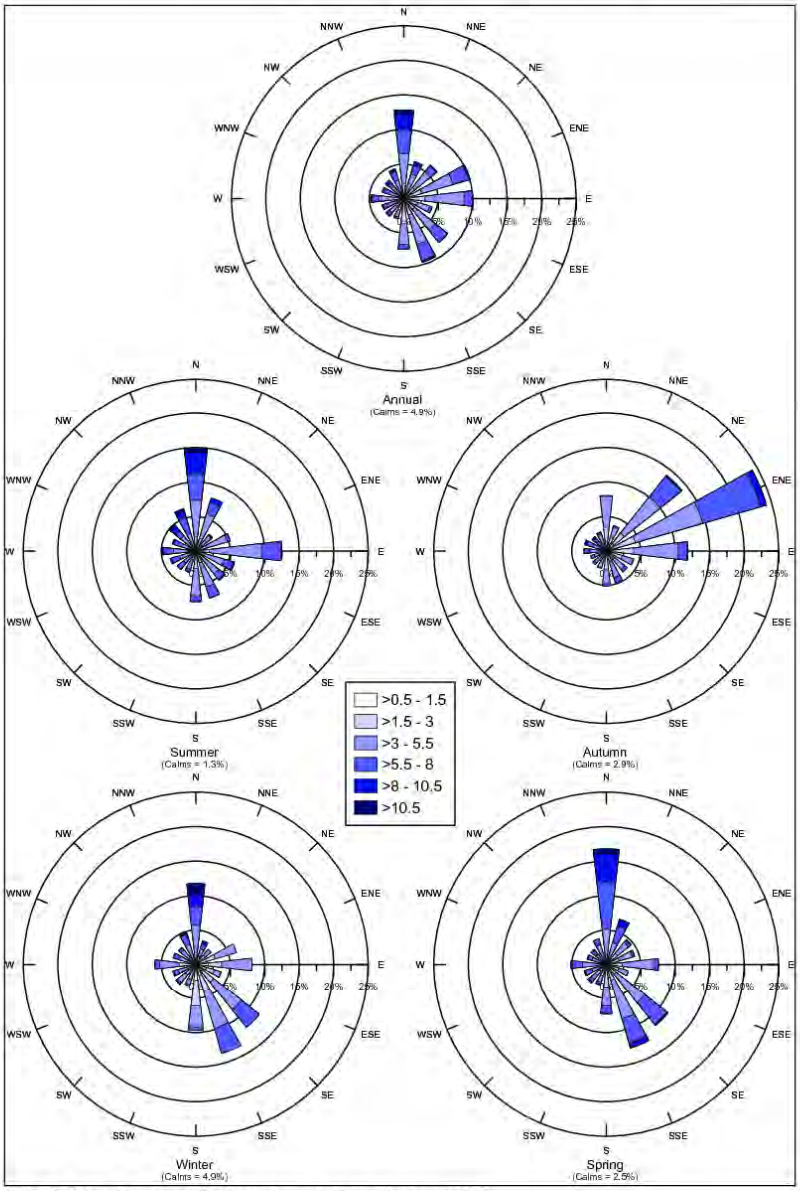
'Normal' or 'Neutral' conditions occur where the temperature slowly increases with height such as overcast conditions and / or when the wind is high enough to cause mixing of any atmospheric layers. These conditions can occur day or night; they will always prevail when it is fairly windy, overcast or 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

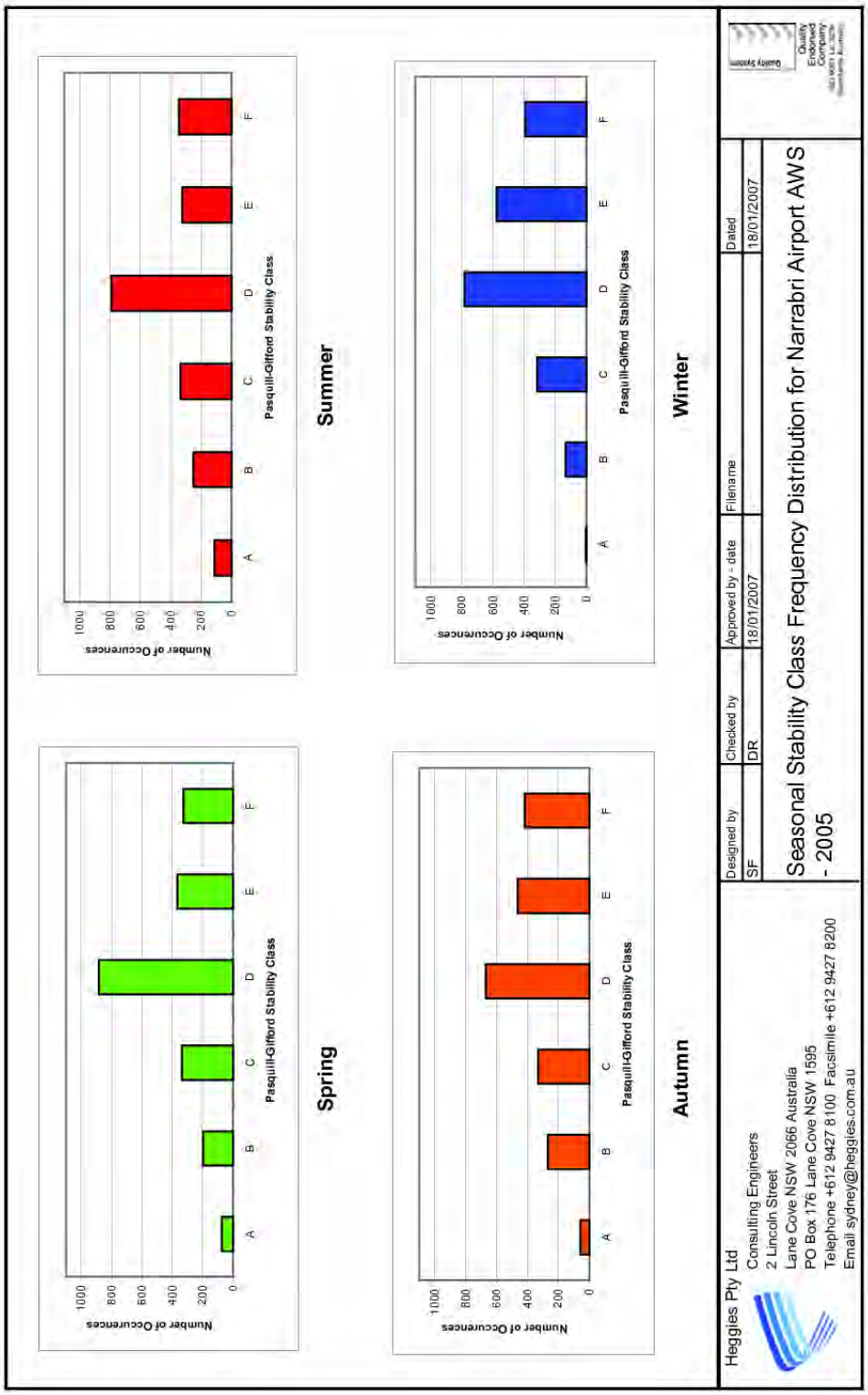
Figure C2 Seasonal Wind Roses for Narrabri Airport AWS, 2005

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Narrabri Coal Seam Gas Utilisation Project *Part 1 – Air Quality Impact Assessment*

Report No. 585/06



Heggies Pty Ltd

ANNEX C: 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(A) 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

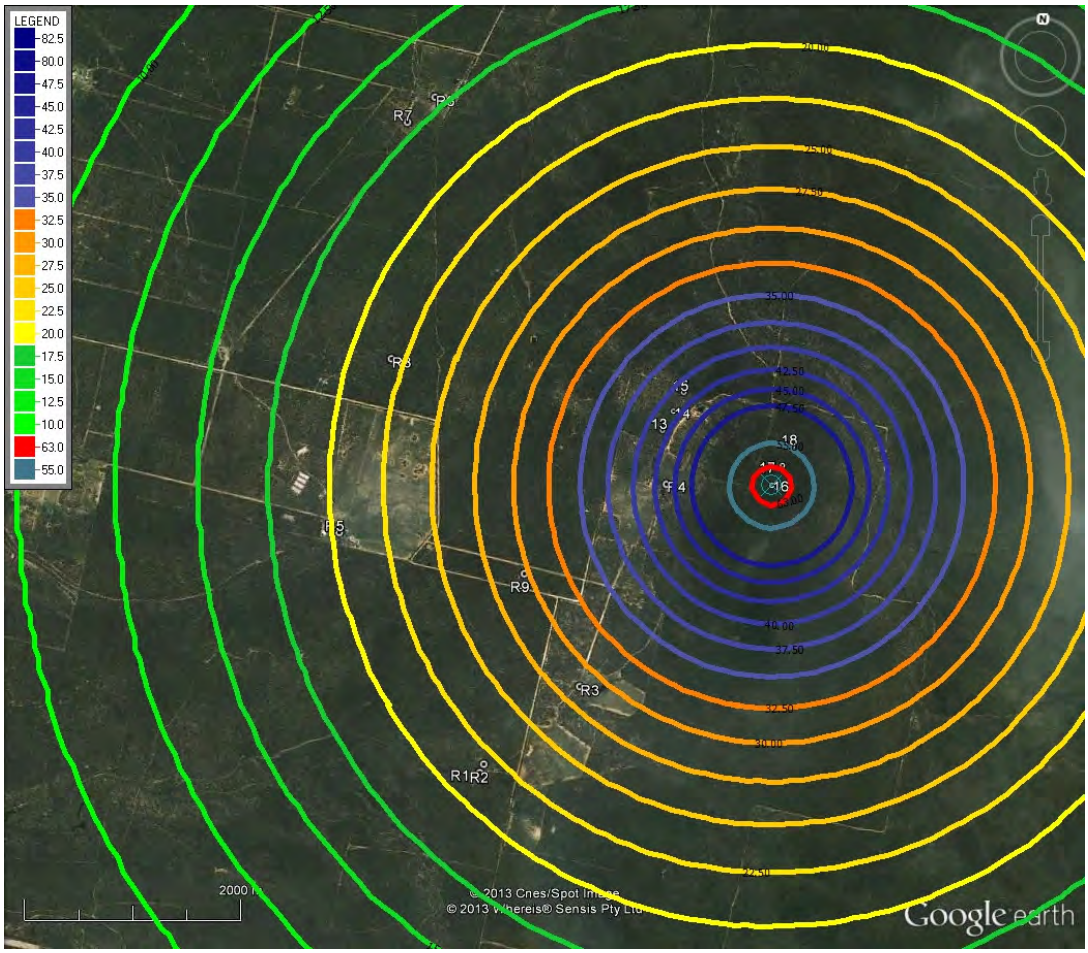
The method of prediction is ideally suited to a combination of both ISO 9613-2 and CONCAWE methods. The calculation programs available for this purpose are (a) SoundPLAN, which has both methods as separate modules, and (b) PEN3D, an environmental noise model developed by Noise Mapping Pty Ltd Queensland. 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 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
Truck	Lin	126	125	113	109	111	104	99	97	92
	A	111	99	97	100	108	104	100	98	91

ANNEX D: Noise Prediction Scenarios



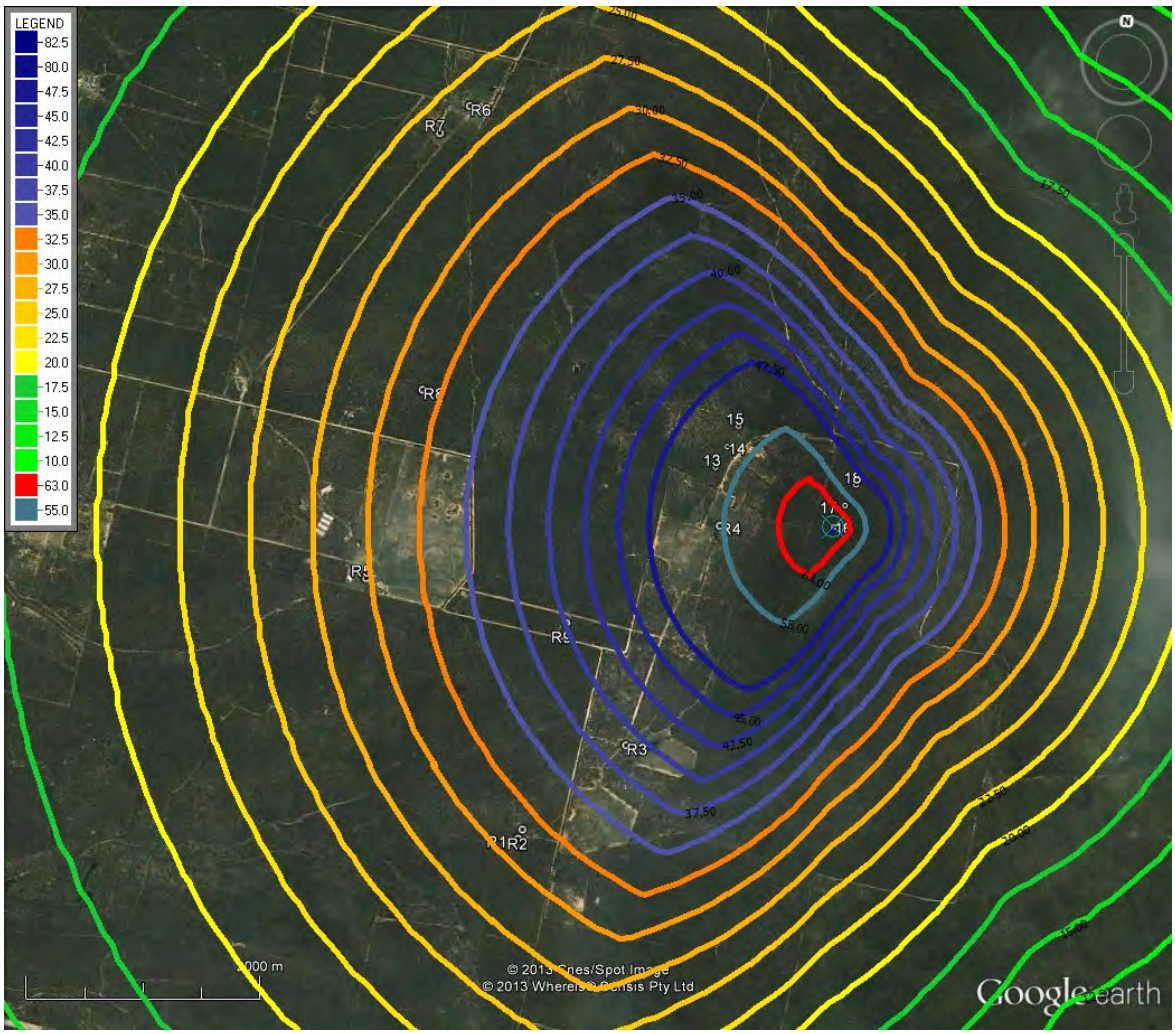
Scenario 1: Dewhurst 16H, site operations or single drilling rig, calm weather

Scenario 1: Point calculations for site operations or single drilling rig (Dewhurst 16H)

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, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
N-R1	21.9 dB(A) LAeq, calculated at 5m from residence location	
N-R2	21.5 dB(A) LAeq, calculated at 5m from residence location	
N-R3	28.7 dB(A) LAeq, calculated at 5m from residence location	
N-R4	N/A*	
N-R5	20.3 dB(A) LAeq, calculated at 5m from residence location	
N-R6	17.1 dB(A) LAeq, calculated at 5m from residence location	
N-R7	17.1 dB(A) LAeq, calculated at 5m from residence location	
N-R8	21.9 dB(A) LAeq, calculated at 5m from residence location	
N-R9	29.7 dB(A) LAeq, calculated at 5m from residence location	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

*The residence indicated by N-R4 is currently leased by Santos and is therefore not considered to be a sensitive receptor for drilling activities.



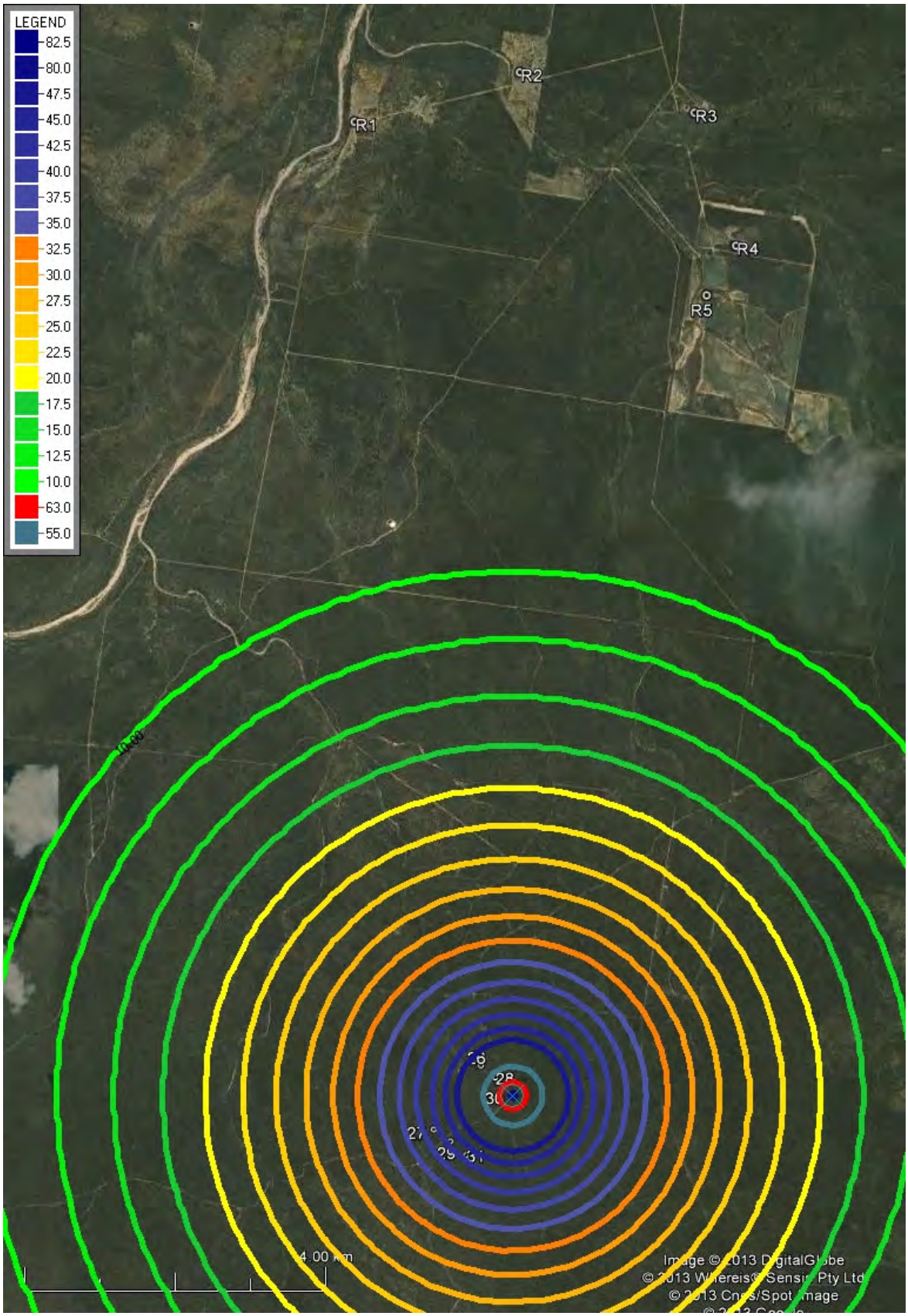
Scenario 2: Dewhurst 16H, site operations or single drilling rig, wind 3 m/s from east

Scenario 2: Point calculations for site operations or single drilling rig (Dewhurst 16H)

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Excavators or drill rig	120	118
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	easterly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
N-R1	31.5 dB(A) LAeq, calculated at 5m from residence location	
N-R2	31.1 dB(A) LAeq, calculated at 5m from residence location	
N-R3	39.0 dB(A) LAeq, calculated at 5m from residence location	
N-R4	N/A*	
N-R5	29.8 dB(A) LAeq, calculated at 5m from residence location	
N-R6	26.1 dB(A) LAeq, calculated at 5m from residence location	
N-R7	26.1 dB(A) LAeq, calculated at 5m from residence location	
N-R8	31.6 dB(A) LAeq, calculated at 5m from residence location	
N-R9	40.1 dB(A) LAeq, calculated at 5m from residence location	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

*The residence indicated by N-R4 is currently leased by Santos and is therefore not considered to be a sensitive receptor for drilling activities.

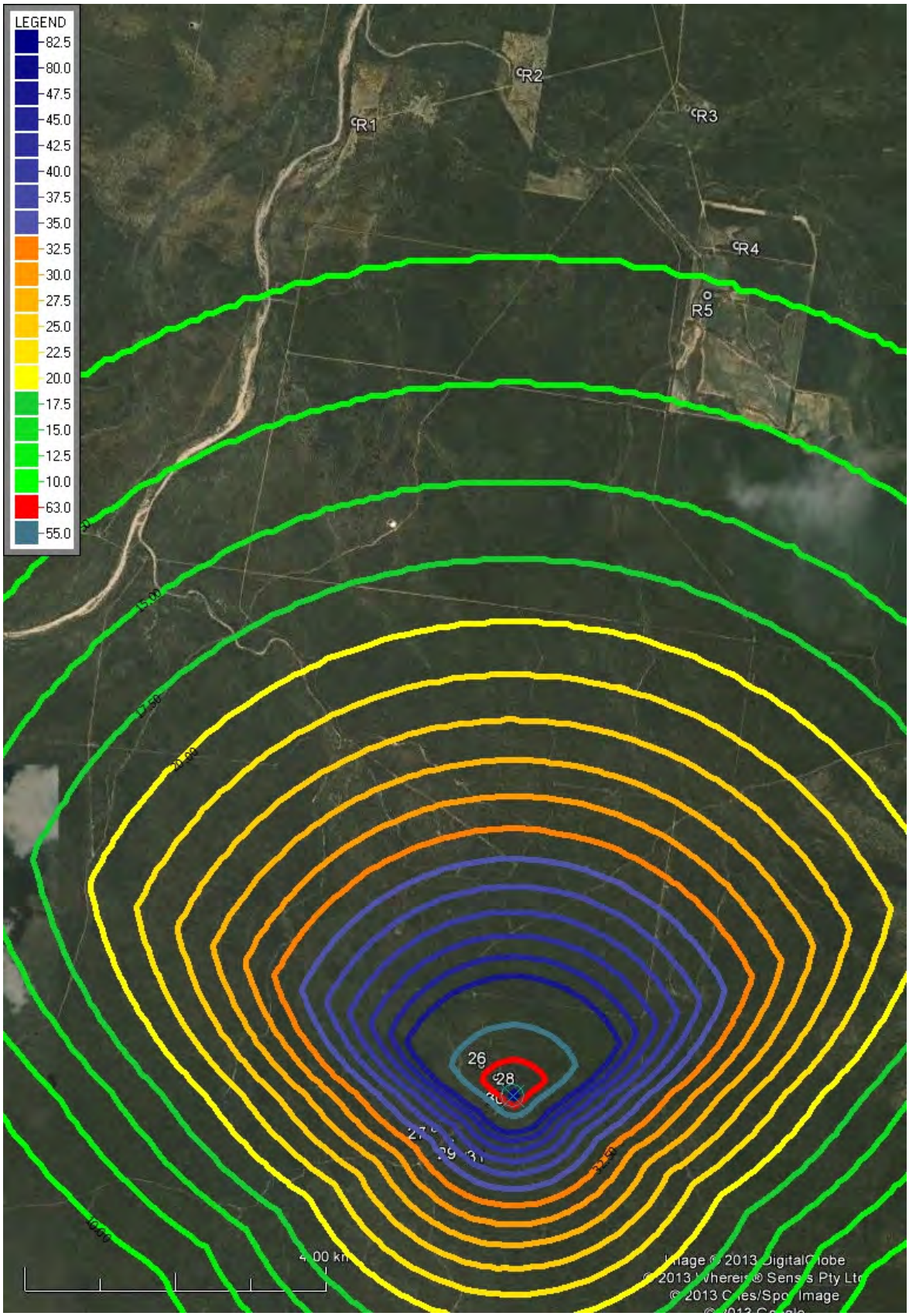


Scenario 3: Dewhurst 30, site operations or single drilling rig, calm weather

Scenario 3: Point calculations for site operations or single drilling rig (Dewhurst 30)

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, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
S-R1	0.2 dB(A) LAeq, calculated at 5m from residence location	
S-R2	-0.3 dB(A) LAeq, calculated at 5m from residence location	
S-R3	0.0 dB(A) LAeq, calculated at 5m from residence location	
S-R4	1.9 dB(A) LAeq, calculated at 5m from residence location	
S-R5	2.8 dB(A) LAeq, calculated at 5m from residence location	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

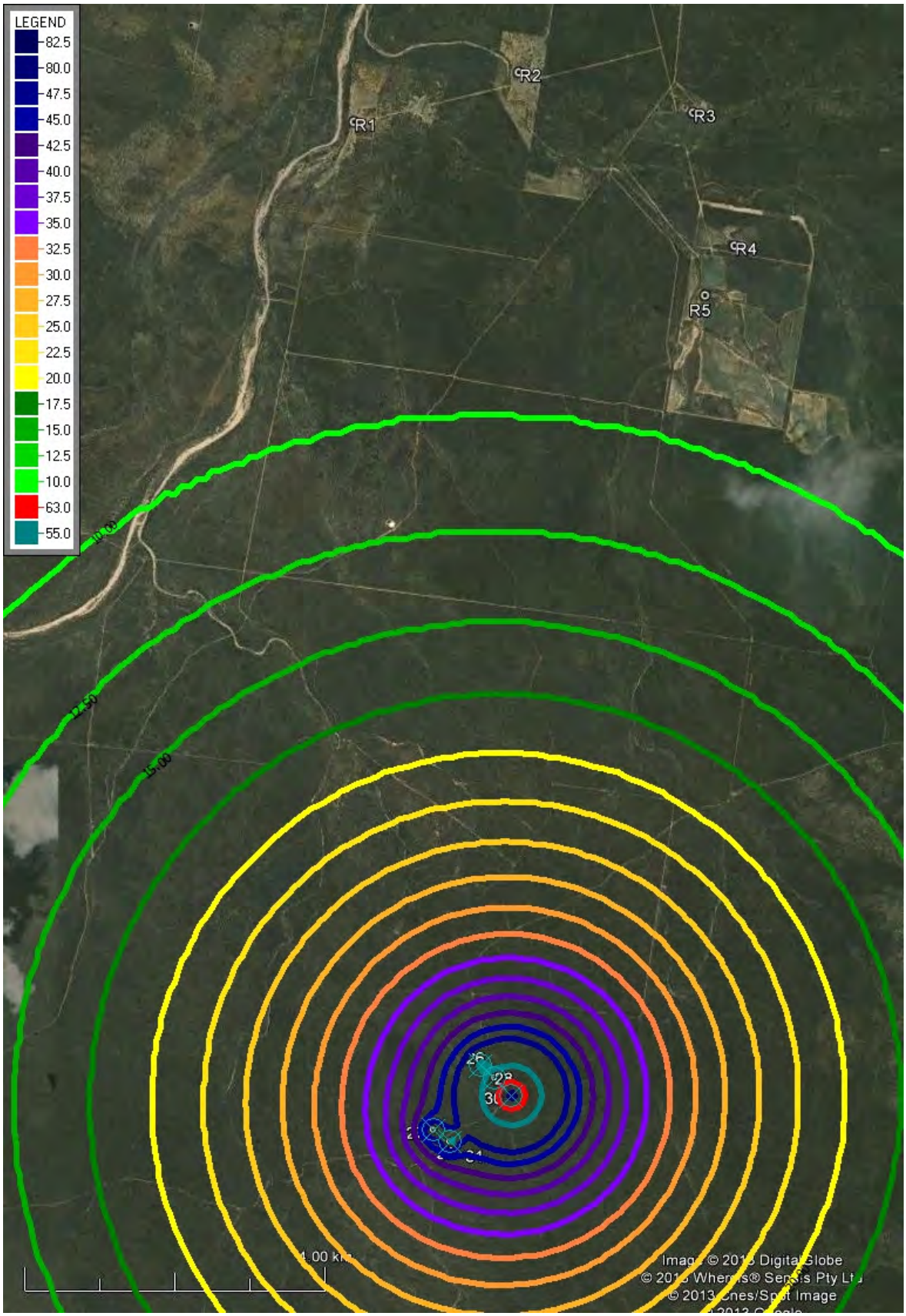


Scenario 4: Dewhurst 30, site operations or single drilling rig, wind 3 m/s from south

Scenario 4: Point calculations for site operations or single drilling rig (Dewhurst 30)

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, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
S-R1	7.7 dB(A) LAeq, calculated at 5m from residence location	
S-R2	7.2 dB(A) LAeq, calculated at 5m from residence location	
S-R3	7.5 dB(A) LAeq, calculated at 5m from residence location	
S-R4	9.3 dB(A) LAeq, calculated at 5m from residence location	
S-R5	10.3 dB(A) LAeq, calculated at 5m from residence location	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

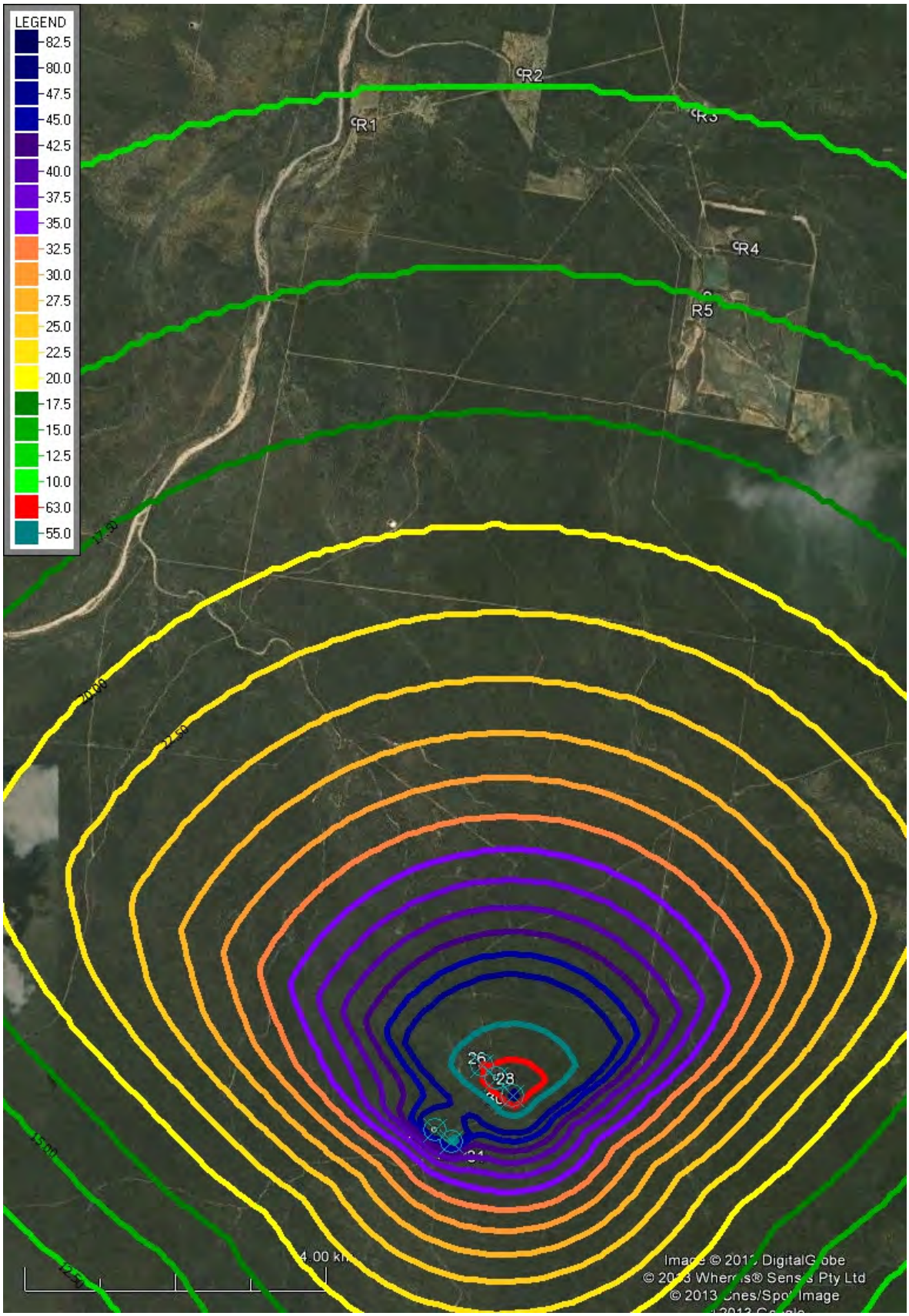


Scenario 5: Drilling operations at Dewhurst 30, with Dewhurst 26-29 running, calm weather

Scenario 5: Point calculations for drilling operations at Dewhurst 30, with Dewhurst 26-29 running

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Excavators or drill rig	120	118
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
S-R1	5.3 dB(A) LAeq, calculated at 5m from residence location	
S-R2	4.8 dB(A) LAeq, calculated at 5m from residence location	
S-R3	5.0 dB(A) LAeq, calculated at 5m from residence location	
S-R4	6.6 dB(A) LAeq, calculated at 5m from residence location	
S-R5	7.4 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

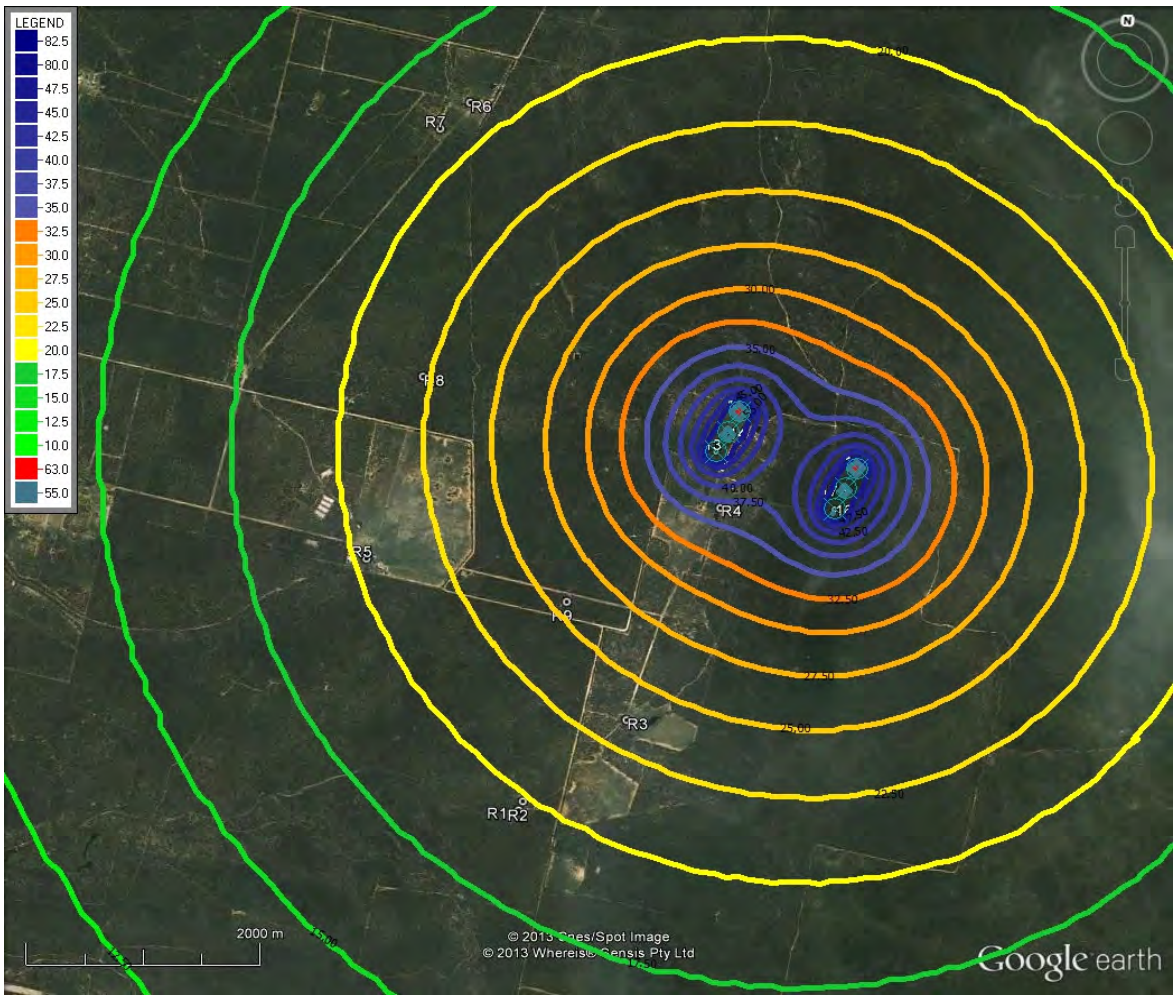


Scenario 6: Drilling operations at Dewhurst 30, with Dewhurst 26-29 running, wind at 3 m/s from the south

Scenario 6: Point calculations for drilling operations at Dewhurst 30, with Dewhurst 26-29 running

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Excavators or drill rig	120	118
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
R1	12.9 dB(A) LAeq, calculated at 5m from residence location	
R2	12.4 dB(A) LAeq, calculated at 5m from residence location	
R3	12.6 dB(A) LAeq, calculated at 5m from residence location	
R4	14.2 dB(A) LAeq, calculated at 5m from residence location	
R5	15.0 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

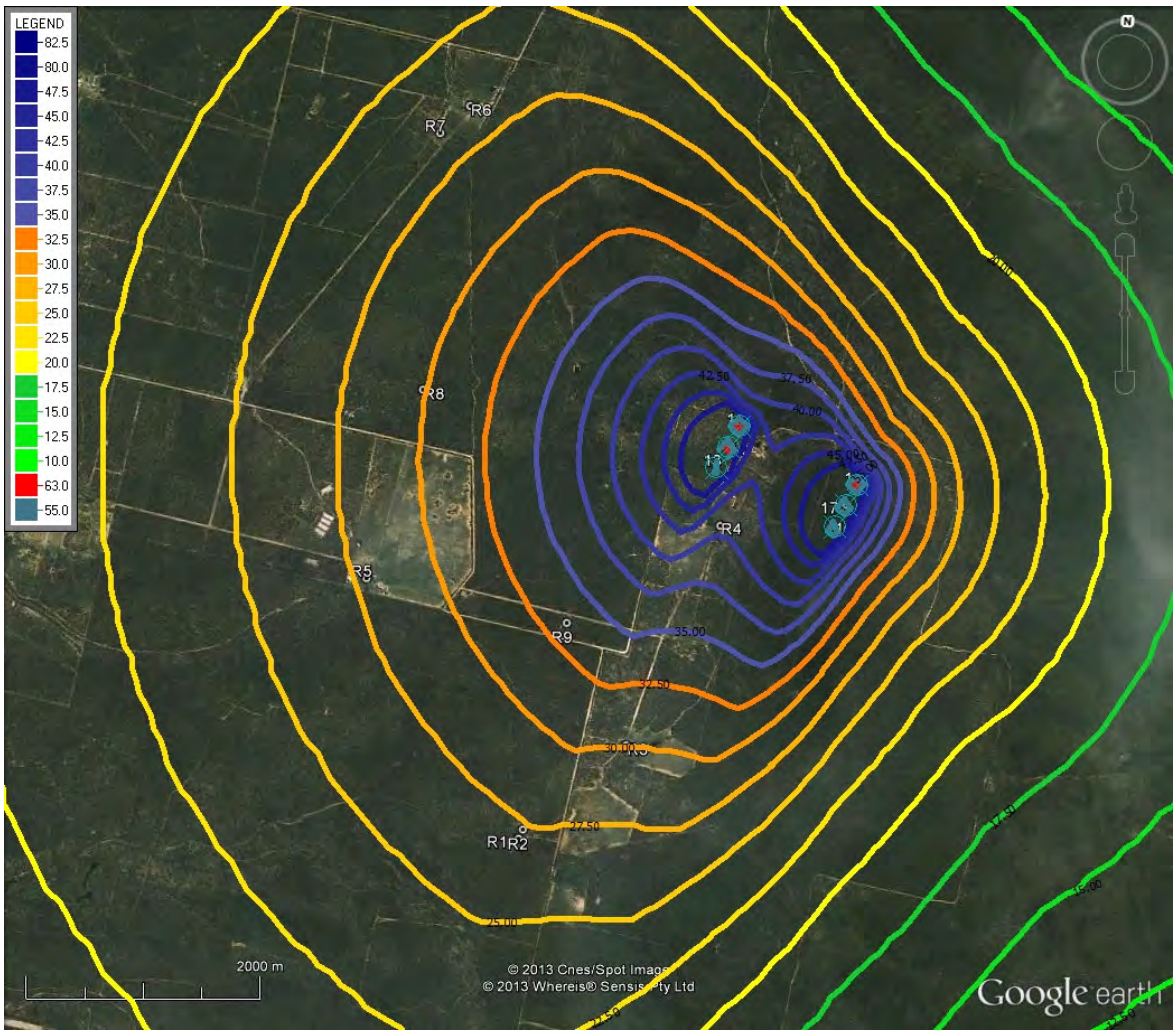


Scenario 7: Dewhurst 13-18H, all wells running, calm weather

Scenario 7: Point calculations for Dewhurst 13-18H

Plant Sound Power Level	dB(Lin)	dB(A)
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
N-R1	19.8 dB(A) LAeq, calculated at 5m from residence location	
N-R2	19.6 dB(A) LAeq, calculated at 5m from residence location	
N-R3	23.5 dB(A) LAeq, calculated at 5m from residence location	
N-R4	36.6 dB(A) LAeq, calculated at 5m from residence location	
N-R5	20.3 dB(A) LAeq, calculated at 5m from residence location	
N-R6	19.1 dB(A) LAeq, calculated at 5m from residence location	
N-R7	19.1 dB(A) LAeq, calculated at 5m from residence location	
N-R8	22.3 dB(A) LAeq, calculated at 5m from residence location	
N-R9	25.6 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

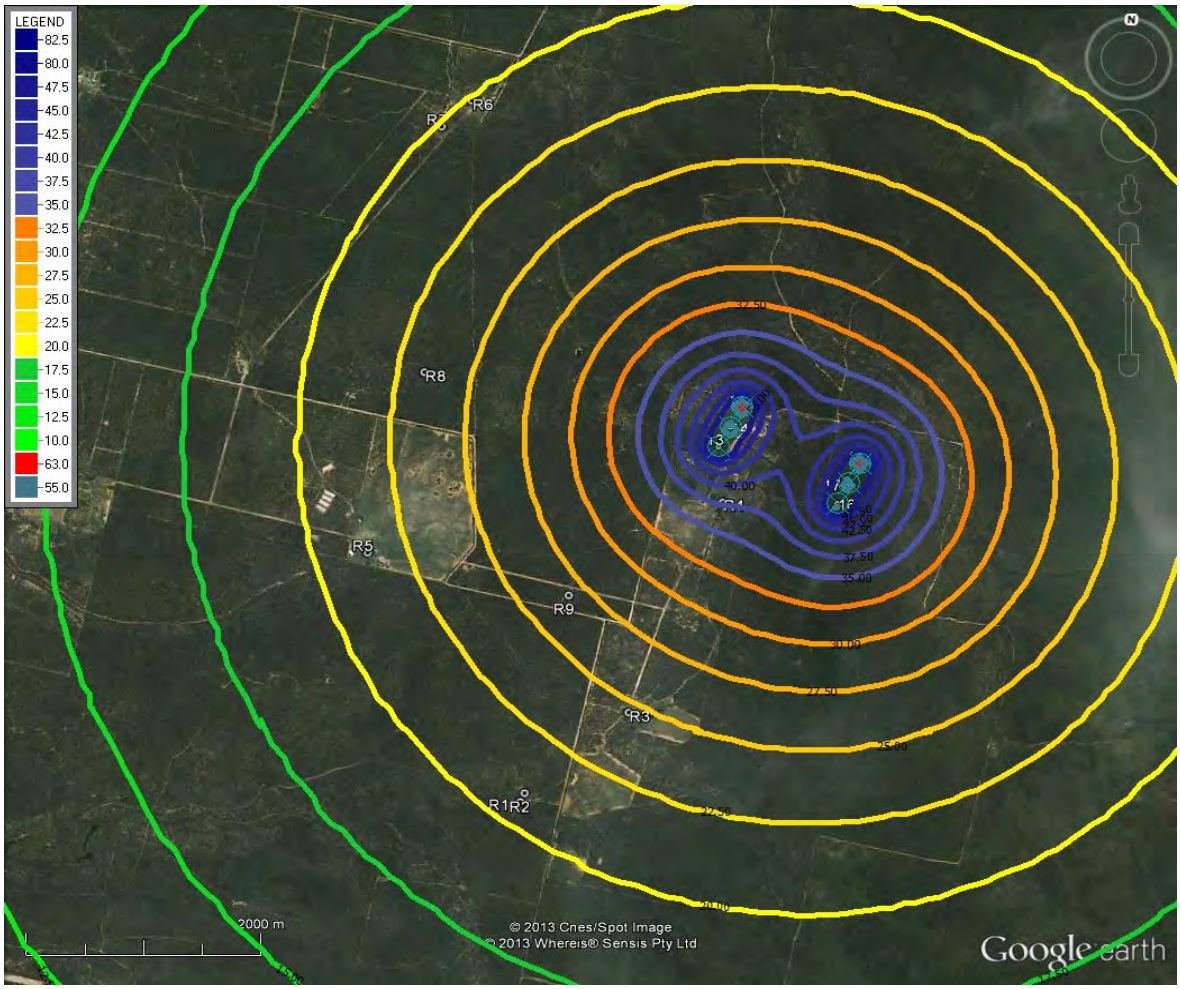


Scenario 8: Dewhurst 13-18H, all wells running, wind at 3 m/s from the east

Scenario 8: Point calculations for Dewhurst 13-18H

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	easterly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
N-R1	27.3 dB(A) LAeq, calculated at 5m from residence location	
N-R2	27.1 dB(A) LAeq, calculated at 5m from residence location	
N-R3	30.0 dB(A) LAeq, calculated at 5m from residence location	
N-R4	40.5 dB(A) LAeq, calculated at 5m from residence location	
N-R5	27.9 dB(A) LAeq, calculated at 5m from residence location	
N-R6	26.6 dB(A) LAeq, calculated at 5m from residence location	
N-R7	26.6 dB(A) LAeq, calculated at 5m from residence location	
N-R8	29.9 dB(A) LAeq, calculated at 5m from residence location	
N-R9	33.4 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

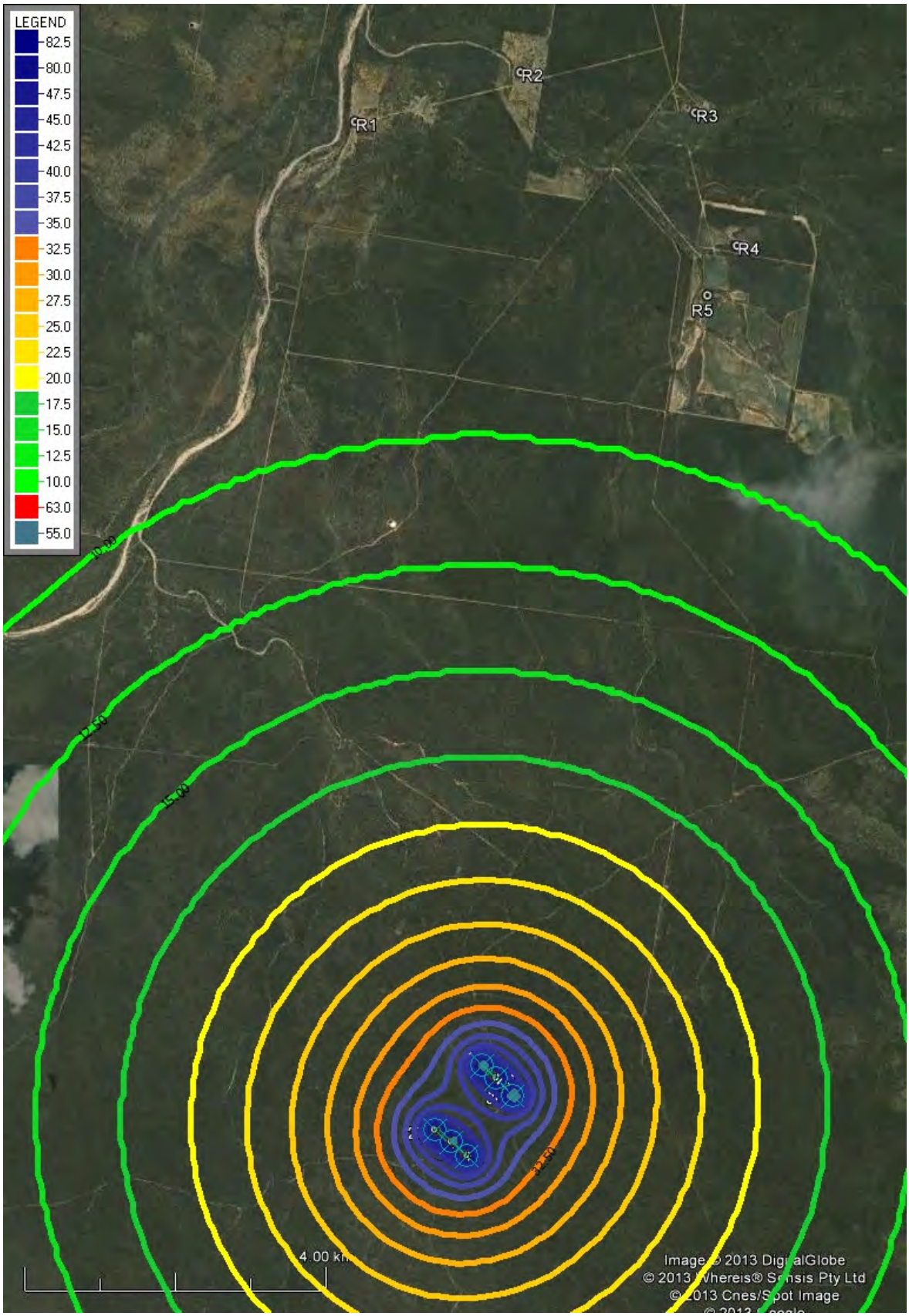


Scenario 9: Dewhurst 13-18H, all wells running, Stability factor 'F' resulting in inversion

Scenario 9: Point calculations for Dewhurst 13-18H

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3°C/100m	
Temperature (modelled, °C)	10	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
N-R1	20.9 dB(A) LAeq, calculated at 5m from residence location	
N-R2	20.6 dB(A) LAeq, calculated at 5m from residence location	
N-R3	24.6 dB(A) LAeq, calculated at 5m from residence location	
N-R4	37.7 dB(A) LAeq, calculated at 5m from residence location	
N-R5	21.4 dB(A) LAeq, calculated at 5m from residence location	
N-R6	20.1 dB(A) LAeq, calculated at 5m from residence location	
N-R7	20.1 dB(A) LAeq, calculated at 5m from residence location	
N-R8	23.4 dB(A) LAeq, calculated at 5m from residence location	
N-R9	26.7 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

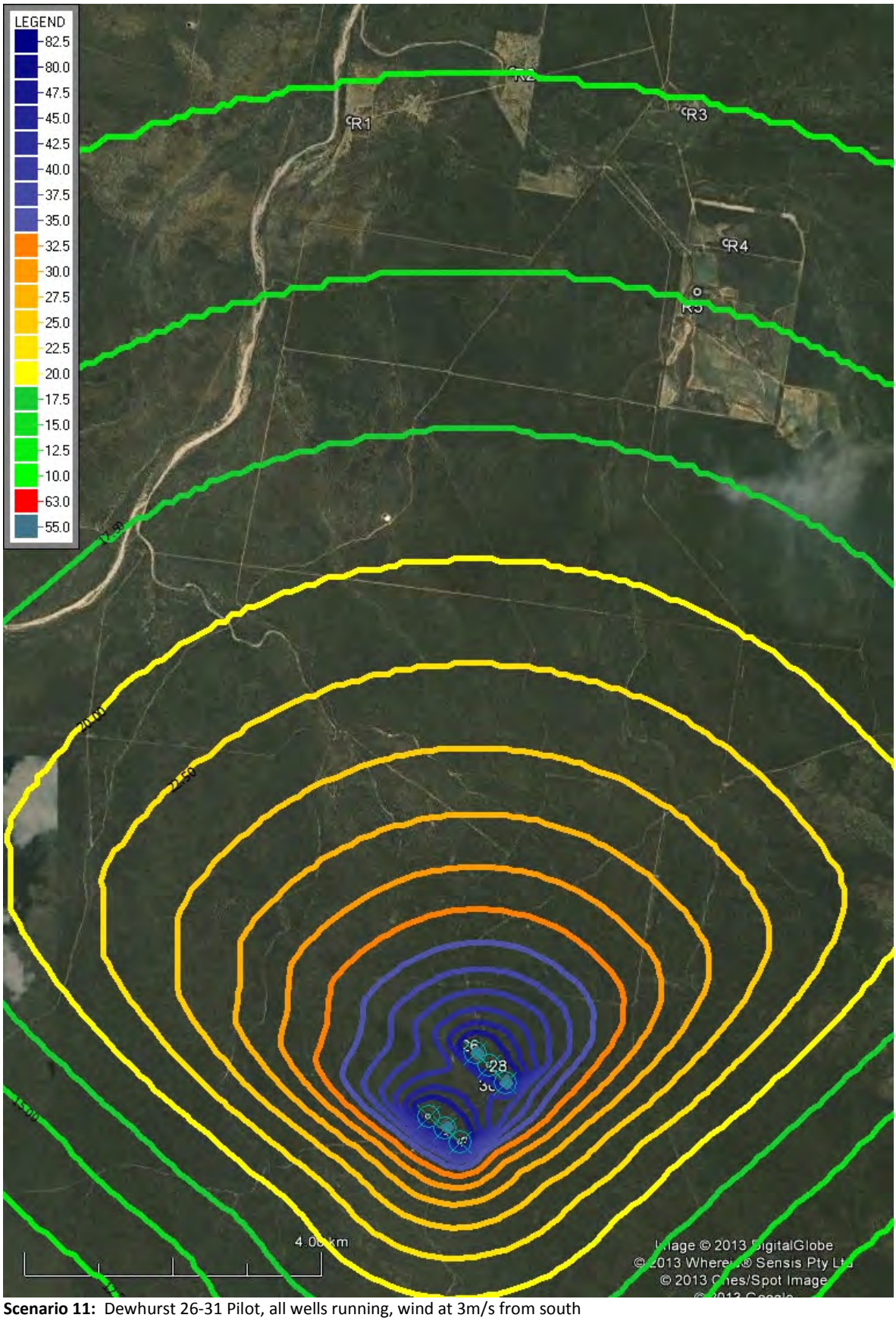


Scenario 10: Dewhurst 26-31 Pilot, all wells running, calm weather

Scenario 10: Point calculations for Dewhurst 26-31

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	calm	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
R1	5.3 dB(A) LAeq, calculated at 5m from residence location	
R2	4.8 dB(A) LAeq, calculated at 5m from residence location	
R3	5.0 dB(A) LAeq, calculated at 5m from residence location	
R4	6.5 dB(A) LAeq, calculated at 5m from residence location	
R5	7.3 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

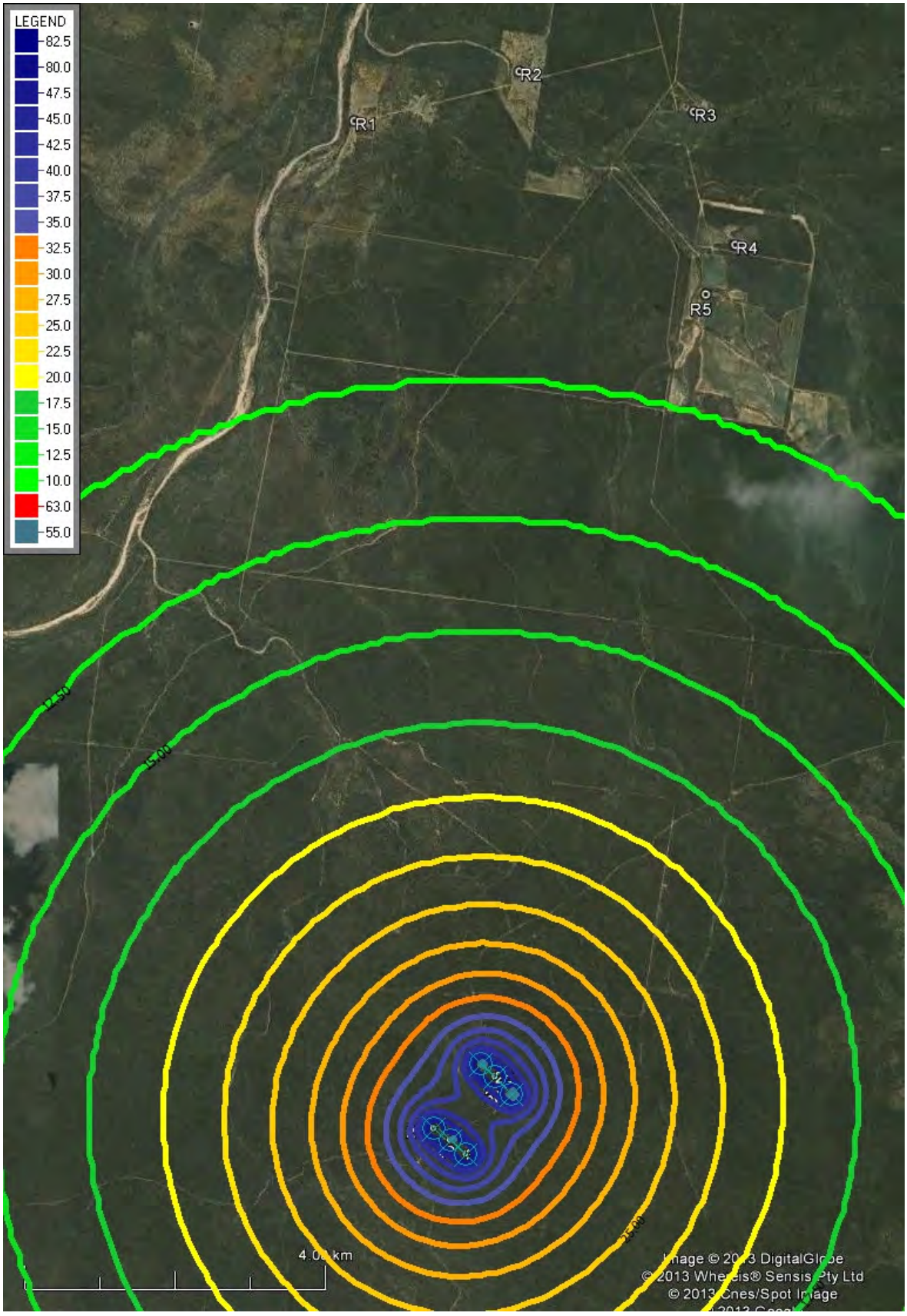


Scenario 11: Dewhurst 26-31 Pilot, all wells running, wind at 3m/s from south

Scenario 11: Point calculations for Dewhurst 26-31

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	3	
Wind direction (modelled)	southerly	
Temperature (modelled, °C)	20	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
R1	13.0 dB(A) LAeq, calculated at 5m from residence location	
R2	12.5 dB(A) LAeq, calculated at 5m from residence location	
R3	12.7 dB(A) LAeq, calculated at 5m from residence location	
R4	14.1 dB(A) LAeq, calculated at 5m from residence location	
R5	14.9 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.



Scenario 12: Dewhurst 26-31 Pilot, all wells running, Stability factor 'F' resulting in inversion

Scenario 12: Point calculations for Dewhurst 26-31

Plant Sound Power Level	**dB(Lin)**	**dB(A)**
Pilot well with generator	114	88
Wind speed (modelled, m/s)	0	
Wind direction (modelled)	Inversion 'F' with temperature gradient 3°C/100m	
Temperature (modelled, °C)	10	
Humidity (modelled, RH%)	50	
Surface roughness (m)	0.023; calculated as hard ground; directivity index 0	
Sound Levels at Residence		
R1	6.3 dB(A) LAeq, calculated at 5m from residence location	
R2	5.8 dB(A) LAeq, calculated at 5m from residence location	
R3	6.0 dB(A) LAeq, calculated at 5m from residence location	
R4	7.5 dB(A) LAeq, calculated at 5m from residence location	
R5	8.2 dB(A) LAeq, calculated at 5m from residence location	
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	

Note: Soft ground conditions (trees, grass) will significantly reduce sound transmission from the drilling operations or operation of the pilot wells. With soft ground, and a directivity index of 3 (plant noise is hemispherical) a sound reduction of approximately 7 dB(A) is obtained.

Appendix 7

Traffic and Transport Assessment



Dewhurst Gas Exploration
Dewhurst, Narrabri
Traffic and Transport Assessment

transportation planning, design and delivery

1451021100 29/10/13

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Dewhurst Gas Exploration

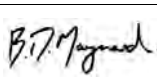
Dewhurst, Narrabri

Traffic and Transport Assessment

Issue: D 29/10/13

Client: RPS Australia East Pty Ltd
Reference: 14S1021100
GTA Consultants Office: NSW

Quality Record

Issue	Date	Description	Prepared By	Checked By	Approved By	Signed
A	17/09/13	Final	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
B	03/10/13	Updated to include Santos minor amendments	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
C	14/10/13	Updated to include Santos minor amendments	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	Brett Maynard
D	29/10/13	Updated to include change in vehicle routes	Brigette Humphrey-Robinson	Rhys Hazell	Brett Maynard	

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Executive Summary

Summary of Existing Assets

A number of forestry and local roads provide access to the State Forest areas and internal properties including the Dewhurst 13-18H Pilot and the Dewhurst 26-31 Pilot. X-line Road and Westport Road link these roads with the Newell Highway. Both roads have previously been used for the construction and operation of existing pilot wells, including the Bibblewindi Multi-Lateral Pilot.

The Newell Highway is a major north-south inland transport corridor linking NSW with Victoria and Queensland. Existing traffic volumes along the Newell Highway are typically in the order of 1,860 vehicles per day with a 40% proportion of heavy vehicles. Based on this and peak hour traffic flows in the order of 150 vehicles, the Newell Highway has a Level of Service B (LOS) or better, with significant spare capacity.

Potential Impacts

Access to Dewhurst 13-18H and Dewhurst 26-31 will be from the Newell Highway via X-line Road in combination with several other minor roads including Tighes Gully Road and Killara Road, which lead to each site and other related services.

Westport Drillers Camp will accommodate all workers during drilling activities and will significantly reduce the number of daily trips made. The camp is located on the edge of the State Forests, approximately 10km north of Dewhurst 26-31 and is anticipated to generate 8 daily shuttle bus trips between each drilling site and the Camp. An additional 8 vehicle trips will be required for the delivery of meals to workers throughout the day.

There will be approximately 24 vehicle trips on a typical day where there are no equipment deliveries. This includes the shuttle buses transporting workers to and from the work site, with less than 10 external vehicle trips (using the Newell Highway) associated with construction vehicles or worker vehicles.

Based on the staging of construction works associated with the two pilots, it is estimated that the construction works would generate up to 66 vehicle trips during the peak day. This includes 44 construction vehicle trips, 16 shuttle bus trips and 6 external worker vehicle trips.

Given the existing traffic volumes on the Newell Highway and the distribution of vehicles over the day, the anticipated traffic generation (typical and maximum) would have a minimal impact on the surrounding road network. The Newell Highway would continue to operate at or near a LOS B with an increase in daily vehicle movements of up to 3%.

The intersection of the Newell Highway with X-line Road would adequately accommodate the increased vehicle volumes, with adequate gaps available in Newell Highway traffic and resulting in a minimal impact on existing intersection operation. Furthermore, the intersection has recently been upgraded and would be capable of accommodating the maximum vehicle size of a 20m long extended trailer truck.

It is recommended that a monitoring and maintenance program be implemented to ensure the intersection of the Newell Highway and X-line Road maintains a suitable condition to assist heavy vehicles and allow for safe operation.

Cumulative Impact Assessment

The Santos Energy NSW Coal Seam Gas Exploration and Appraisal Program (E&A Program) will be conducted over the next two to three years. It is understood that the current construction schedule for all relevant construction works specifies staggered construction activity. As such, cumulative vehicle trips associated with all projects that will occur simultaneously to the two Dewhurst Pilots would generate up to 88 vehicle trips per day on any peak day, including up to 61 construction vehicle trips and up to 26 worker vehicle trips including shuttle buses. This includes vehicles associated with the construction at the Dewhurst 13-18H Pilot and the Dewhurst 30-31 Pilot.

Given the temporary nature of the associated construction works, the impact on the surrounding road network and the Newell Highway would not be significant.

Furthermore, the operational impact on the surrounding road network would be negligible, with up to 10 vehicle trips (spread across the road network) being generated by a single vehicle accessing each of the pilots and other facilities. The majority of these would be retained within the State Forest area, with less than five vehicle trips travelling along the Newell Highway in any one day. Vehicle trips to the forest areas may occasionally increase for short periods for the purposes of well maintenance and work-over activities. However these trips would remain considerably less than those generated during construction. Therefore the road network would be capable of accommodating the temporary increase in vehicle volumes.

Mitigation Measures

It is recommended that signage be installed along the Newell Highway on approach to X-line Road to warn Newell Highway drivers of construction vehicle activity associated with the overall construction works.

The surface condition of X-line Road and site access tracks will be monitored by the contractor and repaired as needed to maintain all-weather access to the site and to minimise the impact on other road users. This will be undertaken in consultation with the appropriate authorities.

It is understood that water will be transported by truck as required, to provide for appropriate dust control and track stabilisation (not part of this assessment). Sediment tracking onto the Newell Highway will be monitored throughout all construction activities.

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1. Introduction

1.1 Background

It is understood that an Environmental Impact Statement (EIS) is to be lodged with the Department of Planning and Infrastructure on behalf of Santos NSW (Eastern) Pty Ltd (Santos) for the proposed expansion of operations at two pilots, referred to as Dewhurst 13-18H and Dewhurst 26-31. This work forms part of the Santos Energy NSW Coal Seam Gas Exploration and Appraisal Program (the E&A Program).

Santos is proposing to redrill three existing wells to convert single horizontal wells to triple stacked horizontal wells within Dewhurst 13-18H. The proposed works at Dewhurst 26-31 involves the construction of two additional wells on new lease areas (Dewhurst 30 and Dewhurst 31). As such, Santos is seeking approval for these construction works at both pilots in combination with the operation of both pilots.

RPS Australia East Pty Ltd commissioned GTA Consultants in July 2013 to prepare a traffic and transport assessment for inclusion in the EIS. The assessment, as detailed in this report identifies the anticipated traffic and transport impacts of the proposed activity.

1.2 Purpose of this Report

This report sets out an assessment of the anticipated traffic and transport implications of the project, as they relate to the proposed activity, including consideration of the following:

i existing traffic conditions surrounding each site
ii construction activities and associated traffic management
iii construction vehicle requirements
iv site accesses and truck routes
v the traffic and transport impact of the construction works and site operation on the surrounding road network.

This report also addresses the relevant traffic and transport issues outlined in the Director General's Requirements (DGRs) issued on 22 July 2013 (reference number: SSD 6038) as detailed in Table 1.1.

Table 1.1: Director General's Requirements (DGRs)

Project Phase	DGR Description	Relevant Section
Traffic and Transport	an assessment of the project on the capacity, functionality, efficiency and safety of the local road network	Section 4.7
	details of road transport volumes and types broken down into origin and destination, travel routes and peak hours for the construction, operation and decommissioning of the project	Section 4.2 Section 4.5
	a description of the measures that would be implemented to maintain and/or improve the capacity, functionality, efficiency and safety of the road networks in the surrounding area over the life of the project	Section 6
	details of the location of all waterways crossings, including any new access tracks or existing waterway crossing upgrades	Not Applicable
	a description of the transfer of gas via pipeline and flowline to the Bibblewindi Water Management Facility and Wilga Park Power Station	Not Applicable

1.3 References

In preparing this Traffic and Transport Assessment, reference has been made to the following:

- Guide to Traffic Management, Part 2: Traffic Theory, Austroads, 2008
- Procedures for use in the Preparation of a Traffic Management Plan (TMP), Roads and Maritime Services, December 2001 (Version 2.0)
- Traffic Control at Work Sites manual, Roads and Maritime Services, June 2010
- Australian Standard, Manual of Uniform Traffic Control Devices – Part 3: Traffic Control for Works on Roads, AS1742.3:2009
- Guide to Traffic Generating Developments, Version 2.2, Roads and Maritime Services, October 2002
- Director General's Requirements, 20 May 2013 (SSD 5934)
- Class Speed Matrix, MetroCount Traffic Executive, 29 September 2011-21 November 2011, Narrabri Shire Council
- Roads and Maritime Services, Traffic Counts, January 2012-March 2012, Roads and Maritime Services
- other documents and data as referenced in this report.

2. Existing Environment

Dewhurst 13-18H

Dewhurst 13-18H encompasses existing well leases including three vertical wells (Dewhurst 13-15) and three horizontal wells (16H-18H). It is located on both private land and Crown land approximately 25km south of Narrabri and 15km east of the Newell Highway.

The surrounding properties predominantly include rural lands primarily for farming purposes, with Pilliga East State Forest and rural properties located south of the site. Jacks Creek State Forest and Bibblewindi State Forest are located immediately to the east and south-west respectively.

It is noted that the closest permanent residence is located 1.8km from the site. The closest dwelling is approximately 500m to the south, however it is understood that this dwelling will not be occupied during the construction phase.

Access to Dewhurst 13-18H is currently provided via X-line Road and/ or Westport Road from the Newell Highway and other local roads and internal forestry roads.

Dewhurst 26-31

Dewhurst 26-31 is a proposed six-well pilot located within the Pilliga East State Forest approximately 44km south of Narrabri and approximately 12km east of the Newell Highway.

The surrounding land use is dominated by the Pilliga East State Forest, the Bibblewindi State Forest and rural land predominantly used for farming. It is understood that the nearest dwellings are located more than 10km from the site, outside the State Forest areas, with Narrabri being the closest accessible town. The Bibblewindi Multi-Lateral Pilot is located approximately 4km north.

Access to Dewhurst 26-31 is provided via X-line Road from the Newell Highway and other local roads and internal forestry roads.

The locations of the subject sites and their surrounding environs are shown in Figure 2.1.

Figure 2.1: Subject Site and Its Environs



Basemap Source: Google Maps

2.1 Road Network

A number of local and forestry roads provide access to the State Forest areas including the Dewhurst 13-18H Pilot and the Dewhurst 26-31 Pilot. X-line Road and Westport Road link these roads with the Newell Highway.

The road network is shown in Figure 2.2 and includes identification of the key roads.

Figure 2.2: Road Network



Basemap Source: Santos

Newell Highway

The Newell Highway is a classified State Road and is a major north-south inland transport corridor linking NSW with Victoria and Queensland. West of the site, it is a two-way, sealed rural highway configured with a 2-lane, 7m wide carriageway, with approximately 0.5m sealed shoulders on both sides.

The Newell Highway carries approximately 1,900 vehicles per day[1] with a posted speed limit of 110km/h.

The Newell Highway is shown in Figure 2.3 and Figure 2.4.

1 Based on the tube counts undertaken by Narrabri Shire Council in September to November 2011

Figure 2.3: The Newell Highway (looking north from X-line Road)



Figure 2.4: The Newell Highway (looking south from X-line Road)



X-line Road

X-line Road is generally an unsealed forestry road travelling in an east-west direction east of the Newell Highway. It connects with the Newell Highway at a priority controlled T-intersection located approximately 35km south of Narrabri. The intersection has recently been upgraded to include approximately 30m of sealed pavement.

X-line Road links with unsealed roads within Bibblewindi State Forest including Tighes Gully Road and Middle Road and is shown in Figure 2.5 and Figure 2.6.

Figure 2.5: X-line Road at the Newell Highway



Figure 2.6: X-line Road (looking east)



Westport Road

Westport Road is an unsealed local road generally aligned in a north-south direction east of the Newell Highway. It connects with the Newell Highway at a priority controlled T-intersection located approximately 15km south of Narrabri and links with a number of local and forestry roads within the State Forests including Killara Road. Westport Road is predominately used by local traffic to access the Newell Highway.

Westport Road is shown in Figure 2.7 and Figure 2.8.

Figure 2.7: Westport Road at the Newell Highway



Figure 2.8: Westport Road (looking east)



As discussed, there are several unsealed forestry roads located within the State Forests which will be used by construction vehicles during the proposed construction activities. These roads are shown in Figure 2.11 and listed below. Photos of select roads are also included.

- Local Roads: Killara Road, Rockdale Road, Westport Road
- Crown Roads: Killara Road (east), Jacks Creek Road
- Forestry Roads: X-line Road, Middle Road, Tighes Gully Road, Garlands Road, Mcfarlanes Road, Bibblewindi Creek Road, Self Camp Road and Beehive Road.

It is noted that Beehive Road and an unnamed road to the north of Dewhurst 13-18H will have parallel gathering lines constructed along them.

Figure 2.9: Killara Road



Figure 2.10: Rockdale Road



2.2 Traffic Volumes

Narrabri Shire Council has provided GTA Consultants with recent traffic volume data for the Newell Highway. The tube count data was collected between September 2011 and November 2011, approximately 20km south of Narrabri and 20km north of X-line Road. The data results are summarised in Figure 2.11 and Figure 2.12 with the following key data gathered:

- Average Daily Traffic: 1,860 vehicles
- proportion heavy vehicles: 40%
- 7 day average peak hour: 134
- highest average peak hour: 156.

In addition, the survey data illustrates that the traffic flows are relatively consistent across the day time period of 8:00am to 4:00pm and are in the order of 140 vehicles per hour. Such observations are consistent with the intended use of the Newell Highway.

Figure 2.11: Newell Highway – 24 Hour Traffic Profile

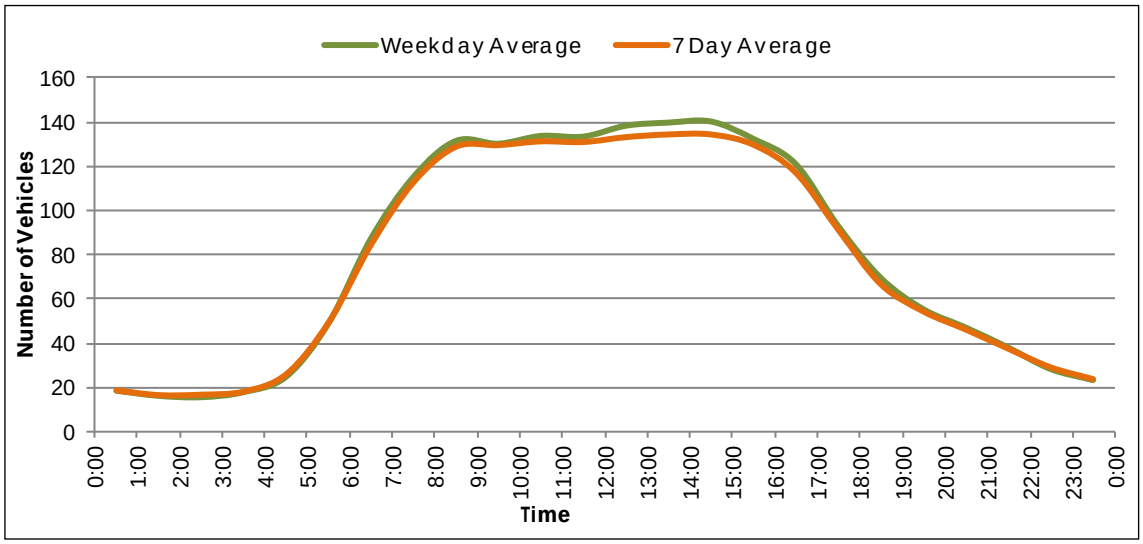


Figure 2.12 illustrates that the Newell Highway carries a high percentage of heavy vehicles, in particular articulated vehicles (Class 10) and B-doubles (Class 11). These two classes account for 32% of all traffic along the Newell Highway with light vehicles (cars, cars with trailers, motorbikes, etc.) accounting for 60% (Class 1-3). The analysis is based on the complete data set (two months) and is representative of the average percentage of vehicle types which typically use the Newell Highway.

Figure 2.12: Newell Highway – Percentage of Vehicle Type

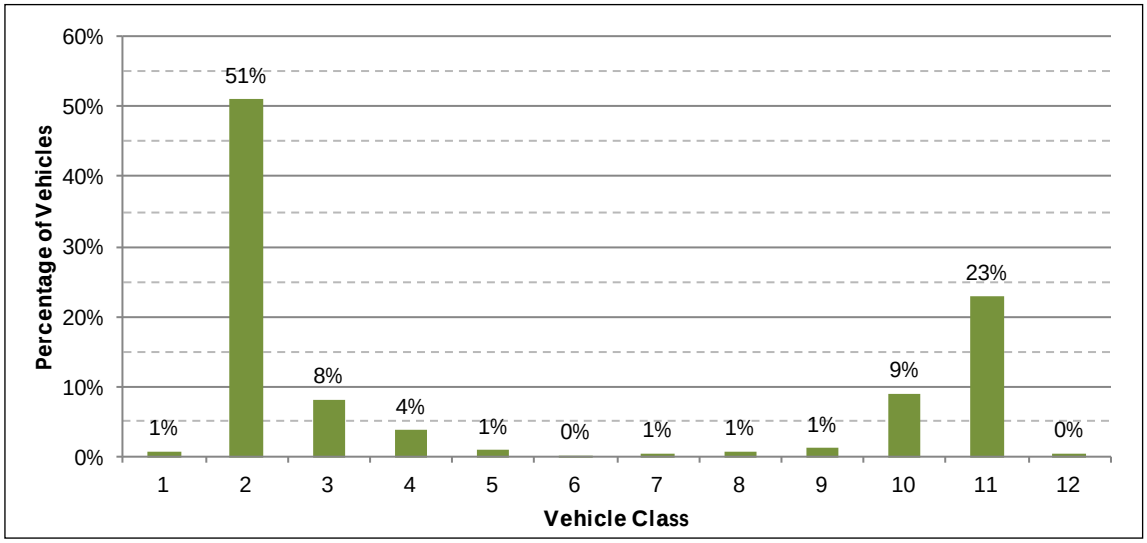


Figure 2.12 references the ARX classification system which is detailed as follows:

- Class 1: bicycle or motorcycle
- Class 2: car
- Class 3: car with trailer
- Class 4-6: two to four axle rigid vehicle
- Class 7-10: three to six axle articulated vehicle
- Class 11: B-double
- Class 12: double or triple road train.

Roads and Maritime Services (RMS) has also provided GTA Consultants with traffic volume data collected from a location near Delwood Road, approximately 18km south of X-line Road between January 2012 and March 2012. The data indicates that the average daily traffic along the Newell Highway is 1,465 vehicles.

Given that cotton harvesting generally peaks throughout April and wheat harvesting throughout September and October, it is apparent that harvesting activity can cause traffic fluctuations of up to 25% along the Newell Highway. As such, the data provided by Council could be considered representative of a peak season period and that provided by RMS as representative of a typical period.

The full traffic volume data is provided in Appendix A.

2.2.1 Site Visit

GTA Consultants undertook a site visit on 29 August 2013. This included an assessment of the surrounding road network, with a sample traffic movement survey at the intersection of Newell Highway and Westport Road during the peak weekday PM period (2:30pm to 4:00pm).

Vehicle movements along the Newell Highway were observed to peak at 143 two-way per hour, with a 35% heavy vehicle proportion, predominately B-doubles. As such, the data collected was generally consistent with the traffic volumes summarised above.

Westport Road at the Newell Highway typically generates less than 10 vehicle movements per hour.

It is worth noting that the local school bus pick-up/ set-down activity occurs on the Newell Highway at Westport Road. The bus was observed to use the Newell Highway road verge to set-down school children in the afternoon, with children collected by private vehicle.

Site observations also indicate that vehicle activity within the local road network is low, with a maximum of 10 vehicle movements in any peak hour, and less than 5 vehicle movements in a typical hour. The forestry roads typically carry even less vehicles.

2.2.2 Level of Service

Reference has been made to the Guide to Traffic Generating Developments (RMS, 2002) to estimate the existing Newell Highway Level of Service (LOS). LOS is a performance standard which describes the efficiency of traffic travelling along a stretch of road or at an intersection. It considers various factors for rural roads, including terrain (level, rolling, mountainous), speed and proportion of heavy vehicles.

The Guide indicates that in order to achieve a LOS B (the highest LOS detailed), traffic volumes are required to be less than 530 vehicles per hour with a 15% heavy vehicle proportion. Assuming a 40% heavy vehicle proportion along this section of the Newell Highway, this equates to 350-400

vehicles per hour. Given that the traffic volumes are approximately 150 vehicles in any peak hour along the Newell Highway this represents a LOS A or LOS B depending upon the seasonal factors. As such, the Newell Highway has considerable spare capacity to accommodate additional vehicle movements.

Given that there is negligible traffic travelling on internal roads in the State Forest areas, they are also assumed to be achieving a LOS A, representing considerable spare capacity.

3. Assessment Approach

The traffic and transport assessment approach identifies the expected impact of the proposal on the surrounding road network during both construction and operation, while incorporating the overall principles of traffic management including:

- identifying the peak and typical vehicle generations and their impact on the intersection of X-line Road with the Newell Highway
- restricting construction vehicle movements to designated routes to/ from each site via the Newell Highway
- managing and controlling construction vehicle activity in the vicinity of each site, particularly at the intersection of X-line Road with the Newell highway.

A conservative approach is generally adopted to understand the impacts of the proposal. As such, the peak construction period traffic generation is calculated using traffic data (provided by Santos) based on truck and worker vehicle generation and the construction works schedule.

Both peak and typical periods have been established, with consideration for the temporary nature of most construction vehicle volumes. This ensures that a greater understanding of the potential impacts associated with the proposal can be realised.

The assessment also considers the cumulative impacts associated with this project and other activities associated with the E&A Program within the State Forest areas, with the timing and staging of each being a key component.

Traffic impact and management considerations for the duration of the construction works and operational works have been developed on the basis of the following which are described in more detail in Section 4:

- overview of construction works
- site access routes
- hours of construction
- construction vehicle types
- construction traffic generation
- operational traffic generation
- traffic effects.

Traffic management measures have been addressed, including provision of signage at the intersection of X-line Road with the Newell Highway to address an increase in truck volumes during construction.

4. Potential Impacts

4.1 Overview of Construction Activities

It is understood that the proposed construction activities are anticipated to commence in April 2014 with completion in September 2014, a period of approximately 5-6 months.

The construction activities required for operation of the pilots include:

Dewhurst 13-18H (3 wells)

April 2014-September 2014

- Site preparation 30 days
- Drilling 65 days
- Surface facilities 65 days

Dewhurst 30-31 (2 wells)

June 2014-September 2014

- Site preparation 20 days
- Drilling 60 days
- Surface facilities 60 days.

Based on the above and with consideration that only one drill rig will be used for all wells, site preparation at Dewhurst 30-31 will occur once drilling has commenced at Dewhurst 13-18H. In addition, drilling at Dewhurst 30-31 can only commence once drilling at Dewhurst 13-18H has been completed.

4.2 Site Access Routes

It is anticipated that the majority of truck arrivals and departures will be via the north, to/ from Narrabri with minor interstate deliveries expected to approach/ depart via the south. All truck movements will be restricted to the most direct route via the Newell Highway and X-line Road with the aim of minimising the impact of construction traffic on the local roads and forestry roads, including Westport Road.

Truck drivers will be advised of the designated truck routes to/ from the site including the need to use X-line Road via the Newell Highway.

The site access routes between the Newell Highway and Dewhurst 13-18H and Dewhurst 26-31 are listed below and are illustrated in Figure 4.1. These routes will be used during construction and operational phases.

- Dewhurst 26-31: X-line Road, Tighes Gully Road, Beehive Road
- Dewhurst 13-18H: X-line Road, Garlands Road, Westport Road, Killara Road, unnamed road to the north.

These routes also link Dewhurst 26-31 and Dewhurst 13-18H and would be required for the transportation of heavy machinery between sites.

It is understood that the majority of these roads have previously been used for the construction and operation of existing pilot wells including the Bibblewindi Multi-Lateral Pilot and Dewhurst 13-

18H. As such, these routes would adequately accommodate all vehicles throughout construction and operation.

All vehicles will be accommodated within the pilot sites throughout the construction period. Construction traffic will not be permitted to queue or park within X-Line Road, surrounding roads or along the Newell Highway.

Figure 4.1: Site Access Routes



Basemap Source: Santos

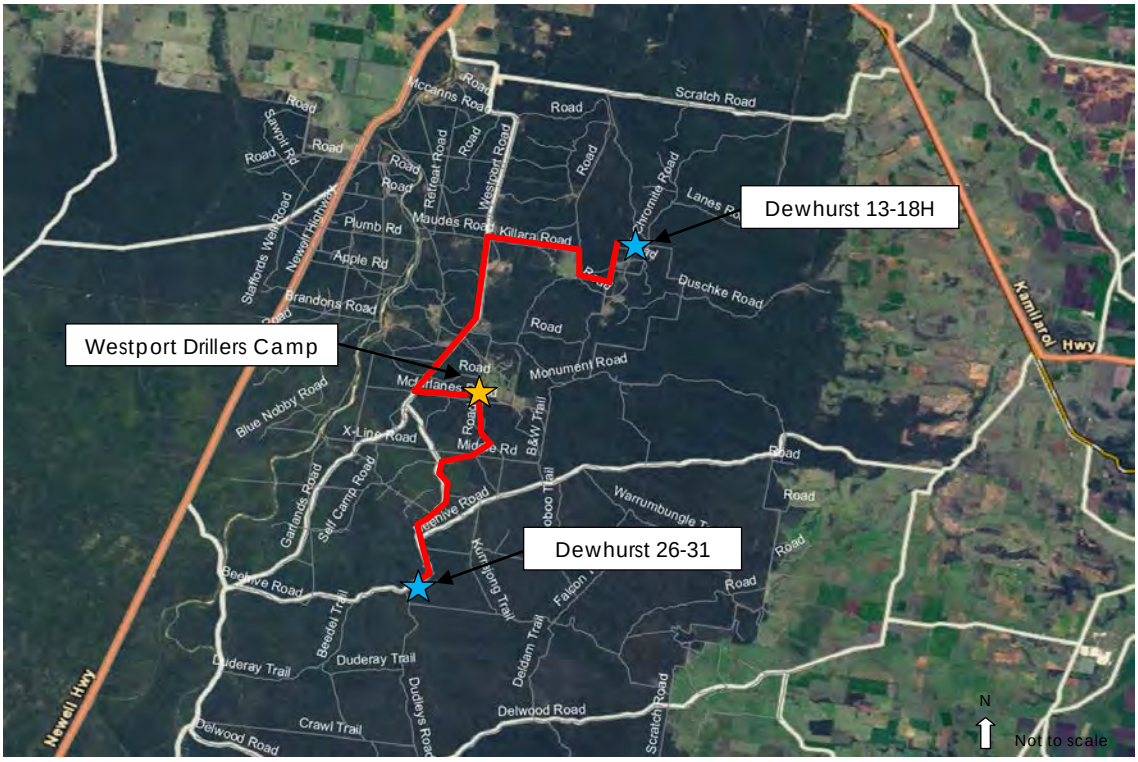
4.2.1 Westport Drillers Camp

It is understood that the Westport Drillers Camp (the camp) will accommodate all workers during drilling activities. A mini-bus will transport workers between the camp and the works site to significantly reduce the number of daily trips made. The camp is located on the edge of the State Forests, approximately 10km north of Dewhurst 26-31 as shown in Figure 4.2.

The site access routes between the camp and the pilots are listed below and shown in Figure 4.2.

- Dewhurst 26-31: Bibblewindi Creek Road, Self Camp Road, Tighes Gully Road, Beehive Road
- Dewhurst 13-18H: Mcfarlanes Road, Garlands Road, Westport Road, Killara Road and unnamed road to the north.

Figure 4.2: Westport Drillers Camp Access Routes



Basemap Source: Santos

4.3 Hours of Construction

The hours of construction work will be determined by the appointed construction contractor. However, it is anticipated that construction will occur across 24 hours, 7 days per week to maximise efficiencies and the use of remote workers.

Given the rural environment these work hours are not expected to negatively impact the surrounding area. However where practical, any associated heavy vehicle activity that passes through residential areas (including Narrabri Town Centre) should be scheduled to occur during typical construction hours (7:00am-6:00pm, Monday to Friday, 8:00am-1:00pm Saturdays).

The contractor will be responsible for instructing and managing all subcontractors with respect to the hours of work.

4.4 Construction Vehicle Types

Construction vehicles likely to be generated by the proposed construction activities include:

- 20m extended trailer truck
- 15m drill rig for drilling works at both sites
- 12m articulated flatbed trucks for the transportation of the excavator, piping and wellhead equipment
- standard operation vehicles including small rigid vehicles, utes, four wheel drives for smaller deliveries and some worker arrival and departures.

The existing intersection configuration at the Newell Highway and X-line Road is capable of accommodating typical vehicle sizes up to 19m, and would be capable of accommodating the

20m extended trailer truck, noting that this intersection was used by similar construction vehicles for construction of the existing pilot wells located within Bibblewindi and Dewhurst. As such, access to the site via X-line Road would be adequate to accommodate the proposed construction vehicles.

4.5 Construction Traffic Generation

The *Guide to Traffic Generating Developments* (the Guide) provides traffic generation estimates for different land uses. However, for construction works at the two pilots, the estimated traffic generation has been calculated based on the daily vehicle movements associated with workers and construction vehicles during each activity as detailed below and summarised in Table 4.1.

It is noted that the Guide defines a vehicle trip as a one-way vehicular movement from one point to another excluding the return journey. This approach has been used throughout this report with a return trip regarded as two vehicle trips.

4.5.1 Worker Vehicle Generation

It is understood that up to 40 workers will be accommodated at the camp at any one time. These workers are required for drilling activities only. Based on a 12 hour working day to accommodate 24 hour construction, there would likely be the need for two daily shift changes (i.e. 20 workers per daily shift).

A shuttle bus will transport up to 10 workers between the camp and the work site at the start and end of each shift. Assuming the transport of workers will be two-way to accommodate workers starting and ending their shifts, there would be up to 8 vehicle trips in any 24 hour period, or 4 vehicle trips per shift associated with the transport of drilling workers. The delivery of meals to the work site will also require 8 vehicle trips. These trips will not require access to the Newell Highway, thus having no impact on the surrounding arterial road network and minimal impact on the local road network.

It is noted that Narrabri Shire Council approved the Westport Drillers Camp in December 2012 with planned accommodation for 24-64 persons. As such, this assessment does not consider vehicles associated with the workforce rotation.

It is anticipated that minimal worker vehicle trips would be required during site preparation and surface facility construction, with workers travelling between Narrabri and the work site. Up to two daily vehicle trips are likely to occur during site preparation and up to 6 daily vehicle trips during surface facilities construction.

4.5.2 Construction Vehicle Generation

Typical construction vehicle volumes are anticipated to be minor, with peak volumes generated at the commencement and completion of a construction activity, when equipment is delivered or removed from a pilot.

Drilling will occur at one pilot well at any one time. As such, associated activities for each pilot well will occur consecutively, with the drilling rig travelling from one pilot well to another once drilling is complete. Relocation of the drilling rig would not impact the external road network.

However, following the completion of Dewhurst 31drilling, the drilling equipment will be removed from site and likely transported to the Narrabri Operations Centre via the Newell Highway, as there will be no further drilling works.

Table 4.1: Estimated Daily Construction and Worker Vehicles

Site	Construction Activity	Estimated Duration	Construction Vehicles	Worker Vehicles	Total Vehicles	Total Trips
Dewhurst 13-18H	Site Preparation	0 days	0	0	**0**	**0**
	Delivery of Drilling Equipment	3 days	15	8 [1]	**23**	**46**
	Drilling	18 days	1	8 [1]	**9**	**18**
	Removal of Drilling Equipment	3 days	18	8 [1]	**26**	**52**
	Delivery of Gathering System Equipment	1 day	8	3	**11**	**22**
	Gathering System	7 days	0	3	**3**	**6**
	Delivery of Surface Facilities Equipment	1 day	3	3	**6**	**12**
	Surface Facilities	21 days	0	3	**3**	**6**
Dewhurst 30-31	Site Preparation	7 days	3	1	**4**	**8**
	Delivery of Drilling Equipment	3 days	19	8 [1]	**27**	**54**
	Drilling	25 days	1	8 [1]	**9**	**18**
	Removal of Drilling Equipment	3 days	18	8 [1]	**26**	**52**
	Delivery of Gathering System Equipment	1 day	3	3	**6**	**12**
	Gathering System	7 days	0	3	**3**	**6**
	Delivery of Surface Facilities Equipment	1 day	3	3	**6**	**12**
	Surface Facilities	21 days	0	3	**3**	**6**

[1] Vehicles associated with transportation of workers by bus and delivery of meals to workers at the works site.

Water may be required for dust suppression during construction. This does not form part of this assessment and will be addressed as required.

4.5.3 Typical Vehicle Generation

Table 4.1 indicates that on typical days where there are no equipment deliveries, there will be an expected overlap of drilling works at Dewhurst 30-31 and surface facility construction at Dewhurst 13-18H. As such, it is anticipated that approximately 24 vehicle trips will be generated on a typical day. This predominately includes shuttle buses transporting workers to the work site, with less than 10 external vehicle trips associated with construction vehicles and/ or worker vehicles.

As such, on a typical day there would be a negligible impact on the Newell Highway, with up to 10 daily vehicle trips at the intersection of X-line Road with the Newell Highway.

4.5.4 Peak Vehicle Generation

Table 4.1 indicates that the peak vehicle activity for each pilot occurs when drilling equipment is delivered to or removed from the work site. Between 46 and 54 daily vehicle trips are likely over a maximum of 3 days per well.

Based on the current staging schedule for each of the two pilots, there will be a peak of approximately 66 vehicle trips. This will occur where drilling activities at Dewhurst 13-18H overlap with surface facility works at Dewhurst 30-31. However, this peak vehicle generation will only occur when drilling equipment is being transported from one well to the next and overlapping

with surface facility equipment delivery at one well. Peak vehicle activity is likely to be over a maximum duration of 3 days and largely infrequent. This will likely include the following:

- 44 external construction vehicle trips including removing equipment from one site via X-line Road, delivering to the next well via internal roads and exiting the forest area via X-line Road
- 16 shuttle bus/ food delivery trips between Westport Drillers Camp and the work site
- 6 external worker vehicle trips between Narrabri and the work site.

Based on the above, a maximum of up to 50 vehicle trips would access X-line Road via its intersection with the Newell Highway.

4.6 Operational Traffic Generation

The pilot wells are anticipated to operate over a period of up to 3 years, with a similar number of staff expected to that of previous operations following the completion of construction works. 1-2 staff will visit each pilot every 1-2 days for monitoring and maintenance purposes for the whole pilot. For the purposes of this assessment, it is estimated that 1 vehicle would visit each well on a daily basis during operations. As such there will likely be two daily vehicle trips, where the vehicle enters the forest area to visit each well and then exits the forest area.

The workforce will be primarily drawn from the local area around Narrabri with arrival/ departures to/ from the north. The anticipated traffic volumes associated with the operation of the pilots will present a negligible impact to the operation of the Newell Highway at X-line Road and other forestry and local roads within the State Forest areas.

Vehicle trips to the forest area may occasionally increase for short periods for the purposes of well maintenance and work-over activities. However these trips would remain considerably less than those generated during construction. Therefore the road network would be capable of accommodating the temporary increase in vehicle volumes.

The operational workforce will function on a typical daytime shift basis and staff will typically travel to and from the sites by 4WD. The shift times are assumed to be between 7:00am and 5:00pm weekdays.

4.7 Traffic Effects

4.7.1 Traffic Generation

There will be up to 66 vehicle trips on a peak day associated with all construction activity at both sites. This includes all worker vehicles, shuttle buses and trucks, with a maximum of 50 external vehicle trips likely to access the Newell Highway via X-line Road.

The peak vehicle activity is likely to occur infrequently and for a maximum duration of 3 days at any one time. On typical days where there are equipment deliveries, there would be up to 24 vehicle trips. This includes construction vehicles and shuttle buses, with a maximum of 10 external vehicle trips likely to access the Newell Highway via X-line Road.

Given the existing traffic volumes on the Newell Highway and the distribution of vehicles over the day, the anticipated traffic generation (peak and typical) would have a minimal impact on the surrounding road network. The Newell Highway will continue to operate at or near LOS B with an increase in daily vehicle movements of between 1% and 3%.

4.7.2 Intersection Operation

Austroads *Guide to Traffic Management Part 2: Traffic Theory* provides further guidance when assessing the impacts associated with increased traffic volumes. This is particularly appropriate when considering the anticipated increase in truck volumes on X-line Road and through its intersection with the Newell Highway. Gap acceptance is the point at which a minor traffic stream can enter the major traffic stream when a suitable gap presents itself.

The critical gap acceptance and follow-up headways for right turning and left turning vehicles from a minor road onto a major road are 7-8 seconds and 3.5 seconds respectively[2]. These thresholds have been determined based on a scenario where the traffic volumes are more than double those on the Newell Highway, including truck volumes.

Based on a worst case scenario, during a weekday peak period, a vehicle would pass X-line Road along the Newell Highway every 20-30 seconds. Given this and with consideration for the known critical gaps, the intersections would be capable of safely accommodating the anticipated increase in vehicles associated with the construction works. In addition, the implementation of the mitigation measures detailed in this report, including the site access plan to provide approaching vehicles with greater awareness of the X-line Road intersection and associated site vehicle activity mean that the Newell Highway would continue to operate in a safe manner throughout the works program.

4.7.3 Emergency Vehicles and Heavy Vehicles

No special provisions are required or proposed for emergency vehicles and there would be no adverse impact on emergency services.

There would be an increase in two-way daily traffic flows of up to 3%, and a 6% increase in truck movements along the Newell Highway on a peak day during construction. This increase in total traffic is considered low and would have a negligible impact on the operation of the Newell Highway.

As discussed, the increase in heavy vehicles represents a low increase in truck proportions and overall the intersection of the Newell Highway and X-line Road would continue to operate at a similar level of service as under existing conditions, therefore having minimal impact on existing truck/ traffic volumes.

4.7.4 Existing and Future Developments

It is understood that there are currently no existing or proposed land use developments within the vicinity of the site that would be adversely impacted by the construction works.

4.7.5 Traffic Movements in Adjoining Council Areas

No adverse effects are expected from the movement of heavy vehicles through adjacent council areas.

[2] Austroads Guide to Traffic Management Part 2: Traffic Theory, Section 5.5, Table 5.2, 2008

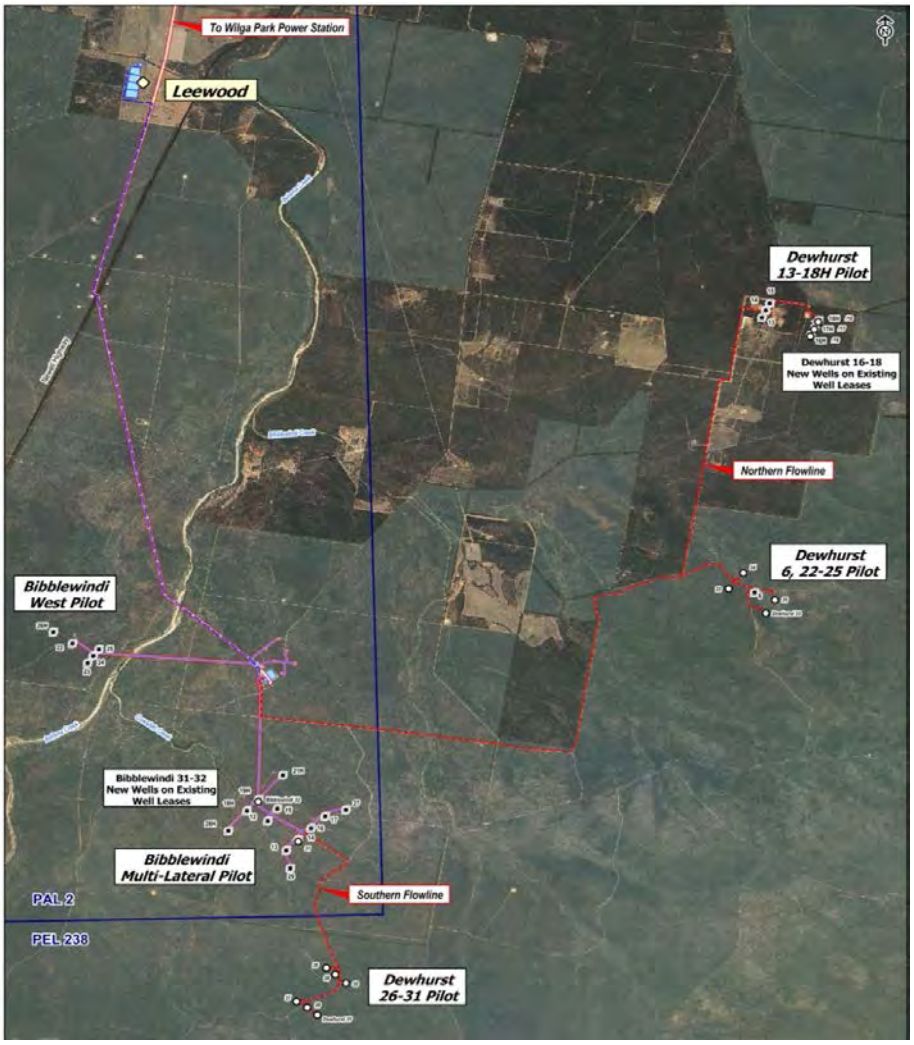
5. Potential Cumulative Impacts

The E&A Program will be conducted over the next two to three years and will include:

- operation of the existing Dewhurst 13-18H Pilot and the construction, drilling and operation of additional lateral wells from well casing within Dewhurst 16H, 17H and 18H (the proposed activity, subject of the EIS)
- construction, drilling and operation of the Dewhurst 26-31 Pilot (incorporates the proposed activity, partially subject of the EIS)
- construction, drilling and operation of the Dewhurst 22-25 Pilot
- operation of the existing Bibblewindi Multi-Lateral Pilot, and the construction, drilling and operation of two additional pilot wells (Bibblewindi 31 and 32) from existing well leases within the pilot
- operation of the existing Bibblewindi West Pilot
- operation of the existing Tintsfield Pilot
- construction of the Dewhurst Northern Water and Gas Flow Lines and operation the Dewhurst Northern Water Flow Line
- construction of the Dewhurst Southern Water and Gas Flow Lines and operation of the Dewhurst Southern Water Flow Line
- construction and operation of the Leewood Produced Water Facility and ancillary infrastructure
- gas and water management during operation of the E&A Program.

These activities are subject to separate environmental assessment and approval processes and most of their locations are shown in Figure 5.1.

Figure 5.1: Santos Activities - Narrabri



Source: Santos

5.1 Construction Vehicle Generation

It is understood that the current construction schedule generally includes staggered commencement dates for each construction activity. As such, a cumulative assessment has been conducted to identify the peak construction traffic impact where an overlap of works occurs with the expansion of two pilots discussed in this report.

The peak construction period is expected to occur mid-way through the proposed works in mid 2014, where there is potential for overlap of construction at three pilots as summarised in Table 5.1.

Table 5.1: Peak Daily Cumulative Construction Vehicle Activity

Project	Stage of Works	Maximum Construction Vehicles	Maximum Worker Vehicles	Total Vehicle Volumes	Total Vehicle Trips
Bibblewindi 31-32	Surface Facility Construction	10	4	**14**	**28**
Dewhurst 13-18H	Drilling	18	8	**26**	**52**
Dewhurst 30-31	Site Preparation	3	1	**4**	**8**
	Total	**31**	**13**	**44**	**88**

It is estimated that approximately 88 vehicle trips could potentially occur on any peak day. This includes 62 construction vehicle trips and 26 worker vehicle trips.

Given that this also includes 16 daily trips generated internally by shuttle buses transporting workers internally within the State Forests, it is anticipated that up to 72 vehicle trips would occur along the Newell Highway and X-line Road on a peak day.

The cumulative impact of the construction works associated with the E&A Program results in less than a 4% increase on existing Newell Highway traffic. The Newell Highway has considerable spare capacity and would be capable of accommodating the peak traffic volumes generated by the E&A Program at Bibblewindi and Dewhurst.

Based on the critical gap acceptance and follow-up headways for right turning and left turning vehicles from a minor road onto a major road as discussed in Section 3, the intersection of the Newell Highway with X-line Road would be capable of accommodating the peak vehicle activity associated with the cumulative vehicle generation.

The specific details regarding the traffic volumes associated with E&A Program works are addressed in their specific approval applications.

5.2 Operational Vehicle Generation

It is anticipated that all pilots will operate simultaneously at some point during the three year operational phase.

During the operational phase, it is envisaged that 1-2 workers in one vehicle will attend all of the pilots and inspect each of the pilot wells and associated facilities (including the flow lines). As such, the cumulative operational vehicle generation would be approximately 10 vehicle trips (spread across the road network). The majority of these would be retained within the State Forest area, with less than five trips along sections of the Newell Highway.

Vehicle trips to the forest areas may occasionally increase for short periods for the purposes of well maintenance and work-over activities. However these trips would remain considerably less than those generated during construction. Therefore the road network would be capable of accommodating the temporary increase in vehicle volumes.

Overall, cumulative activity would have a negligible impact on the Newell Highway and its intersection with X-line Road, with negligible long term impacts on the local road network.

6. Mitigation Measures

6.1 Site Access Plan

Given that X-line Road is anticipated to experience temporary increases in traffic volumes, GTA Consultants has prepared a site access plan for the intersection of the Newell Highway with X-line Road. The site access plan presents the principles of construction traffic management in accordance with the *Traffic Control at Work Sites* manual (RMS, 2010), while also considering permanent directional signage as shown in Appendix B.

Similar signage will be installed at X-line Road during prior works including construction of the Bibblewindi Water Transfer Facility. Based on the current construction schedule, it is understood that there will be continual use of X-line Road for Santos construction activity beyond the completion of works at the Bibblewindi Water Transfer Facility. As such, it is recommended that the signage either be maintained or re-instated for construction works associated with the pilot expansions.

All signage should be covered where construction vehicles no longer occur at this intersection.

All Santos workers and sub-contractors are required to limit vehicle speeds on unsealed roads to less than 80km/h at all times. In-vehicle monitoring systems (VMS) are fitted to all Santos vehicles to ensure that driver activity is safe and compliant with all speed limits.

6.2 Road Maintenance

It is recommended that the surface condition of X-line Road and other local, forestry and site access tracks be monitored by the contractor and repaired as required to maintain all-weather access to the site and to minimise the impact on other road users. This would be undertaken in consultation with the appropriate authorities.

It is understood that water will be transported by truck as required, to provide for appropriate dust control and track stabilisation (not part of this assessment). Sediment tracking onto the Newell Highway will be monitored throughout all construction activities.

Conclusion

Based on the analysis and discussions presented within this report, the following conclusions are made:

i Santos is proposing to expand and operate two pilots, referred to as Dewhurst 13-18H and Dewhurst 26-31.

ii The Newell Highway in the vicinity of the site currently carries approximately 1,860 vehicles per day with relatively consistent hourly flows in the order of 140 vehicles per hour between 8:00am and 4:00pm.

iii The proposed construction works are scheduled to be carried out over a period of up to 5-6 months, with works planned to commence in April 2014 and continue through to September 2014.

iv The Westport Drillers Camp will minimise daily vehicle trips by reducing trips associated with worker movements. It will generate up to 8 shuttle bus trips per day and 8 for food deliveries.

v Up to 40 drilling workers will be accommodated at the Westport Drillers Camp at any one time with up to 20 workers on-site during each shift.

vi It is anticipated that up to 24 vehicle trips will be likely to occur on a typical day, increasing to 66 vehicle trips on a peak day.

vii X-line Road would adequately accommodate all truck movements to/ from the Newell Highway.

viii The operational workforce is expected to be 1-2 staff every 1-2 days, generating two vehicle trips per day, with additional deliveries and visitors anticipated to be minor.

ix A cumulative peak vehicle generation of up to 88 vehicle trips could occur where the proposed construction works overlap with other activities associated with the E&A Program.

x The cumulative operational vehicle activity is expected to have a negligible impact on the surrounding road network.

xi It is recommended that a monitoring and maintenance program be implemented to ensure the intersection of the Newell Highway and X-line Road is in suitable condition to assist heavy vehicles and allow for safe operation.

xii A site access plan has been prepared and signage should be implemented along the Newell Highway, to warn drivers of increased truck activity at X-line Road.

Appendix A

Survey Data

MetroCount Traffic Executive
Class Speed Matrix

ClassMatrix-180 -- English (ENA)

Datasets:

Site: **[SH17] 200m north of SR59**
Direction: 3 - South bound, A hit first., **Lane:** 0
Survey Duration: 9:07 Thursday, 20 October 2011 => 20:36 Monday, 21 November 2011
File: G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1710Dec2011.EC0 (Plus)
Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm: Factory default
Data type: Axle sensors - Paired (Class/Speed/Count)

Site: **[SH17] 200m north of SR59**
Direction: 3 - South bound, A hit first., **Lane:** 0
Survey Duration: 13:04 Thursday, 29 September 2011 => 13:04 Thursday, 29 September 2011
File: G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1729Sep2011.EC0 (Plus)
Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm: Factory default
Data type: Axle sensors - Paired (Class/Speed/Count)

Site: **[SH17] 200m north of SR59**
Direction: 3 - South bound, A hit first., **Lane:** 0
Survey Duration: 13:32 Wednesday, 5 October 2011 => 9:03 Thursday, 20 October 2011
File: G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1720Oct2011.EC0 (Plus)
Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm: Factory default
Data type: Axle sensors - Paired (Class/Speed/Count)

Site: **[SH17] 200m north of SR59**
Direction: 3 - South bound, A hit first., **Lane:** 0
Survey Duration: 13:06 Thursday, 29 September 2011 => 13:30 Wednesday, 5 October 2011
File: G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1705Oct2011.EC0 (Plus)
Identifier: CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm: Factory default
Data type: Axle sensors - Paired (Class/Speed/Count)

Profile:

Filter time: **13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Included classes: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Speed range: 10 - 160 km/h.
Direction: North, East, South, West (bound)
Separation: All - (Headway)
Name: Factory default profile

Scheme: Vehicle classification (ARX)
Units: Metric (meter, kilometer, m/s, km/h, kg, tonne)
In profile: Vehicles = 99331 / 99402 (99.93%)

Class Speed Matrix

ClassMatrix-180
Site: SH17.0S SH17.0S SH17.0S SH17.0S
Description: **Multiple sites - See Header sheet for site descriptions.**
Filter time: **13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Scheme: Vehicle classification (ARX)
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,160) Headway(>0)

Speed (km/h)	Class 1	2	3	4	5	6	7	8	9	10	11	12	Speed Totals	
10 - 20	.	1	.	.	.	.	.	.	.	.	.	.	**1**	**0.0%**
20 - 30	.	21	1	.	2	.	.	.	2	1	.	.	**27**	**0.0%**
30 - 40	1	19	1	4	1	.	.	.	1	2	4	.	**33**	**0.0%**
40 - 50	1	14	4	6	2	1	.	2	1	1	2	.	**34**	**0.0%**
50 - 60	1	40	12	27	2	.	.	2	.	5	3	1	**93**	**0.1%**
60 - 70	1	220	36	63	5	.	2	6	.	7	8	2	**350**	**0.4%**
70 - 80	4	717	256	173	17	7	11	16	10	32	50	16	**1309**	**1.3%**
80 - 90	24	2385	1610	427	58	13	53	126	50	218	386	62	**5412**	**5.4%**
90 - 100	130	10248	2971	1468	585	116	218	450	885	5779	13879	261	**36990**	**37.2%**
100 - 110	312	25357	2585	1199	240	47	192	178	217	2917	8246	108	**41598**	**41.9%**
110 - 120	262	10323	629	357	13	14	58	13	4	39	129	11	**11852**	**11.9%**
120 - 130	54	1131	43	42	.	5	5	.	.	6	8	7	**1301**	**1.3%**
130 - 140	13	230	6	9	1	2	.	1	.	.	1	.	**263**	**0.3%**
140 - 150	.	45	2	3	.	1	.	.	.	.	.	.	**51**	**0.1%**
150 - 160	.	17	.	.	.	.	.	.	.	.	.	.	**17**	**0.0%**
	803	**50768**	**8156**	**3778**	**926**	**206**	**539**	**794**	**1170**	**9007**	**22716**	**468**	**99331**	
Class Totals	**0.8%**	**51.1%**	**8.2%**	**3.8%**	**0.9%**	**0.2%**	**0.5%**	**0.8%**	**1.2%**	**9.1%**	**22.9%**	**0.5%**		

MetroCount Traffic Executive
Weekly Vehicle Counts (Virtual Week)

VirtWeeklyVehicle-178 -- English (ENA)

Datasets:

Site:	**[SH17] 200m north of SR59**
Direction:	3 - South bound, A hit first., **Lane:** 0
Survey Duration:	9:07 Thursday, 20 October 2011 => 20:36 Monday, 21 November 2011
File:	G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1710Dec2011.EC0 (Plus)
Identifier:	CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm:	Factory default
Data type:	Axle sensors - Paired (Class/Speed/Count)

Site:	**[SH17] 200m north of SR59**
Direction:	3 - South bound, A hit first., **Lane:** 0
Survey Duration:	13:04 Thursday, 29 September 2011 => 13:04 Thursday, 29 September 2011
File:	G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1729Sep2011.EC0 (Plus)
Identifier:	CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm:	Factory default
Data type:	Axle sensors - Paired (Class/Speed/Count)

Site:	**[SH17] 200m north of SR59**
Direction:	3 - South bound, A hit first., **Lane:** 0
Survey Duration:	13:32 Wednesday, 5 October 2011 => 9:03 Thursday, 20 October 2011
File:	G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1720Oct2011.EC0 (Plus)
Identifier:	CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm:	Factory default
Data type:	Axle sensors - Paired (Class/Speed/Count)

Site:	**[SH17] 200m north of SR59**
Direction:	3 - South bound, A hit first., **Lane:** 0
Survey Duration:	13:06 Thursday, 29 September 2011 => 13:30 Wednesday, 5 October 2011
File:	G:\Eng\Design\MetroCount v315\User\Data\SH17\2011\SH1705Oct2011.EC0 (Plus)
Identifier:	CG48BDKS MC56-L5 [MC55] (c)Microcom 19Oct04
Algorithm:	Factory default
Data type:	Axle sensors - Paired (Class/Speed/Count)

Profile:

Filter time:	**13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Included classes:	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
Speed range:	10 - 160 km/h.
Direction:	North, East, South, West (bound)
Separation:	All - (Headway)
Name:	Factory default profile
Scheme:	Vehicle classification (ARX)
Units:	Metric (meter, kilometer, m/s, km/h, kg, tonne)
In profile:	Vehicles = 99331 / 99402 (99.93%)

Weekly Vehicle Counts (Virtual Week)

VirtWeeklyVehicle-178
Site: SH17.0S SH17.0S SH17.0S SH17.0S
Description: **Multiple sites - See Header sheet for site descriptions.**
Filter time: **13:04 Thursday, 29 September 2011 => 20:36 Monday, 21 November 2011**
Scheme: Vehicle classification (ARX)
Filter: Cls(1 2 3 4 5 6 7 8 9 10 11 12) Dir(NESW) Sp(10,160) Headway(>0)

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Averages 1 - 5	Averages 1 - 7
Hour									
0000-0100	17.4	11.3	21.9	19.3	23.6	17.5	20.6	18.8	18.9
0100-0200	11.9	8.3	20.3	21.7	20.6	15.3	19.3	16.5	16.8
0200-0300	11.0	8.1	20.9	17.0	22.1	18.0	21.0	15.9	17.0
0300-0400	15.0	11.7	19.0	21.7	23.3	17.6	19.9	18.2	18.4
0400-0500	18.3	20.6	30.3	29.0	28.3	30.9	26.6	25.2	26.2
0500-0600	36.5	40.3	59.7	58.9	53.0	51.0	48.4	49.4	49.5
0600-0700	68.8	73.7	100.6	97.0	98.9	83.6	71.9	87.6	84.6
0700-0800	88.6	108.0	135.7	119.4	126.9	115.3	97.8	115.3	112.6
0800-0900	125.6	112.6	**151.6<**	124.9	142.0	**130.3<**	113.1	131.5	128.5
0900-1000	118.1	117.3	136.0	**132.6<**	146.4	129.4	124.8	130.2	129.2
1000-1100	**128.1<**	121.4	139.9	127.9	**149.8<**	121.0	**128.1<**	**133.7<**	**130.9<**
1100-1200	124.0	**132.0<**	140.6	124.3	145.6	125.9	122.3	133.4	130.6
1200-1300	134.3	120.7	**148.6<**	136.3	150.4	**124.8<**	115.3	138.3	132.8
1300-1400	**146.4<**	122.7	143.6	**138.8<**	145.3	119.1	122.0	139.7	**134.0<**
1400-1500	138.9	**129.6<**	141.6	134.3	**155.6<**	120.8	117.6	**140.2<**	134.0
1500-1600	125.0	124.9	139.4	133.5	139.4	122.4	**122.0<**	132.4	129.4
1600-1700	99.1	117.9	128.6	122.8	137.1	114.1	99.4	121.0	116.8
1700-1800	69.5	92.9	98.9	95.4	109.1	90.3	83.9	93.0	91.2
1800-1900	55.0	68.0	78.0	72.6	75.5	63.4	55.9	69.7	66.7
1900-2000	43.1	57.7	54.3	57.0	66.1	51.9	50.8	55.6	54.4
2000-2100	30.4	47.7	52.0	56.8	50.3	47.1	40.8	47.3	46.3
2100-2200	28.4	40.0	35.7	45.4	40.5	34.6	37.9	38.3	37.7
2200-2300	20.6	33.1	24.9	33.5	29.9	26.6	35.3	28.6	29.3
2300-2400	14.4	24.9	27.7	28.4	22.3	23.8	25.9	23.6	24.0
Totals									
0700-1900	1352.6	1367.9	1582.3	1462.5	1623.0	1376.5	1302.0	1478.2	1436.7
0600-2200	1523.3	1587.0	1824.9	1718.7	1878.8	1593.8	1503.3	1707.0	1659.6
0600-0000	1558.3	1645.0	1877.4	1780.5	1930.9	1644.1	1564.4	1759.2	1712.9
0000-0000	1668.3	1745.3	2049.4	1948.1	2101.8	1794.4	1720.1	1903.1	1859.6
AM Peak	1000	1100	0800	0900	1000	0800	1000		
	128.1	132.0	151.6	132.6	149.8	130.3	128.1		
PM Peak	1300	1400	1200	1300	1400	1200	1500		
	146.4	129.6	148.6	138.8	155.6	124.8	122.0		

*** - No data.**

Traffic Volumes

Station ID: 92742**, Prescribed Direction:** NORTH**, Road Loc Reference :** 0000017~3120~A **(Road Number~Road Link~Carriageway), Report Values Based On:** Vehicle Count**,**
Station Name: , Station Description: SH17 (Newell Hwy), at Wiggans Ck Br**, RMS Region:** WESTERN**, Local Government Area:** NARRABRI**, Suburb:** THE PILLIGA**, Date Range:** 20120101 to 20121231**, Days Available:** 86**,**
4-Bin Classifications: ALL**, 12-Bin Classifications:** ALL**, Days of Week:** ALL**, Hours of Day:** ALL**, Public Holiday:** ALL Days (including public holidays)**, School Holiday:** ALL Days (including school holidays)
For information relating to this report, you can contact us via email at RISS.Info

92742: Traffic Volume - Vehicle Count - Date and Hours by Station

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
Sun, 01/01/2012	8	9	7	12	8	6	20	30	67	93	131	118	141	126	127	149	130	97	88	62	50	33	30	31	**1,573**
Mon, 02/01/2012	19	13	9	12	16	19	52	76	131	153	178	202	178	165	224	206	215	168	137	74	61	50	22	32	**2,412**
Tue, 03/01/2012	31	17	22	9	8	37	50	90	145	143	162	156	175	161	169	182	158	149	96	86	56	54	43	44	**2,243**
Wed, 04/01/2012	33	23	16	23	24	32	58	113	140	169	172	197	182	194	166	179	162	142	127	93	51	57	46	39	**2,438**
Thu, 05/01/2012	43	36	26	23	25	34	62	106	141	180	191	188	208	161	184	164	187	168	111	76	81	61	36	27	**2,519**
Fri, 06/01/2012	19	18	19	14	16	29	58	100	127	175	213	191	169	159	188	205	164	163	102	59	65	53	41	29	**2,376**
Sat, 07/01/2012	27	23	26	19	23	21	43	111	100	169	143	183	138	160	174	160	126	133	99	67	73	61	30	30	**2,139**
Sun, 08/01/2012	22	18	22	14	14	27	46	84	101	121	150	147	157	157	160	173	138	135	94	52	45	38	27	19	**1,961**
Mon, 09/01/2012	19	10	12	10	14	15	52	78	91	115	111	118	139	144	113	152	161	132	99	91	68	43	50	35	**1,872**
Tue, 10/01/2012	27	21	24	12	21	30	60	81	111	156	152	148	177	156	157	140	170	136	109	73	55	45	42	42	**2,145**
Wed, 11/01/2012	20	21	25	22	22	28	52	84	119	134	176	165	136	126	135	150	157	156	101	74	70	52	41	26	**2,092**
Thu, 12/01/2012	36	16	25	15	24	21	60	93	105	145	142	166	169	159	135	137	156	131	112	83	56	49	34	31	**2,100**
Fri, 13/01/2012	26	10	15	15	17	17	49	83	98	141	146	143	125	108	139	125	151	129	89	57	44	49	42	35	**1,853**
Sat, 14/01/2012	31	21	15	27	12	24	52	81	105	121	133	129	124	136	142	156	137	131	82	64	60	42	38	32	**1,895**
Sun, 15/01/2012	20	13	20	11	16	17	41	76	104	123	150	151	144	135	147	180	124	96	75	53	43	30	28	13	**1,810**
Mon, 16/01/2012	9	10	10	5	7	16	37	55	66	90	103	105	104	115	97	104	116	120	69	72	38	47	47	29	**1,471**
Tue, 17/01/2012	27	20	16	15	21	35	54	74	100	113	147	121	114	126	130	143	123	124	73	82	49	48	35	36	**1,826**
Wed, 18/01/2012	12	16	26	14	13	22	61	82	111	112	122	99	137	119	108	136	125	109	100	79	76	41	37	39	**1,796**
Thu, 19/01/2012	26	28	23	20	18	20	43	79	117	133	135	112	108	137	144	130	129	111	90	93	50	44	33	31	**1,854**
Fri, 20/01/2012	20	20	15	16	21	26	46	64	91	124	105	110	108	122	120	126	99	111	76	69	51	52	42	20	**1,654**
Sat, 21/01/2012	23	23	21	16	18	22	35	71	87	100	106	103	123	126	141	114	112	82	83	56	53	40	39	28	**1,622**
Sun, 22/01/2012	28	20	8	9	9	8	28	73	97	109	124	101	121	110	119	129	126	101	66	67	40	21	26	20	**1,560**
Mon, 23/01/2012	11	11	12	12	17	17	36	49	70	95	77	72	87	94	99	101	121	80	84	50	60	49	44	29	**1,377**
Tue, 24/01/2012	36	18	21	16	22	30	45	72	95	118	120	123	137	147	120	118	142	139	93	68	58	47	37	25	**1,847**
Wed, 25/01/2012	13	24	11	15	17	14	42	56	82	108	120	115	105	103	123	103	92	94	72	73	68	50	46	42	**1,588**
Thu, 26/01/2012	34	14	25	25	22	24	37	64	87	119	113	141	131	123	115	125	127	84	102	68	39	37	25	26	**1,707**
Fri, 27/01/2012	12	14	7	12	17	14	20	34	61	77	65	60	75	67	75	79	72	74	60	60	44	45	24	24	**1,092**
Sat, 28/01/2012	24	12	15	19	10	24	36	64	68	99	112	122	96	100	109	99	118	122	70	34	47	38	15	28	**1,481**
Sun, 29/01/2012	19	22	14	9	12	16	35	59	75	102	115	105	114	119	114	109	102	100	64	46	38	20	20	13	**1,442**
Mon, 30/01/2012	7	13	8	8	8	7	28	53	67	73	83	84	81	75	77	90	79	84	72	47	47	56	34	34	**1,215**
Tue, 31/01/2012	33	25	12	23	19	21	39	71	91	102	118	120	134	120	101	108	113	127	71	69	47	48	28	27	**1,667**
Wed, 01/02/2012	24	14	24	18	6	22	28	54	95	90	92	112	93	97	89	99	68	74	51	31	9	3	2	1	**1,196**
Thu, 02/02/2012			1	1	1		8	17	30	31	23	18	19	7	11	12	9	8	1	4	4	2		1	**208**
Fri, 03/02/2012							7	6	11	10	19	12	8	16	13	8	15	13	5	8	4	10	5	5	**175**
Sat, 04/02/2012	3	1	2	1		3	6	14	17	20	21	47	25	21	17	32	25	24	17	11	15	3	4	3	**332**
Sun, 05/02/2012	3	3		1		6	6	14	23	21	39	37	20	22	28	29	39	15	16	15	9	8	8	4	**366**
Mon, 06/02/2012		1	1	1	2	8	15	12	31	22	30	37	31	47	51	44	44	57	54	45	30	35	32	40	**670**
Tue, 07/02/2012	22	10	12	10	16	17	22	48	80	66	79	77	80	85	95	92	96	81	60	46	61	53	53	33	**1,294**
Wed, 08/02/2012	21	20	17	17	11	31	38	46	61	97	88	72	104	75	94	91	96	104	72	54	44	48	41	31	**1,373**
Thu, 09/02/2012	34	21	19	20	21	15	35	45	81	87	87	71	87	104	128	96	101	80	72	69	46	44	45	44	**1,452**
Fri, 10/02/2012	23	22	18	11	15	17	30	39	88	63	80	79	70	74	64	88	90	76	59	44	47	47	33	37	**1,214**
Sat, 11/02/2012	23	21	19	15	13	18	24	49	55	68	65	82	91	82	82	94	112	76	67	69	45	52	45	27	**1,294**
Sun, 12/02/2012	31	26	23	20	16	7	23	41	65	83	84	98	100	122	99	121	94	71	75	51	43	41	33	17	**1,384**
Mon, 13/02/2012	12	11	18	2	9	20	28	39	63	71	74	66	73	87	79	81	82	78	76	63	44	51	39	46	**1,212**
Tue, 14/02/2012	26	26	17	19	36	18	39	59	84	98	100	95	101	133	108	111	101	94	89	69	56	53	37	25	**1,594**
Wed, 15/02/2012	26	19	12	15	24	23	36	71	99	115	111	110	115	100	111	110	99	101	102	76	64	55	47	42	**1,683**
Thu, 16/02/2012	25	18	36	14	21	25	50	73	93	129	100	112	107	128	102	140	126	106	90	83	46	42	49	36	**1,751**

Fri, 17/02/2012	32	12	26	12	17	24	50	79	67	90	103	98	87	118	88	119	107	94	71	39	41	49	38	38	**1,499**
Sat, 18/02/2012	33	29	20	18	10	21	39	56	82	104	118	89	88	97	103	95	105	106	86	66	36	55	47	27	**1,530**
Sun, 19/02/2012	26	22	20	15	19	15	27	44	72	90	93	110	104	100	109	99	102	75	58	61	39	27	27	15	**1,369**
Mon, 20/02/2012	21	14	5	5	8	20	44	45	74	91	64	77	85	91	115	107	118	78	68	56	56	49	52	34	**1,377**
Tue, 21/02/2012	24	16	13	13	18	29	43	60	91	105	101	121	124	122	114	117	97	110	79	77	49	53	37	36	**1,649**
Wed, 22/02/2012	31	14	19	18	20	24	56	68	77	87	108	123	110	130	123	115	116	106	88	83	66	52	38	48	**1,720**
Thu, 23/02/2012	27	25	23	13	18	22	55	75	98	115	130	108	119	140	134	104	126	106	76	61	49	56	40	23	**1,743**
Fri, 24/02/2012	28	22	21	21	17	10	43	66	110	109	84	103	103	104	114	111	103	79	83	56	57	37	35	24	**1,540**
Sat, 25/02/2012	31	22	15	23	19	16	35	45	65	97	87	99	110	100	95	118	95	90	82	38	59	43	38	32	**1,454**
Sun, 26/02/2012	23	21	11	16	13	13	31	55	69	79	69	150	141	114	124	117	123	63	68	54	40	46	31	27	**1,498**
Mon, 27/02/2012	16	5	5	6	5	22	30	58	70	70	88	94	83	86	96	77	92	86	68	54	47	44	49	37	**1,288**
Tue, 28/02/2012	23	16	17	17	25	40	38	75	84	100	104	124	138	125	118	128	101	113	80	68	59	61	37	23	**1,714**
Wed, 29/02/2012	14	12	13	19	18	33	32	81	81	103	93	109	95	108	110	98	102	109	79	70	55	50	48	28	**1,560**
Thu, 01/03/2012	30	17	20	17	21	26	40	75	83	98	121	113	109	102	129	127	123	113	85	61	58	53	23	26	**1,670**
Fri, 02/03/2012	17	14	16	11	21	21	32	61	87	95	111	92	93	103	98	100	102	80	107	43	36	38	19	30	**1,427**
Sat, 03/03/2012	19	17	17	8	18	18	36	46	52	86	96	85	80	120	91	65	81	69	67	52	54	37	31	21	**1,266**
Sun, 04/03/2012	21	18	8	6	10	13	18	45	63	59	96	69	88	81	73	82	90	67	52	46	33	31	23	14	**1,106**
Mon, 05/03/2012	8	4	4	2	6	15	30	43	53	72	52	57	83	57	59	76	69	57	62	37	42	29	18	18	**953**
Tue, 06/03/2012	13	8	13	5	5	13	31	53	56	76	83	62	69	81	56	62	89	63	45	40	22	30	14	14	**1,003**
Wed, 07/03/2012	13	10	10	3	17	13	29	55	66	74	66	78	62	72	73	83	88	67	45	42	42	20	27	28	**1,083**
Thu, 08/03/2012	12	8	8	6	15	16	44	36	57	53	75	76	66	80	78	65	66	71	70	41	41	35	36	19	**1,074**
Fri, 09/03/2012	10	8	14	10	8	14	35	34	65	77	63	82	82	68	88	70	75	72	61	30	31	22	21	25	**1,065**
Sat, 10/03/2012	11	13	10	12	11	23	22	36	59	58	80	61	73	72	74	75	83	53	54	37	41	40	16	24	**1,038**
Sun, 11/03/2012	5	8	8	11	6	11	19	29	47	66	70	67	77	89	97	78	96	76	60	43	35	27	23	17	**1,065**
Mon, 12/03/2012	6	10	6	6	3	16	26	43	49	58	63	79	61	75	66	83	63	89	49	34	33	45	35	28	**1,026**
Tue, 13/03/2012	30	17	12	9	19	16	45	49	81	75	97	88	96	75	72	68	76	68	55	45	42	28	20	20	**1,203**
Wed, 14/03/2012	15	10	12	7	19	21	43	51	77	73	83	76	79	89	83	104	101	73	68	64	37	40	46	29	**1,300**
Thu, 15/03/2012	19	13	12	14	19	13	30	49	70	93	65	93	86	116	100	115	87	76	78	52	37	42	43	18	**1,340**
Fri, 16/03/2012	25	21	11	9	12	15	40	70	69	85	111	113	80	91	101	89	81	82	72	58	32	30	24	22	**1,343**
Sat, 17/03/2012	20	19	9	12	13	9	20	44	50	75	103	75	77	82	70	86	72	62	62	39	32	31	30	15	**1,107**
Sun, 18/03/2012	23	13	8	5	11	17	24	23	52	50	89	76	79	94	96	83	87	99	59	45	41	34	35	14	**1,157**
Mon, 19/03/2012	5	7	6	6	6	18	28	41	70	69	50	77	60	72	94	81	84	74	64	40	28	37	38	26	**1,081**
Tue, 20/03/2012	29	12	15	25	12	21	31	50	70	61	111	93	104	101	112	128	102	109	87	57	54	40	33	22	**1,479**
Wed, 21/03/2012	19	20	7	16	12	26	34	60	61	114	112	94	109	111	137	112	98	98	75	60	51	53	35	40	**1,554**
Thu, 22/03/2012	22	17	22	15	15	20	37	65	88	95	115	117	126	119	123	116	104	100	94	72	53	36	47	26	**1,644**
Fri, 23/03/2012	20	17	16	20	22	20	30	60	83	90	113	99	79	86	111	88	89	108	90	54	43	40	29	29	**1,436**
Sat, 24/03/2012	18	15	22	19	20	24	46	65	82	114	107	117	92	107	83	103	113	80	75	56	56	42	30	25	**1,511**
Sun, 25/03/2012	19	17	13	9	14	17	27	49	100	85	87	126	98	139	168	147	89	93	68	56	30	33	26	16	**1,526**
Mon, 26/03/2012	15	9	6	9	11	20	26	49	55	74	72	79	91	85	94										**695**
TOTAL	**1,761**	**1,344**	**1,259**	**1,105**	**1,255**	**1,648**	**3,118**	**5,021**	**6,811**	**8,148**	**8,740**	**8,869**	**8,847**	**9,052**	**9,192**	**9,211**	**8,924**	**8,000**	**6,362**	**4,822**	**3,907**	**3,462**	**2,794**	**2,266**	**125,918**

92742: Traffic Volume - Vehicle Count - Date and Hours by Direction

NORTH

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL
Sun, 01/01/2012	5	1	4	7	7	3	14	13	30	60	80	77	86	74	56	84	71	47	44	28	18	17	16	14	**856**
Mon, 02/01/2012	11	9	3	7	11	8	26	50	81	95	108	116	94	80	104	103	104	93	73	43	34	29	11	17	**1,310**
Tue, 03/01/2012	19	13	11	6	6	22	31	51	87	88	103	98	117	75	81	88	89	86	44	38	29	28	17	17	**1,244**
Wed, 04/01/2012	19	8	6	5	11	16	27	64	89	96	102	113	104	105	77	87	91	69	74	57	32	38	25	21	**1,336**
Thu, 05/01/2012	22	19	11	5	12	9	29	56	73	112	107	110	119	80	101	78	97	81	65	45	39	25	15	14	**1,324**
Fri, 06/01/2012	10	6	5	4	5	8	24	49	67	95	123	105	103	79	92	91	76	77	54	25	36	22	16	14	**1,186**
Sat, 07/01/2012	9	4	10	5	10	11	20	60	64	105	87	111	82	75	79	81	62	80	58	33	33	27	13	16	**1,135**
Sun, 08/01/2012	9	8	13	7	9	13	28	50	65	68	91	83	89	84	80	95	89	82	53	34	31	26	16	13	**1,136**
Mon, 09/01/2012	12	7	7	6	9	7	30	42	45	62	67	61	79	78	57	76	75	59	46	47	20	17	20	12	**941**
Tue, 10/01/2012	12	6	10	3	7	9	23	46	45	88	77	90	97	88	71	73	103	71	68	46	34	22	21	18	**1,128**
Wed, 11/01/2012	9	11	13	8	14	14	19	49	66	69	108	102	82	69	65	78	88	93	44	41	32	20	14	7	**1,115**
Thu, 12/01/2012	12	9	10	4	9	8	22	40	53	71	74	88	106	85	72	63	92	71	60	55	37	30	23	14	**1,108**

Fri, 13/01/2012	8	2	7	5	6	5	19	36	52	74	80	73	74	59	61	54	83	65	49	28	19	23	18	16	**916**
Sat, 14/01/2012	12	13	3	7	3	9	19	28	51	77	77	82	67	65	70	85	71	66	51	33	31	20	21	20	**981**
Sun, 15/01/2012	5	7	10	6	10	10	24	38	48	67	92	95	96	77	93	106	90	60	56	29	25	13	16	7	**1,080**
Mon, 16/01/2012	5	7	8	3	2	5	17	25	25	59	61	68	61	70	55	58	54	61	25	22	18	9	15	5	**738**
Tue, 17/01/2012	12	7	7	3	5	10	22	32	46	57	86	72	73	77	88	86	71	77	48	62	38	22	16	15	**1,032**
Wed, 18/01/2012	3	6	11	5	7	12	25	42	44	60	65	53	65	72	67	78	69	67	50	50	41	16	20	9	**937**
Thu, 19/01/2012	11	12	4	9	5	9	18	32	54	70	69	64	61	82	91	81	75	63	58	60	31	16	16	13	**1,004**
Fri, 20/01/2012	10	11	9	7	10	12	20	24	34	61	54	59	51	65	62	60	56	65	42	35	32	25	19	10	**833**
Sat, 21/01/2012	6	9	7	5	8	6	13	40	52	44	70	58	71	70	63	63	53	37	40	28	23	14	23	8	**811**
Sun, 22/01/2012	13	11	6	6	5	4	8	37	43	57	64	49	67	70	60	71	71	69	43	48	24	7	12	11	**856**
Mon, 23/01/2012	5	8	8	4	10	10	21	25	34	50	40	39	45	51	50	43	57	40	25	18	21	18	14	13	**649**
Tue, 24/01/2012	13	4	4	2	7	8	17	35	40	39	52	59	64	81	74	62	80	81	51	37	32	29	23	11	**905**
Wed, 25/01/2012	4	9	5	6	12	5	13	25	44	51	52	56	50	46	66	58	46	39	29	31	27	16	15	10	**715**
Thu, 26/01/2012	10	6	4	9	6	7	13	21	32	49	60	92	77	79	68	64	74	57	60	47	27	25	13	16	**916**
Fri, 27/01/2012	5	11	4	4	7	6	7	20	33	40	29	33	36	27	30	36	28	28	25	18	11	16	3	11	**468**
Sat, 28/01/2012	5	5	4	6	1	5	8	20	28	41	48	53	48	54	58	41	59	59	43	9	28	14	1	13	**651**
Sun, 29/01/2012	9	11	7	5	6	8	23	27	37	56	62	69	64	66	63	71	61	58	35	32	20	7	7	7	**811**
Mon, 30/01/2012	3	9	6	2	5	2	15	25	34	42	45	50	55	38	39	40	38	38	36	14	17	18	15	12	**598**
Tue, 31/01/2012	17	13	5	6	5	4	19	32	42	51	69	63	74	68	61	70	75	66	49	40	23	23	14	13	**902**
Wed, 01/02/2012	6	8	7	4	2	10	12	28	40	43	52	61	47	43	47	44	34	30	17	8	4	1	2		**550**
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Fri, 03/02/2012							4		6	4	3	8	5	5	4	6	5	1	3	5	3	10	5	3	**80**
Sat, 04/02/2012	2	1	2			2	2	3	6	3	6	9	5	5	8	14	19	17	11	8	9	1	2	3	**138**
Sun, 05/02/2012	2	3		1		3	2	1	2	2	13	13	9	11	18	14	28	11	12	14	6	6	5	2	**178**
Mon, 06/02/2012		1				2	10	3	12	11	18	23	16	25	29	26	23	26	27	21	13	9	11	10	**316**
Tue, 07/02/2012	7	6	4	1	1	4	10	12	44	29	45	45	45	35	61	64	58	63	35	28	35	17	30	16	**695**
Wed, 08/02/2012	12	10	2	2	4	16	18	18	27	44	38	46	69	51	54	63	48	62	49	35	23	16	11	14	**732**
Thu, 09/02/2012	15	3	7	4	11	5	18	13	36	39	47	42	37	59	83	60	61	50	43	37	29	19	26	15	**759**
Fri, 10/02/2012	9	9	9	2	7	4	14	17	40	29	40	37	33	39	30	39	48	34	34	25	26	22	13	18	**578**
Sat, 11/02/2012	6	9	2	4	3	8	9	23	29	29	27	47	47	52	40	52	50	55	35	39	22	27	18	17	**650**
Sun, 12/02/2012	13	17	7	12	9	4	6	20	48	47	55	55	65	83	64	85	56	47	51	38	27	26	20	12	**867**
Mon, 13/02/2012	6	7	10	2	5	12	16	27	32	42	31	42	38	58	46	40	34	32	23	19	15	18	7	11	**573**
Tue, 14/02/2012	5	7	4	2	13	6	11	28	34	43	49	50	62	83	73	71	59	59	54	39	30	30	17	6	**835**
Wed, 15/02/2012	8	6	3	4	8	7	13	29	36	53	50	68	71	57	75	64	41	63	64	45	35	17	19	13	**849**
Thu, 16/02/2012	8	7	8	6	6	8	18	24	40	58	59	52	66	79	64	77	69	59	53	51	22	21	23	16	**894**
Fri, 17/02/2012	17	6	8	6	5	11	17	28	33	38	55	48	51	45	41	63	58	46	39	19	18	23	18	10	**703**
Sat, 18/02/2012	8	9	3	3	3	5	14	21	32	57	57	49	49	44	45	51	57	62	51	30	18	24	17	12	**721**
Sun, 19/02/2012	16	9	11	5	10	10	12	21	39	51	59	66	64	78	76	59	66	49	33	38	27	12	12	4	**827**
Mon, 20/02/2012	11	9	3	3	3	7	22	26	36	41	34	43	47	45	60	51	61	38	35	23	18	11	21	11	**659**
Tue, 21/02/2012	6	2	6	2	6	4	16	28	40	51	45	72	68	78	70	75	58	68	49	44	30	30	14	17	**879**
Wed, 22/02/2012	16	3	8	6	8	10	22	17	33	45	71	57	56	72	70	65	78	64	54	42	22	17	12	12	**860**
Thu, 23/02/2012	10	6	7	4	7	9	17	29	37	62	79	54	69	67	72	63	73	63	52	38	29	27	24	14	**912**
Fri, 24/02/2012	16	10	9	7	8	2	14	20	44	46	45	54	48	50	51	55	60	36	42	30	30	12	11	7	**707**
Sat, 25/02/2012	14	8	4	11	7	7	8	18	33	40	52	51	69	54	51	65	53	58	38	20	27	18	14	13	**733**
Sun, 26/02/2012	14	8	9	7	7	4	21	24	33	47	34	99	94	65	68	62	77	42	41	41	20	27	21	13	**878**
Mon, 27/02/2012	11	3	2	1	4	13	13	28	36	45	56	52	49	41	49	29	50	47	45	19	18	14	11	13	**649**
Tue, 28/02/2012	10	8	6	3	12	19	17	28	44	50	45	83	90	74	84	81	63	67	47	41	43	26	16	10	**967**
Wed, 29/02/2012	5	5	5	7	9	10	12	37	34	55	43	53	65	58	59	59	62	70	50	39	31	21	11	10	**810**
Thu, 01/03/2012	12	3	10	6	12	8	16	33	42	41	64	68	61	54	72	72	71	73	59	40	36	29	12	7	**901**
Fri, 02/03/2012	6	8	5	5	7	4	13	21	31	46	63	48	48	38	56	64	57	45	52	19	19	20	8	6	**689**
Sat, 03/03/2012	10	7	5	2	5	5	10	23	25	34	54	47	43	72	41	31	38	38	35	31	25	12	17	6	**616**
Sun, 04/03/2012	11	9	4	1	8	5	9	19	25	26	60	36	69	38	40	50	57	42	30	35	21	16	13	7	**631**
Mon, 05/03/2012	5	2	3	1	3	4	12	20	29	36	24	31	51	23	28	39	26	24	36	22	20	11		6	**456**
Tue, 06/03/2012	9	4	7	3	2	2	11	20	33	30	39	27	37	40	37	27	57	34	27	26	13	13	9	5	**512**
Wed, 07/03/2012	8	6	4		9	4	10	27	34	30	38	44	35	44	26	46	40	40	24	25	25	13	10	16	**558**
Thu, 08/03/2012	5	5	1	2	6	3	10	13	23	22	31	28	42	39	39	35	35	42	40	21	32	19	23	10	**526**
Fri, 09/03/2012	3	5	7	5	5	6	16	17	26	23	27	32	39	28	37	34	35	39	30	11	18	9	11	9	**472**

Sat, 10/03/2012	4	4	3	3	3	8	5	12	22	26	40	33	44	29	43	36	40	27	34	27	21	26	5	13	**508**
Sun, 11/03/2012	2	5	3	10	2	8	11	15	26	34	41	45	49	47	61	47	58	48	29	28	23	10	9	6	**617**
Mon, 12/03/2012	2	5	4	4	1	7	10	25	27	30	32	34	29	41	24	41	36	47	23	17	10	12	8	6	**475**
Tue, 13/03/2012	12	5	3	1	5	8	13	17	37	22	36	42	47	39	29	37	47	38	25	16	24	14	5	8	**530**
Wed, 14/03/2012	3	5	4	2	4	5	17	18	38	35	29	38	31	45	50	57	61	53	49	39	24	24	22	11	**664**
Thu, 15/03/2012	10	8	2	9	9	2	11	19	32	47	32	50	36	56	47	62	57	43	50	33	17	23	15	5	**675**
Fri, 16/03/2012	16	10	5	4	6	5	13	25	35	36	53	47	37	36	54	41	30	49	43	36	19	10	9	10	**629**
Sat, 17/03/2012	4	6	3	6	4	6	6	14	26	35	52	44	42	43	37	43	31	37	34	26	14	14	11	6	**544**
Sun, 18/03/2012	11	6	3	2	5	8	14	12	24	32	46	46	52	47	56	44	47	76	35	27	25	19	14	9	**660**
Mon, 19/03/2012	5	4	3	5	3	11	10	20	30	38	36	42	29	31	51	49	45	38	31	14	15	16	13	11	**550**
Tue, 20/03/2012	8	4	2	6	4	8	11	19	28	26	62	58	64	52	59	83	60	66	60	34	29	28	15	9	**795**
Wed, 21/03/2012	9	10	2	4	7	13	15	25	32	47	59	52	63	59	74	60	55	47	47	39	23	20	15	16	**793**
Thu, 22/03/2012	6	8	4	6	7	6	18	27	36	45	47	68	74	57	67	63	66	59	46	54	26	16	23	18	**847**
Fri, 23/03/2012	10	7	5	7	7	5	16	26	37	46	52	52	43	41	72	50	42	62	51	32	21	16	14	8	**722**
Sat, 24/03/2012	7	8	6	10	7	9	18	19	41	55	63	72	48	47	41	59	58	47	47	23	28	18	10	12	**753**
Sun, 25/03/2012	7	11	6	4	6	10	12	25	38	42	40	74	52	79	107	100	60	61	43	32	23	20	15	9	**876**
Mon, 26/03/2012	8	5	3	3	4	4	17	20	27	33	41	47	52	46	57										**367**
TOTAL	**751**	**602**	**476**	**387**	**529**	**631**	**1,310**	**2,243**	**3,255**	**4,087**	**4,680**	**4,932**	**5,013**	**4,819**	**4,957**	**4,997**	**4,909**	**4,507**	**3,565**	**2,677**	**2,045**	**1,563**	**1,205**	**928**	**65,068**

92742: Traffic Volume - Vehicle Count - Date and Hours by Direction

SOUTH

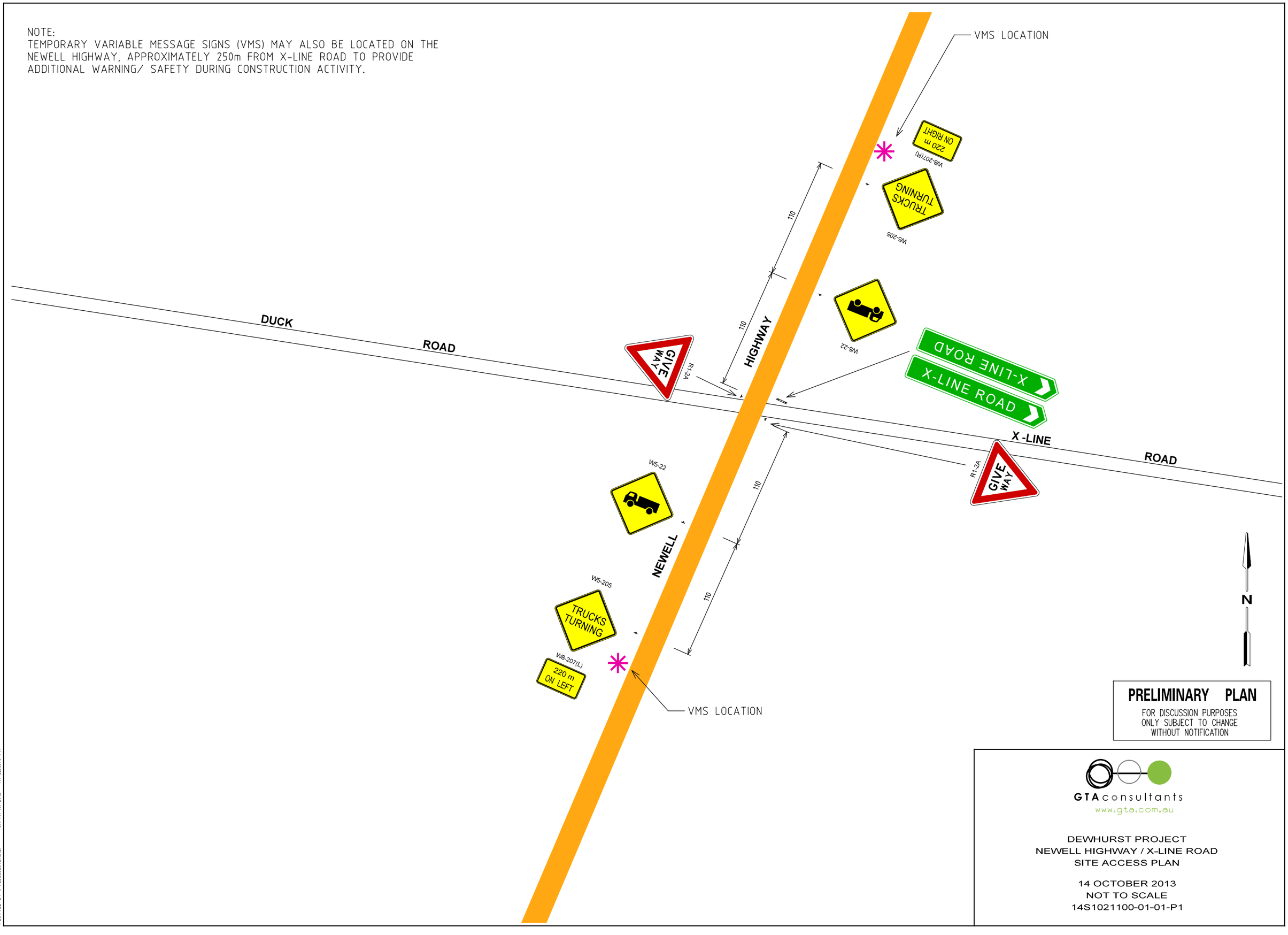
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Sun, 01/01/2012	3	8	3	5	1	3	6	17	37	33	51	41	55	52	71	65	59	50	44	34	32	16	14	17	**717**
Mon, 02/01/2012	8	4	6	5	5	11	26	26	50	58	70	86	84	85	120	103	111	75	64	31	27	21	11	15	**1,102**
Tue, 03/01/2012	12	4	11	3	2	15	19	39	58	55	59	58	58	86	88	94	69	63	52	48	27	26	26	27	**999**
Wed, 04/01/2012	14	15	10	18	13	16	31	49	51	73	70	84	78	89	89	92	71	73	53	36	19	19	21	18	**1,102**
Thu, 05/01/2012	21	17	15	18	13	25	33	50	68	68	84	78	89	81	83	86	90	87	46	31	42	36	21	13	**1,195**
Fri, 06/01/2012	9	12	14	10	11	21	34	51	60	80	90	86	66	80	96	114	88	86	48	34	29	31	25	15	**1,190**
Sat, 07/01/2012	18	19	16	14	13	10	23	51	36	64	56	72	56	85	95	79	64	53	41	34	40	34	17	14	**1,004**
Sun, 08/01/2012	13	10	9	7	5	14	18	34	36	53	59	64	68	73	80	78	49	53	41	18	14	12	11	6	**825**
Mon, 09/01/2012	7	3	5	4	5	8	22	36	46	53	44	57	60	66	56	76	86	73	53	44	48	26	30	23	**931**
Tue, 10/01/2012	15	15	14	9	14	21	37	35	66	68	75	58	80	68	86	67	67	65	41	27	21	23	21	24	**1,017**
Wed, 11/01/2012	11	10	12	14	8	14	33	35	53	65	68	63	54	57	70	72	69	63	57	33	38	32	27	19	**977**
Thu, 12/01/2012	24	7	15	11	15	13	38	53	52	74	68	78	63	74	63	74	64	60	52	28	19	19	11	17	**992**
Fri, 13/01/2012	18	8	8	10	11	12	30	47	46	67	66	70	51	49	78	71	68	64	40	29	25	26	24	19	**937**
Sat, 14/01/2012	19	8	12	20	9	15	33	53	54	44	56	47	57	71	72	71	66	65	31	31	29	22	17	12	**914**
Sun, 15/01/2012	15	6	10	5	6	7	17	38	56	56	58	56	48	58	54	74	34	36	19	24	18	17	12	6	**730**
Mon, 16/01/2012	4	3	2	2	5	11	20	30	41	31	42	37	43	45	42	46	62	59	44	50	20	38	32	24	**733**
Tue, 17/01/2012	15	13	9	12	16	25	32	42	54	56	61	49	41	49	42	57	52	47	25	20	11	26	19	21	**794**
Wed, 18/01/2012	9	10	15	9	6	10	36	40	67	52	57	46	72	47	41	58	56	42	50	29	35	25	17	30	**859**
Thu, 19/01/2012	15	16	19	11	13	11	25	47	63	63	66	48	47	55	53	49	54	48	32	33	19	28	17	18	**850**
Fri, 20/01/2012	10	9	6	9	11	14	26	40	57	63	51	51	57	57	58	66	43	46	34	34	19	27	23	10	**821**
Sat, 21/01/2012	17	14	14	11	10	16	22	31	35	56	36	45	52	56	78	51	59	45	43	28	30	26	16	20	**811**
Sun, 22/01/2012	15	9	2	3	4	4	20	36	54	52	60	52	54	40	59	58	55	32	23	19	16	14	14	9	**704**
Mon, 23/01/2012	6	3	4	8	7	7	15	24	36	45	37	33	42	43	49	58	64	40	59	32	39	31	30	16	**728**
Tue, 24/01/2012	23	14	17	14	15	22	28	37	55	79	68	64	73	66	46	56	62	58	42	31	26	18	14	14	**942**
Wed, 25/01/2012	9	15	6	9	5	9	29	31	38	57	68	59	55	57	57	45	46	55	43	42	41	34	31	32	**873**
Thu, 26/01/2012	24	8	21	16	16	17	24	43	55	70	53	49	54	44	47	61	53	27	42	21	12	12	12	10	**791**
Fri, 27/01/2012	7	3	3	8	10	8	13	14	28	37	36	27	39	40	45	43	44	46	35	42	33	29	21	13	**624**
Sat, 28/01/2012	19	7	11	13	9	19	28	44	40	58	64	69	48	46	51	58	59	63	27	25	19	24	14	15	**830**
Sun, 29/01/2012	10	11	7	4	6	8	12	32	38	46	53	36	50	53	51	38	41	42	29	14	18	13	13	6	**631**
Mon, 30/01/2012	4	4	2	6	3	5	13	28	33	31	38	34	26	37	38	50	41	46	36	33	30	38	19	22	**617**
Tue, 31/01/2012	16	12	7	17	14	17	20	39	49	51	49	57	60	52	40	38	38	61	22	29	24	25	14	14	**765**
Wed, 01/02/2012	18	6	17	14	4	12	16	26	55	47	40	51	46	54	42	55	34	44	34	23	5	2		1	**646**
Thu, 02/02/2012				1	1		4	10	23	19	14	11	14	4	5	6	6		1	3	3	1		1	**127**
Fri, 03/02/2012							3	6	5	6	16	4	3	11	9	2	10	12	2	3	1			2	**95**

Sat, 04/02/2012	1			1		1	4	11	11	17	15	38	20	16	9	18	6	7	6	3	6	2	2		**194**
Sun, 05/02/2012	1					3	4	13	21	19	26	24	11	11	10	15	11	4	4	1	3	2	3	2	**188**
Mon, 06/02/2012			1	1	2	6	5	9	19	11	12	14	15	22	22	18	21	31	27	24	17	26	21	30	**354**
Tue, 07/02/2012	15	4	8	9	15	13	12	36	36	37	34	32	35	50	34	28	38	18	25	18	26	36	23	17	**599**
Wed, 08/02/2012	9	10	15	15	7	15	20	28	34	53	50	26	35	24	40	28	48	42	23	19	21	32	30	17	**641**
Thu, 09/02/2012	19	18	12	16	10	10	17	32	45	48	40	29	50	45	45	36	40	30	29	32	17	25	19	29	**693**
Fri, 10/02/2012	14	13	9	9	8	13	16	22	48	34	40	42	37	35	34	49	42	42	25	19	21	25	20	19	**636**
Sat, 11/02/2012	17	12	17	11	10	10	15	26	26	39	38	35	44	30	42	42	62	21	32	30	23	25	27	10	**644**
Sun, 12/02/2012	18	9	16	8	7	3	17	21	17	36	29	43	35	39	35	36	38	24	24	13	16	15	13	5	**517**
Mon, 13/02/2012	6	4	8		4	8	12	12	31	29	43	24	35	29	33	41	48	46	53	44	29	33	32	35	**639**
Tue, 14/02/2012	21	19	13	17	23	12	28	31	50	55	51	45	39	50	35	40	42	35	35	30	26	23	20	19	**759**
Wed, 15/02/2012	18	13	9	11	16	16	23	42	63	62	61	42	44	43	36	46	58	38	38	31	29	38	28	29	**834**
Thu, 16/02/2012	17	11	28	8	15	17	32	49	53	71	41	60	41	49	38	63	57	47	37	32	24	21	26	20	**857**
Fri, 17/02/2012	15	6	18	6	12	13	33	51	34	52	48	50	36	73	47	56	49	48	32	20	23	26	20	28	**796**
Sat, 18/02/2012	25	20	17	15	7	16	25	35	50	47	61	40	39	53	58	44	48	44	35	36	18	31	30	15	**809**
Sun, 19/02/2012	10	13	9	10	9	5	15	23	33	39	34	44	40	22	33	40	36	26	25	23	12	15	15	11	**542**
Mon, 20/02/2012	10	5	2	2	5	13	22	19	38	50	30	34	38	46	55	56	57	40	33	33	38	38	31	23	**718**
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Thu, 23/02/2012	17	19	16	9	11	13	38	46	61	53	51	54	50	73	62	41	53	43	24	23	20	29	16	9	**831**
Fri, 24/02/2012	12	12	12	14	9	8	29	46	66	63	39	49	55	54	63	56	43	43	41	26	27	25	24	17	**833**
Sat, 25/02/2012	17	14	11	12	12	9	27	27	32	57	35	48	41	46	44	53	42	32	44	18	32	25	24	19	**721**
Sun, 26/02/2012	9	13	2	9	6	9	10	31	36	32	35	51	47	49	56	55	46	21	27	13	20	19	10	14	**620**
Mon, 27/02/2012	5	2	3	5	1	9	17	30	34	25	32	42	34	45	47	48	42	39	23	35	29	30	38	24	**639**
Tue, 28/02/2012	13	8	11	14	13	21	21	47	40	50	59	41	48	51	34	47	38	46	33	27	16	35	21	13	**747**
Wed, 29/02/2012	9	7	8	12	9	23	20	44	47	48	50	56	30	50	51	39	40	39	29	31	24	29	37	18	**750**
Thu, 01/03/2012	18	14	10	11	9	18	24	42	41	57	57	45	48	48	57	55	52	40	26	21	22	24	11	19	**769**
Fri, 02/03/2012	11	6	11	6	14	17	19	40	56	49	48	44	45	65	42	36	45	35	55	24	17	18	11	24	**738**
Sat, 03/03/2012	9	10	12	6	13	13	26	23	27	52	42	38	37	48	50	34	43	31	32	21	29	25	14	15	**650**
Sun, 04/03/2012	10	9	4	5	2	8	9	26	38	33	36	33	19	43	33	32	33	25	22	11	12	15	10	7	**475**
Mon, 05/03/2012	3	2	1	1	3	11	18	23	24	36	28	26	32	34	31	37	43	33	26	15	22	18	18	12	**497**
Tue, 06/03/2012	4	4	6	2	3	11	20	33	23	46	44	35	32	41	19	35	32	29	18	14	9	17	5	9	**491**
Wed, 07/03/2012	5	4	6	3	8	9	19	28	32	44	28	34	27	28	47	37	48	27	21	17	17	7	17	12	**525**
Thu, 08/03/2012	7	3	7	4	9	13	34	23	34	31	44	48	24	41	39	30	31	29	30	20	9	16	13	9	**548**
Fri, 09/03/2012	7	3	7	5	3	8	19	17	39	54	36	50	43	40	51	36	40	33	31	19	13	13	10	16	**593**
Sat, 10/03/2012	7	9	7	9	8	15	17	24	37	32	40	28	29	43	31	39	43	26	20	10	20	14	11	11	**530**
Sun, 11/03/2012	3	3	5	1	4	3	8	14	21	32	29	22	28	42	36	31	38	28	31	15	12	17	14	11	**448**
Mon, 12/03/2012	4	5	2	2	2	9	16	18	22	28	31	45	32	34	42	42	27	42	26	17	23	33	27	22	**551**
Tue, 13/03/2012	18	12	9	8	14	8	32	32	44	53	61	46	49	36	43	31	29	30	30	29	18	14	15	12	**673**
Wed, 14/03/2012	12	5	8	5	15	16	26	33	39	38	54	38	48	44	33	47	40	20	19	25	13	16	24	18	**636**
Thu, 15/03/2012	9	5	10	5	10	11	19	30	38	46	33	43	50	60	53	53	30	33	28	19	20	19	28	13	**665**
Fri, 16/03/2012	9	11	6	5	6	10	27	45	34	49	58	66	43	55	47	48	51	33	29	22	13	20	15	12	**714**
Sat, 17/03/2012	16	13	6	6	9	3	14	30	24	40	51	31	35	39	33	43	41	25	28	13	18	17	19	9	**563**
Sun, 18/03/2012	12	7	5	3	6	9	10	11	28	18	43	30	27	47	40	39	40	23	24	18	16	15	21	5	**497**
Mon, 19/03/2012		3	3	1	3	7	18	21	40	31	14	35	31	41	43	32	39	36	33	26	13	21	25	15	**531**
Tue, 20/03/2012	21	8	13	19	8	13	20	31	42	35	49	35	40	49	53	45	42	43	27	23	25	12	18	13	**684**
Wed, 21/03/2012	10	10	5	12	5	13	19	35	29	67	53	42	46	52	63	52	43	51	28	21	28	33	20	24	**761**
Thu, 22/03/2012	16	9	18	9	8	14	19	38	52	50	68	49	52	62	56	53	38	41	48	18	27	20	24	8	**797**
Fri, 23/03/2012	10	10	11	13	15	15	14	34	46	44	61	47	36	45	39	38	47	46	39	22	22	24	15	21	**714**
Sat, 24/03/2012	11	7	16	9	13	15	28	46	41	59	44	45	44	60	42	44	55	33	28	33	28	24	20	13	**758**
Sun, 25/03/2012	12	6	7	5	8	7	15	24	62	43	47	52	46	60	61	47	29	32	25	24	7	13	11	7	**650**
Mon, 26/03/2012	7	4	3	6	7	16	9	29	28	41	31	32	39	39	37										**328**
TOTAL	**1,010**	**742**	**783**	**718**	**726**	**1,017**	**1,808**	**2,778**	**3,556**	**4,061**	**4,060**	**3,937**	**3,834**	**4,233**	**4,235**	**4,214**	**4,015**	**3,493**	**2,797**	**2,145**	**1,862**	**1,899**	**1,589**	**1,338**	**60,850**

Appendix B

Site Access Plan

NOTE:
TEMPORARY VARIABLE MESSAGE SIGNS (VMS) MAY ALSO BE LOCATED ON THE NEWELL HIGHWAY, APPROXIMATELY 250m FROM X-LINE ROAD TO provide ADDITIONAL WARNING/ SAFETY DURING CONSTRUCTION ACTIVITY.



PRELIMINARY PLAN

FOR DISCUSSION PURPOSES
ONLY SUBJECT TO CHANGE
WITHOUT NOTIFICATION

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DEWHURST PROJECT
NEWELL HIGHWAY / X-LINE ROAD
SITE ACCESS PLAN

14 OCTOBER 2013
NOT TO SCALE
14S1021100-01-01-P1

PLOTTED BY : rebecca.fletcher ON 14/10/2013 AT 35846 PM

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