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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REPORT FOR **RPS Australia East** *on behalf of* **Santos**

CONTACT **Katharine Bond, Belinda Lewis**

Signed

Dr Bob Thorne
(Principal)

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Contents

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.*

<u>It is concluded therefore</u> 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

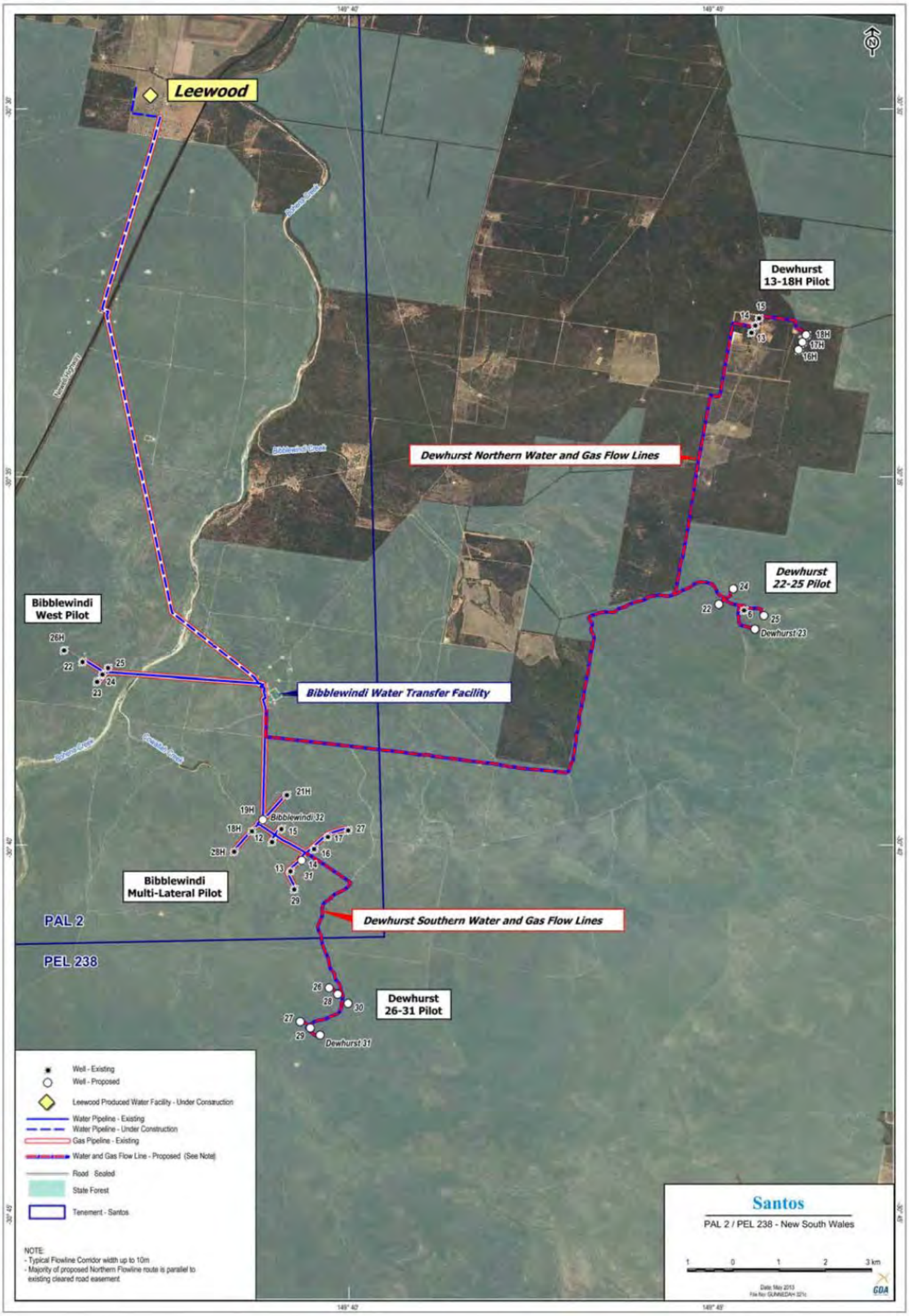
Noise Measurement Services Pty Ltd has been commissioned by RPS Australia East, consulting to Santos NSW (Eastern) Pty Ltd, to complete an environmental noise assessment for the Dewhurst Pilot Expansion Environmental Impact Statement (EIS). Santos NSW (Eastern) Pty Ltd (Santos), as the coal seam gas (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

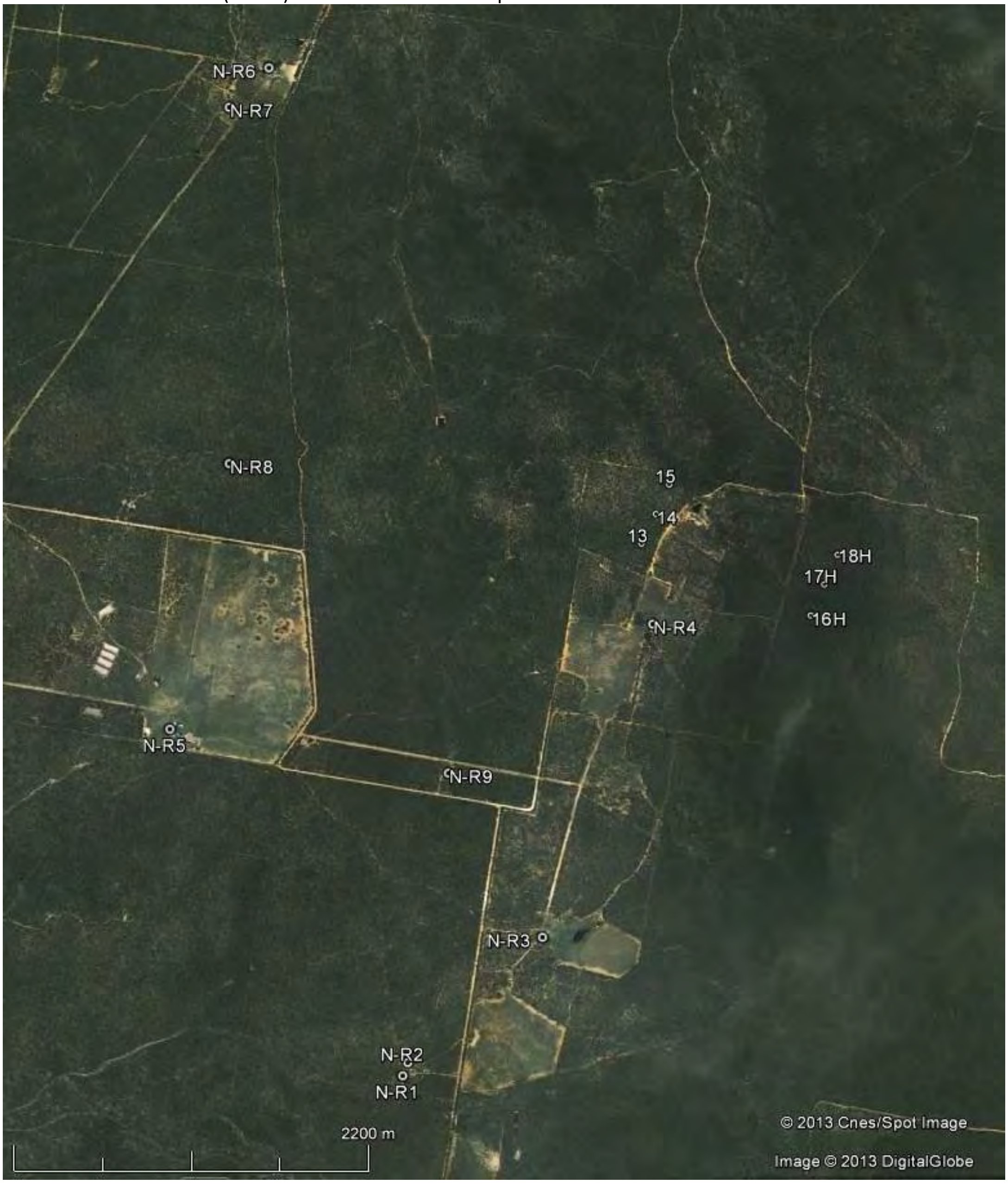


Table 1.3.2: Residential Locations within 15km of Dewhurst 26-31 Pilot (none are known to the south)

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.

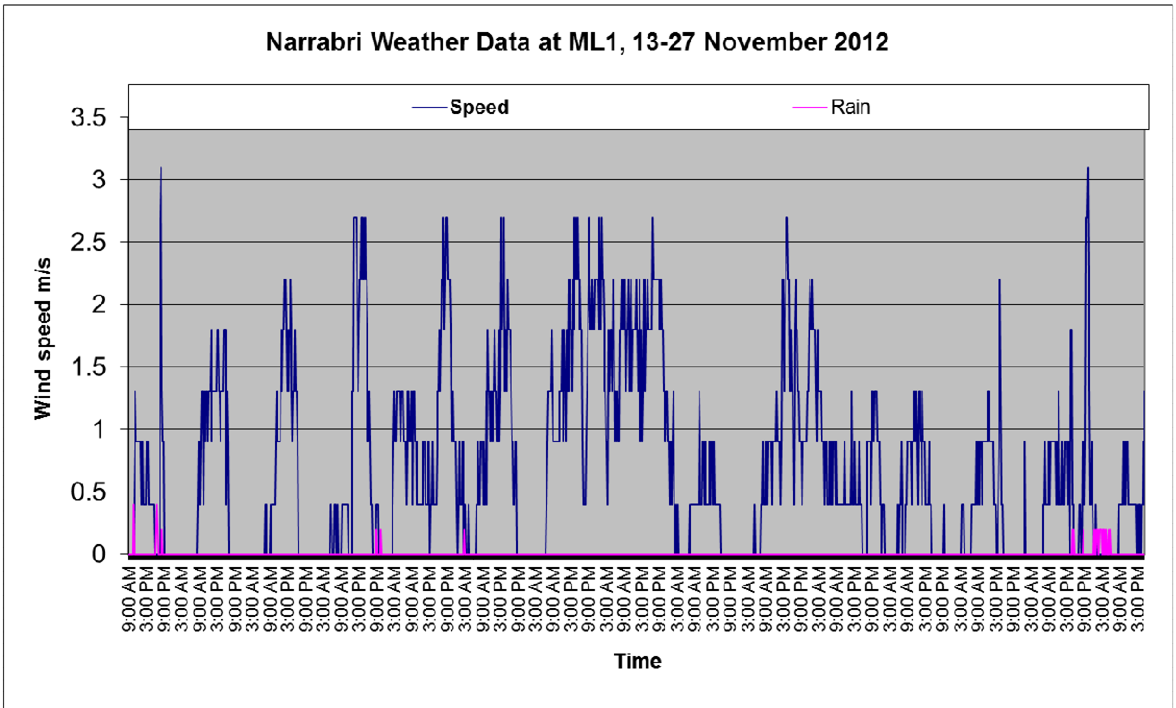


Figure 2.3.1: Weather data at Narrabri during the monitoring in November 2012

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**

<u>Consequently, the Rating Background Level is determined from the RBL values of Table 2.5.1 (ML1)</u>

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

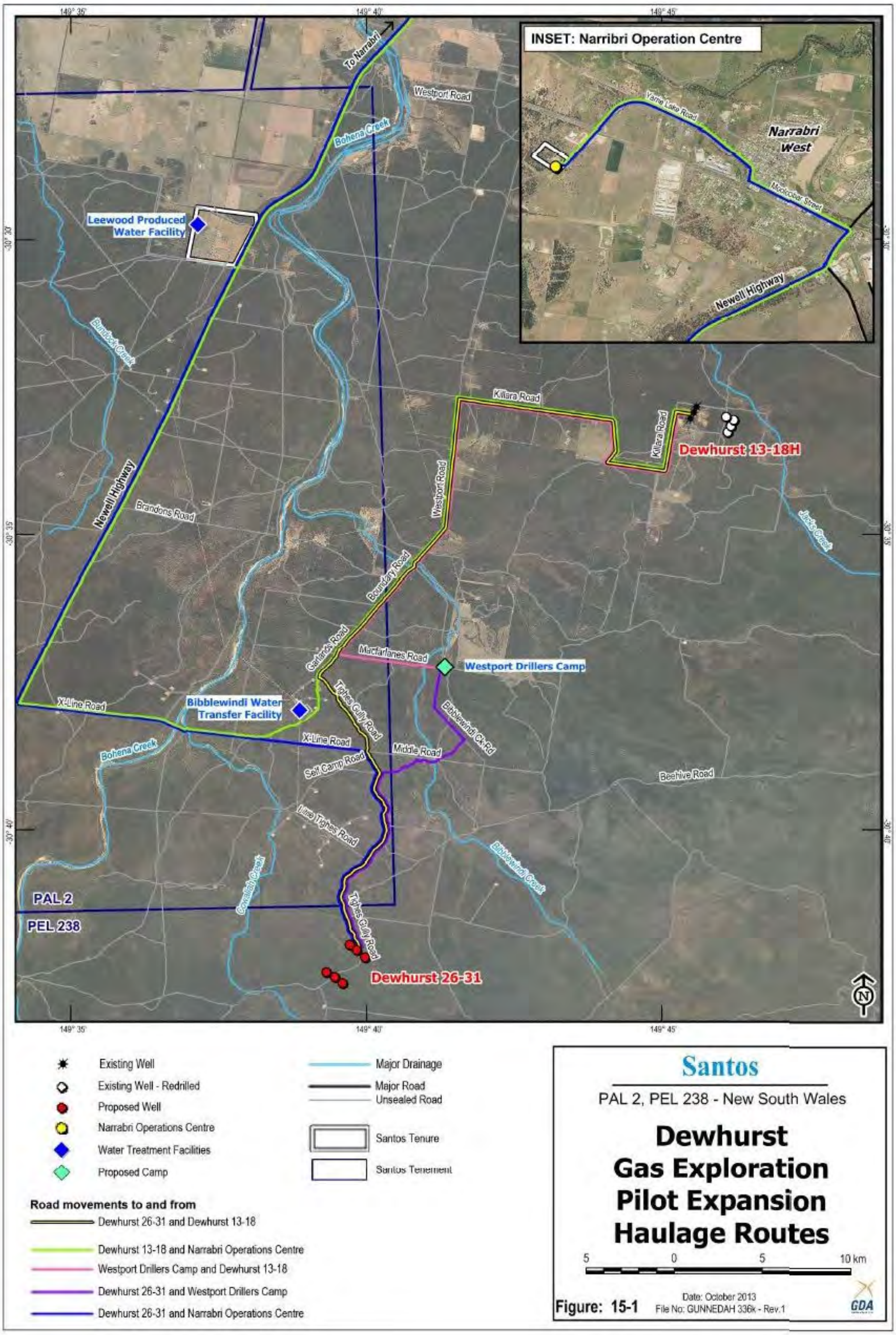


Table 4.4.2.1 Overall Estimated Construction Traffic Volumes (Table 4.1 of GTA Consultants' Report)

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**

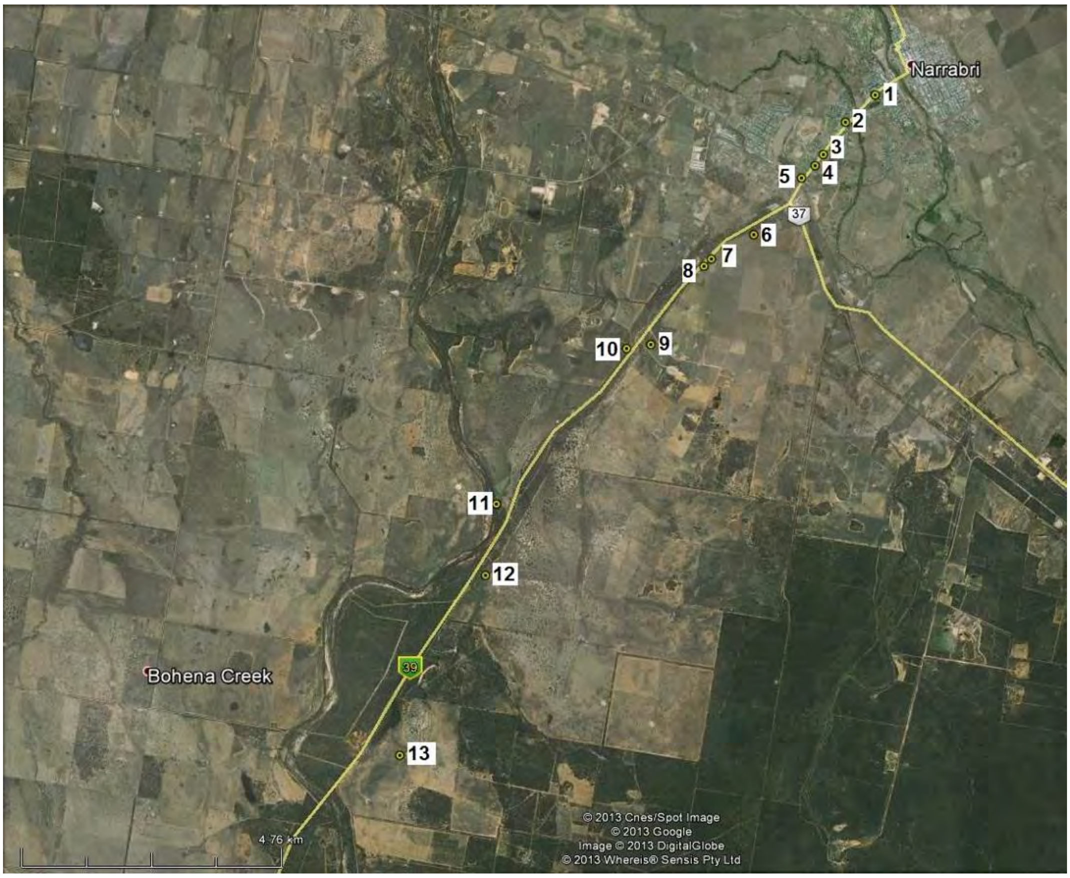
[1] Vehicles associated with transportation of workers by bus and delivery of meals to workers at the works site.

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)



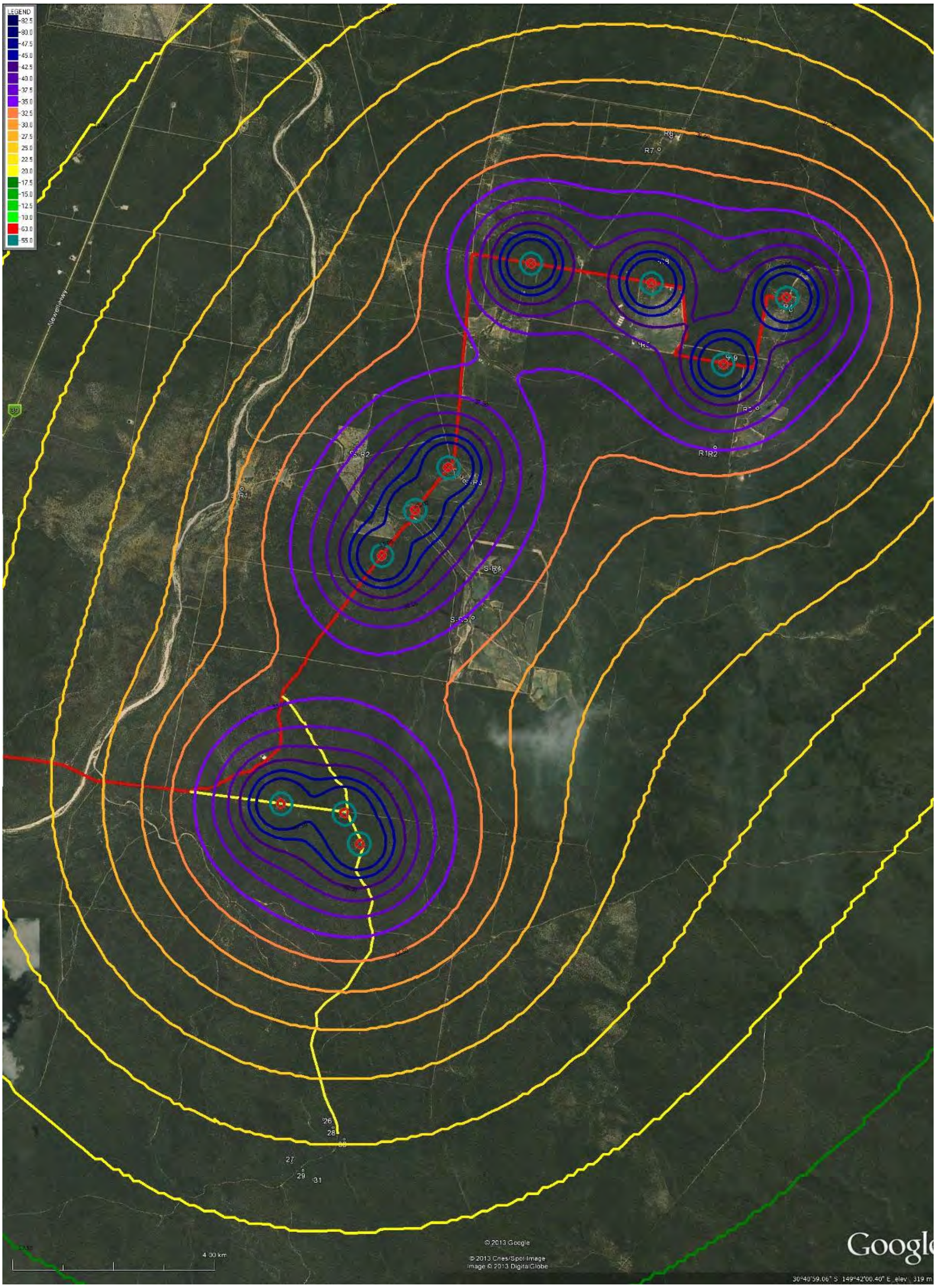
Noise levels associated with the increase in traffic due to the proposed activity are minimal with all construction vehicles and equipment to be delivered during the beginning of the construction works and collected upon completion. Between these times, equipment will remain on site.

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.

<u>In summary it is concluded</u>

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.*

<u>It is concluded therefore</u> 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 case	Front	72	64	47	38	32	27	<10
		Left	70	64	48	39	33	29	<10
		Back	69	63	47	38	33	28	<10
		Right	71	64	48	39	33	29	11
Running casing	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	69	62	45	36	30	25	<10
Running casing	Worst case	Front	72	64	47	38	32	27	<10
		Left	70	64	47	38	32	28	<10
		Back	69	63	47	38	32	28	<10
		Right	71	64	47	38	33	28	10
Cementing Casing	Neutral	Front	70	62	45	36	30	25	<10
		Left	68	61	45	36	30	25	<10
		Back	67	61	44	36	30	25	<10
		Right	68	62	45	36	30	25	<10
Cement Casing	Worst case	Front	72	66	50	40	35	30	<10
		Left	77	69	51	41	35	30	13
		Back	76	69	50	41	35	30	13
		Right	71	66	50	40	35	30	<10
Core Drilling	Neutral	Front	60	54	39	31	26	22	<10
		Left	64	58	41	33	27	23	<10
		Back	64	58	41	33	27	23	<10
		Right	64	58	41	33	27	23	<10
Core Drilling	Worst case	Front	63	57	39	31	26	22	<10
		Left	68	61	43	35	29	25	<10
		Back	68	61	43	35	29	25	<10
		Right	68	61	43	35	29	25	<10

Notes:

'Front' refers to the direction located by the front of the truck holding the drill rig. That is, standing at the front of the truck and looking back to the drill rig is 'front-to-back'.

'Neutral' is the predictions to the ISO 9613-2 methodology, standard assumptions

'Worst Case' is to CONCAWE methodology with a 6m/s breeze blowing from front to back.

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

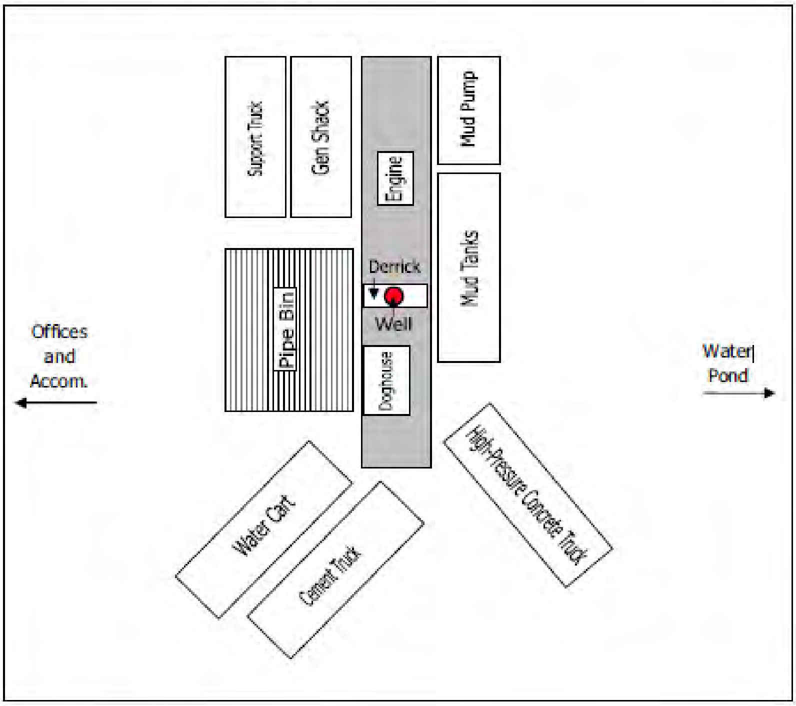


Figure 2-2 EDA Rig 1

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

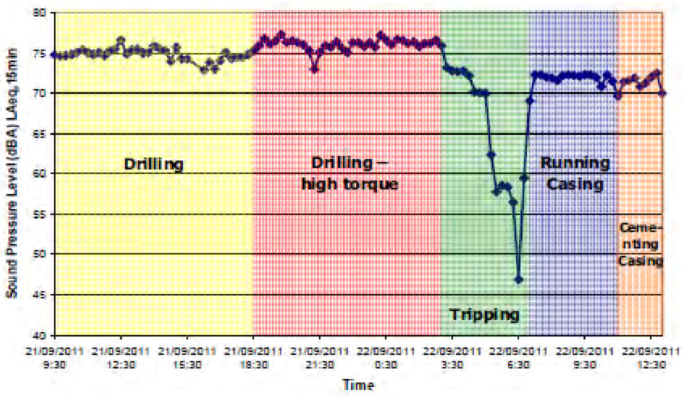


Table 3-1 presents the sound power levels for each plant item. Note that many of these sources radiate over significant areas and thus cannot be equated by point sources in the near field (less than 20m). Determination of the sound power levels has considered the radiated area of these sources. Near 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.

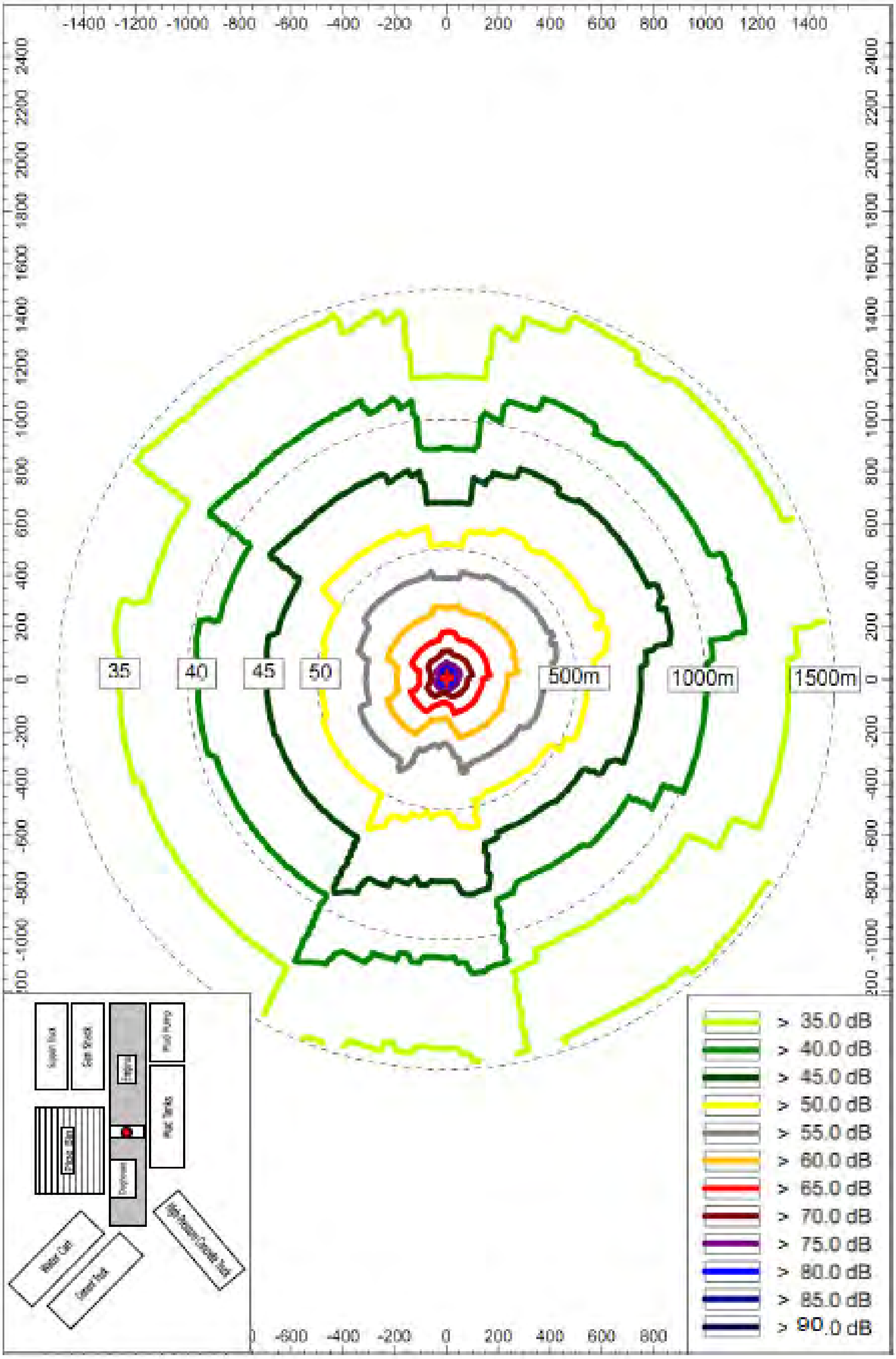
Table 3-1 Individual Source Sound Power Levels (SWL)

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.

Report No. 00574 Version A Appendix A-1

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.

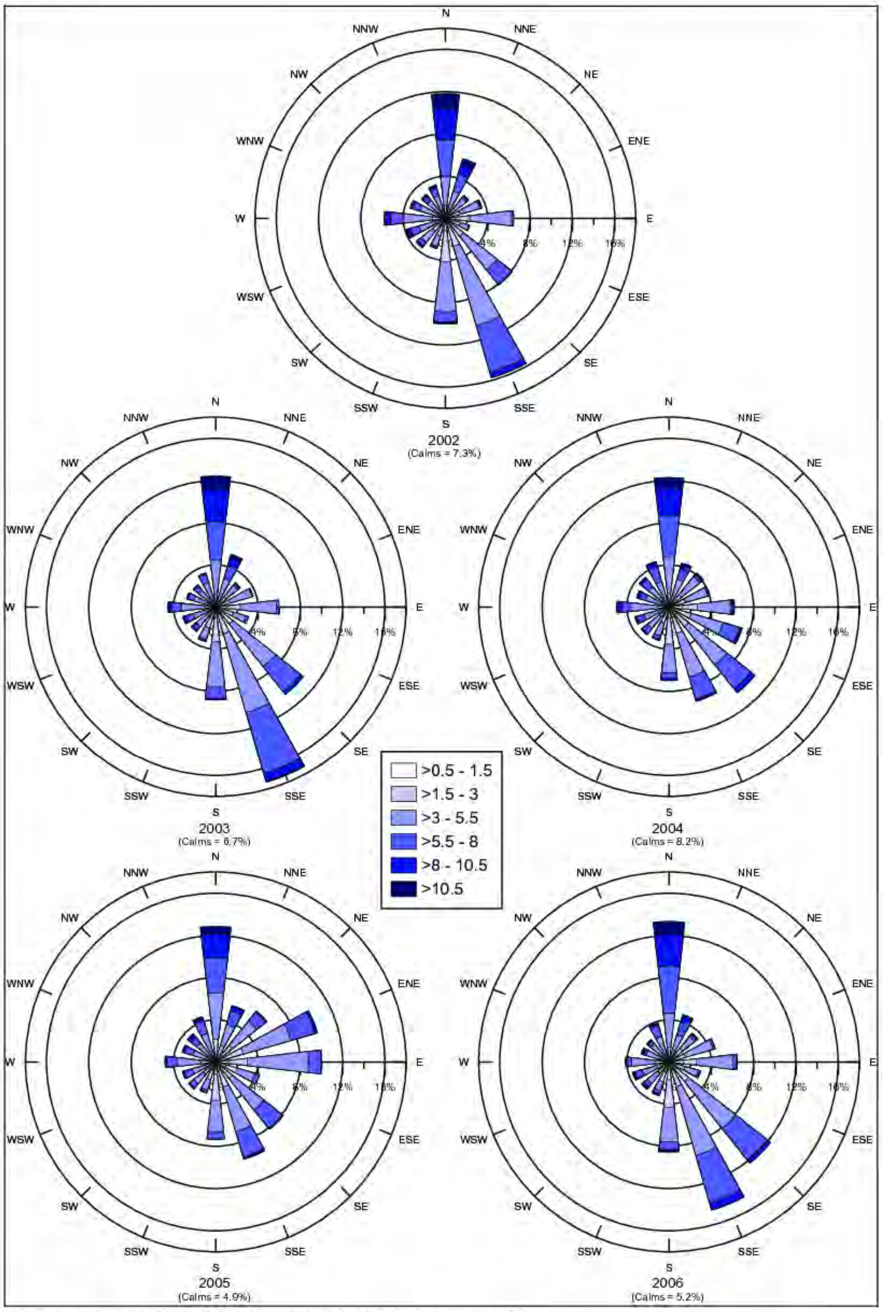
The seasonal variation in wind behaviour at the Narrabri Airport AWS is also presented following as **Figure C2** from the Heggies Report. The seasonal wind roses indicate the following:

- 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.

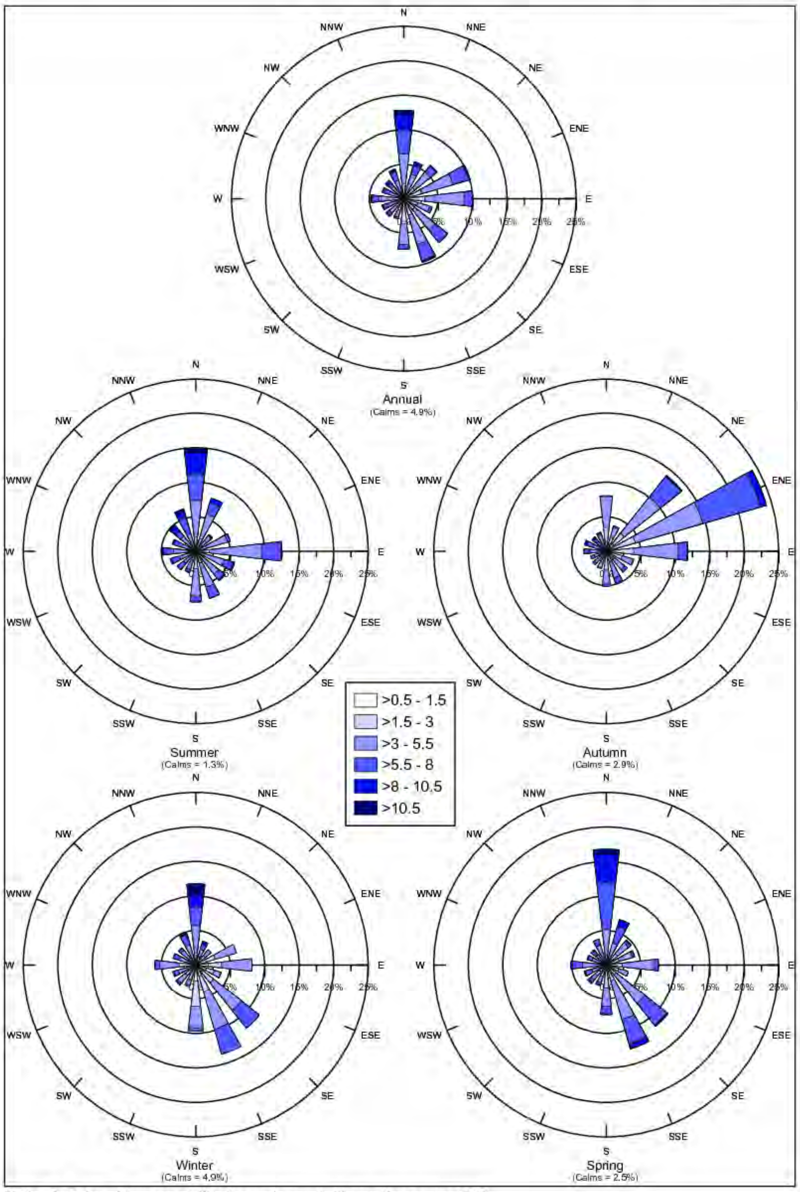
'Normal' or 'Neutral' conditions occur where the temperature slowly increases with height such as overcast conditions and / or when the wind is high enough to cause mixing of any atmospheric layers. These conditions can occur day or night; they will always prevail when it is fairly windy, overcast or 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

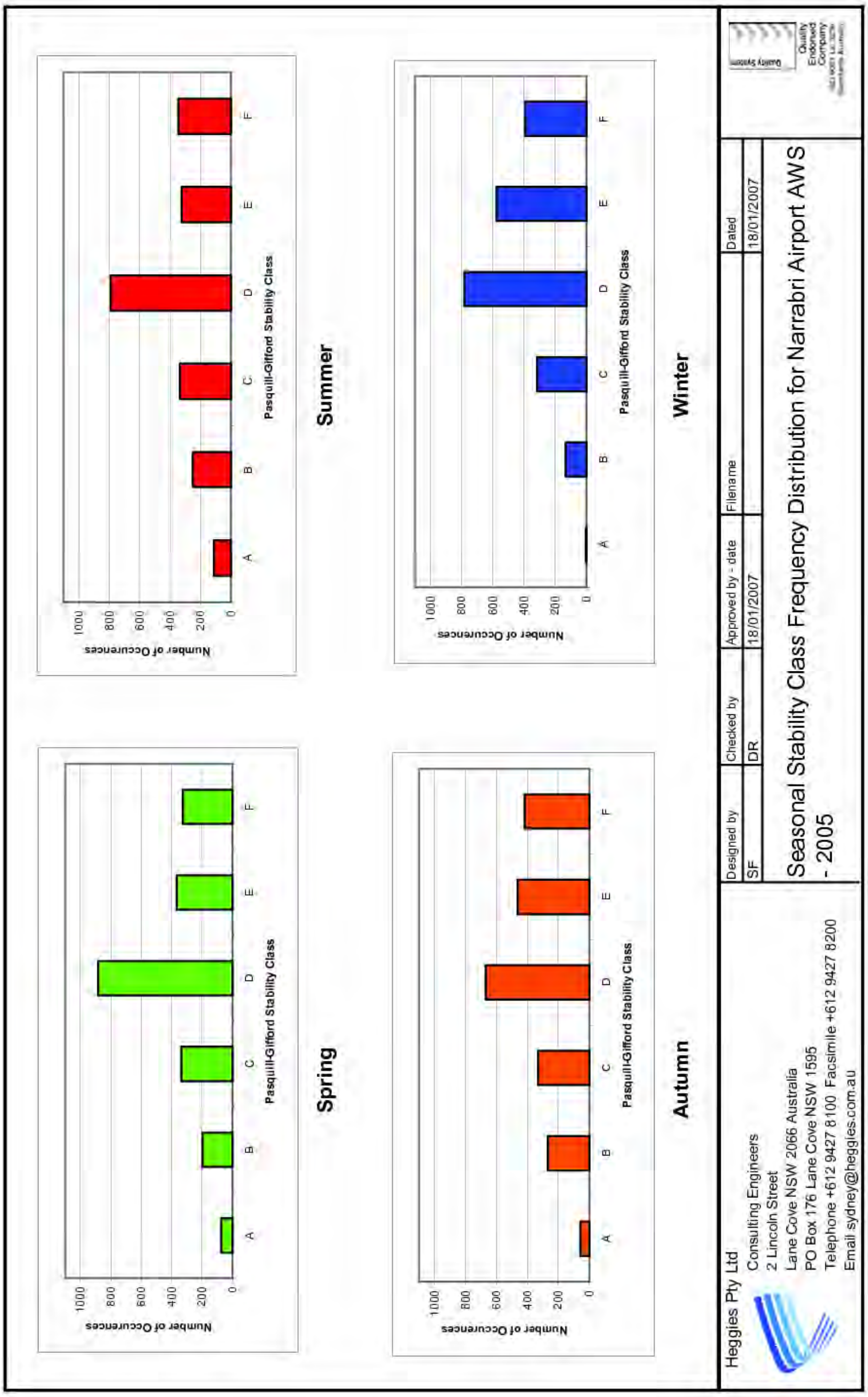
Figure C1 Annual Wind Roses for Narrabri Airport AWS, 2002-2006

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


Summer
Winter
Spring
Autumn
Number of Occurences
Pasquill-Gifford Stability Class
A
B
C
D
E
F
0
200
400
600
800
1000
Heggies Pty Ltd
Consulting Engineers
2 Lincoln Street
Lane Cove NSW 2066 Australia
PO Box 176 Lane Cove NSW 1595
Telephone +612 9427 8100 Facsimile +612 9427 8200
Email sydney@heggies.com.au
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SF
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18/01/2007
Filename
Dated
18/01/2007
Seasonal Stability Class Frequency Distribution for Narrabri Airport AWS - 2005

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:

$$\mathbf{L_p = L_w + D - \sum K}$$

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.

<u>Accuracy of the CONCAWE Noise Prediction Method</u>

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

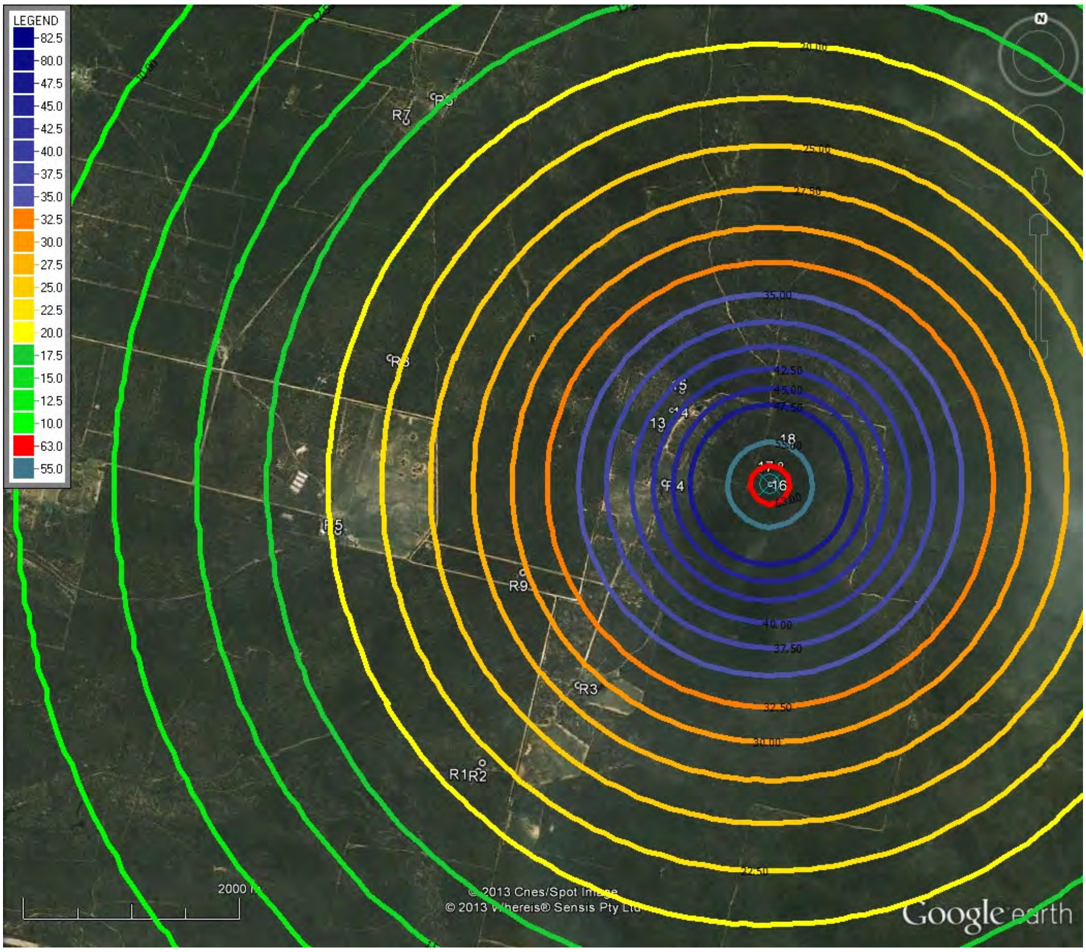
The method of prediction is ideally suited to a combination of both ISO 9613-2 and CONCAWE methods. The calculation programs available for this purpose are (a) SoundPLAN, which has both methods as separate modules, and (b) PEN3D, an environmental noise model developed by Noise Mapping Pty Ltd Queensland. 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



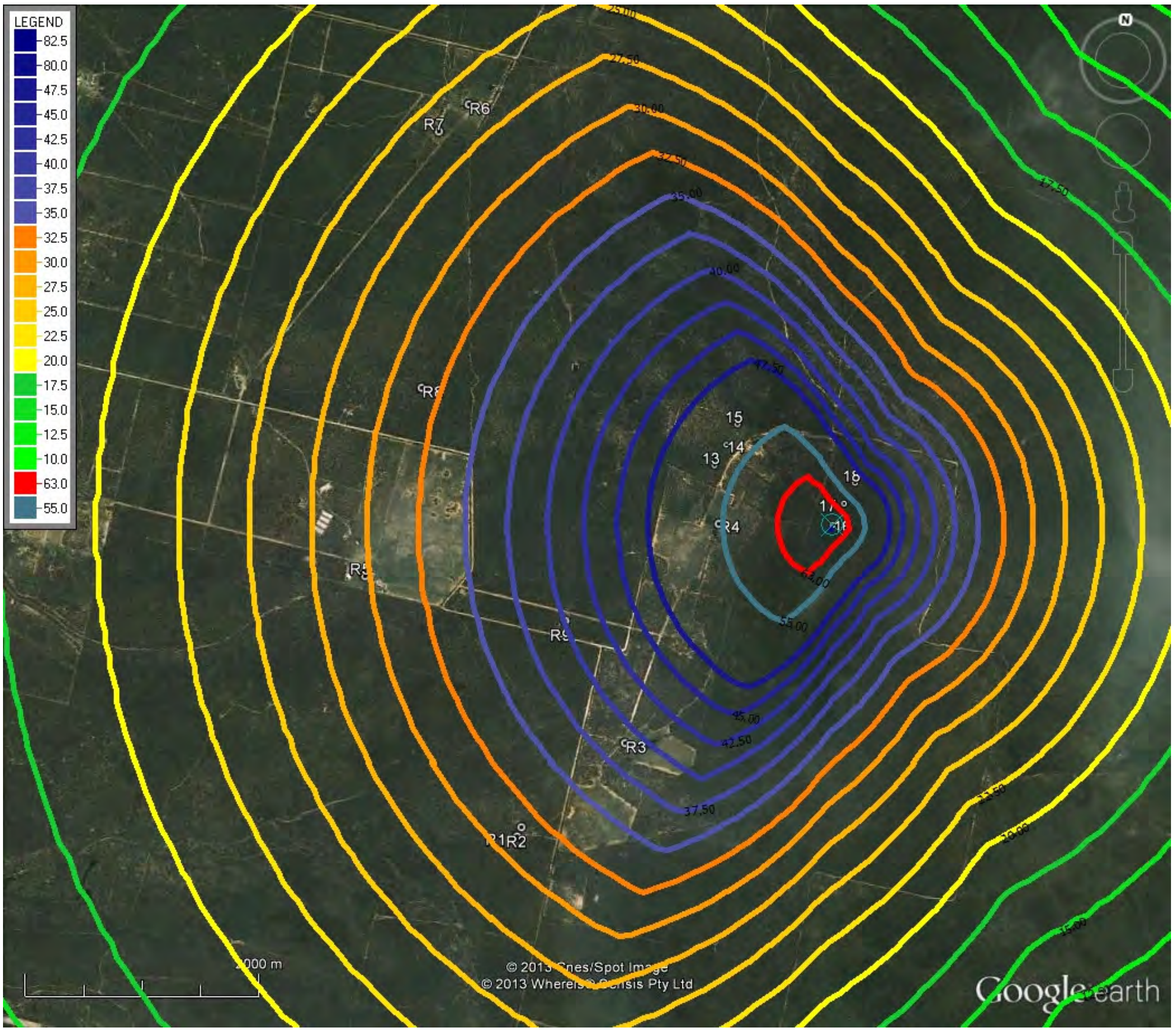
Scenario 1: Dewhurst 16H, site operations or single drilling rig, calm weather

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.



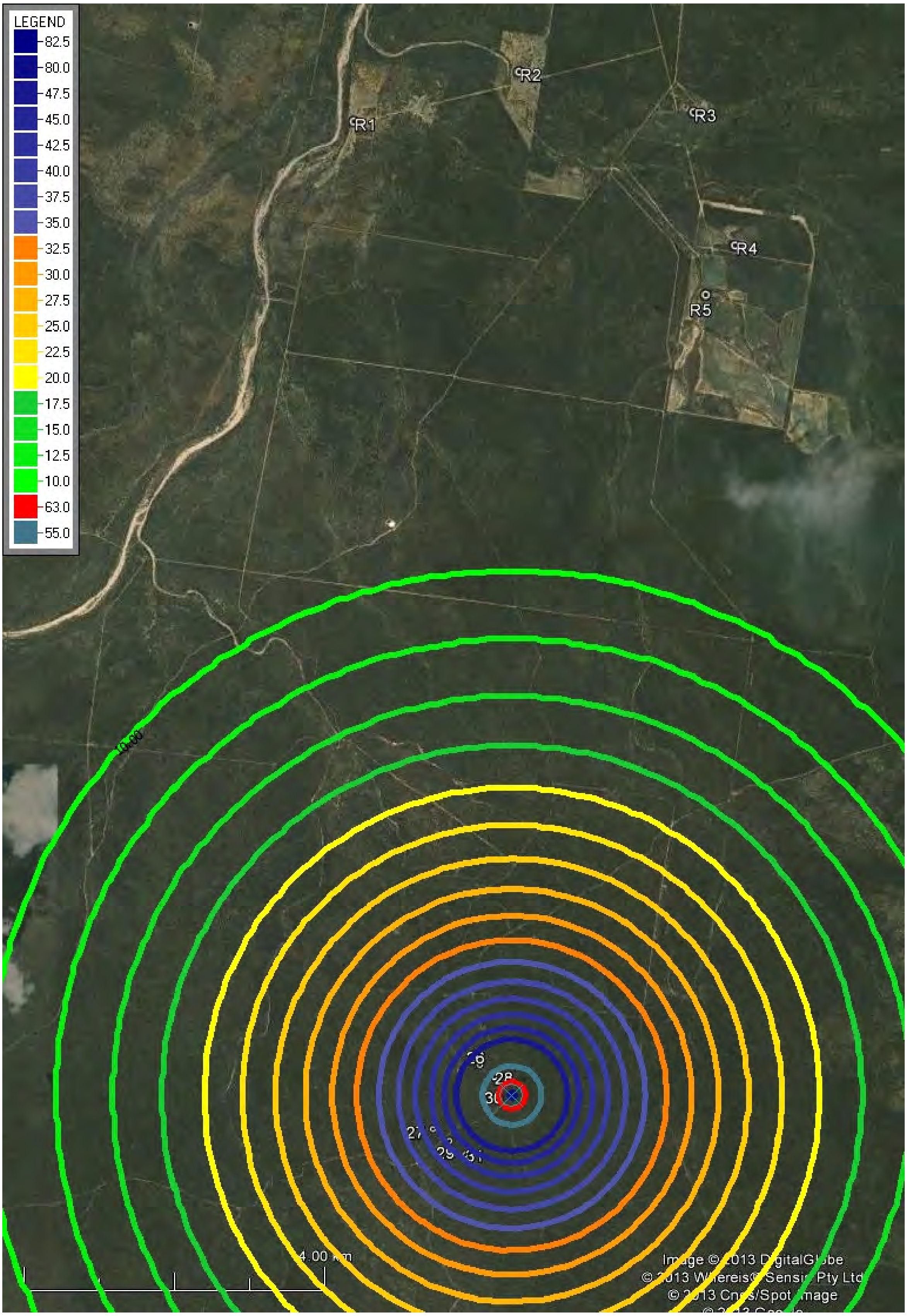
Scenario 2: Dewhurst 16H, site operations or single drilling rig, wind 3 m/s from east

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.

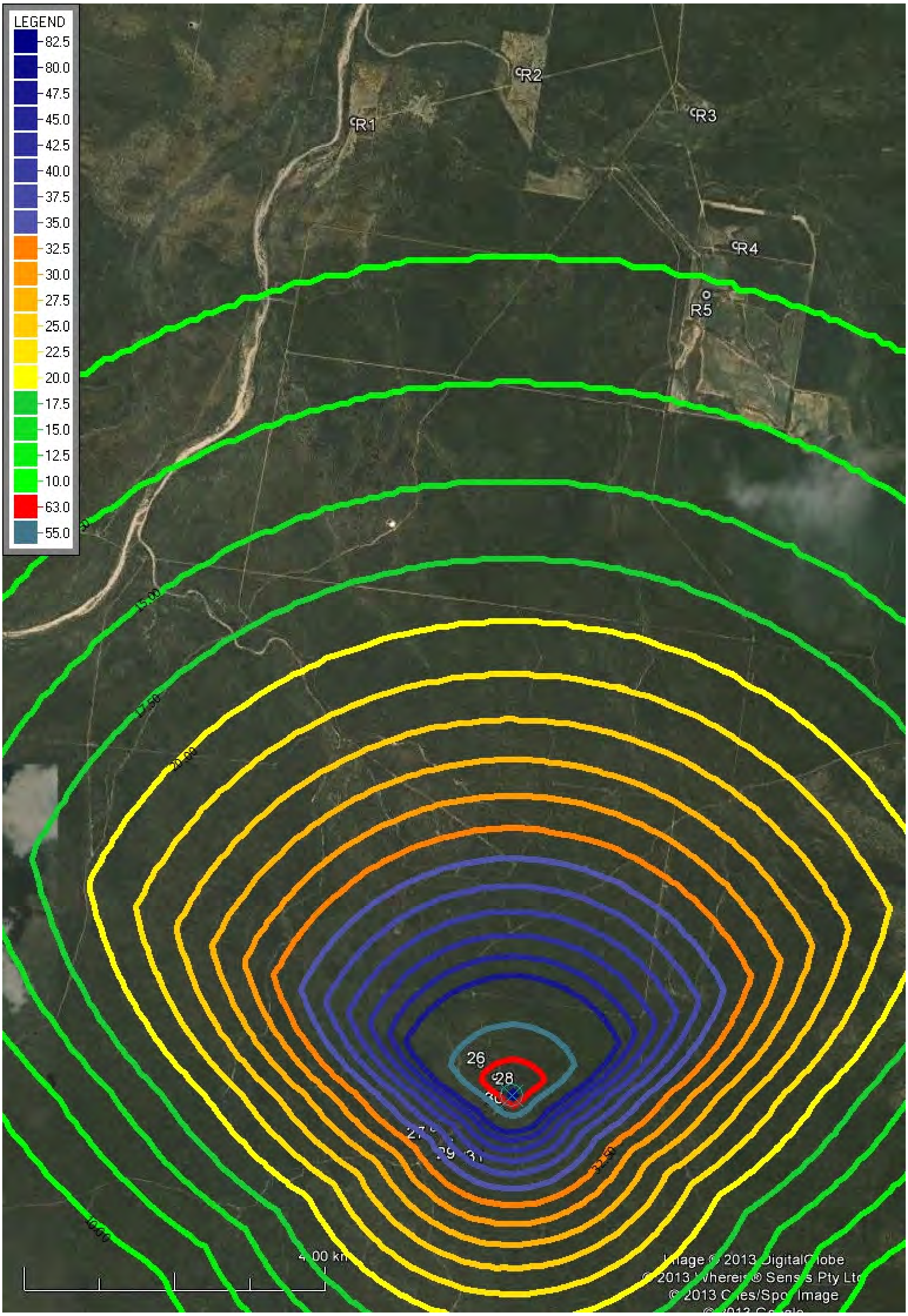


Scenario 3: Dewhurst 30, site operations or single drilling rig, calm weather

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.

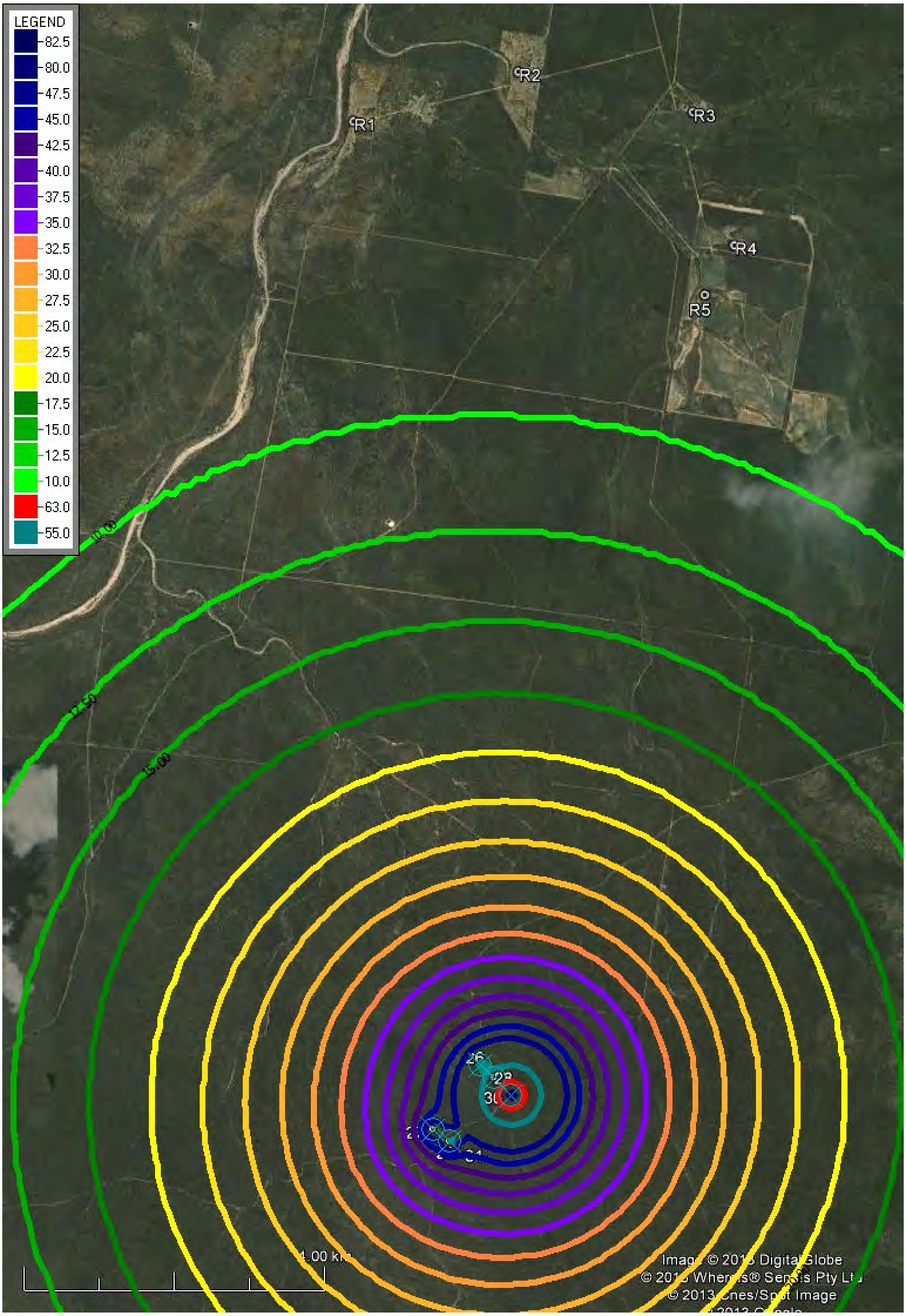


Scenario 4: Dewhurst 30, site operations or single drilling rig, wind 3 m/s from south

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.

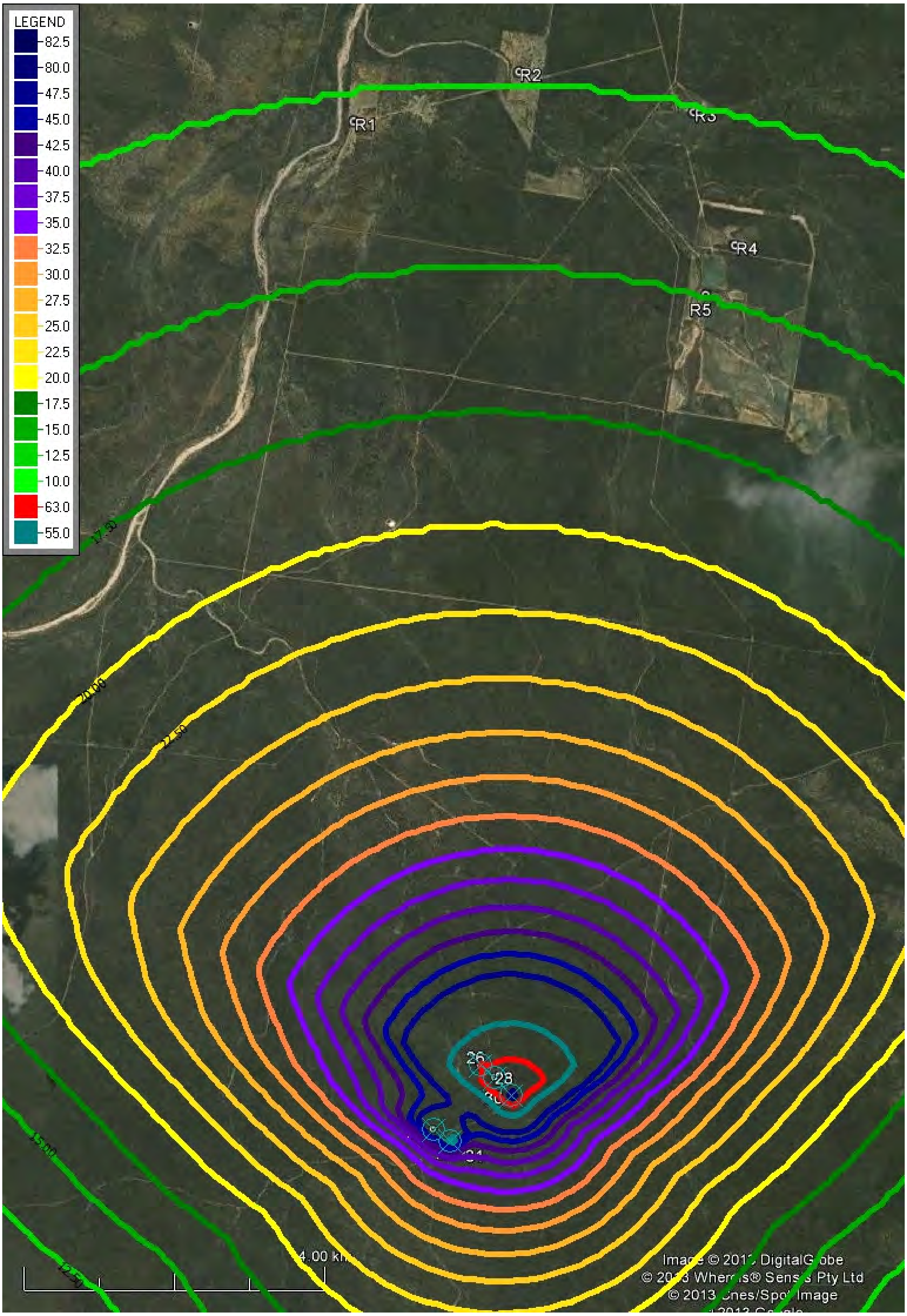


Scenario 5: Drilling operations at Dewhurst 30, with Dewhurst 26-29 running, calm weather

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.

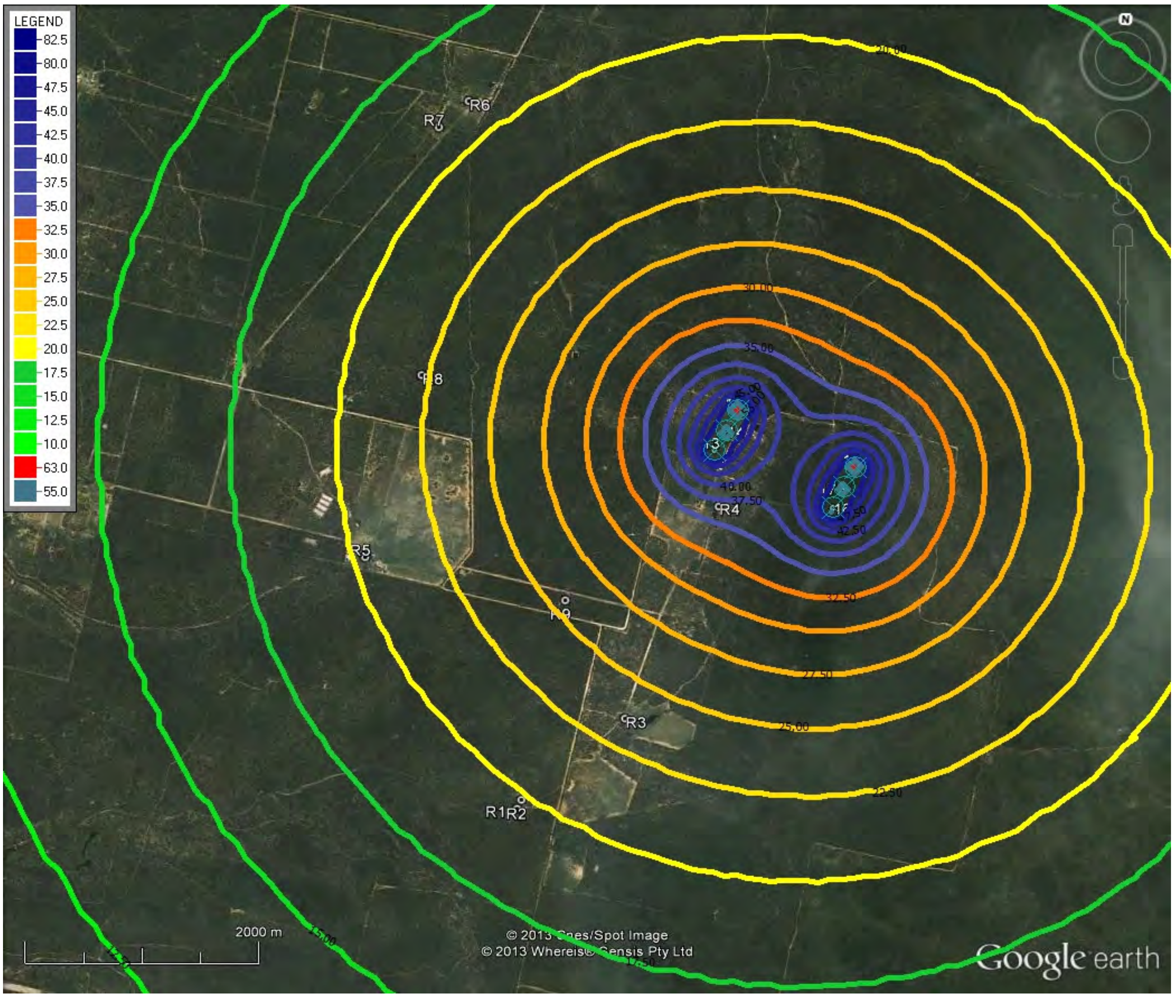


Scenario 6: Drilling operations at Dewhurst 30, with Dewhurst 26-29 running, wind at 3 m/s from the south

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.

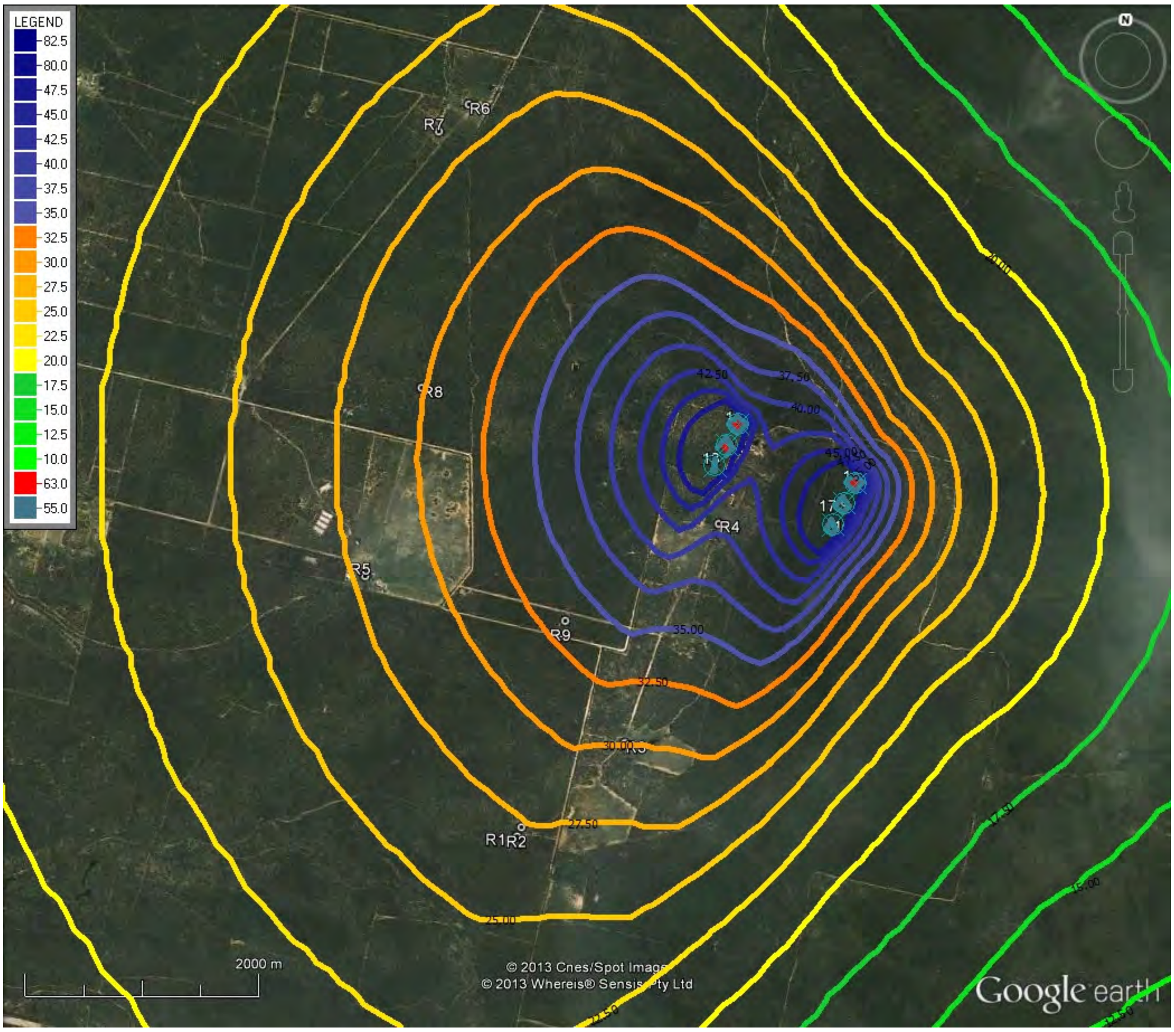


Scenario 7: Dewhurst 13-18H, all wells running, calm weather

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.

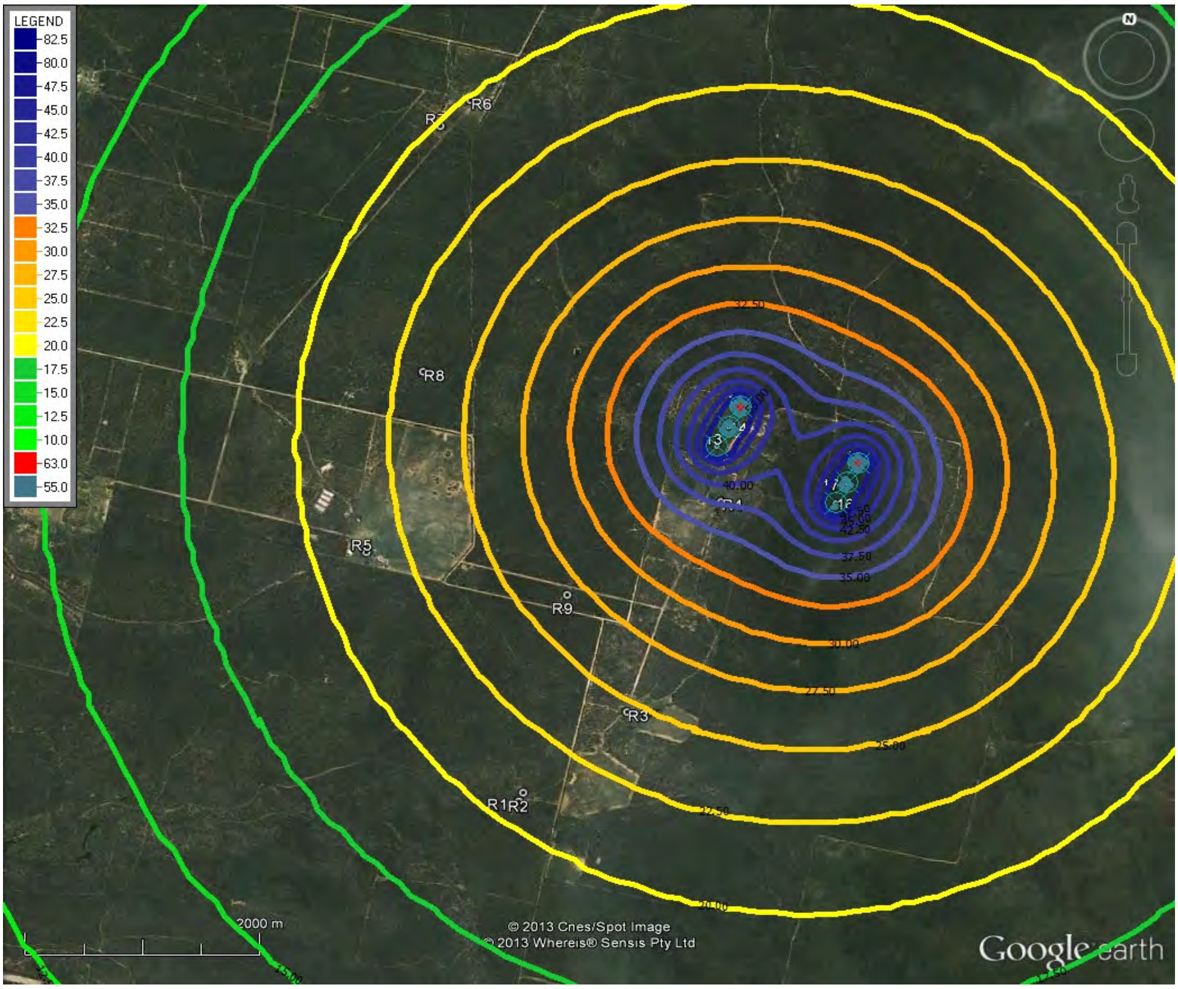


Scenario 8: Dewhurst 13-18H, all wells running, wind at 3 m/s from the east

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.

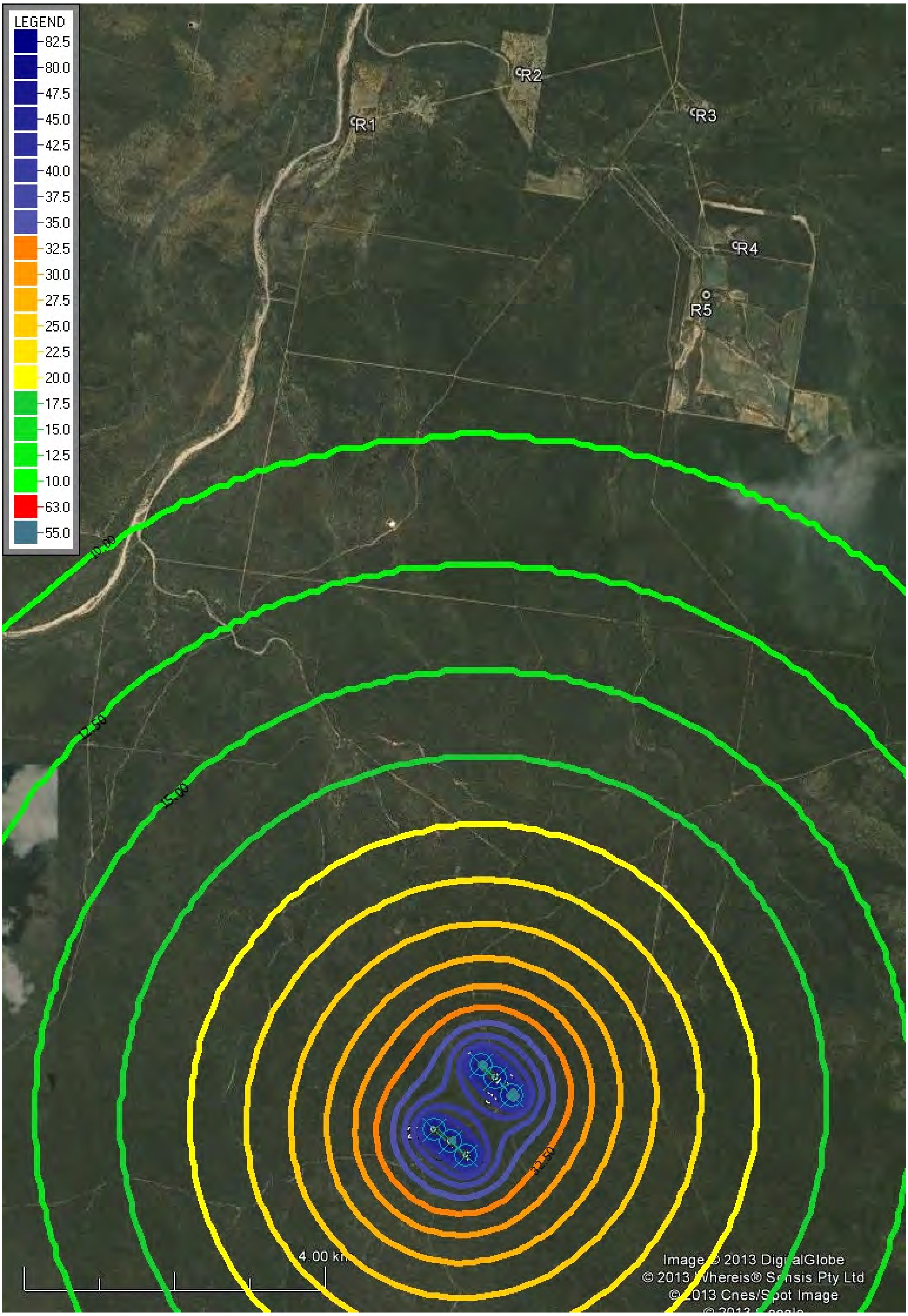


Scenario 9: Dewhurst 13-18H, all wells running, Stability factor 'F' resulting in inversion

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.

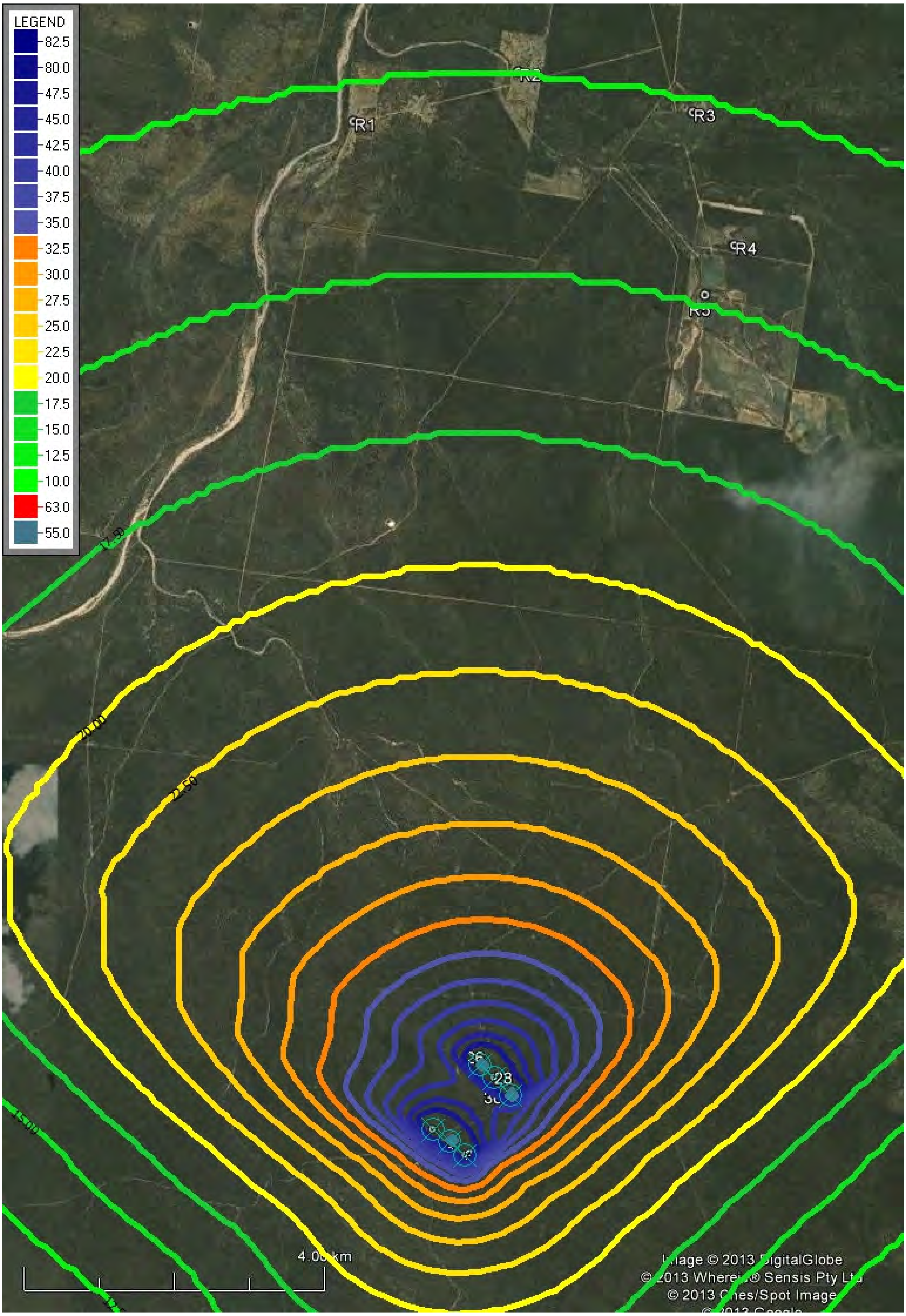


Scenario 10: Dewhurst 26-31 Pilot, all wells running, calm weather

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.

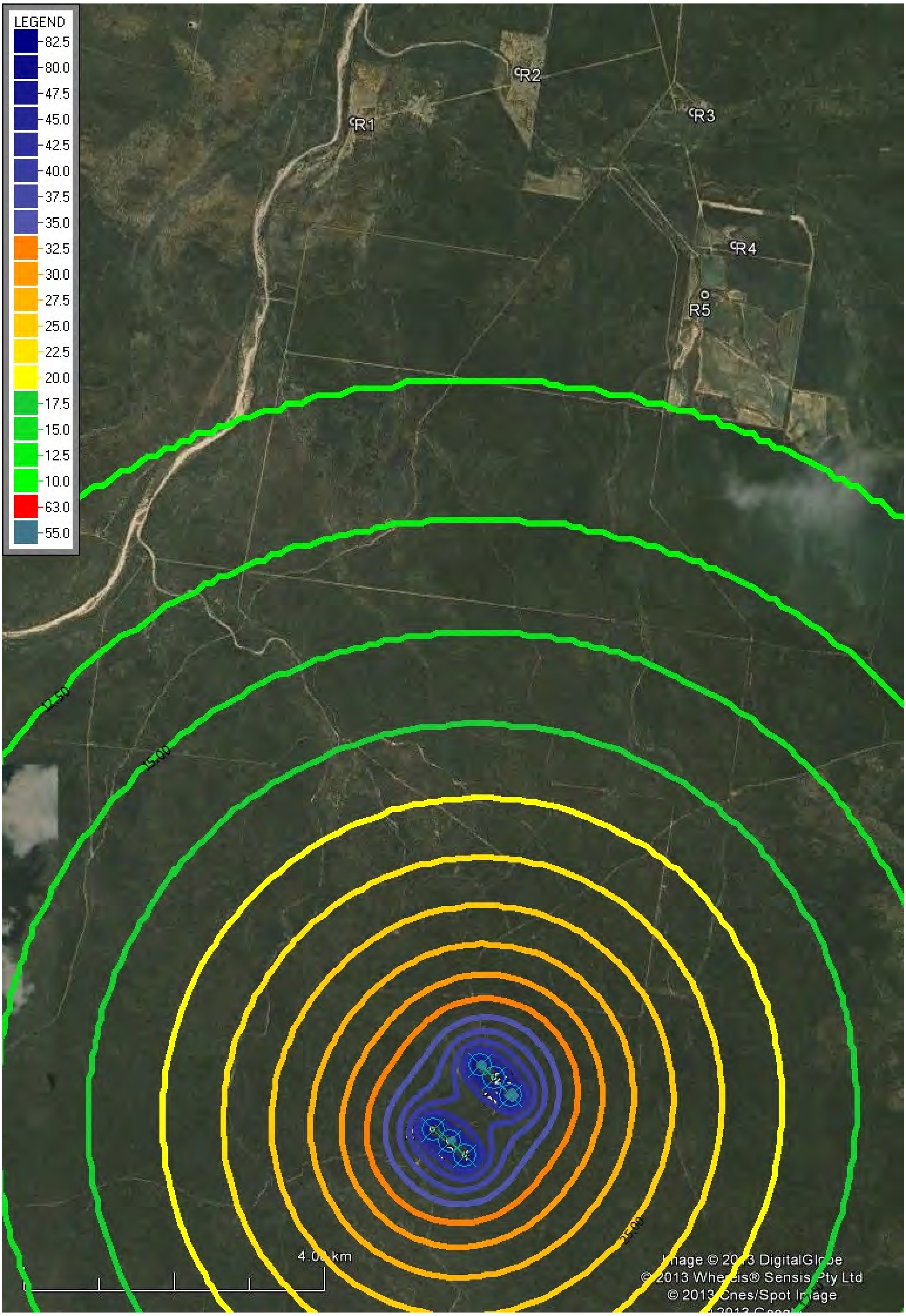


Scenario 11: Dewhurst 26-31 Pilot, all wells running, wind at 3m/s from south

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.