North Orange 1 (NO1) Sewage Pump Station

Noise Impact Assessment

Report Number 610.11488-R2

6 July 2012

Geolyse Pty Ltd c/o Orange City Council
PO Box 1963
Orange NSW 2800

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North Orange 1 (NO1) Sewage Pump Station

Noise Impact Assessment

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1 INTRODUCTION

1.1 Background

SLR Consulting Australia Pty Ltd (SLR Consulting) has been commissioned by Geolyse Pty Ltd (Geolyse) on behalf of Orange City Council to conduct a noise impact assessment for the North Orange 1 (NO1) sewage pump station.

The pump station is located to the north of Orange. Although in a rural setting, further development is continuing to the north of the city and an assessment is required of the potential impacts from noise upon the proposed encroaching development.

1.2 Report Objectives

This report aims to identify offset distances from the pump station at which noise levels from the pump station operations would be considered acceptable for residential development and to establish noise goals for new industrial noise sources in the area. Based on site measurements of the operating noise sources, this report also considers mitigation measures which aim to reduce the extent of noise impacts from the pump house.

1.3 Terminology

Specific acoustic terminology is used within this assessment. An explanation of acoustic terms used in this report is included as **Appendix A**.

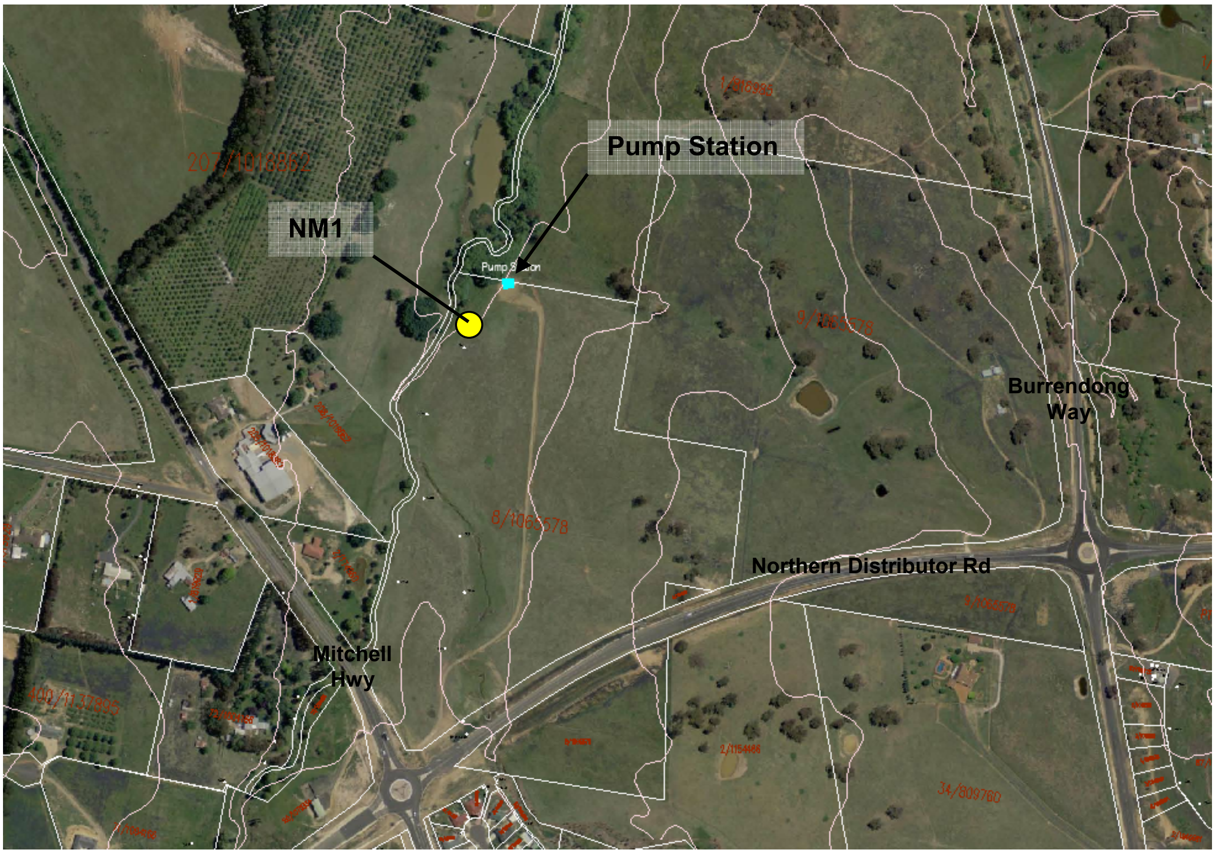
2 PROJECT OVERVIEW

2.1 Location

The pump station is located approximately three kilometres northwest of the Orange city centre in a predominantly rural setting. The nearest existing residential receiver is located over 200 metres to the southwest of the pump station.

An indicative aerial map showing the location of the pump station is shown in **Figure 1**.

Figure 1 Pump Station and Noise Logging Location (NM1)



2.2 Pump Station Operation

It is understood that the pump station operates as required on a 24 hour basis. The typical operation is considered to be intermittent, but with typical 'high demand' periods during the morning and evening periods.

Intermittent periods of up to two minutes of constant use were observed during the site survey with periods of up to approximately 15 minutes when the pump station was not operating.

3 EXISTING NOISE ENVIRONMENT

3.1 Operator Attended Measurements

3.1.1 Noise Measurement Procedure

An operator-attended ambient noise survey was conducted on 13 June 2012 at noise monitoring location NM1 shown in **Figure 1**.

Attended noise measurements were performed using calibrated Brüel and Kjær 2260 Precision Sound Level Meters (serial number 2487418). Instrument calibration was checked before and after each measurement survey, with the variation in calibrated levels not exceeding the acceptable variation of ±0.5 dBA (AS 1055).

The acoustic instrumentation (SLM and calibrator) employed throughout the monitoring programme was designed to comply with the requirements of AS 1259.2-1990, "*Sound Level Meters*" and carry current NATA or manufacturer calibration certificates.

3.1.2 Noise Measurement Results

A summary of the operator attended ambient noise survey is shown in **Table 1**.

Table 1 Operator Attended Ambient Noise Survey

Location/ Description	**Date/ Start time/ Period/ Weather**	**Primary Noise Descriptor (dBA re 20 µPa)**					**Description of Noise Emission, Typical Maximum Levels LAmax (dBA)**
		LAmax	LA1	LA10	LA90	LAeq	
NM1	13/06/2012 1.17pm Day Wind calm	61	48	43	35	41	Road Traffic – up to 58 Birds – up to 43 Pump Station noise not discernible

The results of the operator-attended ambient noise survey indicate noise levels of a typical rural environment. Pump station noise was noted as 'not discernible' during the operator-attended measurement survey.

3.2 Continuous Unattended Monitoring

3.2.1 Noise Monitoring Procedure

One environmental noise logger (Svantek SVAN957 serial number 20668) was deployed from 13 June to 22 June 2012 at location NM1 as shown in **Figure 1** in order to measure prevailing ambient noise levels.

3.2.2 Noise Monitoring Results

The results of the noise monitoring have been processed in accordance with the procedures contained in the *NSW Industrial Noise Policy* (INP) so as to establish representative ambient noise levels representative of the future residential sites.

A summary of the unattended continuous noise monitoring during INP defined time periods is contained in **Table 2.** A full graphical representation of the noise level recorded is provided in **Figure 2**.

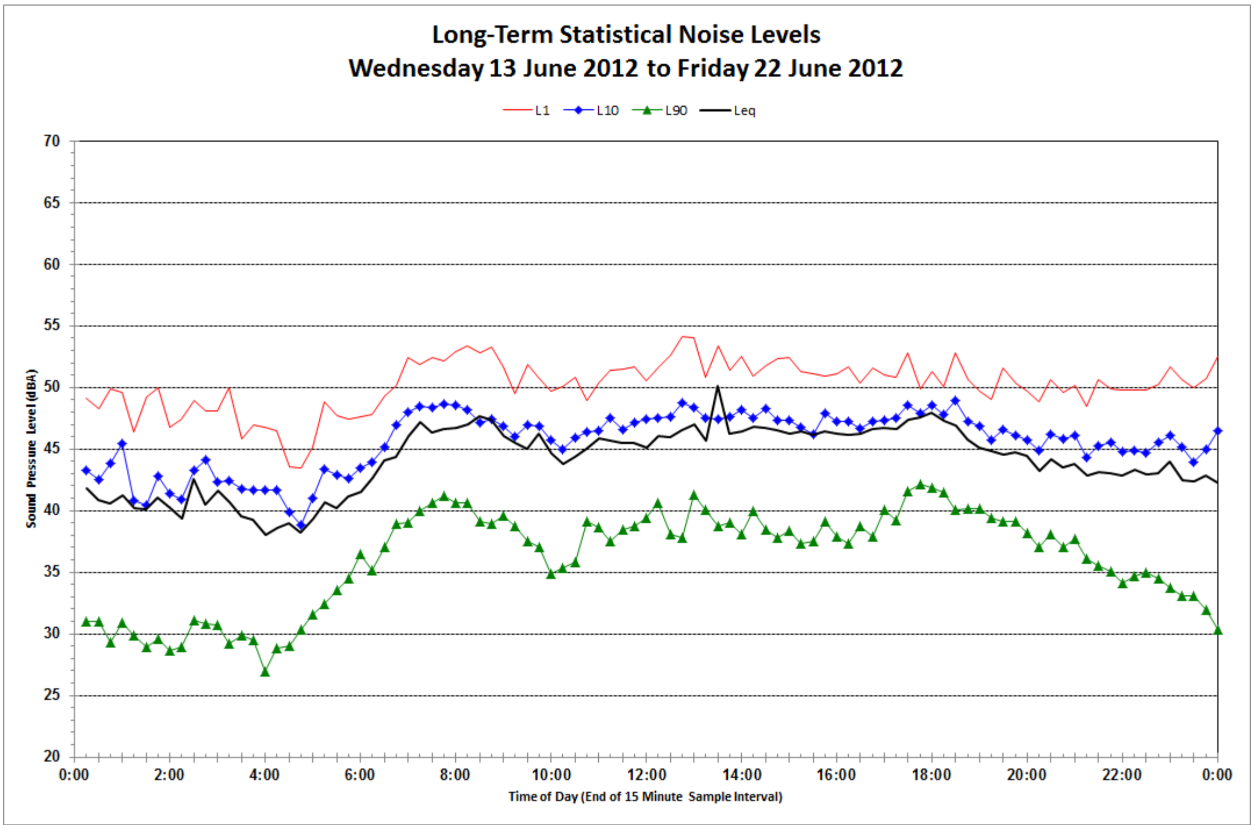
Table 2 Unattended Noise Logger Results.

Location	Period[1]	LA1	LA10	RBL LA90	LAeq
NM1	Daytime	51	48	39	47
	Evening	50	46	38	45
	Night	49	44	32	42

Note 1: INP Governing Periods - Day: 7.00 am to 6.00 pm Monday-Saturday, 8.00 am to 6.00 pm Sundays, Evening: 6.00 pm to 10.00 pm, Night: 10.00 pm to 7.00 am Monday to Saturday, 10.00 pm to 8.00 am Sunday.

Results of continuous unattended noise monitoring at this location show noise levels typical of a rural environment with higher daytime ambient noise levels likely to be due to increased road traffic on nearby roads. Intermittent pump station noise is not considered likely to affect the rating background level at the noise logging location.

Figure 2 Continuous Unattended Ambient Noise Levels at monitoring position NM1



4 NOISE GOALS

4.1 Introduction

The Environment Protection Authority's (EPA) *NSW Industrial Noise Policy* (INP) provides criteria for the assessment of noise impact associated with industrial activities. It aims to balance the need for industrial activity with the desire for quiet within the community.

Section 10 in the INP establishes a noise reduction program for existing industrial noise sources, based on an agreed process for assessing and managing noise. This approach is designed to allow established industries to adapt to changes in the noise expectations of the community while remaining economically viable.

The noise goals established under the guidance of the INP are not considered mandatory, but rather have been used in this assessment to indicate the extent of the existing potential noise impacts from the pump station, and to consider benefits of proposed mitigation measures. In order to assess whether the proposed noise mitigation measures are feasible and reasonable, the INP gives the following guidance for the case of existing industrial noise sources:

> *The need for reduced noise from existing sites must be weighed against the wider economic, social and environmental considerations. Where noise emissions from the site exceed the project-specific noise levels, the regulatory authorities and the noise-source manager need to negotiate achievable noise limits for the site. The project-specific noise levels should not be applied as mandatory noise limits. The project-specific noise levels supply the initial target levels and drive the process of assessing all feasible and reasonable control measures. Achievable noise limits result from applying all feasible and reasonable noise control measures. For sites with limited mitigation measures the achievable noise limits may sometimes be above the project-specific noise levels.*

4.2 INP Noise Goals

The INP sets two separate noise criteria: one to account for intrusive noise and the other to protect the amenity of particular land uses. These criteria are to be met at the most-affected boundary of the receiver property. In addition, the online Application Notes for the INP state that the potential for sleep disturbance should also be assessed.

4.2.1 INP Criteria for Intrusive Noise

To provide for protection against intrusive noise, the INP states that the L_{Aeq} noise level of the source, measured over a period of 15 minutes, should not be more than 5 dBA above the ambient (background) L_{A90} noise level (or RBL), measured during the daytime, evening and night-time periods at the nearest sensitive receivers. In this case, the intrusiveness criteria are determined from the RBL in **Table 2** measured at noise monitoring location NM1 (refer to **Figure 1**).

4.2.2 INP Criteria for Amenity

To provide protection against impacts on amenity, the INP specifies suitable maximum noise levels for particular land uses and activities during the daytime, evening and night-time periods. For this assessment, the land surrounding the pump station is considered to be ‘Suburban’ to account for the potential residential development. According to the INP, a ‘Suburban’ area would be characterised by local traffic with intermittent traffic flows, decreasing noise levels in the evening period; and/or evening ambient noise levels defined by the natural environment and infrequent human activity.

The relevant INP amenity criteria are presented in **Table 3**.

Table 3 INP Amenity Noise Levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level (dBA)	
			Acceptable	Recommended Maximum
Residence	Suburban	Day	55	60
		Evening	45	50
		Night	40	45

4.2.3 Modifying Factor Adjustments

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise sources at the same level. To account for this additional annoyance, the INP describes modifying factors to be applied.

The modifying factors recommended in the INP for tonal/intermittent noise are presented in **Table 4**.

Table 4 INP Modifying Factor Corrections

Factor	When to apply	Correction [1]
Intermittent noise	Level varies by more than 5 dB	5 dB[2]

Note 1 - Corrections to be added to the measured or predicted levels.
Note 2 - Adjustment to be applied for night-time only as stated in the INP.

The INP states that modifying factors are to be applied to the noise from the source measured or predicted at the receiver, before comparison with the intrusiveness or amenity criteria.

Noise from the pump station occurs intermittently throughout the 24-hour period. For this assessment, the modifying factor is required to account for the potentially annoying intermittent characteristic of noise during periods of pump station operation. The total correction applied for these operations is 5 dB.

4.2.4 Sleep Disturbance

The current approach to assessing potential sleep disturbance is to apply an initial screening criterion of background plus 15 dB (as described in the Application Notes to the INP), and to undertake further analysis if the screening criterion cannot be achieved. The sleep disturbance screening criterion applies outside bedroom windows during the night-time period. Where the screening criterion cannot be met, the additional analysis should consider the level of exceedance as well as factors such as:

- How often high noise events will occur
- The time of day (normally between 10pm and 7am)
- Whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).

Other guidelines that contain additional advice relating to potential sleep disturbance impacts should also be considered, including the *Road Noise Policy* (RNP). The RNP provides a review of research into sleep disturbance. From the research to date, the RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to awaken people from sleep
- One or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

It is generally accepted that internal noise levels in a dwelling, with the windows open are 10 dB lower than external noise levels. Based on a worst case minimum attenuation, with windows open, of 10 dB, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions. The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA are not likely to affect health and wellbeing significantly.

4.2.5 Noise Goal Summary

A summary of the operational noise goals for the pump station facility is provided in **Table 5**.

Table 5 Project Specific INP Assessment Criteria for Noise Emissions to Nearby Residences

Time of Day	Noise Level dBA re 20 µPa				
	ANL[1] (period)	Measured RBL[2] $L_{A90(15minute)}$	INP Criteria		
			Intrusive	Amenity	Sleep Disturbance Screening
			$L_{Aeq(15minute)}$ Criterion for New Sources	$L_{Aeq(Period)}$ Criterion for New Sources[3]	L_{Amax}
Day	55	39	44	55	n/a
Evening	45	38	43	45	n/a
Night	40	32	37	40	47

Note 1: ANL Acceptable Noise Level for a suburban area

Note 2: RBL Rating Background Level

Note 3: Site observations indicate no other industrial noise sources contribute to the measured ambient noise levels hence the Amenity criteria is taken directly from the Acceptable Noise Level (ANL).

The more stringent of the intrusiveness or the amenity criteria determines the noise goals. For the pump station operations, the night-time intrusiveness criterion will apply. Based on the INP noise goals, pump station noise emissions (including the 5 dB penalty for intermittent noise) of greater than 37 dBA $L_{Aeq(15minute)}$ would be considered to represent a potential noise impact on encroaching residential development.

5 OPERATIONAL NOISE

5.1 Assessment Methodology

Computer based acoustic propagation modelling of the proposed site has been carried out using SoundPLAN V7.1. The acoustic modelling has been undertaken to assist in understanding the extent of potential noise impacts in the surrounding area.

5.2 Noise Sources

In the absence of manufacturer's stated equipment sound power levels and operating specifications operator-attended noise measurements in the vicinity around the pump station were conducted on 13 June 2012 in order to calibrate the noise model.

It should be noted that the relative contributions of pump station noise is inherently problematic to quantify. Generally, pump station noise may consist of a number of noise sources including pump vibration noise, piping vibration noise caused by pressure pulsation from the pump or other transmitted vibrations, disturbed flow in piping/pipe bends/tee branches/valves, inlet stream in wet well, pump cavitation and fans associated with the pump operation.

Site observations during the operator-attended noise survey indicated significant noise break-out from the pump house.

The results of noise measurements made to the south and east of the pump station during periods of pump station operation are summarised in **Table 6**.

Table 6 Operator Attended Noise Measurement Summary – Pump Station Operating

Measurement Description	Measured Noise Level per Octave Band (dB)								Overall (dBA)
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
5 m south of pump pit, approx 8m from pump house	66	58	55	60	57	56	50	39	62
30 m east of pump house	58	52	42	37	42	37	31	30	46

5.3 Model Inputs

Estimation of noise source contribution has been made based on pumphouse construction and site observations and measurements during pump station operation (refer **Section 5.2**). The model inputs are summarised in **Table 7**.

Table 7 Noise Model Parameters

Description	Input to prediction model
Pump house roof construction	Single layer corrugated steel (0.5 mm)
Pump house facade	Single layer brick
Ventilation grill on doors (south and east facade)	Open, not acoustic
Noise sources	Estimated contribution from pump house breakout via door vents and roof from measured levels (refer to **Section 5.2**) and building construction (outlined above).
Ground topography	10 m elevation contours provided by Geolyse input into 3D noise model

5.4 Noise Model Validation

To validate the noise model, receiver points representing the measurement locations were established in the model. The model was then used to calculate noise levels at these locations. **Table 8** presents the comparison between the model results and the unattended noise measurements at the logger locations.

Table 8 Predicted Noise Levels (No Mitigation) Compared With Measurements

Location	Noise Level during pump station operation L_{Aeq} dBA	
	Measured	Modelled
5 m south of pump pit, approx 8m from pump house	62	62
30 m east of pump house	46	46

Overall the model is found to agree well with the observed noise environment and is suitable for predicting noise levels during pump station operation in the surrounding area.

5.5 Predicted Noise Levels – Existing Operations

As outlined in **Section 4.2.5**, pump station noise emissions (including penalty adjustments) in excess of 37 dBA $L_{Aeq(15minute)}$ is considered to represent a potential noise impact on encroaching residential development based on the INP noise goals.

L_{Aeq} noise contours for periods of operation of the pump station are included in **Appendix B**. A review of these noise contours indicates that pump station noise levels of around 37 dBA (during periods of operation) are predicted at approximately 80 m to the east of the pump station and 100 m to the south of the pump station. No existing residential receivers lie within this zone.

It should be noted that the INP noise goals are based on pump station $L_{Aeq(15minute)}$ noise levels incorporating non-operational periods and a 5 dB penalty for intermittent noise. Based on site observations, an assessment that assumes five minutes 'on-time' in any one 15-minute period, for night-time operations, can be considered conservative. For intermittent pump station operation of up to five minutes of combined 'on-time' in any one 15-minute period, the predicted noise levels during periods of operation (as shown by the noise contours) are consistent with the adjusted $L_{Aeq(15minute)}$ noise level.

5.6 Mitigation Options

Council have requested that mitigation options are identified to control or minimise noise impacts that are applicable to the site.

Site observations indicated significant noise breakout from the pump house via the roof and vent openings on the doors (south and east facades). Noise from the submersible pump (in the well) may have also contributed to the noise emissions from the pump station however the relative contributions during operation could not be established from site measurements.

In the absence of equipment sound power data for all operating plant, the following mitigation options are proposed in order to address the likely dominant noise sources:

- Install acoustic vents to replace the existing open grills on the pump house doors. These units should be well sealed to avoid gaps between the door surface and the unit and should have a minimum sound reduction index, Rw of 28 dB.
- Increase the acoustic performance of the ceiling/roof of the pump house by installation of 100 m thick Rockwool insulation over 13mm plasterboard (or similar density material) to the underside of the existing roof. Any gaps between the roof/ceiling and the brick wall should be sealed using a heavy duty mastic.
- Installation of a solid barrier (minimum 1.8m height) to the south and east of the pump station. This should be located as close as practicable to the pump station (immediately adjacent to the wells/pits on the receiver side). Any joins in the noise barrier should be sealed with a heavy duty mastic and/or overlapping panels as necessary to avoid air gaps. The barrier could be made of mostly solid materials, such as steel (colorbond), timber or fibre cement.
- Installation of seals around the well cover.

The above options are proposed to address the noise from the pump station as a whole. Based on the current level of knowledge regarding the site equipment, the relative effectiveness of any one measure to reduce the overall pump station noise emissions cannot be specified. Notwithstanding this, should a staged approach to mitigation be required, it is recommended that the installation of acoustic vents to replace existing openings be treated as a priority as site observations noted significant noise breakout from the pump house.

5.7 Predicted Noise Levels – With Mitigation

L_{Aeq} noise contours for periods of operation of the pump station with the mitigation options outlined in **Section 5.6** incorporated to the pump station and included in the prediction model are shown in **Appendix C**. Review of these noise contours indicates that pump station noise levels of around 37 dBA (during periods of operation) are predicted at approximately 25 m to the east and south of the pump station.

6 EMERGENCY EQUIPMENT – NOISE GOALS

It is understood that an emergency diesel generator may be installed to service the pump station in the event of a power outage. Operation of the generator within the pump station site has the potential to introduce a new source of noise to the area.

Council have advised that the operation of an emergency generator would, based on operator's experience, typically happen 4 or 5 times a year, with, the power outage lasting up to an hour, on average.

Noise emissions from emergency diesel generators are assessed under the guidance of the INP. The noise goals for nearby residential receivers are consistent with those specified in **Table 5**. For single-event noise duration of up to one hour, no adjustments to the predicted noise level for duration are applicable for the night-time period.

Once the generator model/specification is selected, an assessment of the potential noise impacts at nearby noise-sensitive receivers should be undertaken. Should this assessment identify a requirement for noise mitigation, options would include unit re-location, installation of exhaust silencers, installation of acoustic cladding and/or enclosure of the unit.

7 CONCLUSION

SLR Consulting has conducted an acoustical assessment of predicted noise impacts of the North Orange 1 (NO1) sewage pump station upon the proposed encroaching residential development.

Noise goals have been established under the guidance of the INP and have been used in this assessment to indicate the extent of the existing potential noise impacts from the pump station. Computer based acoustic propagation modelling of the proposed site has been carried out using SoundPLAN V7.1.

The assessment has predicted potential noise impacts due to the existing pump station operations extending approximately 80 m to the east of the pump station and 100 m to the south of the pump station.

In the absence of equipment sound power data for all operating plant, a number of noise mitigation options have been proposed (refer to **Section 5.6**) in order to address the likely dominant noise sources. With these mitigation options incorporated a reduction in the extent of noise impacts to around 25 m from the pump station (east and south) is predicted.

1 Sound Level or Noise Level

The terms ‘sound’ and ‘noise’ are almost interchangeable, except that in common usage ‘noise’ is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2 ‘A’ Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an ‘A-weighting’ filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as ‘linear’, and the units are expressed as dB(lin) or dB.

3 Sound Power Level

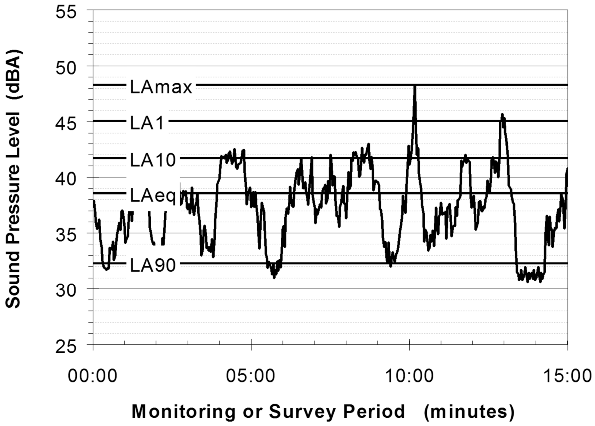
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the ‘repeatable minimum’ L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or ‘average’ levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than ‘broad band’ noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

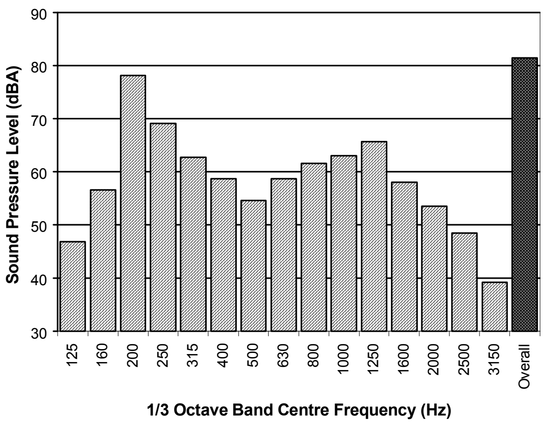
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

10 Over-Pressure

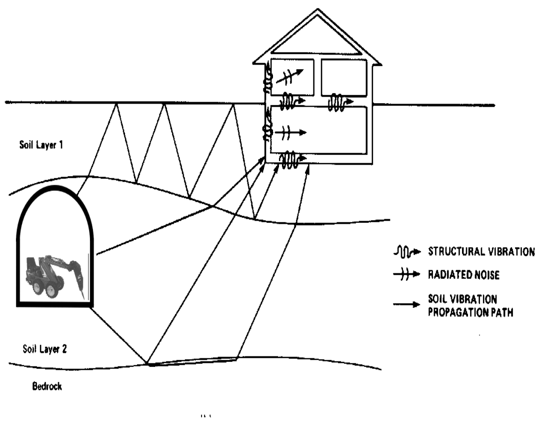
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

Appendix B
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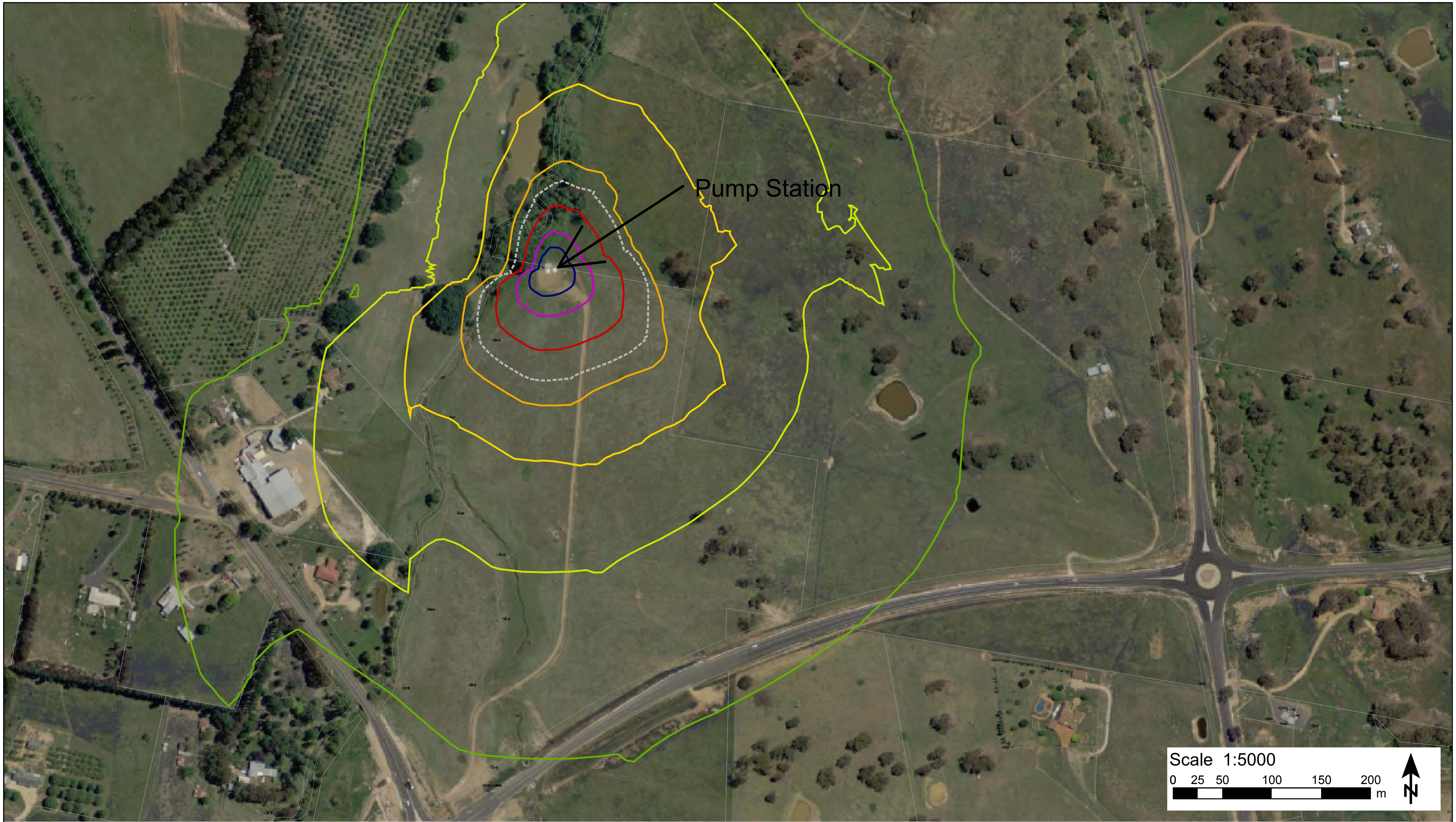
LAeq Noise Contours During Operation – No Mitigation



NOTES	LEGEND		
	37 dBA Noise Contour	Noise Level LAeq (dBA)	
	Cadastre Boundary		<= 20
	Pump Station Building	20 <	<= 25
		25 <	<= 30
		30 <	<= 35
		35 <	<= 40
		40 <	<= 45
		45 <	<= 50
		50 <	

Revision	Drawn By	Chkd By	Date	Comments
0	DS	RBH	05/07/12	N/A

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Site
Geolyse Pty Ltd c/o Orange City Council

Project
North Orange (NO1) Sewage Pump Station

Drawing
Operational Noise Modelling
Noise Contours - No Mitigation

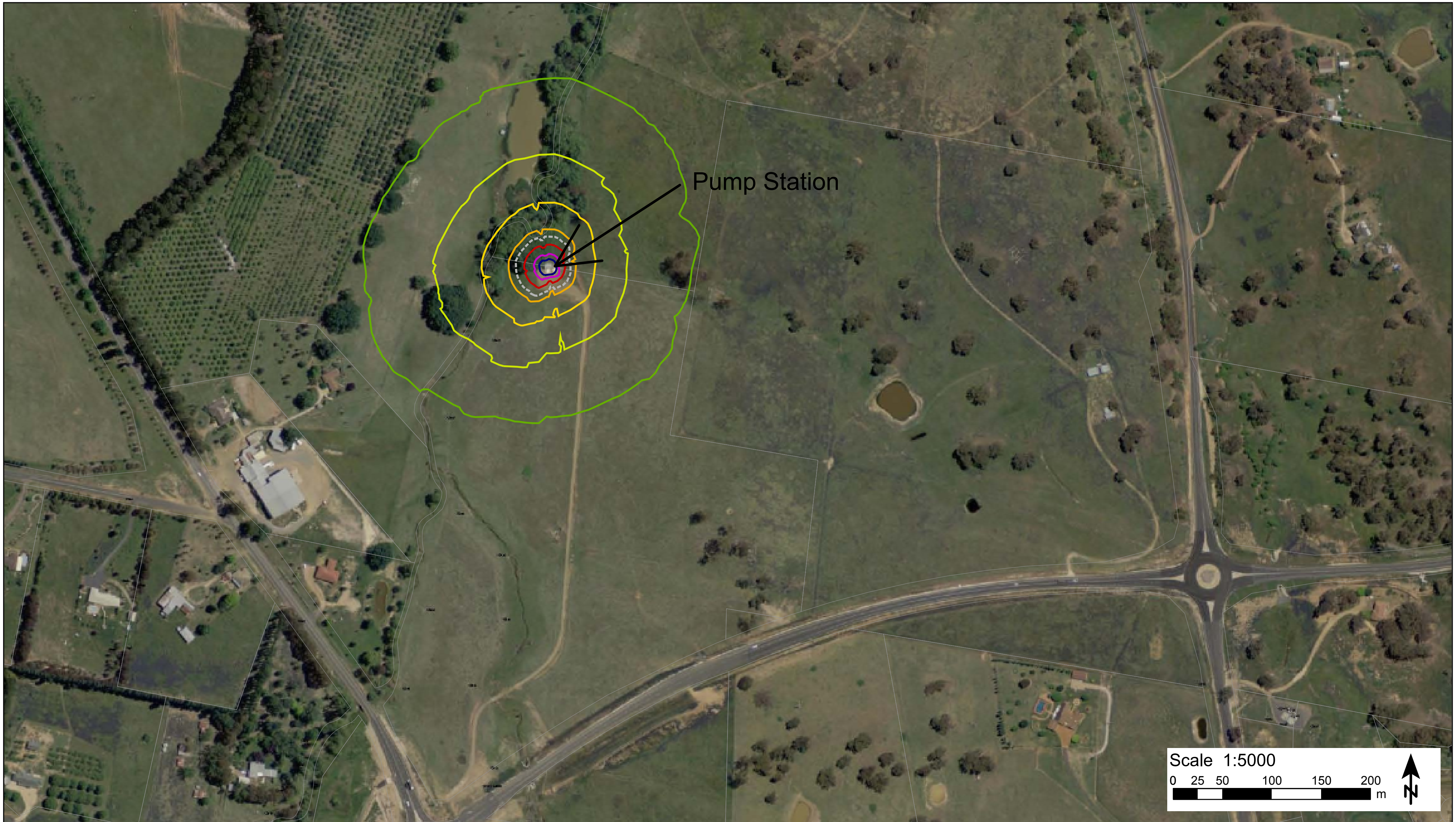
Project No.	Drawing Number	Revision
610.11488	610.11488-NO_MITIGATION-05/07/2012	0

Scale
1:5000

Appendix C

Report 610.11488-R2

LAeq Noise Contours During Operation – With Mitigation



NOTES

LEGEND

37 dBA Noise Contour

Cadastre Boundary

Pump Station Building

Noise Level
LAeq (dBA)

<= 20
20 < <= 25
25 < <= 30
30 < <= 35
35 < <= 40
40 < <= 45
45 < <= 50
50 <

Revision	Drawn By	Chkd By	Date	Comments
0	DS	RBH	05/07/12	N/A

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Scale
1:5000