LACHLAN'S LINE PEDESTRIAN BRIDGE

Construction Noise and Vibration Assessment

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with the Client. Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.17971-R01-v1.0	2 March 2018	Antony Williams	Mark Russell	Antony Williams

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Landcom to undertake a noise and vibration assessment of the potential impacts associated with construction of a pedestrian bridge as part of the Lachlan's Line Precinct in North Ryde.

The pedestrian bridge ('the Project') involves the construction of a bridge from the Lachlan's Line Precinct, over the M2 Motorway and Delhi Road, to the North Ryde Station.

The pedestrian bridge was previously approved for construction during the hours of 7:00 am and 7:00 pm Monday to Fridays inclusive and 8:00am to 4:00pm Saturdays, under SSD 5093. However, TfNSW Transport Management Centre have recently advised that certain aspects of the work are now required to be completed during night-time periods.

1.1 Sensitive Receivers

The surrounding area of the project is a combination of residential and commercial uses.. The nearest existing residential receivers are located to the south west on Epping Road, at a distance of around 50 m.

The project area is adjacent to the North Ryde Precinct, which is a large redevelopment project which will provide new homes and jobs, new parks and public plazas, walking and cycling links and community facilities with direct access to the North Ryde train station.

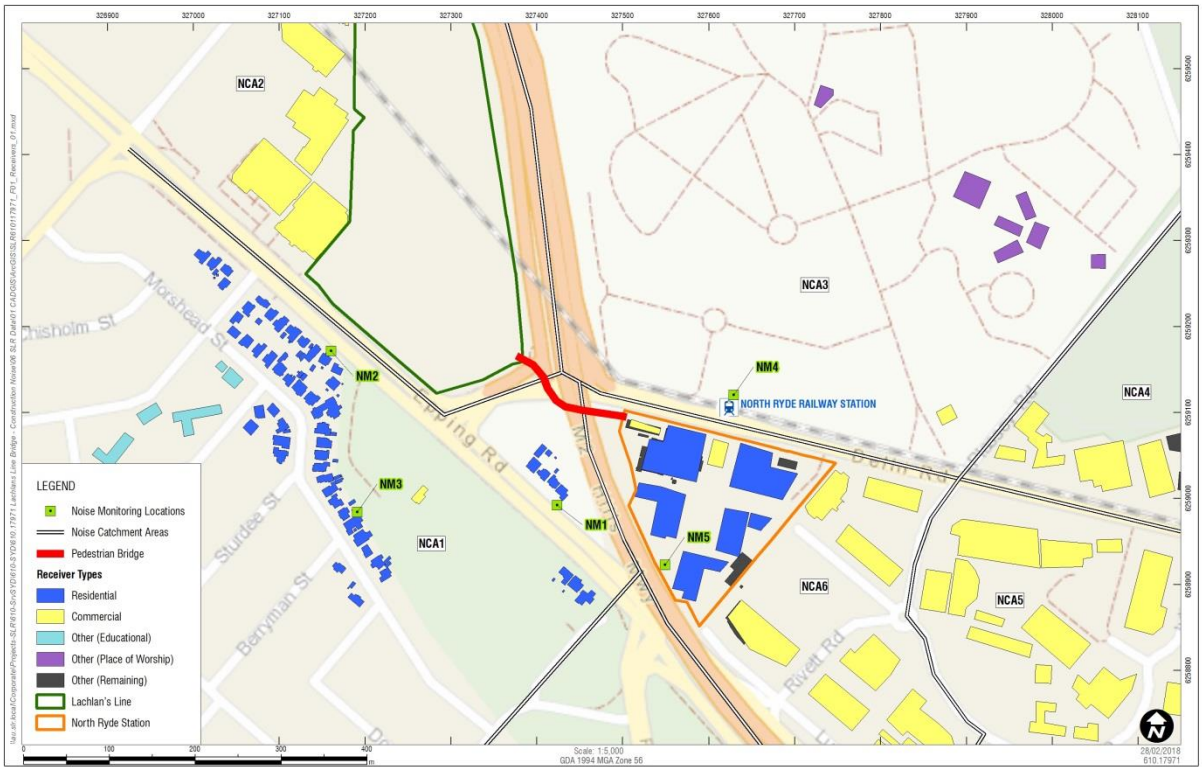
Lachlan's Line is part of the North Ryde Precinct and is located to the north west of the Project, at the intersection of Epping Road and the M2 Motorway. When complete it will include over 2,700 apartments, retail, open space and pedestrian and cycle links to North Ryde Station.

A mixed-use development at 1-7 Delhi Road, next to North Ryde Station is also within the North Ryde Precinct and to the south east of the Project. This development provides 380 apartments in four buildings up to 14 storeys, and will include car parking spaces, retail space and a new public plaza around North Ryde Station, connecting Delhi Road and Station Street.

Macquarie Park Cemetery and Crematorium with the associated Palm, Camellia and Magnolia Chapels in located to the north east of the Project.

The sensitive receivers identified in the vicinity of the Project are shown in **Figure 1**. Noise Catchment Areas (NCAs) have been defined which represent the changing land use surrounding the project and are shown in **Table 1**. A visualisation of the bridge is shown in **Figure 2.**

Figure 1 Site Location and Surrounds



Note: The size and location of buildings within the future North Ryde Precinct have been estimated from the available information

Figure 2 Visualisation of Pedestrian Bridge

Table 1 Sensitive Receivers

NCA	Description	Type/Use
NCA01	Existing residential receivers adjacent to Epping Road. The nearest residential receivers are around 50 m from the works. Contains the existing Truscott Street Public School.	Residential / Educational
NCA02	Existing commercial receivers both adjacent to Delhi Road and Epping Road.	Residential / Commercial
NCA03	The Macquarie Park Cemetery and Crematorium to the north of Delhi Road. Contains chapels (Camellia, Palm & Magnolia) and places of worship.	Place of Worship
NCA04	Generally commercial area to north of Delhi Road, with the Quest Hotel.	Commercial / Hotel
NCA05	Generally commercial area to south of Delhi Road	Commercial
NCA06	Existing commercial receivers to south of Delhi Road. Also includes the North Ryde Station residential development.	Residential / Commercial

1.2 Relevant Policy and Guidelines

The following relevant regulatory policy and guidelines, managed by the NSW Environmental Protection Authority (EPA), have been referenced in the assessment of noise and vibration impacts from the construction of the Project:

- Construction noise – *Interim Construction Noise Guideline* (ICNG) dated 2009

An explanation of specific acoustic terminology used within this report is included as **Appendix A**.

2 EXISTING ACOUSTIC ENVIRONMENT

2.1 Ambient Noise Surveys

To determine the existing noise environment and quantify background noise levels, noise logging data as measured for the Lachlan's Line project in 2012 has been used for this assessment. The measured noise levels have been used to establish existing noise levels as a basis for assessing potential noise impacts during construction.

The noise monitoring locations, shown in **Table 2**, are considered to be representative of receivers and communities potentially affected by the construction and operation of the project.

The noise monitoring locations are identified on the site plan drawings in **Table 2**

Table 2 Ambient Noise Survey Locations

Location	Noise Monitoring Location Address
NM1	21A Epping Road
NM2	24 Epping Road
NM3	37 Morshead Street
NM4	Macquarie Park Cemetery
NM5	North Ryde Station Site South

2.2 Unattended Noise Monitoring

2.2.1 Methodology

The noise loggers continuously measured noise levels in 15 minute sampling periods to determine the existing L_{Aeq}, L_{A90} and other relevant statistical noise levels during the daytime, evening and night-time periods.

The noise measurements were carried out with ARL 316 and Svantek 957 Noise Loggers. The equipment was set up with microphones at 1.5 m above the ground level. All microphones were fitted with wind shields.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of Australian Standard AS IEC 61672.1—2004 – *Electroacoustics—Sound level meters, Part 1: Specifications* and carried appropriate and current National Association of Testing Authorities (NATA) calibration certificates. The calibration of the loggers was checked both before and after each measurement survey and the variation in calibration at all locations was found to be within acceptable limits at all times.

The results of the noise monitoring have been processed to exclude noise identified as extraneous and/or data affected by adverse weather conditions (such as strong wind or rain) so as to establish representative noise levels in each area.

2.2.2 Noise Monitoring Results

The results of the unattended ambient noise surveys are summarised in **Table 3** as the Rating Background Level (RBL) and L_{Aeq} noise levels for the ICNG daytime, evening and night-time periods.

Table 3 Summary of Unattended Noise Logging Results

Noise Monitoring Location	Measured Noise Level (dBA)[1]					
	ICNG Time Periods					
	RBL			LAeq		
	Daytime	Evening	Night	Daytime	Evening	Night
NM1	60	56	44	74	71	69
NM2	60	59	46	72	70	68
NM3	45	44	38	55	55	50
NM4	57	54	44	69	67	64
NM5	63	59	45	70	68	66

Note 1: ICNG Governing Periods – Day: 7.00 am to 6.00 pm Monday to Saturday, 8.00 am to 6.00 pm Sunday; 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.

3 PROJECT CRITERIA AND TRIGGER LEVELS

3.1 NSW Interim Construction Noise Guideline

The *Interim Construction Noise Guideline* (ICNG) sets out ways to assess and manage the impacts of construction noise on residences and other sensitive land uses. It does this by presenting assessment approaches that are tailored to the scale of the construction works.

The ICNG requires project specific Noise Management Levels (NMLs) to be established for noise affected receivers. In the event construction noise levels are predicted to be above the NMLs, feasible and reasonable work practices are to be investigated to minimise noise emissions.

3.1.1 Residential Receivers

The ICNG provides an approach for determining $L_{Aeq(15minute)}$ NMLs at adjacent residential receivers based on measured $L_{A90(15minute)}$ rating background noise levels (RBL), as described in **Table 4**.

Table 4 Determination of NMLs for Residential Receivers

Time of Day	NML $L_{Aeq(15minute)}$	How to Apply
Standard hours Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	RBL + 10 dBA	• The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq(15minute) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practises to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

	Highly Noise Affected
	75 dBA
		• The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise.
		• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:
		  • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences.
		  • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside recommended standard hours	RBL + 5 dBA	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practises have been applied and noise is more than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Note 1 The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW *Industrial Noise Policy*.

3.1.1.1 Sleep Disturbance

The most recent guidance in relation to sleep disturbance is contained in the EPA's *Application Notes – NSW Industrial Noise Policy* (2010). The pertinent section of the Application Notes states the following:

> *"DECC*[W] *reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.*
>
> *From the research, DECC*[W] *recognised that current sleep disturbance criterion of an L_{A1}, (1 minute) not exceeding the L_{A90}, (15 minute) by more than 15 dBA is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, DECC*[W] *will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.*
>
> *The detailed analysis should cover the maximum noise level or $L_{A1,}$ (1 minute), that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:*
>
> - *How often high noise events will occur*
> - *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)*
> - *The LA1, (1 minute) descriptor is meant to represent a maximum noise level measured under "fast" time response. DECC[W] will accept analysis based on either LA1, (1 minute) or LAmax".*

Where construction is required to be undertaken during the night-time period the potential for sleep disturbance should be assessed. The current approach to identifying potential sleep disturbance impacts is to set a screening criterion 15 dB above the RBL during the night-time period (10.00 pm to 7.00 am).

The term 'screening criterion' indicates a noise level that is intended as a guide to identify the likelihood of sleep disturbance. It is not a firm criteria to be met, however where the criterion is met sleep disturbance is considered to be unlikely. When the screening criterion is not met, a more detailed analysis is required.

The detailed analysis should assess the maximum noise level or $L_{AF1(1minute)}$, the extent that the maximum noise level exceeds the background noise level and the number of times any exceedance occurs during the night-time period.

3.1.1.2 Commercial and Industrial Premises

The ICNG notes that due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories:

- Industrial premises: external $L_{Aeq(15minute)}$ 75 dBA
- Offices, retail outlets: external $L_{Aeq(15minute)}$ 70 dBA
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.

The external noise levels should be assessed at the most-affected occupied point of the premises.

3.1.1.3 Other Sensitive Land Uses

The ICNG's quantitative assessment method provides NMLs for other sensitive land uses, such as educational institutes, hospitals, medical facilities and outdoor recreational areas. These land uses are considered potentially sensitive to construction noise only when the properties are in use.

The ICNG does not however provide an NML for all classifications of sensitive land use. Where sensitive land uses with no classification are identified within a construction noise catchment, the following guidance is given:

> *The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels (Standards Australia 2000).*

The project specific $L_{Aeq(15minute)}$ NMLs for other non-residential noise sensitive receivers from the ICNG are provided in **Table 5**.

Table 5 NMLs for Other Sensitive Receivers

Land Use	NML LAeq(15minute) (Applied when the property is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of Worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, eg reading, meditation)	External noise level 60 dBA
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS 2107 for specific uses.

3.1.2 NML Summary

Using the measured background noise levels in **Table 3**, the NMLs derived for the project are detailed in **Table 6**.

The noise monitoring locations were selected to capture background noise levels at the typically most affected receiver locations in the various catchments along the alignment. The most affected receivers are usually front row receivers which have a direct line of sight to the construction works.

Whilst background noise levels may reduce for receivers which are further back from the construction works (and nearby roads), the construction noise predictions are likely to drop off at a quicker rate meaning the level of impact would be lower than the most affected 'front row' receivers.

Table 6 Residential Receiver NMLs for Construction

NCA	Logger ID	Standard Construction (RBL+10dB)	Out of Hours (RBL+5dBA)			Sleep Disturbance Screening (RBL+15)
		Daytime	Daytime	Evening	Night-time	
NCA1	NM3	55	50	49	43	53
NCA2	NM2	70	65	64	51	61
NCA3	NM4	67	62	59	49	59
NCA4	NM4	67	62	59	49	59
NCA5	NM4	67	62	59	49	59
NCA6	NM4	67	62	59	49	59

3.2 Construction Vibration Criteria

The construction of the Project would involve intermittent sources of vibration which are associated with two main types of vibration impact: disturbance at receivers and potential cosmetic structural damage to buildings.

3.2.1 Human Comfort Vibration Objectives

The EPA's *Assessing Vibration: a technical guideline* (2006) provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV) rather than a continuous vibration level. The VDV is dependent upon the level and duration of the vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the guideline for vibration that is intermittent nature are presented in **Table 7**.

Table 7 Preferred and Maximum Vibration Dose Values for Intermittent Vibration

Building Type	Vibration Dose Value ($m/s^{1.75}$)	
	Preferred	**Maximum**
Residential Daytime	0.20	0.40
Residential Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80
Workshops	0.80	1.60

Note: Daytime is 7:00 am to 10:00 pm and night-time is 10:00 pm to 7:00 am.

3.2.2 Effects on Building Structures

The levels of vibration to cause damage to buildings tend to be at least an order of magnitude (10 times) greater than levels considered acceptable by people. This also applies to heritage buildings, unless they are structurally unsound. For this reason, the controlling vibration criterion at most locations is determined by the criteria for human responses which are more stringent than criteria for damage to building contents or structures.

For the purpose of this assessment, vibration from the construction of the Project has been assessed to the human perception objectives in **Table 12**. Where vibration levels are within the human comfort criteria they would also comply with those for limiting damage to buildings and structures.

4 CONSTRUCTION NOISE

4.1 Works Description

4.1.1 Construction Activities

The activities likely to be required to construct the project involve conventional construction equipment such as earth moving equipment, concreting equipment, piling plant and cranes.

Table 8 outlines the construction scenarios that have been developed to assess potential impacts associated with construction of the project.

Table 8 Construction Activities

Works ID	Scenario	Activity
W.0001	Clearing and establishment of pier 2 & 3	Tree removal
W.0002		Vegetation and earthworks
W.0003		Construction
W.0004	Service relocations, construction of piers, barriers, etc	Utilities
W.0005		Pier and piles
W.0006	Steel structure on-site fabrication	Helix and deck pre-assembly
W.0007	Span installation	Installation of bridge

4.1.2 Working Hours

The pedestrian bridge was previously approved (SSD 5093) for construction during the hours of 7:00 am and 7:00 pm Mondays to Fridays inclusive and between the hours of 8:00am and 4:00pm Saturdays. However, TfNSW Transport Management Centre have recently advised that certain aspects of the work are now required to be completed during night-time periods.

As such, the above construction scenario will be required to be completed during evening and night-time periods to ensure minimal disruption of the surrounding road network and to ensure the safety of construction workers.

4.2 Overview of Construction Noise Modelling

4.2.1 Source Location

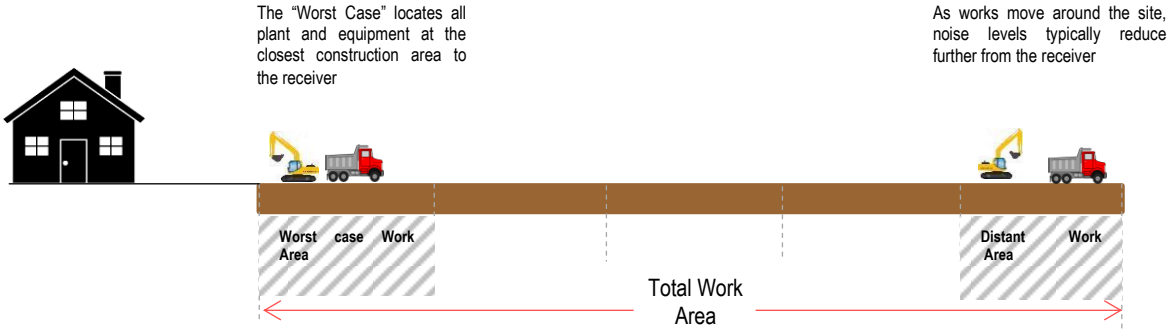
Consistent with the requirements of the ICNG, this assessment provides a 'realistic worst-case' noise impact assessment based on the required construction works within a 15-minute period. This is typically associated with works located nearest to a particular receiver.

In reality, the potential construction noise impacts at any particular location can vary greatly depending on factors including the following:

- The position of the works within the site and distance to the nearest sensitive receiver
- The overall duration of the works
- The intensity of the noise levels
- The time at which the works are undertaken
- The character of the noise.

Noise levels at sensitive receivers can also be significantly lower than the worst-case scenario when the construction works move to a more distant location in a works area. This concept is shown in **Figure 3**.

Figure 3 Illustration of Works Areas



The above figure illustrates that when works move away from a receiver the noise levels from the operation of the construction equipment would reduce accordingly.

4.2.2 Calculation Type

To quantify noise levels from the construction activities a computer noise prediction model using the ISO 9613 algorithms was developed using SoundPLAN software.

Local terrain, receiver buildings and structures have been digitised in the noise model to develop a three-dimensional representation of the construction sites and surrounding environment. In accordance with the ICNG, noise levels are predicted at all receivers in the various catchment areas surrounding the works.

4.2.3 Construction Activity Source Noise Levels

Sound power levels for the typical operation of construction equipment applied in the modelling are listed in **Table 9**. These noise levels have been taken from SLR's noise database.

Table 9 Construction Works and Sound Power Levels for Construction Equipment

		Plant Item	Chainsaw	Chipper	Concrete Pump	Concrete Saw[1]	Concrete Truck / Agitator	Excavator (1.5 tonne)	Excavator (10 tonne)	Franna Crane	Grinder 4"[1]	Mobile Crane (100 tonne)	Mobile Crane (300 tonne)	Piling Rig (Bored)	Stump Grinder	Truck (25t)	Wacker Rammer[1]	Welding Equipment
		Sound Power Level (L_{Aeq})	108	120	106	115	106	84	94	99	98	101	104	108	110	98	108	97
		Minutes Used in Worst-case 15 Minute Period	5	15	7.5	5	7.5	15	15	15	7.5	15	15	7.5	15	15	15	15
Works ID	**Scenario**	**Activity**																
W.0001	Clearing and establishment of pier 2 & 3	Tree removal	X	X											X			
W.0002		Vegetation and earthworks						X								X		
W.0003		Construction								X	X					X		
W.0004	Service relocations, construction of piers, barriers, etc	Utilities				X	X		X		X					X	X	
W.0005		Pier and piles			X				X	X	X			X		X		
W.0006	Steel structure on-site fabrication	Helix and deck pre-assembly								X	X	X				X		X
W.0007	Span installation	Installation of bridge									X	X	X					X

Note 1: The ICNG requires that activities identified as particularly annoying (such as jackhammering, rock breaking and power saw operation) have a 5 dB 'penalty' added to predicted noise levels when using the quantitative method.

4.3 Predicted Noise Levels

A summary of the predicted noise levels (without additional mitigation) in each of the NCAs for the various work activities is presented in **Table 10**. The noise levels are representative of the worst-case impacts, at that particular receiver type, where works are at their closest and are intended to give an overview of the likely noise levels from the construction works.

It is understood that the construction works would be completed prior to the new residential development at Lachlan's Line being completed and habited.

Construction noise levels have been predicted to the residential buildings in the North Ryde Precinct (near to North Ryde Station), as shown in **Figure 1**.

The following tables colour the predicted noise levels based on the exceedance of the NML during that period and for that receiver type. A qualitative description of the NML exceedance bands is given below, noting that the impact of these potential exceedances would depend on the period in which they were to occur (ie the night-time period is typically more sensitive than the daytime or evening for most people):

- Noise levels 1 to 10 dB above NML – impacts would typically be marginal to minor
- Noise levels 11 dB to 20 dB above NML – impacts would typically be moderate
- Noise levels >20 dB above NML – impacts would typically be high

For most construction activities, it is expected that the construction noise levels would frequently be lower than predicted at the most-exposed receiver, as the noise levels presented in this report are based on a realistic worst-case assessment.

The predicted NML exceedances for the project for all receiver types are summarised in **Table 11**. The assessment presented takes into consideration all construction scenarios associated with the project. The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dB and are separated into daytime, evening and night-time periods, as appropriate.

Table 10 Predicted Worst-case Noise Levels from Project – All Works and All NCAs

NCA	NML	Predicted $L_{Aeq(15minute)}$ Noise Level (dBA)[1]						
		W.0001 Tree removal	W.0002 Vegetation and earthworks	W.0003 Construction	W.0004 Utilities	W.0005 Pier and piles	W.0006 Helix and deck pre-assembly	W.0007 Installation of bridge
Residential - Standard Daytime								
NCA01	55	72	50	54	65	61	47	57
NCA02	-	-	-	-	-	-	-	-
NCA03	-	-	-	-	-	-	-	-
NCA04	-	-	-	-	-	-	-	-
NCA05	-	-	-	-	-	-	-	-
NCA06	67	76	54	58	69	65	43	61
Residential - Evening								
NCA01	49	72	50	54	65	61	47	57
NCA02	-	-	-	-	-	-	-	-
NCA03	-	-	-	-	-	-	-	-
NCA04	-	-	-	-	-	-	-	-
NCA05	-	-	-	-	-	-	-	-
NCA06	59	76	54	58	69	65	43	61
Residential - Night-time								
NCA01	43	72	50	54	65	61	47	57
NCA02	-	-	-	-	-	-	-	-
NCA03	-	-	-	-	-	-	-	-
NCA04	-	-	-	-	-	-	-	-
NCA05	-	-	-	-	-	-	-	-
NCA06	49	76	54	58	69	65	43	61
Commercial								
NCA01	70	63	41	45	56	52	40	49
NCA02	70	57	35	39	50	46	54	54
NCA03	70	46	<30	<30	39	35	35	37
NCA04	70	45	<30	<30	38	34	34	36
NCA05	70	37	<30	<30	30	<30	34	35
NCA06	70	83	61	65	76	72	41	68
Other Sensitive[2]								
NCA01	-	52	30	34	45	41	41	41
NCA02	-	-	-	-	-	-	-	-
NCA03	-	47	<30	<30	40	36	39	39
NCA04	-	44	<30	<30	37	33	32	35
NCA05	-	-	-	-	-	-	-	-
NCA06	-	-	-	-	-	-	-	-

Note 1: Colouring indicates the predicted NML exceedances (see legend) based on the worst-case predicted noise level for the appropriate receiver type.

Note 2: 'Other sensitive' receiver NMLs are dependent on classification. The most affected 'other sensitive' receiver type may change between each activity resulting in different NMLs

Legend

1 - 10 dB above NML | 11 - 20 dB above NML | >20 dB above NML

Table 11 Overview of Predicted NML Exceedances – All Catchments – All Receiver Types

Activity ID	Scenario	Activity	Number of Receivers																
			Total	HNA[1]	With NML Exceedance[2]														
					Standard Daytime			Out of Hours Works[3]											
								Daytime OOH			Evening			Night-time			Sleep Disturbance		
					1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
W.0001	Clearing and establishment of pier 2 & 3	Tree removal	150	1	28	5	-	37	8	1	37	6	4	17	34	6	23	26	6
W.0002		Vegetation and earthworks	150	-	-	-	-	-	-	-	1	-	-	6	-	-	8	1	-
W.0003		Construction	150	-	-	-	-	4	-	-	4	-	-	8	1	-	8	1	-
W.0004	Clearing and establishment of pier 2 & 3	Utilities	150	-	7	-	-	16	4	-	22	4	-	37	8	1	37	8	1
W.0005		Pier and piles	150	-	5	-	-	8	1	-	8	1	-	31	6	-	26	6	-
W.0006	Steel structure on-site fabrication	Helix and deck pre-assembly	150	-	-	-	-	-	-	-	-	-	-	12	-	-	4	-	-
W.0007	Span installation	Installation of bridge	150	-	1	-	-	4	-	-	5	-	-	30	5	-	6	-	-

Note 1: HNA = Highly Noise Affected. Based on ICNG definition (ie predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 2: Based on worst-case predicted noise levels.

Note 3: OOH = Out of hours. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

When considering the predicted noise levels and NML excedances from the project as a whole, the above tables indicate that:

- The highest noise levels and NML exceedances are generally predicted during works which use noise intensive plant items. This includes the following activities:
  - W.0001 – Clearing and establishment of pier 2 & 3, tree removal (chain saws and wood chipper)
  - W.0004 – Road pavement demolition and excavation, vegetation and earthworks (concrete saw)
- Works activity W.0001 and W.0004 are predicted to result in the highest absolute noise levels, which results from the use of noise intensive plant items.
- Works activities that do not include high noise generating items of plant generally result in considerably lower impacts.
- Potentially significant impacts from night-time works are predicted at the surrounding residential receivers when noise intensive plant items, such as chain saws, wood chippers and concrete saws, are in use.
- The highest impacts are generally seen in NCA01 and NCA06, where residential receivers are in relatively close proximity to the construction works. The location of the most potentially impacted receivers are shown in **Figure 4**.

Figure 4 Most Potentially Affected Receivers - Predicted Worst-case Noise Levels

- Commercial receivers are predicted to experience moderate impacts with the highest impacts generally seen in NCA06, which is immediately to the east of the works on Delhi Road. Commercial receivers would however not be expected to be in use during the night-time.

- Other sensitive receivers such as hotels, education facilities and places of worship are expected to be minimally affected by the works.
- One Highly Noise Affected residential receiver is predicted within NCA06 (ie the nearest apartment building to the immediate east of the bridge). No other NCAs are predicted to include highly noise affected residential receivers during construction works.
- The above shows that relatively high noise impacts at the nearest receivers are predicted during some of the higher noise generating construction activities. It is however noted that during most activities, construction noise levels would frequently be lower than the worst-case levels predicted above for significant periods of time.

4.4 Mitigation

The expected NML exceedances may be concerning for surrounding residents at times and particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies.

The standard suite of mitigation measures includes management measures such as community consultation, site inductions (with guidance on how to minimise noise and vibration) and the preparation of site specific construction noise and vibration management plans.

Examples of mitigation measures which may be considered appropriate for these works are:

- Use of localised acoustic hoarding around significantly noisy items of plant, where practicable. This would be expected to provide between 5 dB and 10 dB of additional noise attenuation provided the line-of-sight between all receivers and the construction equipment is broken. The barrier is most affective when it is located either close to the noise source or the receiver.
- Scheduling of the higher NML exceedance activities/locations to be undertaken predominantly during less noise-sensitive periods, where possible. Particularly where highly noise intensive plant items, such a chain saws or concrete saws, are required. The community should be consulted to assist in identifying less noise sensitive periods.
- Briefing of the work team in order to create awareness of the locality of sensitive receivers and the importance of minimising noise emissions.
- Ensuring any spoil is placed and not dropped into awaiting trucks.
- Establishing load points as far as practicable from sensitive receivers.
- Use of less noise-intensive equipment, where feasible and reasonable.
- Non-tonal reversing alarms fitted to all construction vehicles.
- Scheduling of respite periods and possible provision of temporary relocation where continuously noisy night-time activities are required, if appropriate.

The highest NML exceedances are predicted during works *'W.0001 – Clearing and establishment of pier 2 & 3, tree removal'* and *'W.0004 – Clearing and establishment of pier 2 & 3, utilities'*, both of which require the use of a noise intensive plant items, such as chainsaws, wood chippers or concrete saws.

It is therefore recommended that particular attention is directed to scheduling these works to be undertaken during standard daytime construction hours. Where this is not possible, it should be scheduled to finish by 11:00 pm, where practicable.

It is recommended that the wood chipper is not used during the night-time periods.

In order to minimise the potential noise and vibration impacts upon nearby sensitive receivers, construction works should be undertaken during the EPA's standard daytime construction periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays) where possible, however it is acknowledged that approvals by authorities may not permit lane possessions during these times..

Out of Hours Works should be minimised as far as is practicable, within the limitations of completing the works adjacent to an active road network.

4.5 Construction Traffic

The requirements for construction traffic accessing the site would be minimal and would not be expected to result in any additional noise impacts at the nearest receivers due to the roads in the area being major routes with high existing volumes of traffic.

4.6 Construction Vibration

4.6.1 Safe Working Distances for Vibration Intensive Plant

The level of vibration potentially experienced at a receiver is dependent upon the vibration energy generated by the source, the predominant frequencies of vibration, the localised geotechnical conditions and the interaction of structures and features which can dampen vibration.

The recommended safe working distances for construction plant in **Table 12** are referenced from the RMS *Construction Noise and Vibration Guideline*. Consistent with the guidelines for ground vibration (refer **Section 3.2**); the recommendations provide for the practical management of potential vibration to minimise the likelihood of cosmetic damage to buildings and disturbance or annoyance in humans.

Table 12 Recommended Safe Working Distances for Construction Equipment

Equipment Item	Rating/ Description	Safe Working Distance	
		Cosmetic Damage[1]	Human Response
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (y > 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	300 kg – 18 to 34t excavator	2 m	7 m

Equipment Item	Rating/ Description	Safe Working Distance	
		Cosmetic Damage[1]	Human Response
Medium Hydraulic Hammer	1,600 kg – 5 to 12t excavator	7 m	23 m
Large Hydraulic Hammer	1,600 kg – 12 to 18t excavator	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	4 m
Jackhammer	Hand held	1 m (nominal)	2 m

Note 1: Referenced from British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2.

4.6.2 Vibration Assessment

At this stage in the project, no vibration intensive plant items are anticipated to be required during the works. As such, no vibration impacts are expected at the nearest receivers.

If vibration intensive works are required, a site-specific vibration assessment should be undertaken by the contractor prior to the commencement of works.

5 Conclusion

A noise and vibration impact assessment has been completed for the proposed night-time construction of a pedestrian bridge at the Lachlan's Line Precinct.

The expected construction noise impacts may be concerning for surrounding residents at times and particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies.

The potential impacts should be managed through the application of the mitigation measures as recommended in this report.

APPENDIX A

Acoustic Terminology

Acoustic Terminology

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 2×10^{-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

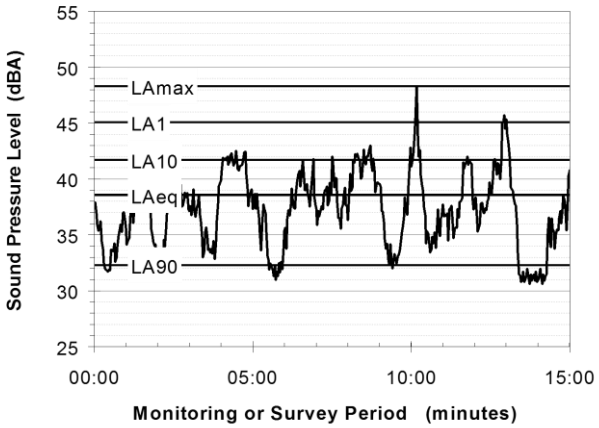
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

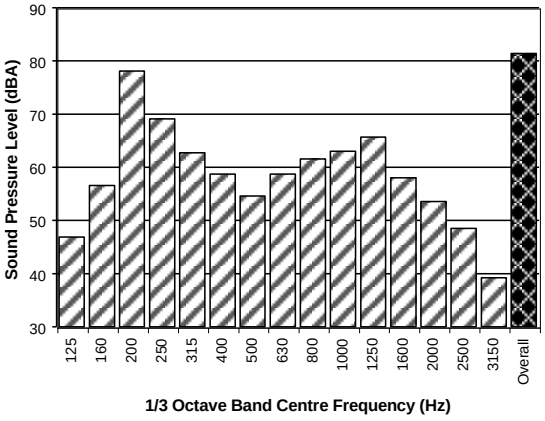
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

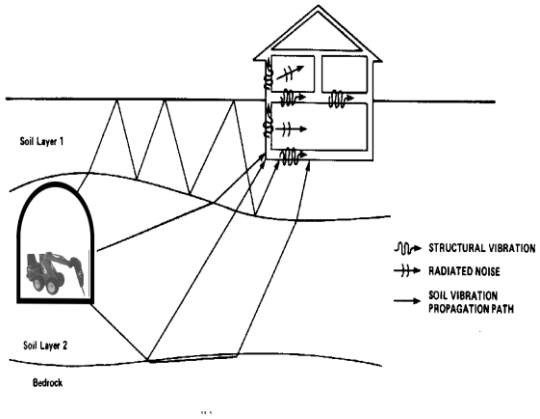
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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

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