TRANSPORT ACCESS PROGRAM

Glenbrook Station Upgrade
Noise and Vibration Impact Assessment

Prepared for:

Transport for NSW Infrastructure and Services
Level 5, Tower A, Zenith Centre,
821 Pacific Highway, Chatswood,
NSW, 2067

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PREPARED BY

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
T: +61 2 9427 8100 F: +61 2 9427 8200
E: sydney@slrconsulting.com www.slrconsulting.com

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 Transport for NSW Infrastructure and Services (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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DOCUMENT CONTROL

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610.18158-R01-v1.3	22 October 2018	Robert Hall	Dominic Sburlati	Robert Hall
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EXECUTIVE SUMMARY

Transport for NSW (TfNSW) proposes to upgrade Glenbrook Station to meet disability access requirements (the Proposal) as outlined in the *Disability Discrimination Act 1992* (DDA Act). The Proposal would include upgrading the station access and station facilities as well as installing a lift and access path.

This report presents an assessment of construction and operational noise and vibration associated with the concept design and identifies feasible and reasonable noise and vibration mitigation and management measures to be incorporated in the detailed design and construction planning stage of the Proposal. This assessment forms part of the input to the Review of Environmental Factors (REF).

Construction noise impacts

Most of the Proposal's construction works are to be undertaken during standard daytime construction hours only. However, some works would need to be undertaken during rail possessions and would therefore need to be undertaken during the more noise sensitive night-time period.

Minor daytime construction noise management level exceedances are predicted at surrounding residential receivers on both sides of the rail corridor for most of the Proposal's construction works activities. Due to the nearby residential receivers being located close to the works, high daytime noise management level (NML) exceedances of up to 39 dB are predicted during the most noise intensive work periods. These impacts would be limited to residential receivers located directly adjacent Glenbrook Station on Burfitt Parade which have direct line of sight to the proposed works. Receivers which are located further away from the proposed worksite would have much lower NML exceedances or no predicted noise or vibration impact.

During rail possessions, when works are required to be performed during evening and night-time periods, exceedances of the night-time noise management levels of up to 20 dBA are predicted for residential receivers surrounding the Proposal. High exceedances of the night-time NMLs of more than 30 dBA are predicted for residential receivers within approximately 100 metres of the works. The high magnitude of impacts at the closest receivers is a result of their close proximity to the works (noise intensive construction plant may be positioned as close as 25 metres away on the opposite side of the Burfitt Parade), and the low night-time NMLs. It is anticipated that night-time works would be limited to approximately three rail possessions.

Management of potential impacts from vibration producing construction plant is restricted to the Glenbrook Station region.

Specific and additional mitigation and management measures for construction noise and vibration are outlined in this report. Where vibration intensive works are required to be undertaken within the specified safe working distances outlined in this report, or in close proximity to vibration sensitive heritage structures, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

EXECUTIVE SUMMARY

Operational noise impacts

This assessment presents the applicable noise criteria for industrial noise sources associated with the Proposal. At this stage of the design specific mechanical systems have not been selected, which means it is too early to assess compliance with the applicable noise criteria however given this type of noise source (i.e. lift) generally has relatively low noise emissions, it an anticipated that the lift system design could be relatively easily mitigated if required during the detailed design phase of the Proposal. It is anticipated that the operational noise criteria established in this assessment would inform the detailed design process.

CONTENTS

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

GLOSSARY

Item	Description / Definition
CNS	Construction Noise Strategy
CNVS	Construction Noise and Vibration Strategy
DEC	Department of Environment and Conservation (now OEH / EPA)
DECC	Department of Environment and Climate Change (now OEH / EPA)
DECCW	Department of Environment, Climate Change and Water (now OEH / EPA)
REF	Review of Environmental Factors
EPA	Environment Protection Authority
ICNG	Interim Construction Noise Guideline
INP	Industrial Noise Policy
NPfI	Noise Policy for Industry
Lidar	Light Detection and Ranging
NML	Noise Management Level
NSW	New South Wales
RBL	Rating Background Level
RING	Rail Infrastructure Noise Guideline
RMS	Root Mean Square
RNP	Road Noise Policy
SLR	SLR Consulting Australia Pty Ltd
SWL	Sound Power Level
TfNSW	Transport for NSW

1 Introduction

Transport for NSW (TfNSW) proposes to upgrade Glenbrook Station to meet disability access requirements (the Proposal) as outlined in the *Disability Discrimination Act 1992* (DD Act). The Proposal would include upgrading the station access and station facilities as well as installing a lift and access path.

The Proposal is part of the Transport Access Program (TAP) which is a NSW Government initiative to provide a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure. A key objective of the program is to ensure that all stations, and in this instance Glenbrook Station, meet legislative requirements under the Disability Standards for Accessible Public Transport 2002 (DSAPT).

The Proposal would provide safe and equitable access to the island platform and the surrounding pedestrian network at Glenbrook Station and would also improve customer facilities and amenity. The improvements would in turn assist in supporting the growth in public transport use and would provide an improved customer experience for existing and future users of the station.

1.1 Report objectives

SLR Consulting Australia Pty Ltd (SLR) has been engaged by RPS to prepare a construction and operational noise and vibration assessment for the proposed station upgrade at Glenbrook.

The aims of this assessment are to:

- summarise the construction and operational noise and vibration assessment of the concept design for the Proposal
- identify feasible and reasonable noise and vibration mitigation and management measures to be incorporated in the detailed design and construction planning stage of the Proposal.

This assessment forms part of the input to the Review of Environmental Factors (REF).

1.2 Relevant guidelines

The noise and vibration guidelines for construction and operations are based on publications managed by the NSW Environment Protection Authority (EPA). The EPA guidelines applicable to this assessment include:

- operational noise – *Noise Policy for Industry* (NPfI, EPA 2017)
- construction noise – *Interim Construction Noise Guideline* (DECC 2009)
- construction and operational vibration (human comfort) – *Assessing Vibration – a technical guideline* (DEC 2006)
- operational road traffic noise – NSW *Road Noise Policy* (RNP), NSW EPA 2011).

The following additional guidelines are also referenced in this study:

- construction noise and vibration mitigation - *Construction Noise and Vibration Strategy* (CNVS, Transport for NSW, 2018).

1.3 Terminology

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

2 Proposal description

2.1 Proposal overview

The Proposal involves an upgrade of Glenbrook Station as part of the Transport Access Program which would improve accessibility and amenity for customers.

The Proposal would include the following key elements:

- installation of a new lift on the platform to provide access to the existing footbridge (footbridge and stairs to be retained)
- provision of a new station entrance which would include demolition of the existing (non-compliant) ramp from the footbridge to Burfitt Parade to be replaced with new stairs and a new accessible path from the existing footbridge extending east to the raised pedestrian crossing
- landscaping around the station entrance
- internal reconfiguration of the station building to allow for a new Family Accessible Toilet, a new ambulant toilet, communications room and staff facilities
- installation of a glass canopy at the entrance to the Family Accessible Toilet
- new formalised kiss and ride on Burfitt Parade
- installation of a pad mount electrical transformer adjacent to the new stairs
- ancillary works including lighting, fencing, new bin storage, minor drainage works, seating adjustments, improvement to station communication systems (including CCTV cameras), hearing loops, installation of wayfinding signage and other signage to identify existing and new accessible features including installation of new tactile ground surface indicators (TGSIs).

2.2 Identification of sensitive receivers

The Proposal works are located as shown in **Figure 1**. Also shown are the locations of the closest representative noise sensitive receiver Noise Catchment Areas (NCA01 to NCA04) and noise monitoring locations L01 and L02.

Figure 1 Site location showing indicative works location

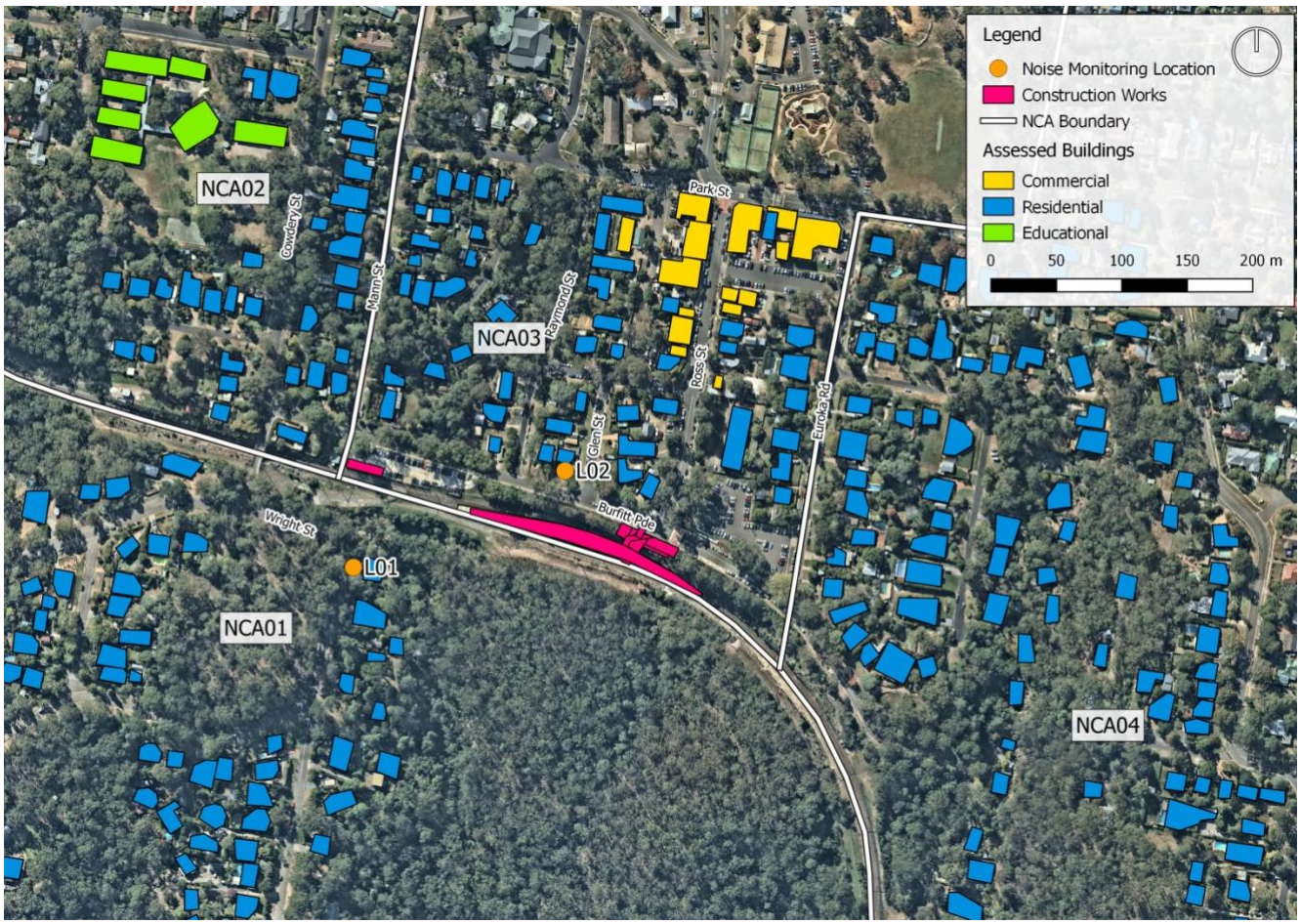


Table 1 provides a summary of the noise catchment areas shown as NCA01 through NCA04 in **Figure 1**.

Table 1 Representative noise sensitive receivers

NCA	Boundary description	Sensitive receiver descriptions
NCA01	Receivers located on the southern side of the rail corridor.	Mostly single storey residential buildings. Closest receivers located approximately 85 m southwest of the Glenbrook Station platform.
NCA02	Receivers located on the northern side of the rail corridor and west of Mann Street.	Mostly single storey residential buildings. Closest receivers located approximately 125 m northwest of the Glenbrook Station platform. One educational receiver (Glenbrook Public School) located approximately 320 m northwest of the Glenbrook Station platform.

NCA	Boundary description	Sensitive receiver descriptions
NCA03	Receivers located on the northern side of the rail corridor between Mann Street and Euroka Street.	Mostly single storey residential buildings. Closest receivers located approximately 40 m north of the Glenbrook Station platform. Some commercial premises located approximately 160 m north of the Glenbrook station platform on Ross Street and Park Street.
NCA04	Receivers located on the northern side of the rail corridor and east of Euroka Street.	Mostly single storey residential buildings. Closest receivers located approximately 95 m east of the Glenbrook Station platform.

3 Existing acoustic environment

3.1 Continuous unattended monitoring

3.1.1 Noise monitoring procedure

ARL model 316 noise logger (serial number 16-306-039) was deployed from 23 July 2018 to 31 July 2018 at address 2 Wright Street, Glenbrook, referred to as noise monitoring location L01 in **Figure 1**. ARL model 316 noise logger noise logger (serial number 16-306-041) was deployed from 23 July 2018 to 31 July 2018 at address 11 Burfitt Parade, Glenbrook, referred to as noise monitoring location L02 in **Figure 1**.

These locations were selected based on an inspection of the potentially affected areas, giving consideration to other noise sources which may influence the recordings, security issues for the noise monitoring device and gaining permission for access to the location from the resident or landowner.

The results of the noise monitoring have been processed in accordance with the procedures contained in the *Noise Policy for Industry* (NPfI) so as to establish representative noise levels from all noise sources in the area at the residences.

3.1.2 Noise monitoring results

A summary of the unattended continuous noise monitoring is provided in **Table 2**. A full graphical representation of the unattended noise monitoring results is provided in **Appendix B**.

Table 2 Unattended noise logger results

Location	Address	Period[1]	Measurement parameter (dBA)			
			L_{A1}	L_{A10}	L_{A90} (RBL)	L_{Aeq}
L01	2 Wright Street, Glenbrook	Daytime	59	48	33	50
		Evening	59	44	32	52
		Night-time	50	41	26	51
L02	11 Burfitt Parade, Glenbrook	Daytime	59	52	35	52
		Evening	56	48	34	52
		Night-time	51	41	26	50

Note 1: NPfI Governing Periods - Day: 7am to 6pm Monday to Saturday, 8am to 6pm Sundays & Public Holidays, Evening: 6pm to 10pm, Night: 10pm to 7am Monday to Saturday, 10pm to 8am Sundays & Public Holidays.

The results of continuous unattended noise monitoring at these location show levels typical of an outer-city suburban noise environment with low night-time noise levels. Daytime noise levels are likely to be dominated by the natural environment, road traffic on adjacent roads, and rail traffic.

3.2 Operator attended measurements

3.2.1 Noise measurement procedure

Operator-attended ambient noise surveys were conducted on 23 July 2018 at noise monitoring locations L01 and L02 shown in **Figure 1**.

The operator-attended noise measurements were performed using a calibrated Brüel & Kjær Type 2260 Sound Level Meter (serial number 2414604). Instrument calibration was checked before and after the measurement survey, with the variation in calibrated levels not exceeding the acceptable variation of ±0.5 dB (AS 1055).

The acoustic instrumentation employed throughout the noise monitoring survey was designed to comply with the requirements of *AS IEC 61672.1-2004: Electroacoustics - Sound level meters - Specifications* as a type 1 precision sound level meter and has an accuracy suitable for both field and laboratory use. Both the meter and calibrator carry current NATA calibration certificates.

3.2.2 Noise measurement results

A summary of the operator-attended ambient noise survey is shown in **Table 3**.

Table 3 Operator attended ambient noise survey

Measurement Location	Measured noise levels (dBA)			Observations (dBA)
	LAmax	LAeq	LA90	
L01 - 2 Wright Street, Glenbrook	73	50	36	Recorded Noise Levels (LAmax): Light-vehicle traffic Station/Wright St: 63-66 dBA Train passby Blue Mountains Line: 68 dBA Birds: 57-73 dBA Animals: 56 dBA
L02 - 11 Burfitt Parade, Glenbrook	70	50	37	Recorded Noise Levels (LAmax): Light-vehicle traffic Burfitt Pde/Mann St: 62-70 dBA Train passby Blue Mountains Line: 67-70 dBA Birds: 54-66 dBA Motorbike: 68 dBA

Daytime ambient noise levels were observed to be largely controlled by traffic movements along adjacent roads.

4 Construction noise assessment

4.1 Noise and vibration guidelines

4.1.1 Construction noise metrics

The three primary noise metrics used to describe construction noise emissions:

- **$L_{A1(1minute)}$** - the "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, assessment may be conducted using the L_{Amax} or maximum noise level
- **$L_{Aeq(15minute)}$** - the "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.
- **L_{A90}** - the "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction Noise Management Levels (NMLs) are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).

4.1.2 NSW Interim Construction Noise Guideline

The *Interim Construction Noise Guideline* (ICNG) sets out ways to deal with 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 construction projects.

The ICNG requires proposal 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 investigated to minimise noise emissions.

4.1.2.1 Residential receivers

The ICNG provides an approach for determining $L_{Aeq(15minute)}$ NMLs at residential receivers adjacent to the works by applying the measured $L_{AF90(15minute)}$ rating background noise levels (RBL), as described in **Table 4**.

Table 4 ICNG - determination of NMLs for residential receivers

Time of day	NML $L_{Aeq(15minute)}$	How to apply
Standard hours Monday to Friday 7am to 6pm Saturday 8am to 1pm 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 $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices 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 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[1] + 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 practices 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*.

4.1.2.2 Sleep disturbance

For the purposes of this assessment, the following night-time sleep disturbance noise goal has been used:

- night-time RBL +15 dBA "screening criterion"

4.1.2.3 Commercial receivers

The ICNG explains 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.

4.1.2.4 Other sensitive land uses

The ICNG's quantitative assessment method provides NMLs for other sensitive land uses, such as educational institutes, hospital, medical facilities, etc. These land uses are considered potentially sensitive to construction noise only when the properties are in use. The ICNG NMLs for the other sensitive receivers identified in the Proposal area are reproduced in **Table 5**.

Table 5 ICNG NMLs – other sensitive land uses

Receiver		Land use	Management Level $L_{Aeq(15min)}$ (dBA) (applies when property is in use)
NCA03	Glenbrook Public School	Other Sensitive (Educational)	Internal noise level[1] 45 dB(A)

Note 1: Internal noise level

As the noise management level for the Glenbrook Public School is an internal noise management level, the corresponding external noise level (which the assessments are based upon) has been determined on the assumption that a 10 dB noise reduction from outside to inside is applicable. This is generally considered to be a typical assumption for a 'windows open' scenario.

4.1.2.5 NML summary

Adopting the measured background noise levels in **Table 2**, the NMLs derived for the Proposal are outlined in **Table 6**.

Table 6 NMLs for construction

NCA	Receiver type	RBL			Standard construction (RBL+10dB)	Out of Hours (RBL+5dBA)[1]			Sleep disturbance screening (RBL+15)
		Day	Eve.	Night[2]	Daytime period	Daytime period	Evening period	Night-time period	
NCA01	Residential (L01)	33	32	30	43	38	37	35[2]	45
NCA02	Residential (L02)	35	34	30	45	40	39	35[2]	45
	Other Sensitive (Educational)	45[3]	n/a	n/a	55[4]	55[2]	n/a	n/a	n/a
NCA03	Residential (L02)	35	34	30	45	40	39	35[2]	45
	Commercial	70	n/a	n/a	70	70	n/a	n/a	n/a
NCA04	Residential (L02)	35	34	30	45	40	39	35[2]	45

Note 1: Out of Hours construction hours – Evening hours are 6pm to 10pm. Night-time hours are 10pm to 7am Sunday to Saturday and 10pm Saturday to 8am Sunday

Note 2: Based on the 30 dBA minimum night-time RBL in accordance with the NPfI.

Note 3: ICNG internal noise goal.

Note 4: ICNG internal goal + 10 dB as openable windows are assumed. An outside-to-inside attenuation of 10 dB is assumed.

4.2 Construction-related vibration assessment criteria

The effects of vibration in buildings can be divided into three main categories – those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

4.2.1 Human comfort vibration

The EPA's *Assessing Vibration: a technical guideline* 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 short-term vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the document for vibration of an intermittent nature (ie construction works where more than three distinct vibration events occur) are presented in **Table 7**.

Table 7 Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$) (*Assessing Vibration: a technical guideline)*

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

1 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.
2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas.
Source: BS 6472–1992

4.2.2 Effects on building contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. For most receivers, the controlling vibration criterion will be the human comfort criterion, and it is therefore not normally required to set separate criteria in relation to the effect of construction vibration on most building contents.

Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives

4.2.3 Structural damage vibration

Structural damage vibration limits are based on Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* and British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*. These standards provide frequency-dependent vibration limits related to cosmetic damage, noting that cosmetic damage is very minor in nature, is readily repairable and does not affect the structural integrity of the building. The recommended vibration limits from BS 7385 for transient vibration for minimal risk of cosmetic damage to residential and industrial buildings is shown in **Table 8**.

Table 8 Transient vibration guide values for minimal risk of cosmetic damage (BS 7385)

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

4.2.4 Safe working distances

As a guide, safe working distances for the proposed items of vibration intensive plant are provided in the CNVS and are reproduced below in **Table 9**.

Table 9 Recommended safe working distances for vibration intensive plant

Plant item	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (NSW EPA Vibration Guideline)
Vibratory roller	< 50 kN (Typically 1-2t)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4t)	6 m	20 m
	< 200 kN (Typically 4-6t)	12 m	40 m
	< 300 kN (Typically 7-13t)	15 m	100 m
	> 300 kN (Typically 13-18t)	20 m	100 m
	> 300 kN (Typically > 18t)	25 m	100 m
Small hydraulic hammer	300 kg - 5 to 12t excavator	2 m	7 m
Medium hydraulic hammer	900 kg - 12 to 18t excavator	7 m	23 m
Large hydraulic hammer	1600 kg - 18 to 34t excavator	22 m	73 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure
Bored piling	< 800 mm	2 m	n/a

Note 1: More stringent conditions may apply to heritage or other sensitive structures, Refer **Section 4.8.4**.

The safe working distances presented in **Table 9** are quoted for both cosmetic damage (refer to BS 7385:2 *Evaluation and Measurement for Vibration in Buildings Part 2: Guide to Damage Levels from Ground-borne Vibration*, 1993) and human comfort (refer to NSW EPA *Assessing Vibration: a technical guideline*, 2006).

The safe working distances for building damage should be complied with at all times. The distances are noted as being indicative and would vary depending on the particular item of plant and local geotechnical conditions. They apply to addressing the risk of cosmetic (minor – easily reparable) damage of typical buildings under typical geotechnical conditions.

Where vibration intensive works are required to be undertaken within the specified safe working distances, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

In relation to human comfort, the safe working distances relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed.

4.3 Construction timing

4.3.1 Staging

Subject to approval, construction is expected to commence in early 2019 and take around 12 months to complete. The construction methodology would be further developed during the detailed design of the Proposal by the nominated Contractor in consultation with TfNSW.

The proposed construction activities for the Proposal are identified in **Section 4.4**. The construction staging outlined in this assessment is indicative and is based on the current concept design and may change once the detailed design methodology is finalised. The staging is also dependent on the Contractor's preferred methodology, program and sequencing of work.

4.3.2 Construction hours

Where possible, works required for the Proposal would be undertaken during standard (NSW) Environment Protection Authority (EPA) construction hours, which are as follows:

- 7am to 6pm Monday to Friday
- 8am to 1pm Saturdays
- no work on Sundays or public holidays.

Works may need to occur outside standard hours and would include night works and works during routine rail possessions, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed and trains are not operating.

Out of hours works are required in some cases to minimise disruptions to customers, pedestrians, motorists and nearby sensitive receivers; and to ensure the safety of railway workers and operational assets. It is estimated that approximately three rail possessions would be required to facilitate the following:

- overhead wiring works
- electrical upgrades (like the installation of transformer)
- excavation and installation of the lift
- works to the footbridge (extension, waiting bay, hand rails etc)
- platform works (such as regrading, trenching for power/communications systems).

Out of hours works may also be scheduled outside rail possession periods. Approval from TfNSW would be required for any out of hours work and the affected community would be notified as outlined in TfNSW's *Construction Noise and Vibration Strategy* (TfNSW, 2018).

4.4 Construction works scenarios

In order to assess the potential noise and vibration impacts during construction, a number of scenarios comprising typical plant and equipment have been developed. These are summarised in **Table 10**.

Piling works are associated with several works activities. For the purpose of this assessment, it is assumed that piling works would be performed using bored piling. If the construction contractor elects to use an alternative piling method, the noise and vibration levels generated by the use of this plant may be different to those presented in this assessment and should be reviewed during detailed design.

Table 10 Construction scenarios

Plant Item			Back hoe	Grinder	Bobcat	Compressor	Grout mixer and pump	Concrete Vacuum Grinder	Concrete Pump	Concrete truck / agitator	Concrete saw	Circular saw	Excavator (20 tonne)	Franna crane	Chipper	Generator	Hand tools	Mobile crane (300 tonne)	Mobile crane (100 tonne)	Piling rig (Bored)	Chainsaw	Scissor lift	Jackhammer	Truck	Truck (HIAB)	Welding equipment
Sound Power Level (LAeq)			102	98	104	95	97	108	106	106	103	104	99	99	120	101	94	104	101	108	108	92	108	103	98	97
Assumed On-time in 15 Minute Period (Minutes)			15	7.5	15	15	7.5	7.5	7.5	7.5	7.5	15	15	15	15	15	15	15	15	7.5	15	15	5	15	15	15
SWL Max			111	126	110	97	105	113	109	112	111	112	107	107	124	104	100	110	106	118	108	102	112	108	103	100
Works ID	**Scenario**	**Activity**																								
1.1	Site Establishment	Compound Establishment															X								X	
1.2		Temporary Access		X	X												X								X	
1.3		Vegetation Clearing											X		X						X			X		
1.4		Stair Demolition		X							X		X											X		
1.5		Temporary Power Supply														X										
1.6		Services Relocation	X								X												X	X		
2.1	Main Works – Burfitt Parade	Piling Works							X	X			X							X				X		
2.2		Deck Construction								X							X		X							

Plant Item			Back hoe	Grinder	Bobcat	Compressor	Grout mixer and pump	Concrete Vacuum Grinder	Concrete Pump	Concrete truck / agitator	Concrete saw	Circular saw	Excavator (20 tonne)	Franna crane	Chipper	Generator	Hand tools	Mobile crane (300 tonne)	Mobile crane (100 tonne)	Piling rig (Bored)	Chainsaw	Scissor lift	Jackhammer	Truck	Truck (HIAB)	Welding equipment
Sound Power Level (LAeq)			102	98	104	95	97	108	106	106	103	104	99	99	120	101	94	104	101	108	108	92	108	103	98	97
Assumed On-time in 15 Minute Period (Minutes)			15	7.5	15	15	7.5	7.5	7.5	7.5	7.5	15	15	15	15	15	15	15	15	7.5	15	15	5	15	15	15
SWL Max			111	126	110	97	105	113	109	112	111	112	107	107	124	104	100	110	106	118	108	102	112	108	103	100
Works ID	**Scenario**	**Activity**																								
3.1	Main Works – Platform Level (Possession Dependant)	Install Transformer								X			X						X					X		
3.2		Lift Excavation											X							X				X		
3.3		FRP Lift Pit							X	X																
3.4		Install Lift Structure		X								X					X	X							X	
3.5		Install CSR for Lift Power										X					X									
3.6		Lift Equipment Delivery																X							X	
3.7		Install Handrails to Walkways		X								X					X									X
3.8		Platform Re-surfacing						X																		
4.1	Main Works – Platform Level (Non-Possession)	CSR for Station Power										X					X									
4.2		Power Fitout														X	X					X				
4.3		Station Amenity Fitout					X										X									
4.4		Lift Fitout and Commissioning		X												X	X									X
4.5		Station Commissioning															X									

4.5 Predicted noise impacts

In order to quantify noise emissions from the proposed construction works, a 3D computer noise model has been used to predict the $L_{Aeq(15minute)}$ and $L_{A1(1minute)}$ noise levels at the nearest receivers.

The predictions include the source noise levels of the anticipated equipment, the location of the nearest sensitive receivers, the number of plant items likely to be operating at any given time, the distance between the equipment and the receivers, and any shielding or reflections that the topography or buildings may provide.

The resultant daytime, daytime Out of Hours, evening and night-time worst-case $L_{Aeq(15minute)}$ and $L_{A1(1minute)}$ noise level predictions are presented in **Table 11**. The results are presented as a summary of the worst-case impacts for each works scenario when the works are located at the nearest position within the works area to each receiver.

In practice, the noise levels will vary due to the fact that plant will move around the worksites and will not all be operating concurrently. As such, noise levels are likely to be lower than the worst-case noise levels presented for notable periods of time during the works.

The ICNG states that where construction works are planned to extend over more than two consecutive nights, the impact assessment should cover the maximum noise level from the proposed works.

Table 11 Predicted noise levels

Ref	Works Scenario	Works Activity	Worst Case Construction Period	NCA	Type	Noise Level – LAeq(15minute) (dBA)												Noise Level – LA1(60second) (dBA) (sleep disturbance)		
						Worst-case Predicted	RBL			NML				Exceedance				Worst-case Predicted	Screening Criteria (RBL+15 dBA)	Exceedance
							Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
1.1	Site Establishment	Compound Establishment	Standard Daytime	NCA01	RES	47	33	32	30	43	38	37	35	4	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	50	35	34	30	45	40	39	35	5	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	37	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	61	35	34	30	45	40	39	35	16	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	41	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	37	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
1.2		Temporary Access	Standard Daytime	NCA01	RES	49	33	32	30	43	38	37	35	6	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	46	35	34	30	45	40	39	35	1	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	40	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	70	35	34	30	45	40	39	35	25	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	54	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	53	35	34	30	45	40	39	35	8	n/a	n/a	n/a	n/a	n/a	n/a
1.3		Vegetation Clearing	Standard Daytime	NCA01	RES	63	33	32	30	43	38	37	35	20	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	61	35	34	30	45	40	39	35	16	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	54	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	84	35	34	30	45	40	39	35	39	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	69	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	69	35	34	30	45	40	39	35	24	n/a	n/a	n/a	n/a	n/a	n/a

Ref	Works Scenario	Works Activity	Worst Case Construction Period	NCA	Type	Noise Level – LAeq(15minute) (dBA)												Noise Level – LA1(60second) (dBA) (sleep disturbance)		
						Worst-case Predicted	RBL			NML				Exceedance				Worst-case Predicted	Screening Criteria (RBL+15 dBA)	Exceedance
							Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
1.4	Site Establishment	Stair Demolition	Standard Daytime	NCA01	RES	48	33	32	30	43	38	37	35	5	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	46	35	34	30	45	40	39	35	1	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	40	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	70	35	34	30	45	40	39	35	25	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	54	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	53	35	34	30	45	40	39	35	8	n/a	n/a	n/a	n/a	n/a	n/a
1.5		Temporary Power Supply	Standard Daytime	NCA01	RES	49	33	32	30	43	38	37	35	6	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	52	35	34	30	45	40	39	35	7	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	39	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	63	35	34	30	45	40	39	35	18	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	43	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	39	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
1.6		Services Relocation	Standard Daytime	NCA01	RES	51	33	32	30	43	38	37	35	8	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	49	35	34	30	45	40	39	35	4	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	42	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	72	35	34	30	45	40	39	35	27	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	57	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	57	35	34	30	45	40	39	35	12	n/a	n/a	n/a	n/a	n/a	n/a

Ref	Works Scenario	Works Activity	Worst Case Construction Period	NCA	Type	Noise Level – LAeq(15minute) (dBA)												Noise Level – LA1(60second) (dBA) (sleep disturbance)		
						Worst-case Predicted	RBL			NML				Exceedance				Worst-case Predicted	Screening Criteria (RBL+15 dBA)	Exceedance
							Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
2.1	Main Works - Burfitt Pde	Piling Works	Standard Daytime	NCA01	RES	53	33	32	30	43	38	37	35	10	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	51	35	34	30	45	40	39	35	6	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	45	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	75	35	34	30	45	40	39	35	30	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	60	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	60	35	34	30	45	40	39	35	15	n/a	n/a	n/a	n/a	n/a	n/a
2.2		Deck Construction	Standard Daytime	NCA01	RES	49	33	32	30	43	38	37	35	6	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	47	35	34	30	45	40	39	35	2	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	41	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	71	35	34	30	45	40	39	35	26	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	56	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	56	35	34	30	45	40	39	35	11	n/a	n/a	n/a	n/a	n/a	n/a
3.1	Main Works - Platform Level (Possession)	Install Transformer	OOHW Period 2	NCA01	RES	49	33	32	30	43	38	37	35	6	11	12	14	57	45	12
				NCA02	RES	47	35	34	30	45	40	39	35	2	7	8	12	55	45	10
				NCA02	EDU	42	-	-	-	55	55	-	-	0	0	0	0	50	-	-
				NCA03	RES	72	35	34	30	45	40	39	35	27	32	33	37	80	45	35
				NCA03	COM	56	-	-	-	70	70	-	-	0	0	0	0	64	-	-
				NCA04	RES	55	35	34	30	45	40	39	35	10	15	16	20	63	45	18
3.2		Lift Excavation	OOHW Period 2	NCA01	RES	44	33	32	30	43	38	37	35	1	6	7	9	52	45	7
				NCA02	RES	46	35	34	30	45	40	39	35	1	6	7	11	54	45	9
				NCA02	EDU	39	-	-	-	55	55	-	-	0	0	0	0	47	-	-
				NCA03	RES	60	35	34	30	45	40	39	35	15	20	21	25	68	45	23
				NCA03	COM	48	-	-	-	70	70	-	-	0	0	0	0	56	-	-
				NCA04	RES	52	35	34	30	45	40	39	35	7	12	13	17	60	45	15

Ref	Works Scenario	Works Activity	Worst Case Construction Period	NCA	Type	Noise Level – LAeq(15minute) (dBA)												Noise Level – LA1(60second) (dBA) (sleep disturbance)		
						Worst-case Predicted	RBL			NML				Exceedance				Worst-case Predicted	Screening Criteria (RBL+15 dBA)	Exceedance
							Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
3.3	Main Works - Platform Level (Possession)	FRP Lift Pit	OOHW Period 2	NCA01	RES	47	33	32	30	43	38	37	35	4	9	10	12	55	45	10
				NCA02	RES	49	35	34	30	45	40	39	35	4	9	10	14	57	45	12
				NCA02	EDU	42	-	-	-	55	55	-	-	0	0	0	0	50	-	-
				NCA03	RES	64	35	34	30	45	40	39	35	19	24	25	29	72	45	27
				NCA03	COM	52	-	-	-	70	70	-	-	0	0	0	0	60	-	-
				NCA04	RES	55	35	34	30	45	40	39	35	10	15	16	20	63	45	18
3.4		Install Lift Structure	OOHW Period 2	NCA01	RES	46	33	32	30	43	38	37	35	3	8	9	11	54	45	9
				NCA02	RES	48	35	34	30	45	40	39	35	3	8	9	13	56	45	11
				NCA02	EDU	41	-	-	-	55	55	-	-	0	0	0	0	49	-	-
				NCA03	RES	62	35	34	30	45	40	39	35	17	22	23	27	70	45	25
				NCA03	COM	50	-	-	-	70	70	-	-	0	0	0	0	58	-	-
				NCA04	RES	54	35	34	30	45	40	39	35	9	14	15	19	62	45	17
3.5		Install CSR for Lift Power	OOHW Period 2	NCA01	RES	39	33	32	30	43	38	37	35	0	1	2	4	47	45	2
				NCA02	RES	41	35	34	30	45	40	39	35	0	1	2	6	49	45	4
				NCA02	EDU	34	-	-	-	55	55	-	-	0	0	0	0	42	-	-
				NCA03	RES	55	35	34	30	45	40	39	35	10	15	16	20	63	45	18
				NCA03	COM	43	-	-	-	70	70	-	-	0	0	0	0	51	-	-
				NCA04	RES	47	35	34	30	45	40	39	35	2	7	8	12	55	45	10
3.6		Lift Equipment Delivery	OOHW Period 2	NCA01	RES	48	33	32	30	43	38	37	35	5	10	11	13	56	45	11
				NCA02	RES	46	35	34	30	45	40	39	35	1	6	7	11	54	45	9
				NCA02	EDU	39	-	-	-	55	55	-	-	0	0	0	0	47	-	-
				NCA03	RES	68	35	34	30	45	40	39	35	23	28	29	33	76	45	31
				NCA03	COM	53	-	-	-	70	70	-	-	0	0	0	0	61	-	-
				NCA04	RES	52	35	34	30	45	40	39	35	7	12	13	17	60	45	15

Ref	Works Scenario	Works Activity	Worst Case Construction Period	NCA	Type	Noise Level – LAeq(15minute) (dBA)												Noise Level – LA1(60second) (dBA) (sleep disturbance)		
						Worst-case Predicted	RBL			NML				Exceedance				Worst-case Predicted	Screening Criteria (RBL+15 dBA)	Exceedance
							Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
3.7	Main Works - Platform Level (Possession)	Handrail to Walkways	OOHW Period 2	NCA01	RES	49	33	32	30	43	38	37	35	6	11	12	14	57	45	12
				NCA02	RES	47	35	34	30	45	40	39	35	2	7	8	12	55	45	10
				NCA02	EDU	41	-	-	-	55	55	-	-	0	0	0	0	49	-	-
				NCA03	RES	69	35	34	30	45	40	39	35	24	29	30	34	77	45	32
				NCA03	COM	55	-	-	-	70	70	-	-	0	0	0	0	63	-	-
				NCA04	RES	53	35	34	30	45	40	39	35	8	13	14	18	61	45	16
3.8		Platform Re-surfacing	OOHW Period 2	NCA01	RES	52	33	32	30	43	38	37	35	9	14	15	17	57	45	12
				NCA02	RES	50	35	34	30	45	40	39	35	5	10	11	15	55	45	10
				NCA02	EDU	42	-	-	-	55	55	-	-	0	0	-	-	47	-	-
				NCA03	RES	60	35	34	30	45	40	39	35	15	20	21	25	65	45	20
				NCA03	COM	45	-	-	-	70	70	-	-	0	0	-	-	50	-	-
				NCA04	RES	52	35	34	30	45	40	39	35	7	12	13	17	57	45	12
4.1	Main Works - Platform Level (Non Possession)	CSR for Station Power	Standard Daytime	NCA01	RES	42	33	32	30	43	38	37	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	43	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	34	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	56	35	34	30	45	40	39	35	11	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	43	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	48	35	34	30	45	40	39	35	3	n/a	n/a	n/a	n/a	n/a	n/a
4.2		Power Fitout	Standard Daytime	NCA01	RES	44	33	32	30	43	38	37	35	1	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	45	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	36	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	58	35	34	30	45	40	39	35	13	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	45	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	50	35	34	30	45	40	39	35	5	n/a	n/a	n/a	n/a	n/a	n/a

Ref	Works Scenario	Works Activity	Worst Case Construction Period	NCA	Type	Noise Level – LAeq(15minute) (dBA)												Noise Level – LA1(60second) (dBA) (sleep disturbance)		
						Worst-case Predicted	RBL			NML				Exceedance				Worst-case Predicted	Screening Criteria (RBL+15 dBA)	Exceedance
							Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night			
4.3	Main Works - Platform Level (Non Possession)	Amenity Fitout	Standard Daytime	NCA01	RES	44	33	32	30	43	38	37	35	1	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	41	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	34	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	52	35	34	30	45	40	39	35	7	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	36	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	44	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
4.4		Lift Fitout and Commissioning	Standard Daytime	NCA01	RES	42	33	32	30	43	38	37	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	44	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	37	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	58	35	34	30	45	40	39	35	13	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	46	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	50	35	34	30	45	40	39	35	5	n/a	n/a	n/a	n/a	n/a	n/a
4.5		Station Commissioning	Standard Daytime	NCA01	RES	41	33	32	30	43	38	37	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	RES	39	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA02	EDU	31	-	-	-	55	55	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	RES	49	35	34	30	45	40	39	35	4	n/a	n/a	n/a	n/a	n/a	n/a
				NCA03	COM	34	-	-	-	70	70	-	-	0	n/a	n/a	n/a	n/a	n/a	n/a
				NCA04	RES	41	35	34	30	45	40	39	35	0	n/a	n/a	n/a	n/a	n/a	n/a

Note 1: Worst-case predicted noise levels greater than 75 dBA are highlighted in pink and indicates highly affected receiver noise levels as defined in the ICNG.
Note 2: Predicted exceedances of the sleep disturbance screening criteria are highlighted in brown.

4.6 Discussion

4.6.1 Site establishment

Minor exceedances of the daytime NMLs are predicted for the nearest residential receivers in NCA01, NCA02, and NCA04 during most of the proposed works activities associated with site establishment, with the exception of the high noise activity works including vegetation clearing works. Vegetation clearing works are predicted to generate high exceedances the NMLs in NCA01, NCA02, and NCA04 of up to 20 dB, 16 dB, and 24 dB respectively during the use of chainsaw and chipper equipment.

In NCA03, the most potentially affected residential receivers are predicted to exceed the daytime NMLs by up to 39 dB during works activities associated with site establishment. These impacts would be limited to residential receivers located directly adjacent Glenbrook Station on Burfitt Parade which have direct line of sight to the proposed works. Impacts of this magnitude would be apparent during the use of high noise construction equipment such as chainsaws, chippers, and saws. Receivers in NCA03 which are located further away from the proposed worksite would have lower NML exceedances. For example, the predicted noise levels at the second row of receivers typically reduces by around 10 dBA compared to the front row.

Site establishment works are proposed to be undertaken during standard daytime construction hours only. The use of high noise equipment associated with vegetation clearing works is not anticipated to extend for more than a few days.

4.6.2 Main Works - Burfitt Parade

Exceedances the daytime NMLs of up to 15 dB are predicted for the nearest residential receivers in NCA01, NCA02, and NCA04 during the proposed main works activities on Burfitt Parade.

Receivers located directly adjacent the works in NCA03 are predicted to exceed the NMLs by up to 30 dB. Receivers in NCA03 which are located further away from the proposed worksite would have significantly lower NML exceedances.

The proposed main works activities on Burfitt Parade are proposed to be undertaken during standard daytime construction hours only.

4.6.3 Main works - platform level: rail possessions

Minor exceedances the standard daytime NMLs of 10 dB or less are predicted for the nearest residential receivers in NCA01, NCA02, and NCA04 during the proposed works activities associated with platform level main works. During rail possessions, when works are required to be performed during evening and night-time periods, exceedances the night-time NMLs of up to 20 dBA are predicted for the potentially most affected receivers in these NCAs.

The most potentially affected receivers in NCA03 are predicted to exceed the standard daytime NMLs by up to 27 dB. During night-time rail possessions, major exceedances of the night-time NMLs of up to 37 dBA are predicted for the potentially most affected receivers in NCA03. Receivers in NCA03 which are located further away from the proposed worksite would have significantly lower NML exceedances.

The high magnitude of impacts at the closest receivers in NCA03 is a result of their close proximity to the works (construction plant may be positioned as close as 25 metres away on the opposite side of the Burfitt Parade), and the low night-time NMLs. Night-time noise management levels are based on the background noise levels, which for this outer-city suburban region are very low compared to more urban areas.

4.6.4 Main works - platform level: non-possessions

No significant exceedances are predicted for residential receivers in NCA01 and NCA02 during most of the proposed works activities associated with non-possession platform works. At times, the receivers closest to the works in NCA04 may experience minor exceedances of the standard daytime NMLs of up to 5 dB.

Receivers located directly adjacent Glenbrook Station in NCA03 are predicted to exceed the NMLs by up to 13 dB. Receivers in NCA03 which are located further away from the proposed worksite would have significantly lower NML exceedances and receivers located over 100 metres from the station would not exceed the NML.

4.6.5 Highly noise affected receivers

Receivers are considered to be highly noise affected if noise levels from construction exceed 75 dBA $L_{Aeq(15minute)}$.

With reference to **Table 11**, very few activities are predicted to result in 'highly noise affected' receivers. Due to the close vicinity of the works to receivers directly adjacent Glenbrook Station on Burfitt Parade, worst case construction works during vegetation clearing and piling are predicted to result in daytime noise levels above 75 dBA $L_{Aeq(15minute)}$ at the nearest receivers in NCA03.

The location of receivers with potential to be highly noise affected at noise intensive times during these activities is shown in **Figure 2**.

Figure 2 Highly noise affected receivers

Figure 2 shows the location of the three residential receiver buildings that are predicted to be highly noise affected during noise intensive works. This includes two residential buildings adjacent Glenbrook Station, and one residential building on Ross Street positioned on the far side of the carpark.

4.6.6 Cumulative noise impacts

Cumulative noise impacts warrant assessment where more than one works scenario operates at the same time and in the same location such that the same receiver is impacted by noise from more than one works scenario. Generally, the proposed works are scheduled in consecutive phases and therefore cumulative noise impacts are not predicted as the assessment is controlled by noise impacts from the individual phases (as assessed).

4.7 Construction road traffic

The proposed construction activities would not generate a significant amount of construction traffic. The relatively small number of construction vehicles accessing the site is predicted to have an insignificant effect on existing road traffic noise levels and further consideration of noise impacts due to construction traffic is not required.

4.8 Construction vibration assessment

4.8.1 Vibration intensive equipment

Vibration intensive equipment is proposed during the service relocation works scenarios which include the use of jackhammers and bored piling.

Piling works are associated with several works activities. For the purpose of this assessment, it is assumed that piling works would be performed using non-vibration intensive bored piling. If the construction contractor elects to use an alternative piling method, the vibration levels generated by the use of this plant may be higher than those presented in this assessment.

4.8.2 Cosmetic damage assessment

For most sources of intermittent vibration during construction, the predominant vibration energy occurs at frequencies usually in the 10 Hz to 100 Hz range. On this basis, and with reference to BS 7385:2 and **Section 4.2**, a vibration damage screening level of 7.5 mm/s has been adopted for the purpose of assessing potential impacts from continuous vibration.

BS 7385:2 sets guide values for vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk is usually taken as 95 per cent probability of no effect.

Based on the safe working distances presented in the TfNSW CNVS, indicative vibration levels at the representative receivers are shown in **Table 12**.

Table 12 Indicative vibration levels at nearby receivers

Receiver	Approximate distance to works	Indicative Vibration Level (mm/s)[1]
NCA01	> 100 m	< 0.1 mm/s
NCA02	> 100 m	< 0.1 mm/s
NCA03	25 m	0.1 mm/s
NCA04	> 100 m	< 0.1 mm/s

Note 1: Estimated from the safe working distances specified in TfNSW CNVS and assumed dense rock.

The information presented in **Table 12** indicates that the separation distance from the nearest receivers is sufficient to mitigate the potential impacts. As such it is considered that structural or cosmetic damage impacts from vibration intensive works are unlikely for the adjacent receivers.

4.8.3 Human comfort vibration assessment

In relation to human comfort (response), the safe working distances in **Section 4.2.4** relate to continuous vibration and apply to **residential** receivers. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are permitted, as discussed in *Assessing Vibration - a technical guideline*.

Based on the safe working distances in **Section 4.2.4**, and the distance of the proposed works to nearby sensitive receivers outlined in **Table 12**, the proposed works are expected to comply with the human comfort vibration criteria at all residential receivers.

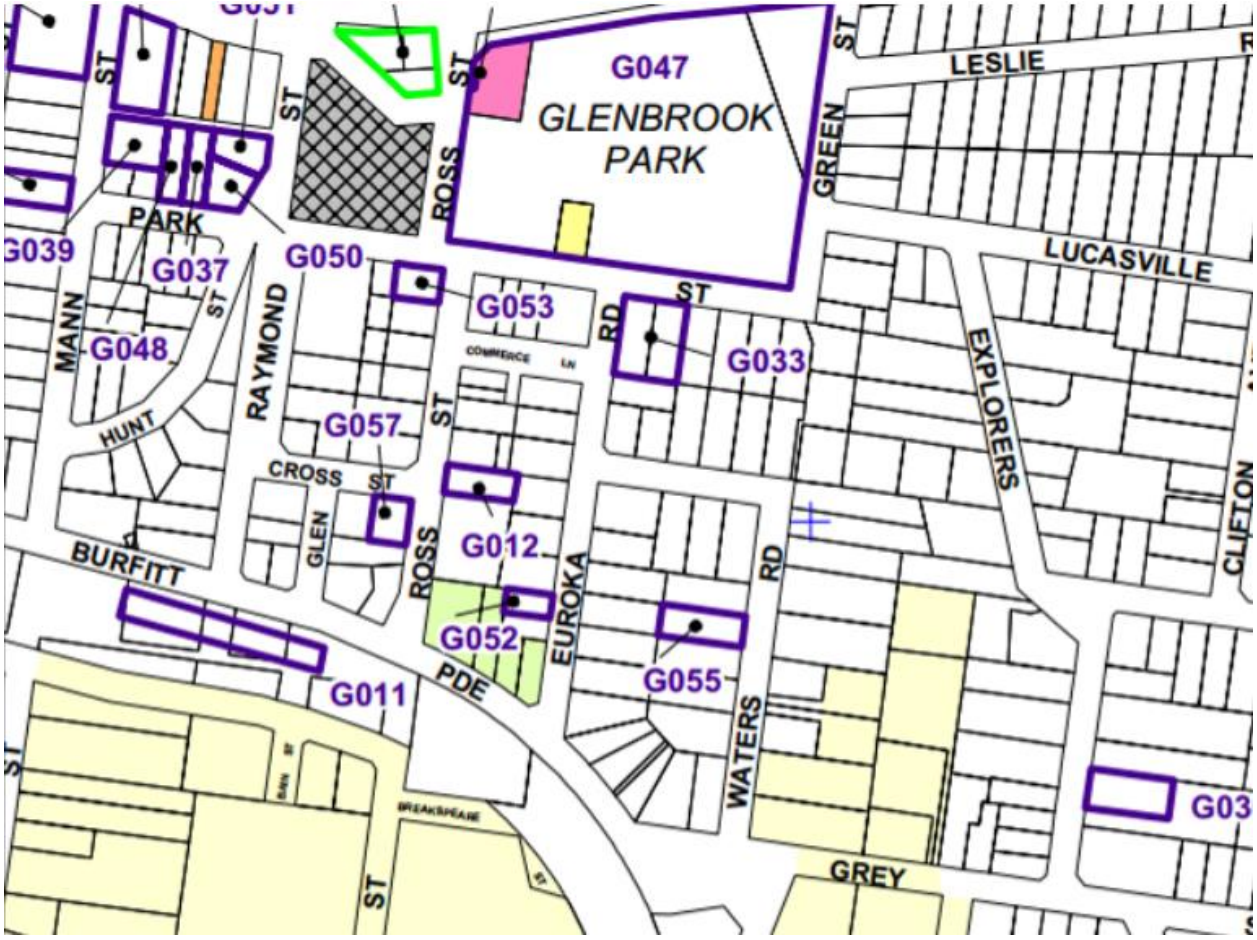
4.8.4 Heritage buildings

At this stage in the Proposal, the following heritage listed structures have been identified within approximately 100m of the proposed works involving vibration-generating plant described in **Section 4.8.1**. These locations are shown in **Figure 3**.

Table 13 Heritage listed structures within 100 metres of vibration generating works

LEP Designation	Address	Description
G011	Burfitt Parade, Glenbrook	Select railway station buildings
G057	3 Ross Street, Glenbrook	Australia Post - Post Office
G052	15 Euroka Road, Glenbrook	Residential house

Figure 3 Blue Mountains Local Environmental Plan 2005



BS 7385 states that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Heritage buildings are to be considered on a case by case bases. Where a historic building is deemed to be sensitive to damage from vibration (following inspection), it is recommended to reduce the vibration criteria accordingly in line with the TfNSW CNVS. The more conservative DIN 4150 superficial cosmetic damage criteria of 2.5 mm/s should be considered for vibration sensitive structures. Where heritage buildings of a typical residential-type construction are not found to be structurally unsound, DIN 4150 superficial cosmetic damage criteria of 5 mm/s may be more suitable as a screening criterion.

The separation distance between the proposed equipment and the above non-station heritage items on Ross Street and Euroka Road would be sufficient to mitigate vibration levels from the use of vibration plant described in **Section 4.8.1** such that the DIN4150 criteria is not exceeded.

Where vibration intensive works are required to be undertaken within the specified safe working distances outlined in **Section 4.2.4**, or in close proximity to vibration sensitive heritage structures such as the station building and existing footbridge, vibration monitoring should be undertaken to ensure acceptable levels of vibration are satisfied.

5 Construction noise and vibration mitigation measures

5.1 Standard mitigation measures

Particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies as per the standard mitigation measures detailed in the ICNG.

Reference can also be made to the Transport for NSW (TfNSW) Construction Noise and Vibration Strategy (CNVS) which detail a number of standard mitigation measures for construction activities likely to result in adverse noise or vibration impacts associated with infrastructure projects.

Where identified in the impact assessment, particular effort should be directed towards the implementation of all feasible and reasonable noise mitigation and management strategies, noting that additional site specific measures may also be recommended.

Standard mitigation measures which may be considered appropriate for the Proposal, as taken from the CNVS, are shown in **Table 14**.

Table 14 Recommended standard noise mitigation measures

Action required	Applies to	Details
Management measures		
Implementation of any project specific mitigation measures required	Airborne noise. Ground-borne noise and vibration	In addition to the measures set out in this table, any *project specific* mitigation measures identified in the environmental assessment documentation (eg Environmental Impact Statement, Review of Environmental Factors, submissions or representations report) or approval or licence conditions must be implemented
Implement community consultation measures	Airborne noise. Ground-borne noise and vibration	Periodic Notification (monthly letterbox drop)[1] Website Project information and construction response telephone line Email distribution list Place Managers

Action required	Applies to	Details
Register of Noise Sensitive Receivers	Airborne noise Ground-borne noise and vibration	A register of all noise and vibration sensitive receivers (NSRs) would be kept on site. The register would include the following details for each NSR: • address of receiver • category of receiver (eg Residential, Commercial etc.) • contact name and phone number
Site inductions	Airborne noise Ground-borne noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height; throwing of metal items; and slamming of doors. No excessive revving of plant and vehicle engines Controlled release of compressed air.
Monitoring	Airborne noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels satisfy the criteria for that vibration generating activity. Where there is potential for exceedances of the criteria further vibration site law (ie the site-specific reduction in vibration level with distance) investigations would be undertaken to determine the site-specific safe working distances for that vibration generating activity. Continuous vibration monitoring with audible and visible alarms would be conducted at the nearest sensitive receivers whenever vibration generating activities need to take place inside the applicable safe-working distances.
Construction respite period	Ground-borne noise and vibration Airborne noise	High noise and vibration generating activities[2] may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block[3].
Source controls		
Construction hours and scheduling	Airborne noise Ground-borne noise and vibration	Works are only proposed to occur during Standard Construction Hours. Work generating high noise and/or vibration levels would be scheduled during less sensitive time periods.
Equipment selection	Airborne noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable.

Action required	Applies to	Details
Maximum noise levels	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the criteria in Table 11 (of the CNVS).
Rental plant and equipment	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table 11 (of the CNVS).
Plan worksites and activities to minimise noise and vibration	Airborne noise Ground-borne vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work.
Path controls		
Shield stationary noise sources such as pumps, compressors, fans etc	Airborne noise	Stationary noise sources would be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained where necessary. Appendix F of AS 2436: 1981 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where necessary) and consideration of site topography when situating plant.

Note 1 Detailing all upcoming construction activities at least 14 days prior to commencement of relevant works.
Note 2 Includes jack and rock hammering, sheet and pile driving, rockbreaking and vibratory rolling.
Note 3 "Continuous" includes any period during which there is less than a 60 minutes respite between ceasing and recommencing any of the work.

5.2 Additional noise mitigation measures

Additional noise mitigation measures to be explored in the CNVMPs in the event of predicted exceedances of the noise goals, particularly during Out of Hours Works (OOHWs), are described in the Transport for NSW *Construction Noise and Vibration Strategy* (CNVS). This strategy includes definition of the level of noise impact which triggers consideration of each additional mitigation measure (reproduced in **Table 15**).

The additional mitigation measures described in the CNVS are summarised below, with discussion of their potential applicability to these works. The objective of these additional noise mitigation measures is to engage, inform and provide project-specific messages to the community, recognising that advanced warning of potential disruptions can assist in reducing the impact.

- **Periodic Notifications** – Periodic notifications include regular newsletters, letterbox drops or advertisements in local papers to provide an overview of current and upcoming works and other topics of interest
- **Website** – The project website would form a resource for members of the community to seek further information, including noise and vibration management plans and current and upcoming construction activities

- **Project Info-line and Construction Response Line** – Transport for NSW operate a Construction Response Line and Project Info-line. These numbers provide a dedicated 24 hour contact point for any complaints regarding construction works and for any project enquiries. All complaints require a verbal response within two hours. All enquiries require a verbal response within 24 hours during standard construction hours, or on the next working day during out of hours work (unless the enquirer agrees otherwise)
- **Email Distribution List** – An email distribution list would be used to disseminate project information to interested stakeholders
- **Signage** – Signage on construction sites would be provided to notify stakeholders of project details and project emergency or enquiry information
- **Specific Notifications (SN)** – Specific notifications would be letterbox dropped or hand distributed to the nearby residences and other sensitive receivers no later than seven days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications, or to advertise unscheduled works
- **Phone Calls (PC)** – Phone calls may be made to identified/affected stakeholders within seven days of proposed work
- **Individual Briefings (IB)** – Individual briefings may be used to inform stakeholders about the impacts of high noise activities and mitigation measures that would be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities
- **Monitoring (M)** – Ongoing noise monitoring during construction at sensitive receivers during critical periods would be used to identify and assist in managing high risk noise events. Monitoring of noise would also be undertaken in response to complaints. All noise monitoring would be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, who is familiar with the requirements of the relevant standards and procedures
- **Project Specific Respite Offer (RO)** – Residents subjected to lengthy periods of noise or vibration may be eligible for a project specific respite offer. The purpose of such an offer is to provide residents with respite from an ongoing impact
- **Alternative Accommodation (AA)** – As described in the Transport for NSW *Construction Noise Strategy*, provision of alternative accommodation for residents would be considered in the event that highly intrusive noise impacts are predicted during the night-time period (between 10pm and 7am).

Table 15 Additional mitigation measures matrix – Airborne construction noise (TfNSW Construction Noise and Vibration Strategy)

Time period	Receiver perception	dBA above RBL	dBA above NML	Additional management measures
Standard Mon-Fri (7am - 6pm) Sat (8am - 1pm) Sun/Pub Hol (Nil)	Noticeable	5 to 10	0	-
	Clearly Audible	>10 to 20	<10	-
	Moderately Intrusive	>20 to 30	>10 to 20	PN, V
	Highly Intrusive	>30	>20	PN, V
	Above 75 dBA	N/A	N/A	PN, V, SN
OOHW Period 1 Mon-Fri (6pm - 10pm) Sat (7am - 8am) & (1pm - 10pm) Sun/Pub Hol. (8am - 6pm)	Noticeable	5 to 10	<5	-
	Clearly Audible	>10 to 20	5 to 15	PN
	Moderately Intrusive	>20 to 30	>15 to 25	PN, V, SN, RO
	Highly Intrusive	>30	>25	PN, V, SN, RO, RP, DR
OOHW Period 2 Mon-Fri (10pm - 7am) Sat (10pm - 8am) Sun/Pub Hol. (6pm - 7am)	Noticeable	5 to 10	<5	PN
	Clearly Audible	>10 to 20	5 to 15	PN, V
	Moderately Intrusive	>20 to 30	>15 to 25	PN, V, SN, RP, DR
	Highly Intrusive	>30	>25	PN, V, SN, AA, RP, DR

Notes: PN = Project notification, SN = Specific notification, individual briefings, or phone call, V = Verification of monitoring, AA = Alternative accommodation, DR = Duration Reduction RO = Project specific respite offer, RP = Respite Period

5.3 Additional vibration mitigation measures

No construction vibration impacts are predicted for non-station sensitive receivers surrounding the Proposal. As such vibration mitigation is only required to manage exceedances of the building damage criteria, particularly for Glenbrook Station heritage listed structures.

Where the vibration management levels for building damage may be exceeded, vibration monitoring should be conducted to determine site specific minimum working distances. Alternative construction methodologies may need to be considered where it is not possible to complete the works within the building damage vibration management levels. The additional mitigation measures described in the CNVS are summarised below in **Table 16**.

Table 16 Additional mitigation measures matrix – Construction vibration (TfNSW Construction Noise Strategy Revision 4)

Time Period	Receiver Perception	Vibration Management Level	Additional Management Measures
Standard Mon-Fri (7am - 6pm) Sat (8am - 1pm) Sun/Pub Hol (Nil)	Human comfort	Exceeds HVML	PN, V, RO
	Building damage	Exceeds DVML	V, AC
OOHW Period 1 Mon-Fri (6pm - 10pm) Sat (7am - 8am) & (1pm - 10pm) Sun/Pub Hol. (8am - 6pm)	Human comfort	Exceeds HVML	PN, V, SN, RO, RP, DR
	Building damage	Exceeds DVML	V, AC
OOHW Period 2 Mon-Fri (10pm - 7am) Sat (10pm - 8am) Sun/Pub Hol. (6pm - 7am)	Human comfort	Exceeds HVML	PN, V, SN, RO, AA, RP, DR
	Building damage	Exceeds DVML	V, AC

Notes: PN = Project notification SN = Specific notification, individual briefings, or phone call, V = Verification of monitoring, AA = Alternative accommodation, DR = Duration Reduction, RO = Project specific respite offer, RP = Respite Period, AC = Alternative construction methodology

5.4 Summary of additional mitigation

Based on the predicted noise levels in **Section 4.5**, additional mitigation measures as per the requirements shown in **Table 15** have been determined for works during the proposed construction hours. The extent of additional mitigation measures are representative of the worst-case construction activities with the daytime and night-time affected receiver areas shown **Figure 4** and **Figure 5** respectively.

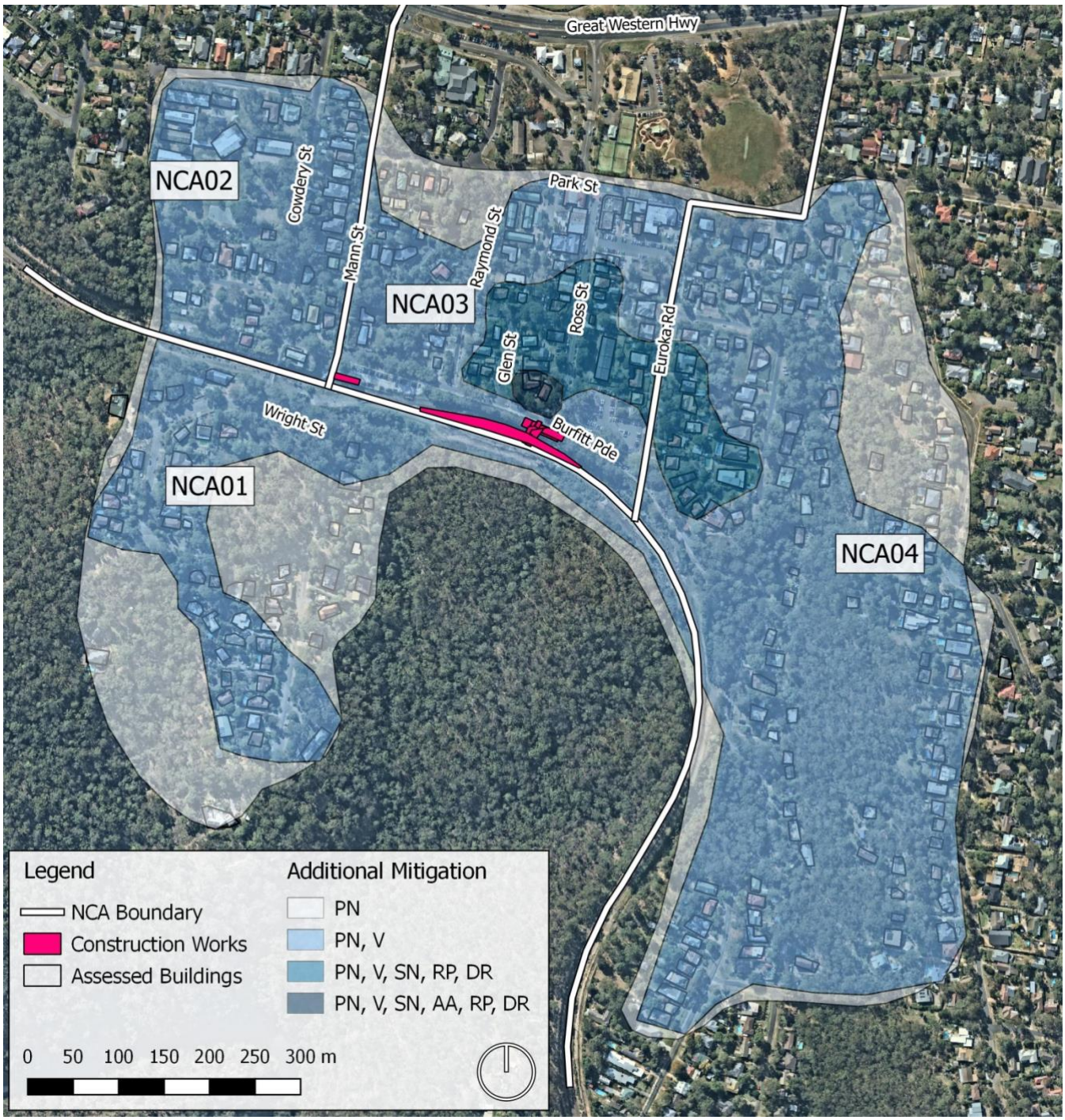
Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified, it may be beneficial to increase the work duration, number of evenings or nights worked so that the project can be progressed and completed in a shorter timeframe. The approach to respite periods would be confirmed during preparation of the CNVMP and consultation with the community.

Figure 4 Additional mitigation summary - Standard daytime

Notes: PN = Project notification SN = Specific notification, individual briefings, or phone call, V = Verification of monitoring

Additional mitigation measures are required for daytime works at residential receivers to the north and northeast of Glenbrook Station. These mitigation requirements are a result of construction activities with high noise plant such as chippers.

Figure 5 Additional mitigation summary - Out of hours period 2 works



Notes: PN = Project notification SN = Specific notification, individual briefings, or phone call, V = Verification of monitoring, AA = Alternative accommodation, DR = Duration Reduction, RO = Project specific respite offer, RP = Respite Period, AC = Alternative construction methodology

Additional mitigation measures are required for out of hours works at residential receivers surrounding the Proposal. These mitigation measures mostly involve project notification and verification monitoring during both OOHW period 1 and OOHW period 2. Receivers located to the north and northeast of Glenbrook Station require consideration of additional measures with two residential receivers located immediately opposite the works qualifying for consideration alternative accommodation for works during the OOHW period 2. Where works are proposed over a possession weekend, mitigation measures to address the OOHW period 2 impacts would cover the requirements of the OOHW period 1 for those works. The extent of impacts would depend on the finalised possession activities and would be confirmed in a CNVIS for the possession activities and managed in accordance with the CNVMP.

6 Operational noise assessment

6.1 NPfI trigger noise levels

The EPA has regulatory responsibility for the control of noise from 'scheduled premises' under the *Protection of the Environment Operations Act 1997*. In implementing the NPfI, the EPA has two broad objectives:

- controlling intrusive noise levels in the short term
- maintaining noise amenity levels for particular land uses over the medium to long-term.

In general terms, the NPfI sets out procedures for establishing the project intrusiveness $L_{Aeq(15minute)}$ and project amenity $L_{Aeq(period)}$ noise levels, with a view to determining the lower (that is, the more stringent) being the Project Trigger Noise Level (PTNL), NPfI Section 2.1 states:

> *The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited and amenity is protected and that no single industry can unacceptably change the noise level of an area.*

For assessing intrusiveness, the existing background noise generally needs to be measured. The intrusiveness trigger level essentially means that the equivalent continuous noise level (L_{Aeq}) of the source should not be more than 5 dBA above the measured (or default) Rating Background Level (RBL).

The amenity assessment is based on amenity noise levels specific to the land use and associated activities. The project noise levels relate only to industrial-type noise and do not include road, rail or community-related noise. Based on the NPfI land use descriptions residences surrounding the development have been classified for the purposes of this noise assessment as 'Suburban'.

Applicable PTNLs for all noise sensitive receiver areas surrounding the Proposal have been established with reference to the NPfI and are contained in **Table 17**.

Table 17 Project Trigger Noise Levels

Type of receiver	Noise amenity area	NCA	Time of day	Measured level, dBA		Project Trigger Noise Level, dBA		
				RBL[1]	LAeq(period)	Intrusive	Amenity	**Overall**
Residential	Suburban	NCA01	Day	35[1]	50	40	50	**40**
			Evening	32	52	37	40	**37**
			Night	30[1]	51	35	35	**35**
		NCA02 to NCA04	Day	35	52	40	50	**40**
			Evening	34	52	39	40	**39**
			Night	30[1]	50	35	35	**35**

Note 1: Minimum 35 dBA daytime and 30 dBA evening / night-time RBL in accordance with the NPfI.

Note 2: Project Intrusive is the RBL plus 5 dB

Note 3: Project amenity (period) noise level is the Amenity Criteria minus 5 dB.

Note 5: Resulting PTNL is the lower of the project intrusive and the project amenity noise levels.

6.2 Operational noise sources

The key identified fixed noise sources associated with the station upgrade include a new power transformer and a new station lift with capacity to carry up to 17 passengers. The new transformer would be installed on the western side of the station entry footpath and the new lift would be installed at the end of the concourse connecting the station platform to provide access to the footbridge. The position of the new transformer and lift is displayed in **Figure 6**.

Figure 6 Position of New Mechanical Plant

6.3 Operational noise source management

At this stage of the design specific transformer and lift systems have not been selected, which means it is too early to assess compliance with the applicable noise criteria. However given this type of noise source generally has relatively low noise emissions, it an anticipated that the transformer and lift system designs could be relatively easily mitigated if required during the detailed phase of the Proposal through the selection of appropriate equipment. The applicable criteria for operational noise from the new station lift shown in Table 17.

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 less-obtrusive noise sources at the same level. To account for this additional annoyance, the NPfI describes modifying factors to be applied when assessing amenity and intrusiveness. It assumed that the new noise sources would not exhibit these characteristics if designed and constructed in accordance with industry best practice procedures.

The station upgrade has potential for minor modifications to existing noise producing plant such as the relocation of HVAC system components. Given that the specifications for new mechanical plant and reconfigurations of existing plant will not be available or finalised until the detailed design phase of the Proposal, this assessment is limited to setting the applicable noise criteria. Compliance with the criteria would be assessed at the detailed design phase of the Proposal and form part of the detailed design documentation.

Cumulative noise impacts from all Glenbrook Station noise sources should be assessed in the detailed design stage when selecting specific equipment locations and models for the lift facilities.

APPENDIX A

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

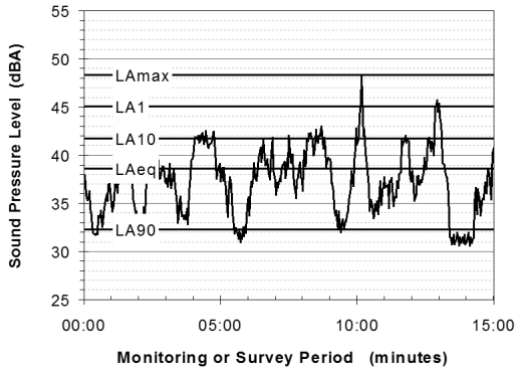
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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. 7. Impulsiveness

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

6 Frequency Analysis

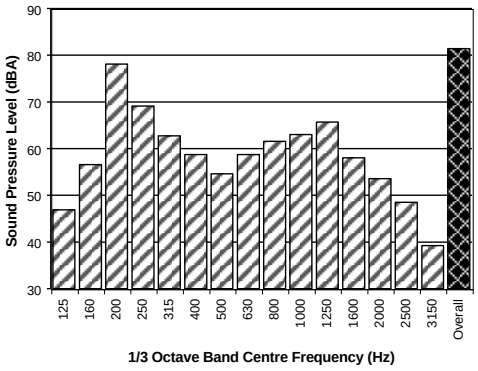
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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.



7 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_0), where V_0 is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

8 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.

9 Over-Pressure

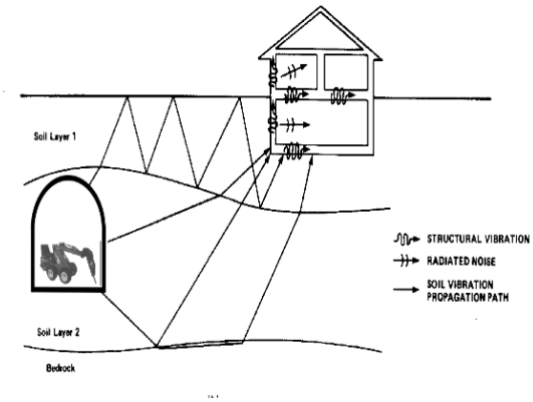
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

10 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

Ambient Noise Monitoring Results

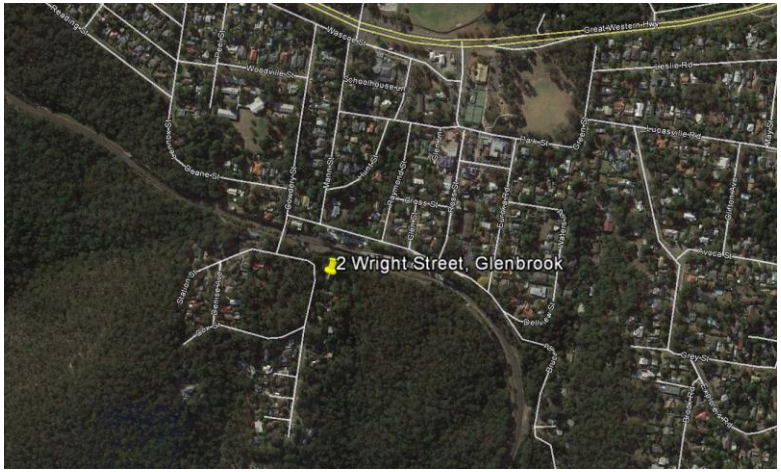
Noise Monitoring Location	L01	Map of Noise Monitoring Location
Noise Monitoring Address	**2 Wright Street, Glenbrook**	

Logger Device Type: ARL EL215/316, Logger Serial No: 16-306-039
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2414604

Ambient noise logger deployed at residential address 2 Wright Street, Glenbrook. Logger located with view of Burfitt Parade and the Western Rail Line to the north and Wright St and Station St to the west.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Station St and Wright St to the south. Train passbys on the Western Line contribute to the LAeq at this location.

Recorded Noise Levels (LAmax):
23/07/2018: Light-vehicle traffic Station/Wright St: 63-66 dBA, Train passby Western Rail Line: 68 dBA, Birds: 57-67 dBA, Animals: 56 dBA



Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	33	51	48	59
Evening	32	52	45	59
Night-time	26	51	41	50

Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	51	55
Night-time (10pm-7am)	51	56

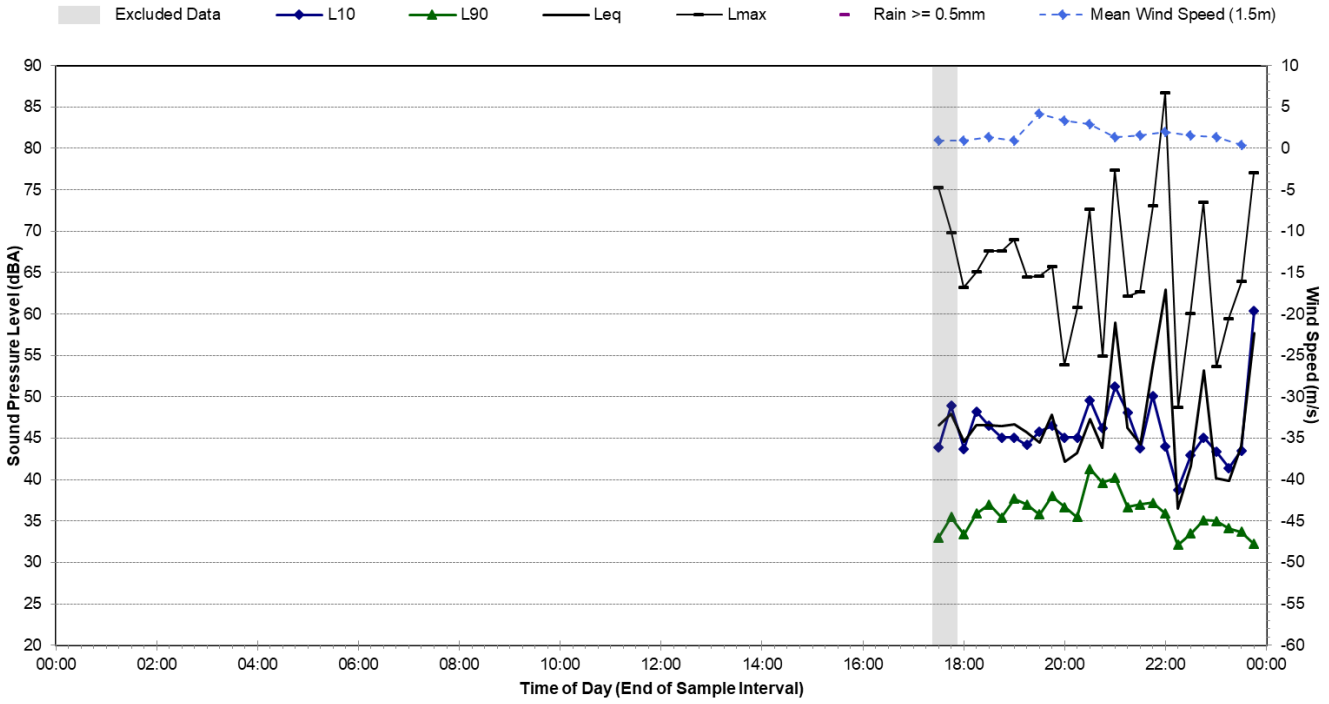
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
23/07/2018	16:50	36	50	73

Photo of Noise Monitoring Location

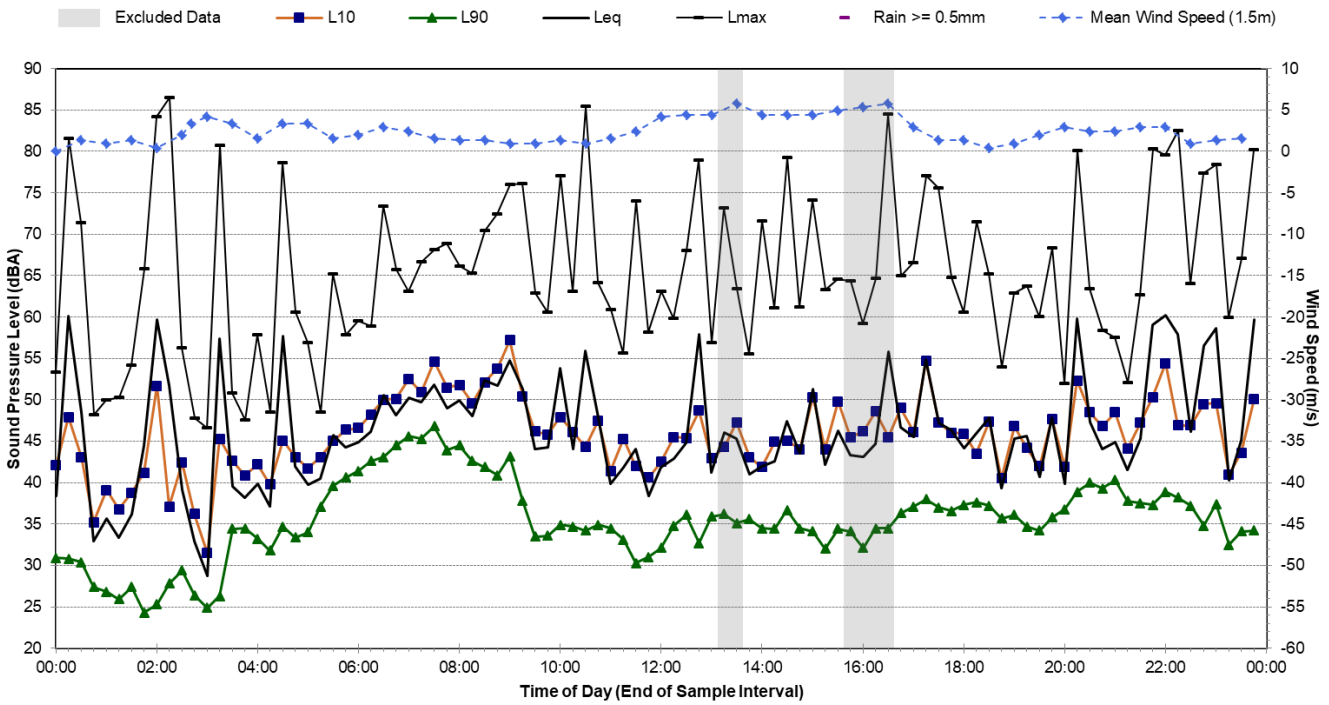
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Monday, 23 July 2018



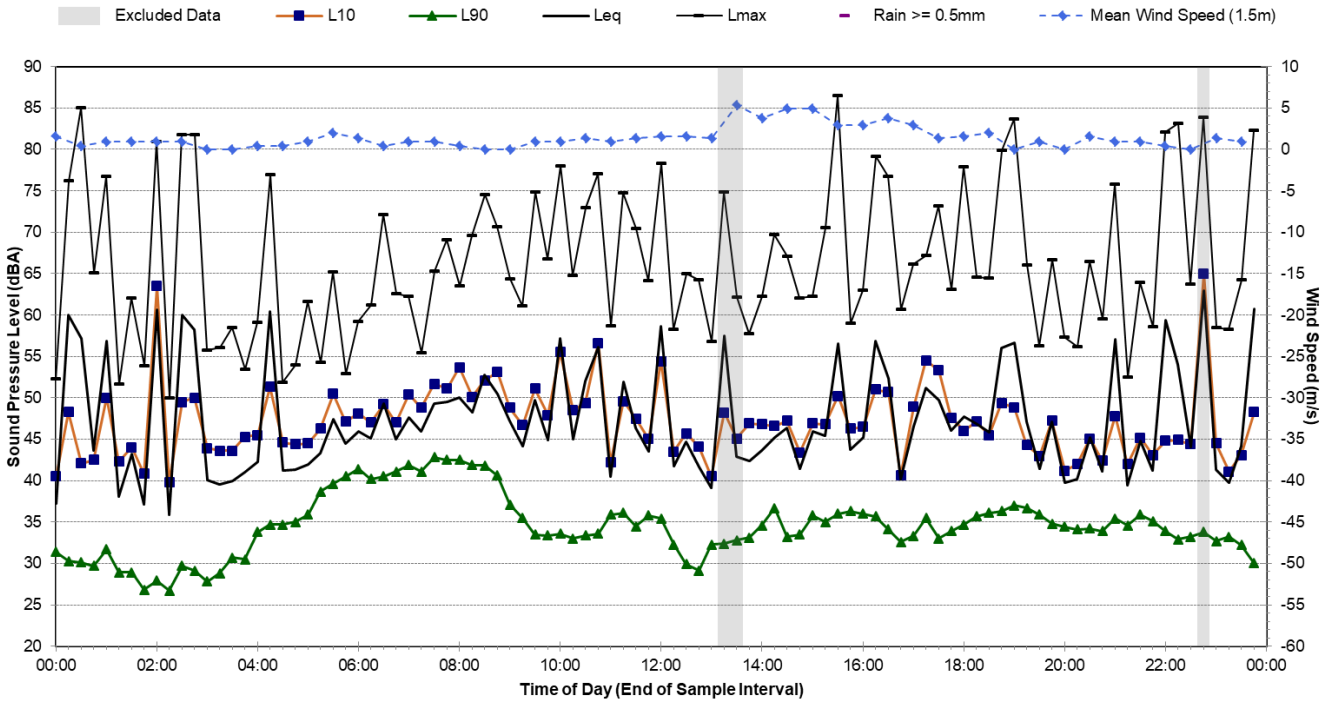
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Tuesday, 24 July 2018



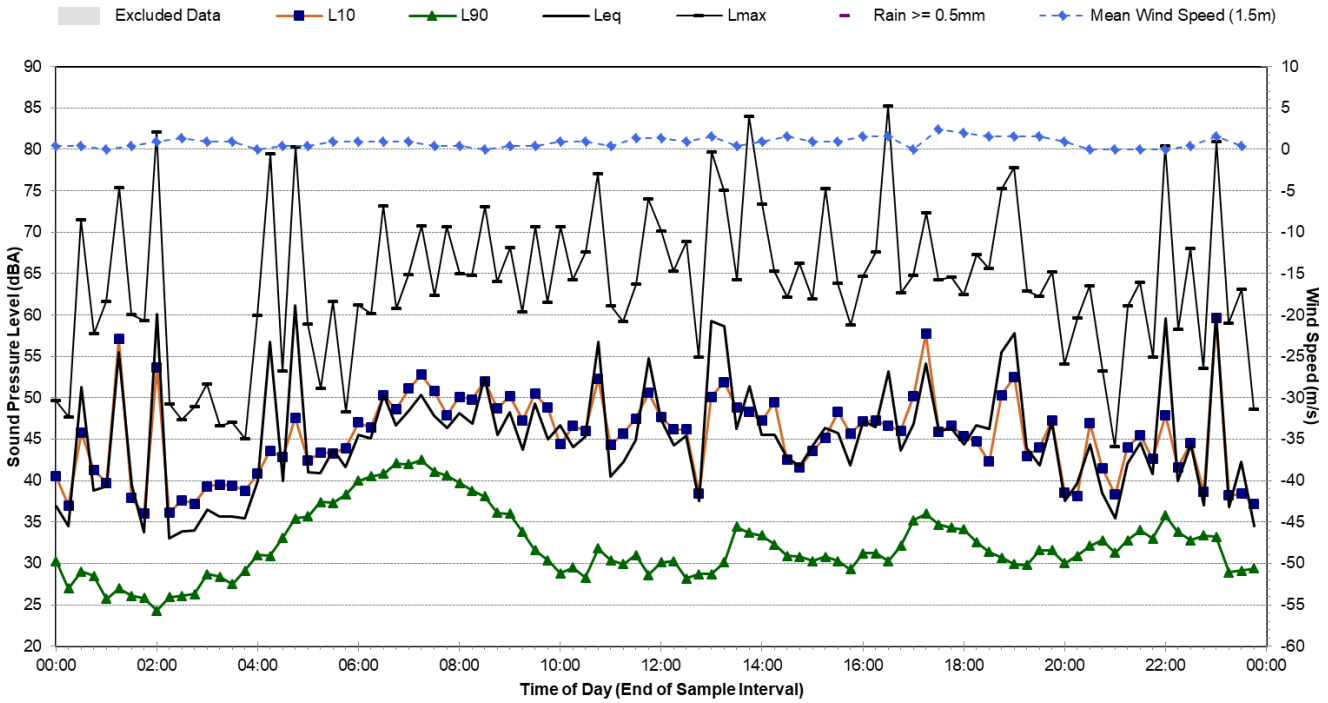
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Wednesday, 25 July 2018



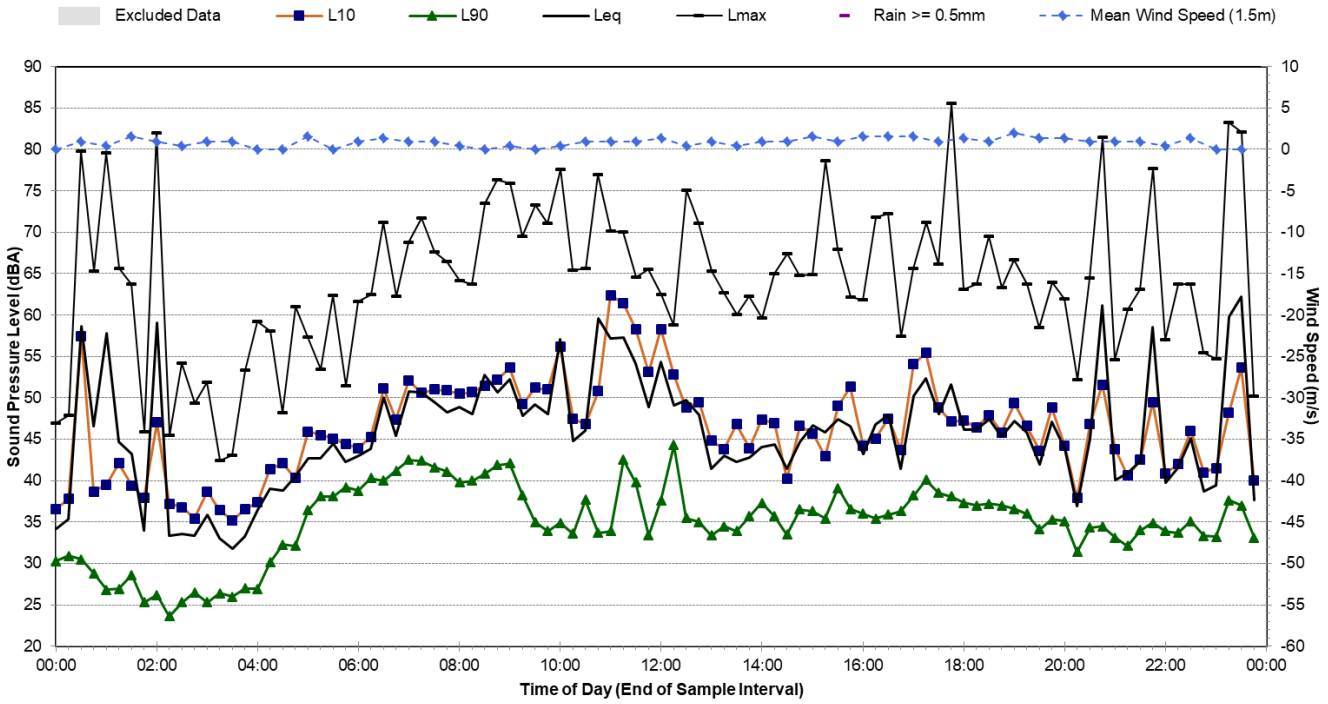
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Thursday, 26 July 2018



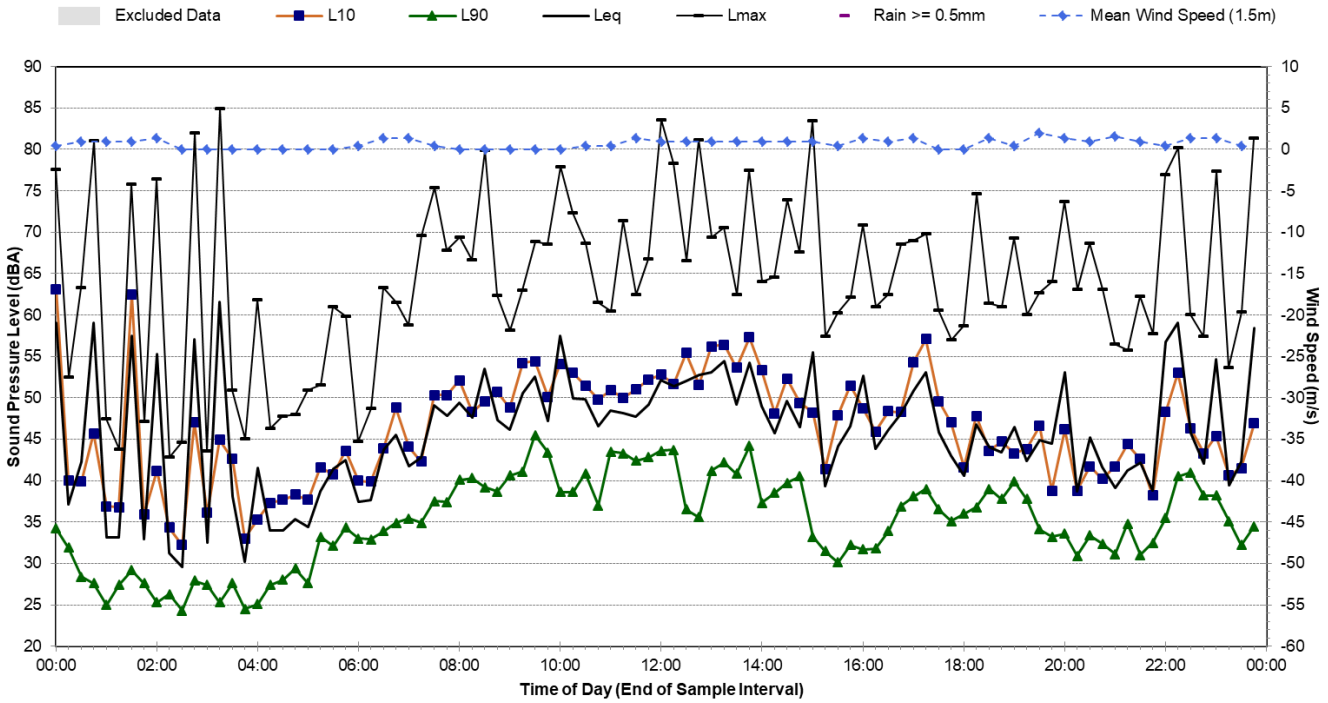
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Friday, 27 July 2018



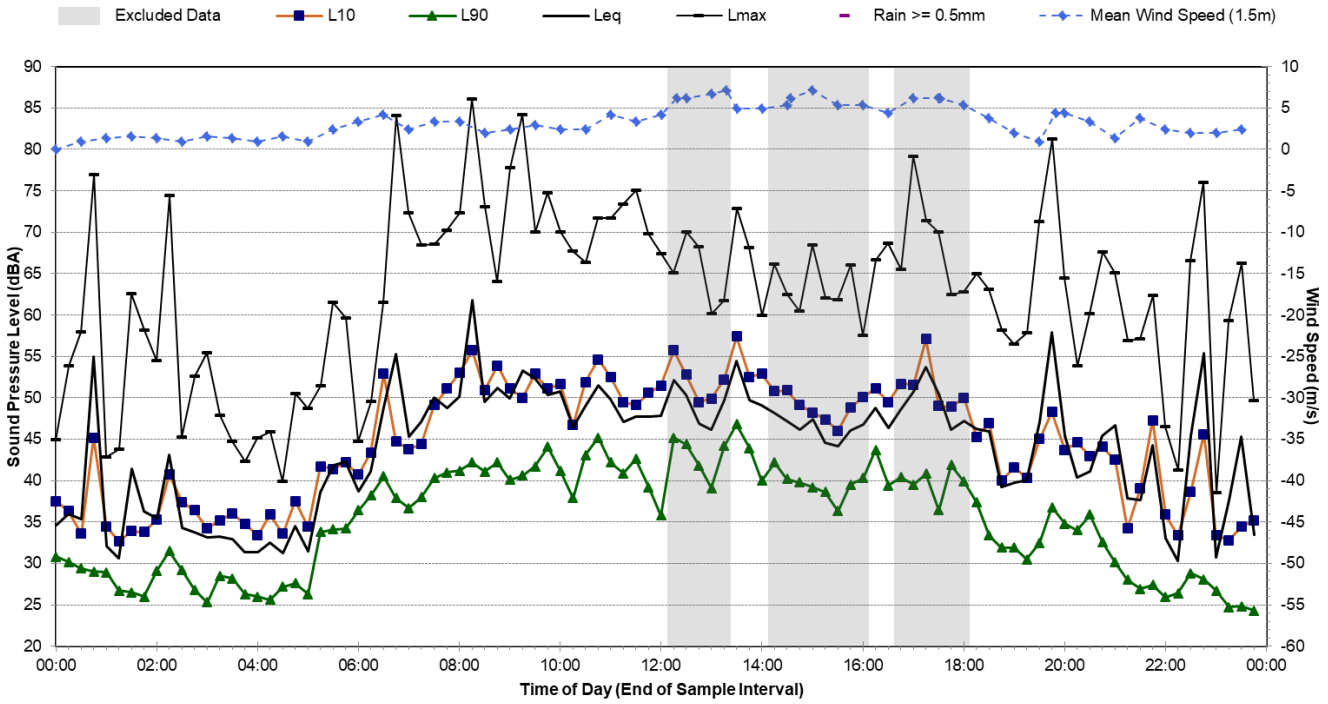
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Saturday, 28 July 2018



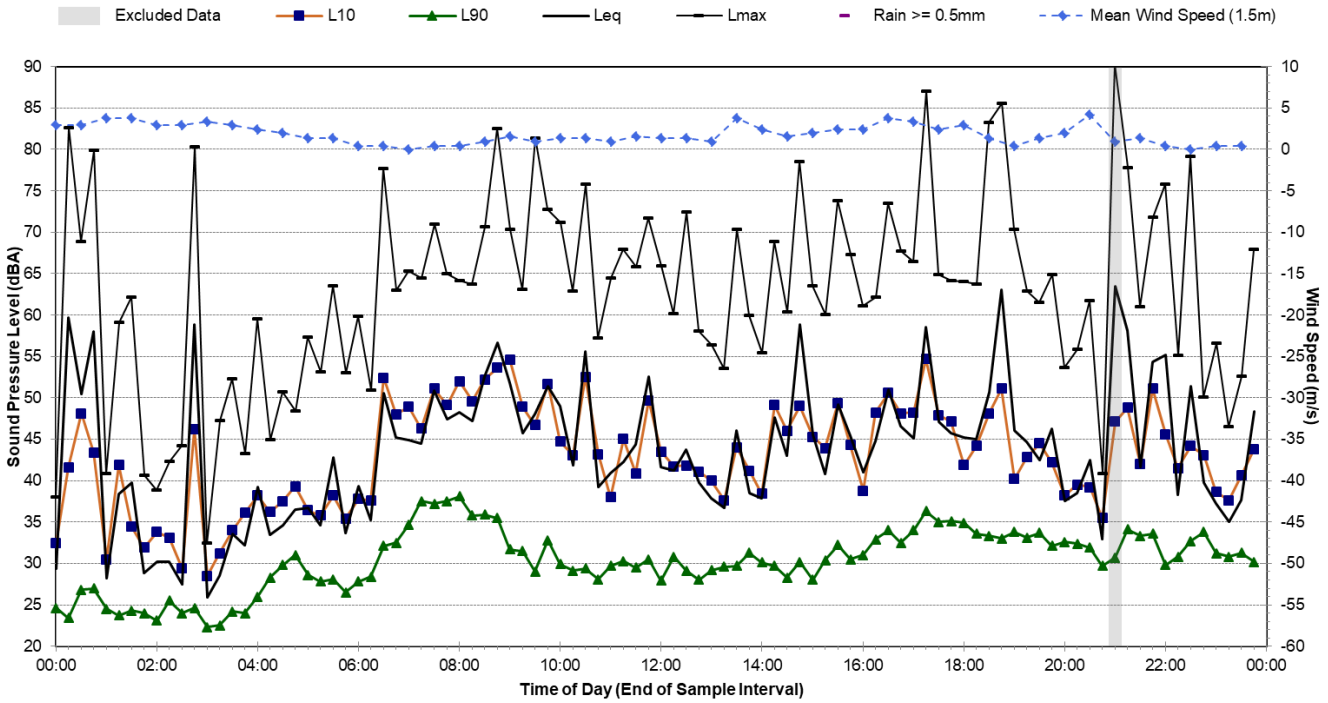
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Sunday, 29 July 2018



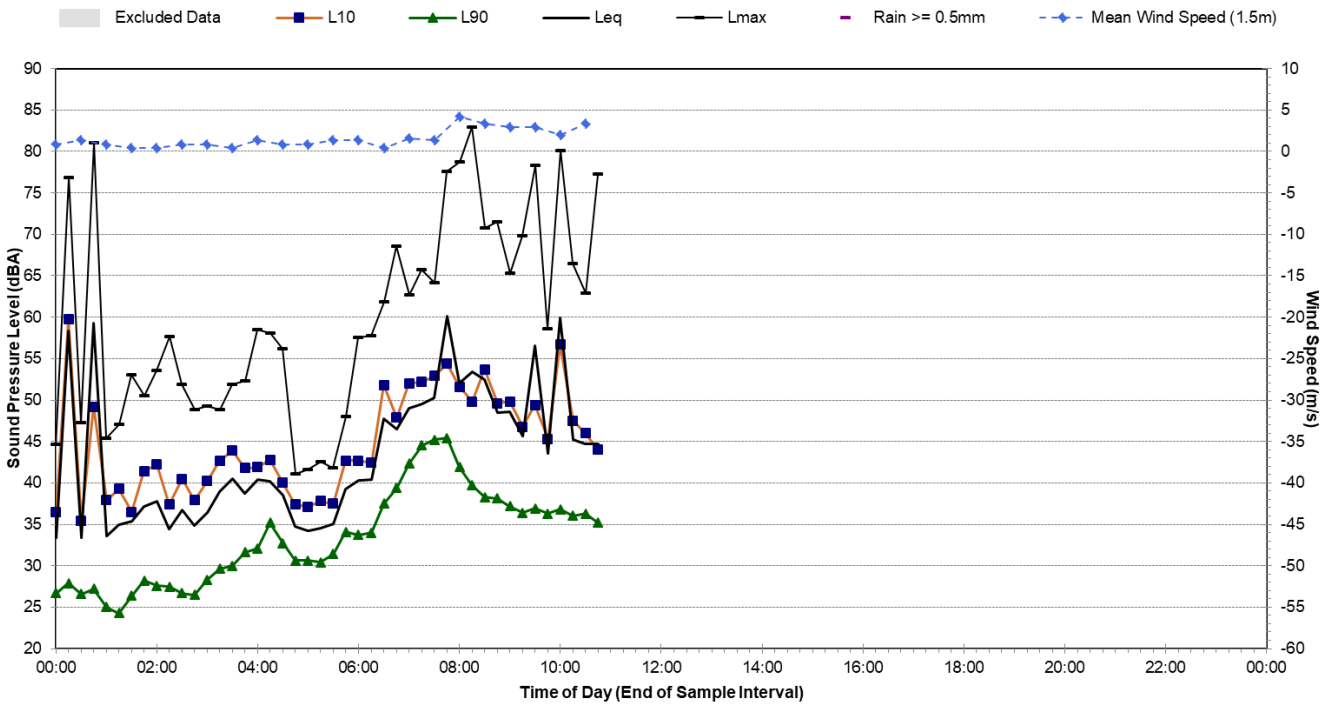
Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Monday, 30 July 2018



Statistical Ambient Noise Levels

2 Wright Street, Glenbrook - Tuesday, 31 July 2018



Noise Monitoring Location	L02	Map of Noise Monitoring Location
Noise Monitoring Address	**11 Burfitt Parade, Glenbrook**	

Logger Device Type: ARL EL215/316, Logger Serial No: 16-306-041
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2414604

Ambient noise logger deployed at residential address 11 Burfitt Parade, Glenbrook. Logger located with view of Burfitt Parade and the Western Rail Line to the south and Mann St and Station St to the west.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Burfitt Pde and Mann St to the south and west respectively. Train passbys on the Western Line contribute to the LAeq at this location.

Recorded Noise Levels (LAmax):
23/07/2018: Light-vehicle traffic Burfitt Pde/Mann St: 62-84 dBA, Train passby Western Rail Line: 67-70 dBA, Birds: 54-66 dBA, Motorbike: 68 dBA

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	35	52	52	59
Evening	34	52	48	56
Night-time	26	50	41	51

Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	52	56
Night-time (10pm-7am)	50	55

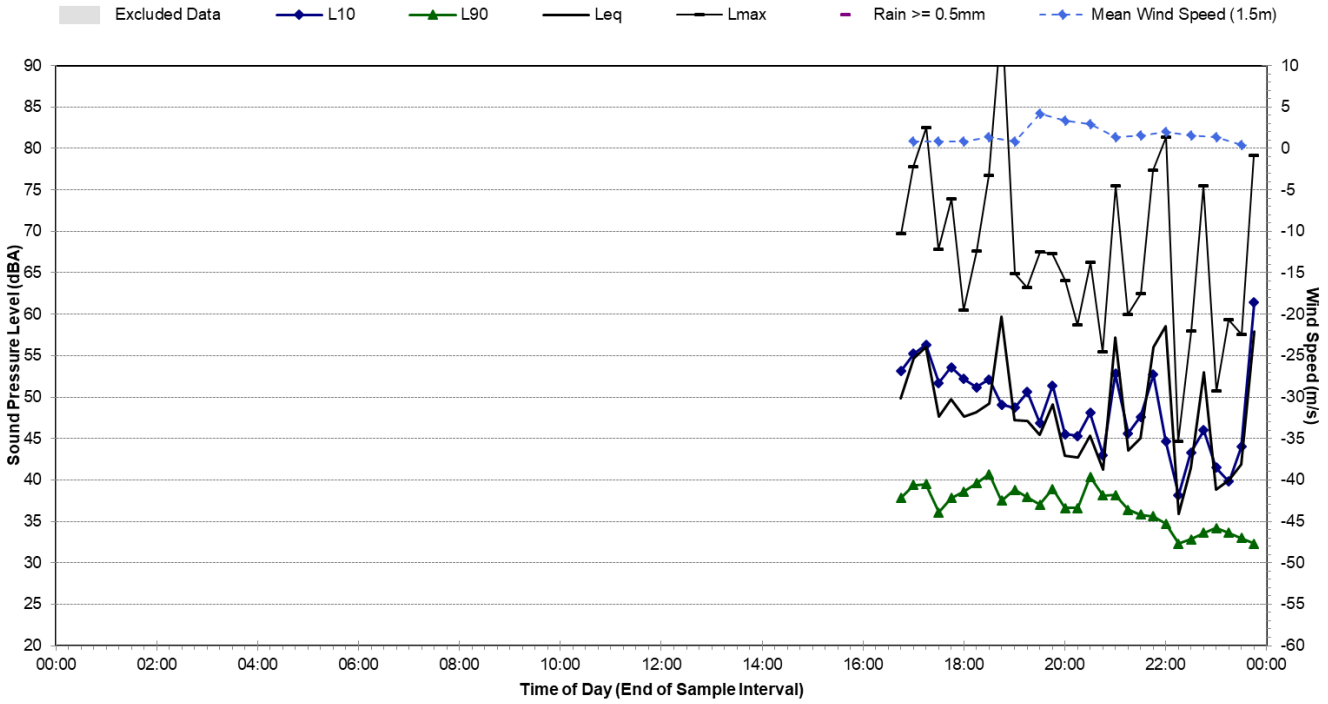
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
23/07/2018	16:05	37	50	70

Photo of Noise Monitoring Location

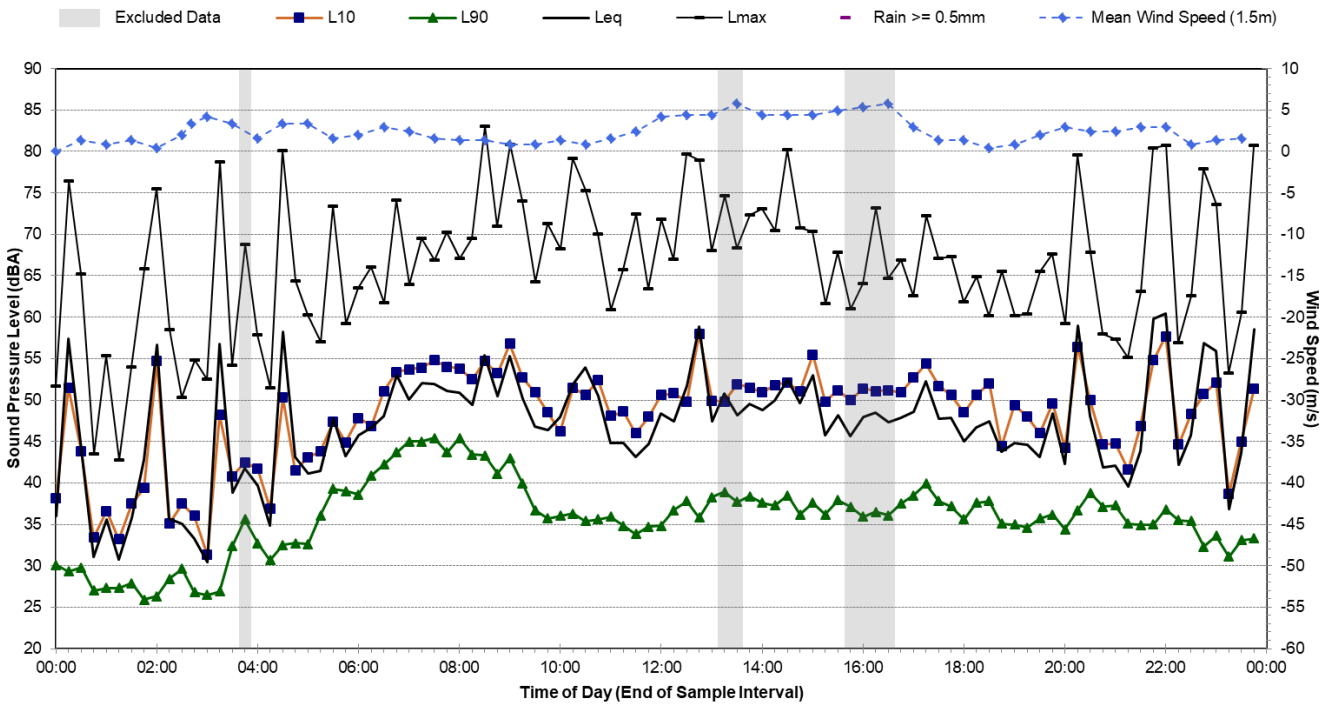
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Monday, 23 July 2018



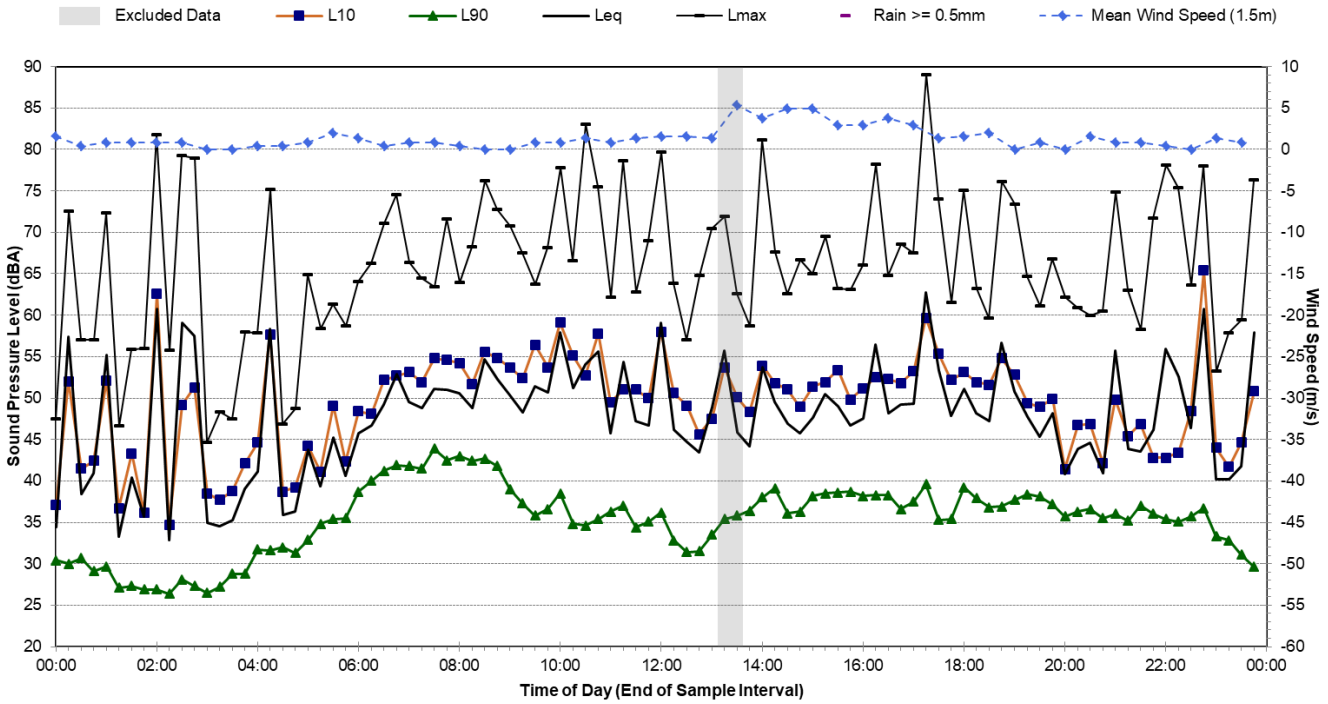
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Tuesday, 24 July 2018



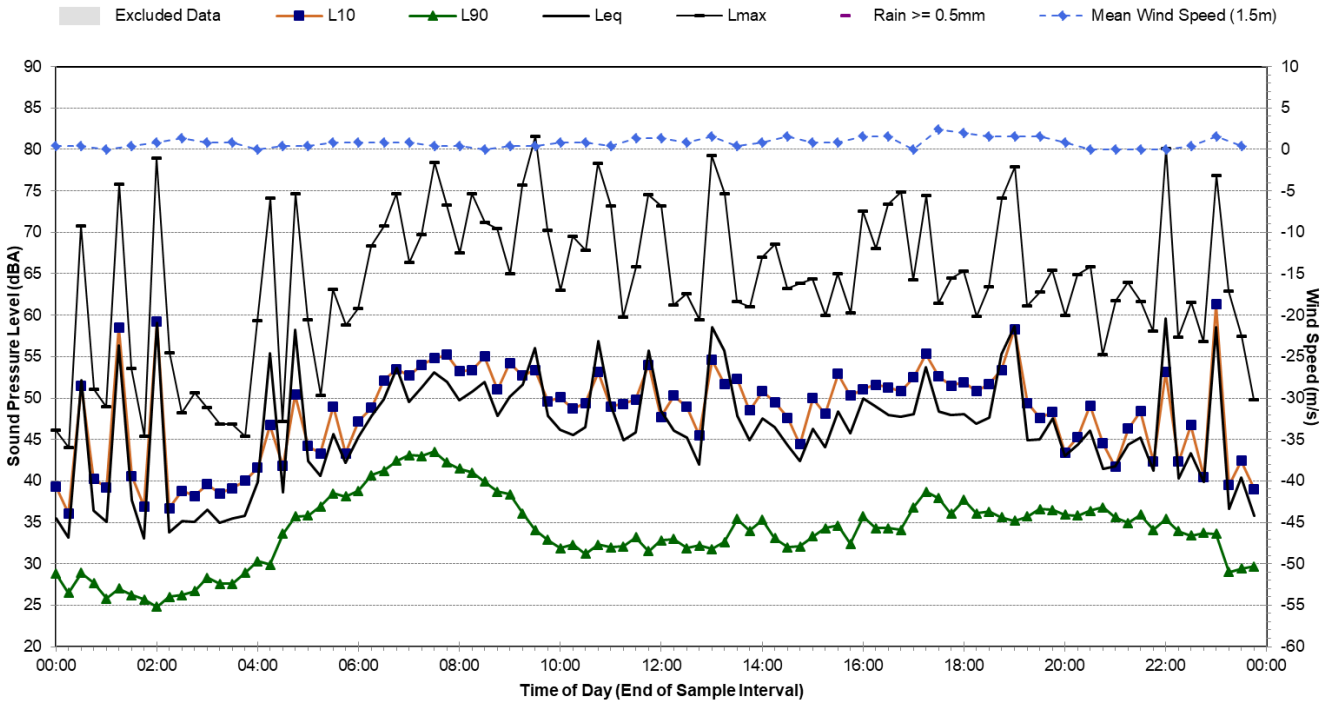
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Wednesday, 25 July 2018



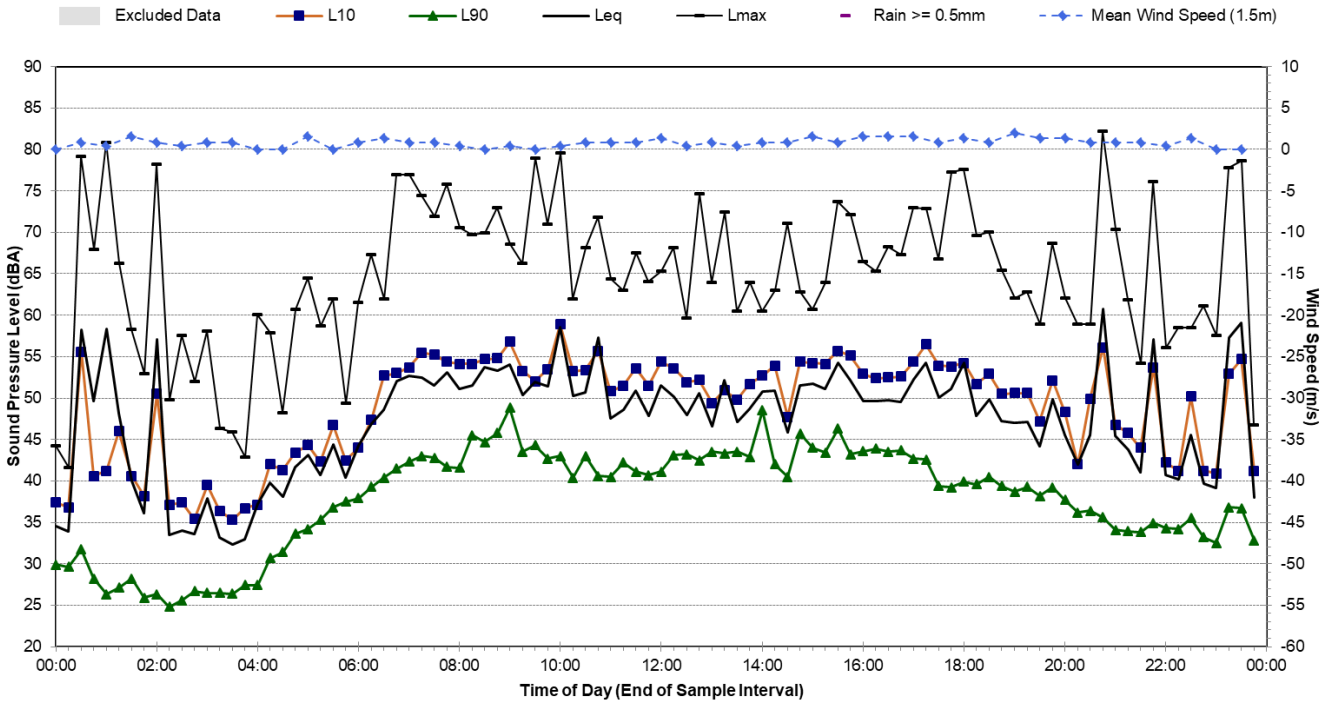
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Thursday, 26 July 2018



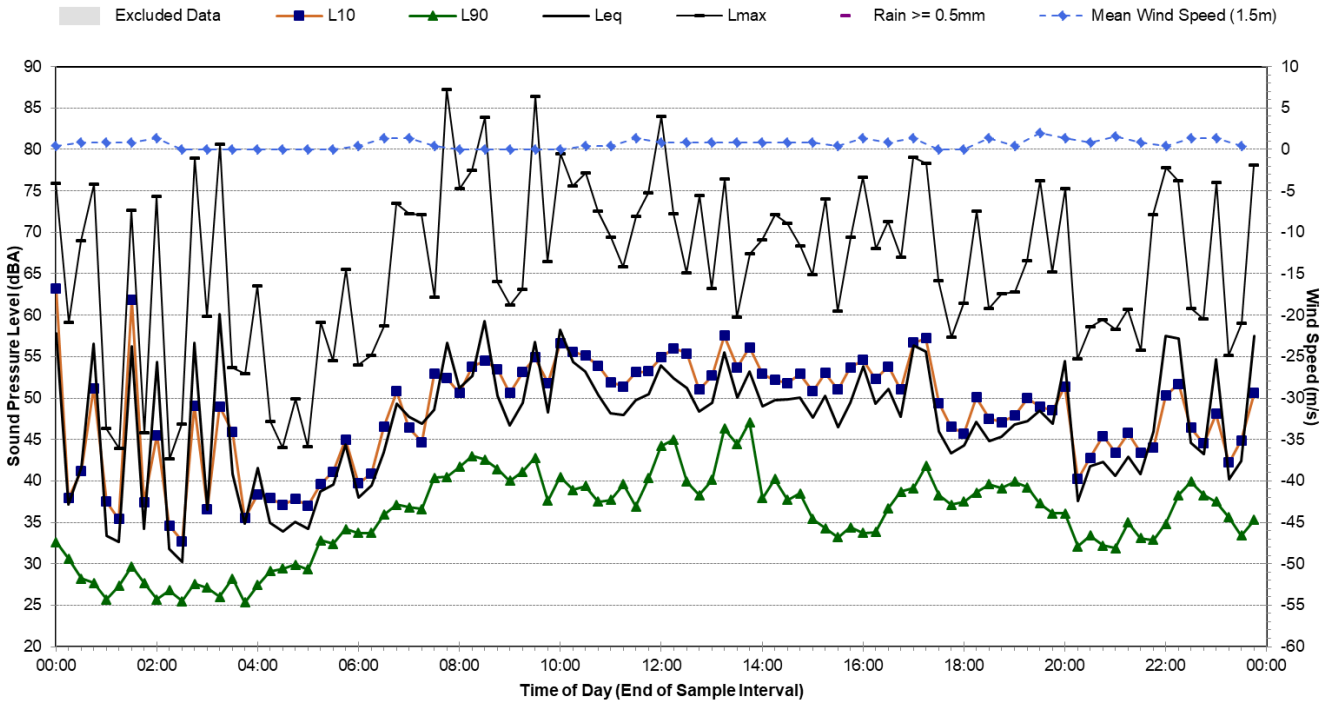
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Friday, 27 July 2018



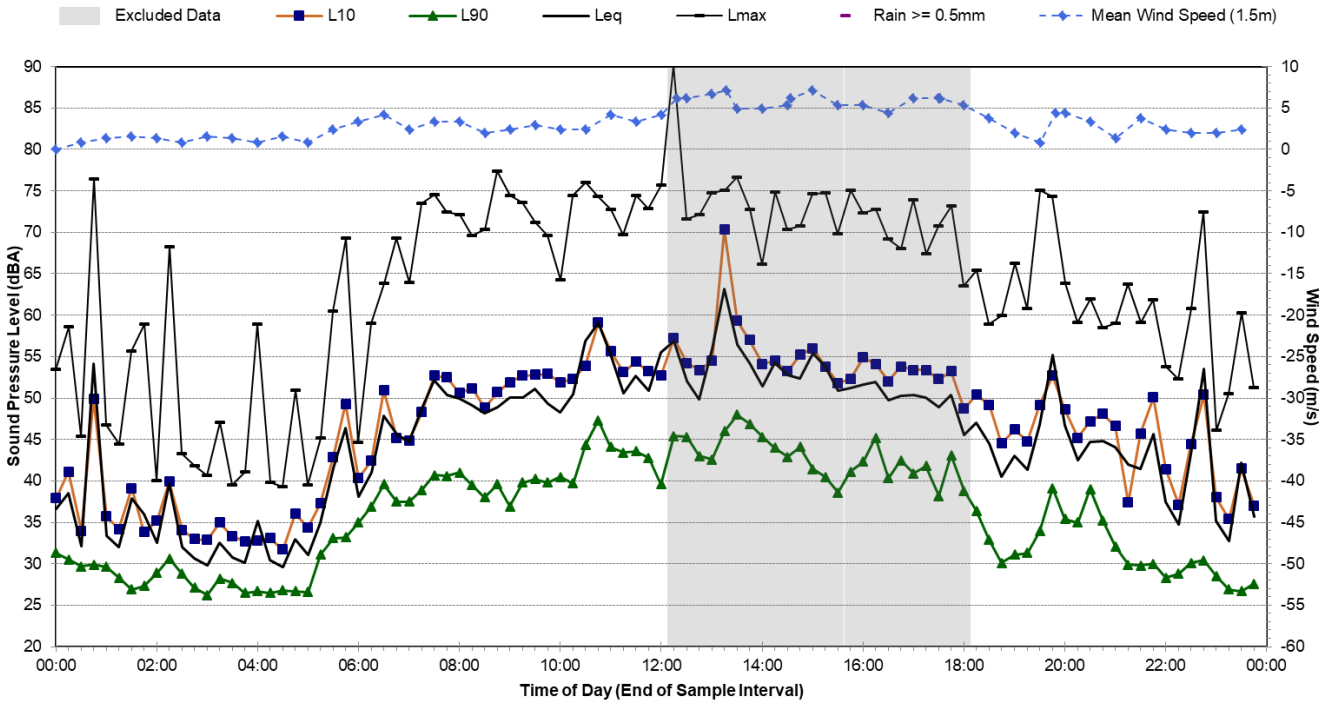
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Saturday, 28 July 2018



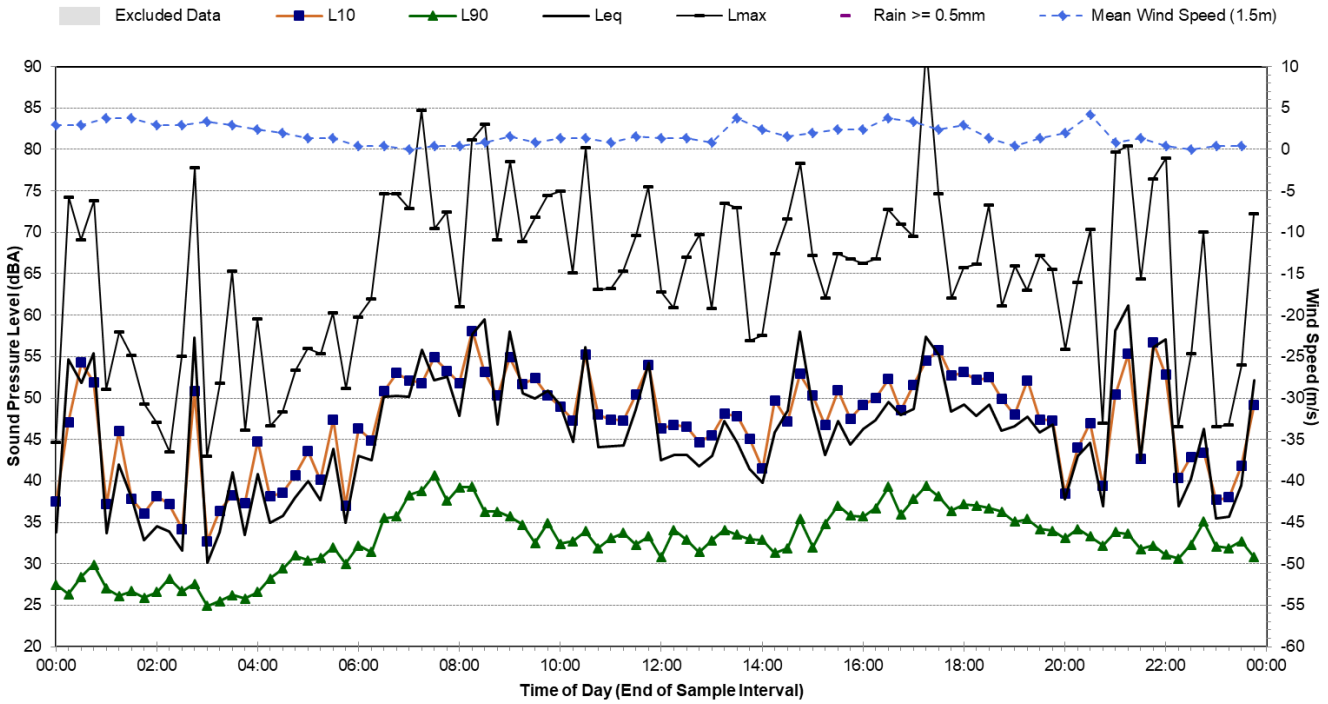
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Sunday, 29 July 2018



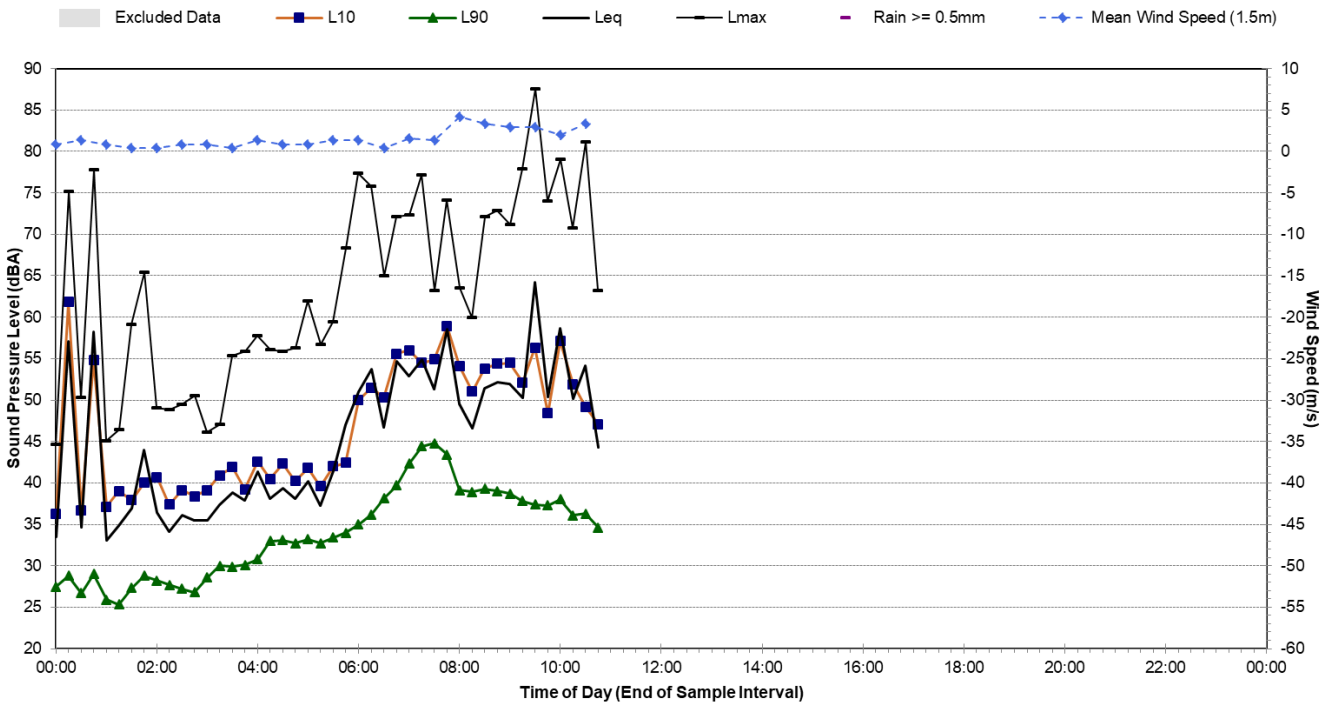
Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Monday, 30 July 2018



Statistical Ambient Noise Levels

11 Burfitt Parade, Glenbrook - Tuesday, 31 July 2018



ASIA PACIFIC OFFICES

BRISBANE
Level 2, 15 Astor Terrace
Spring Hill QLD 4000
Australia
T: +61 7 3858 4800
F: +61 7 3858 4801

CANBERRA
GPO 410
Canberra ACT 2600
Australia
T: +61 2 6287 0800
F: +61 2 9427 8200

DARWIN
5 Foelsche Street
Darwin NT 0800
Australia
T: +61 8 8998 0100
F: +61 2 9427 8200

GOLD COAST
Ground Floor, 194 Varsity Parade
Varsity Lakes QLD 4227
Australia
M: +61 438 763 516

MACKAY
21 River Street
Mackay QLD 4740
Australia
T: +61 7 3181 3300

MELBOURNE
Suite 2, 2 Domville Avenue
Hawthorn VIC 3122
Australia
T: +61 3 9249 9400
F: +61 3 9249 9499

NEWCASTLE
10 Kings Road
New Lambton NSW 2305
Australia
T: +61 2 4037 3200
F: +61 2 4037 3201

PERTH
Ground Floor, 503 Murray Street
Perth WA 6000
Australia
T: +61 8 9422 5900
F: +61 8 9422 5901

ROCKHAMPTON
rockhampton@slrconsulting.com
M: +61 407 810 417

SYDNEY
2 Lincoln Street
Lane Cove NSW 2066
Australia
T: +61 2 9427 8100
F: +61 2 9427 8200

TAMWORTH
PO Box 11034
Tamworth NSW 2340
Australia
M: +61 408 474 248
F: +61 2 9427 8200

TOWNSVILLE
Level 1, 514 Sturt Street
Townsville QLD 4810
Australia
T: +61 7 4722 8000
F: +61 7 4722 8001

AUCKLAND
68 Beach Road
Auckland 1010
New Zealand
T: +64 27 441 7849

NELSON
5 Duncan Street
Port Nelson 7010
New Zealand
T: +64 274 898 628

NEW PLYMOUTH
Level 2, 10 Devon Street East
New Plymouth 4310
New Zealand
T: +64 0800 757 695