Noise and Vibration Impact Assessment

Huntlee Stage 2

Huntlee Pty Ltd

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Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
2.0	21 June 2024	Jonathan Caine	Martin Davenport	Martin Davenport

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Huntlee Pty Ltd (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.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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

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1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Swan Project Advisory Pty Ltd (the Client) on behalf of Huntlee Pty Ltd to conduct a transport noise impact assessment to accompany the development application for the development of the Huntlee New Town Stage 2 project, within the Singleton Council and Cessnock City Council Local Government Areas.

The proposal has been declared a State Significant Development (SSD) (SSD 70748466) by the Minister for Planning under Section 4.36(3) of the *Environmental Planning and Assessment Act 1979*.

The following report uses specialist acoustic terminology. An explanation of common terms is provided in **Appendix A.**

2.0 Development Overview

This report supports an Environmental Impact Statement and State Significant Development Application (SSDA) that seeks consent for the Huntlee New Town Stage 2 development, comprising the concept development for the Stage 2 sites including Villages 2 and 3, land off Old North Road and the Town Centre North area, and the detailed development for the central and southern areas of Village 2 The proposal represents the next phase of an extensive planning, assessment and consultation process completed to date for the development of the Huntlee New Town site.

Specifically, this SSDA proposes the following works for the Huntlee New Town:

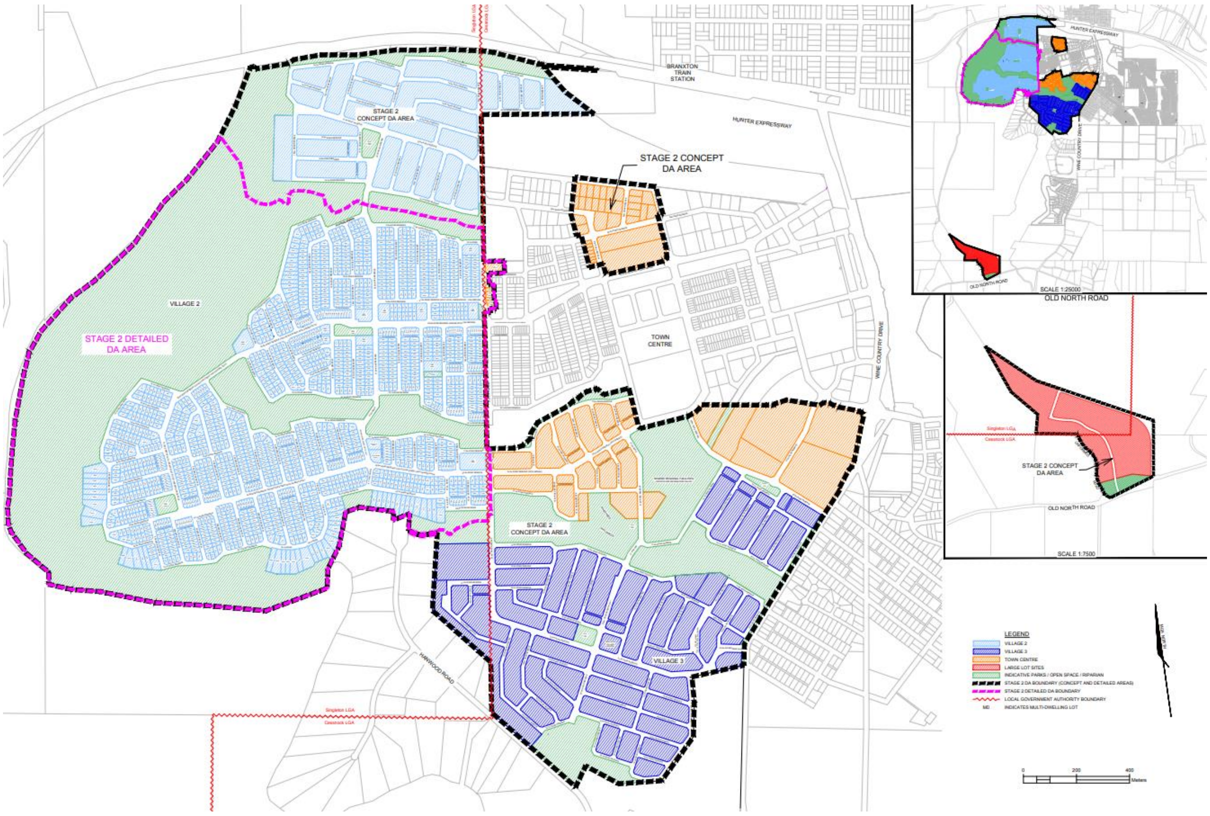
- A Concept Master plan for the Stage 2 site, comprising:
- Overall Stage 2 development footprint, including:
    - The remaining Town Centre North area,
    - Villages 2 and 3, and
    - A large lot residential area located to the south of the site on Old North Road;
- Proposed land use and development yield, including the provision for residential subdivision of approximately 5,000 lots;
- Associated new road network and required upgrades to existing network~~;~~
- Site-wide open space and riparian areas;
- Detailed development of Village 2 Central and South and eastern connection to the Town Centre, comprising:
- Demolition and clearing of existing built form structures;
- Clearing of existing vegetation within proposed development footprints;
- Open space, recreation, community and riparian areas;
- Construction of road and access infrastructure;
- Bulk earthworks;
- Stormwater and drainage works;
- Utilities and services, including
    - Sewer and potable water reticulation;

    - Electricity and communications infrastructure;

- Subdivision to facilitate approximately 1,750 lots across the Village 2 Central and South areas and Town Centre development lots, comprising approximately 1,730 residential lots, eight (8) medium density superlots, two (2) commercial/mixed use lots and open space areas; and
- Select clearing and grading to establish temporary Asset Protection Zones where development interfaces with the Concept Master plan area.

Figure 1 demonstrates the location of the Stage 2 Concept and Detailed areas, in the context of the surrounding development.

Figure 1 Proposed Concept and Detailed Area Layout



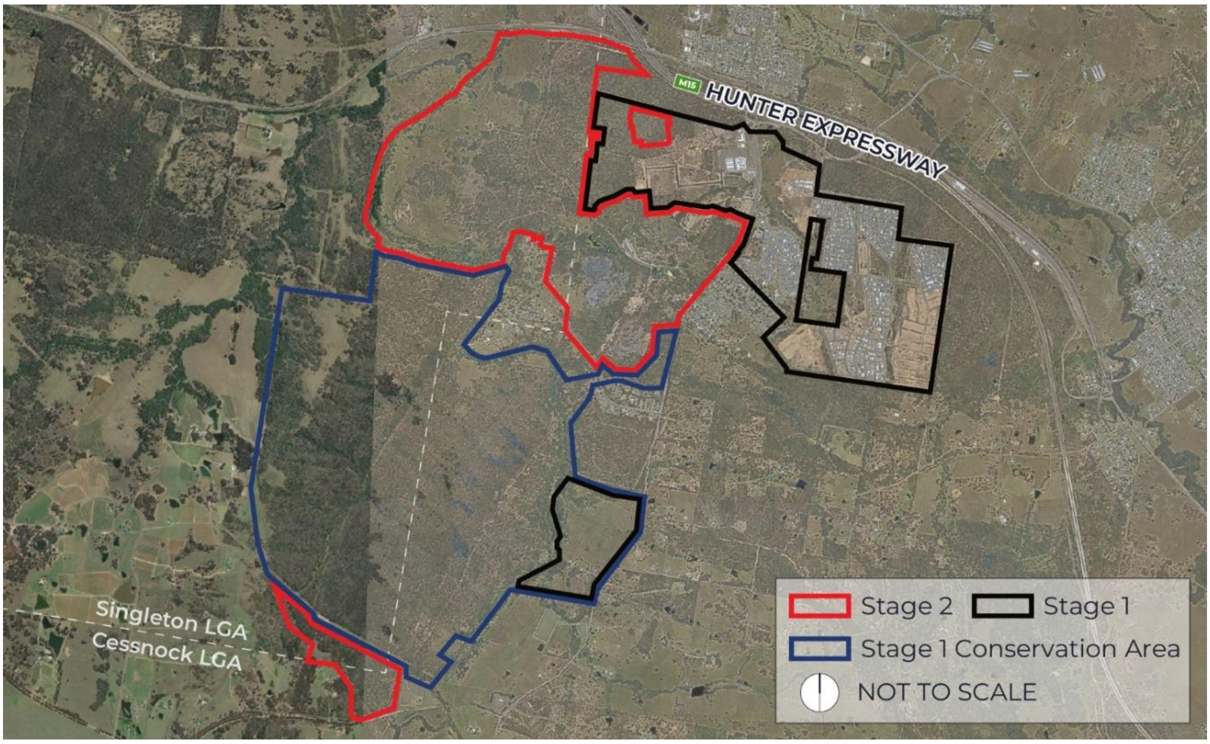
Source: Daly Smith

2.1 Subject Site

The subject site forms a large component of the 1,622 hectare Huntlee New Town, situated to the south of Branxton in the Hunter Valley. It is located approximately 20km north of Cessnock, 23km south-east of Singleton, and 55km north-west of Newcastle.

The subject Site comprises a number of allotments located in both Cessnock and Singleton Local Government Areas (LGAs). It has a combined area of approximately 541.71ha, is irregular in shape and is generally extended to the west and south of the approved Huntlee Town Centre. The site is bound to the west by the Black Creek and floodplain. An aerial photo of the site is provided at **Figure 2**.

Figure 2 Site Aerial



Source: Nearmap and Ethos Urban

3.0 Transport Noise Impact Assessment Procedures

The NSW Government's State Environmental Planning Policy (Transport and Infrastructure) 2021 (the SEPP) was introduced to aid the delivery of infrastructure across the State by improving regulatory certainty and efficiency and outlines provisions to ensure noise sensitive developments located near major railways and roadways are not adversely affected by traffic noise.

The policy applies to developments that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 20,000 vehicles and the relevant consent authority considers that the roadway/railway is likely to cause adverse noise impacts.

The Hunter Expressway in the vicinity of the Development Site experiences 20,000 or more vehicles per day, therefore the relevant acceptable internal noise levels provided in the SEPP are applicable to the project.

In accordance with the SEPP, Table 3.1 of the NSW Department of Planning and Infrastructure's guideline document entitled *Development near Rail Corridors and Busy Roads – Interim Guideline* (the DP&I Guideline) of December 2008, provides noise criteria for residential and non-residential buildings. These criteria are summarised in **Table 1**.

Table 1 SEPP Internal Noise Criteria

Residential Buildings		
Type of Occupancy	Noise Level (dBA)	Applicable Time Period
Sleeping Areas (bedroom)	35	Night 10 pm to 7 am
Other habitable rooms (excl. garages, kitchens, bathrooms & hallways)	40	At any time
Non-Residential Buildings		
Type of Occupancy		Recommended Max Level dBA
Educational Institutions including child care centres		40
Places of Worship		40
Note 1: Airborne noise is calculated is Laeq(15hour) daytime and LAeq(9hour) night-time.		

If internal noise levels with windows or doors open exceed the above criteria by more than 10 dB, then a natural ventilation path from a non-noise affected façade or forced ventilation system for the habitable rooms may be necessary to enable residents to leave windows close during noisy periods.

Where windows must be kept closed, the adopted ventilation systems must meet the requirements of the *National Construction Code Series Building Code of Australia,* Australian Building Codes Board (ABCB), 2014, and Australian Standard 1668 – *The use of ventilation and air conditioning in buildings*.

It is generally accepted that internal noise levels in a dwelling are 10 dB lower than external noise levels with the windows open, and 20 dB lower than external noise levels with the windows closed and standard glazing.

As the road traffic noise model predicts external noise levels, the internal noise goals have been adjusted by 10 dB for open windows and 20 dB for closed windows and standard glazing to provide external noise goals. The external noise goals applicable for the project are provided in **Table 2**.

Table 2 External Noise Goals Applicable to the Project

Type of Occupancy	External Noise Goals (dBA)[1,2]		Applicable Time Period
	Windows Open	Windows Closed	
Residential Buildings			
Sleeping areas (bedrooms)	45	55	Night-time (10:00 pm to 7:00 am)
Other habitable rooms (excluding garages, kitchens, bathrooms and hallways)	50	60	At any time
Non-Residential Buildings			
Educational institutions, child care centres and places of worship	50	60	When in use
Note 1: Airbourne noise is calculated as Laeq(15hour) for the daytime and Laeq(9hour) for the night-time.			

Type of Occupancy	External Noise Goals (dBA)[1,2]		Applicable Time Period
	Windows Open	Windows Closed	
Note 2: External noise goals are applicable 1 m from the external façade of a habitable room.			

Where external noise levels exceed the "windows open" criteria, affected facades may require windows and doors to be closed and alternative ventilation arrangements must therefore be produced.

Where external noise levels exceed the "windows closed" criteria, an upgraded building construction may be required, along with alternative ventilation. The weakest acoustic element of a façade is usually the windows/doors.

4.0 Existing Noise Environment

A site inspection was conducted 11 August 2023 to gain an appreciation of the study area and to commence the noise monitoring program. Two (2) environmental noise 'loggers' were positioned across the study area to record ambient noise levels over a period of eleven days from 11 August 2023 to 22 August 2023, inclusive. The noise loggers were set to record statistical indices over 15-minute intervals including L_{Amax}, L_{A1}, L_{A10}, L_{A90}, L_{Aeq} noise levels.

All instrumentation used during noise measurements complied with the requirements of AS IEC 61672.1-2004 and carried current NATA or manufacturer calibration certificates. Instrument calibration was checked before and after each measurement survey, with the variation in calibrated levels not exceeding ±1.0 dBA.

Details for the noise logger locations, and the equipment utilised for the survey, are provided in **Table 3** and the noise logger locations are shown in **Figure 3**.

Table 3 Unattended Noise Monitoring Information

Location ID	Logger Type and Serial Number	Location	Comments
L01	SVAN 977 98670	Latitude: 343885.00 m E Longitude: 6385170.00 m S	Located in the Northwest corner of the site, nearest the rail corridor.
L02	SVAN 977 98475	Latitude: 344568.00 m E Longitude: 6384804.00 m S	Located at the northern end of the site, nearest the M15 Expressway.

The microphone of each noise logger was positioned 1.5 m above ground level and fitted with a microphone windshield. The logged results were analysed in accordance with the NSW Road Noise Policy (RNP), with the noise levels summarised in **Table 4**.

The results of the unattended noise surveys are provided in graphical format in **Appendix B.** A summary of noise levels measured during the unattended noise monitoring program is provided in **Table 4**.

Table 4 Unattended Noise Monitoring Results Summary

Location	Ambient Noise Levels			
	$L_{Aeq(15hour)}$	$L_{Aeq1hour)}$ Day	$L_{Aeq(9hour)}$	$L_{Aeq1hour)}$ Night
L01	54	55	53	56
L02	60	61	58	59

Note 1: The $L_{Aeq(1hour)}$ descriptor is the noisiest 1 hour of the relevant period; day (7.00 am to 10.00 pm) or night (10.00 pm to 7.00 am).

All noise levels reported here are free-field measurements, meaning that no significant reflections from building facades influenced the measured noise levels.

Short-term attended noise monitoring was also completed at each monitoring location. The attended measurements allow the contributions of the various noise sources at each location to be determined. At each location the attended measurements were performed for 15 minutes using a calibrated Bruel and Kjaer Type 2 2250L Sound Level Meter (S/N: 3003389).

Table 5 Operator Attended Noise Monitoring Results

Location	Date/Start Time/Weather	Primary Noise Descriptor					Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		L_{Amax}	L_{A1}	L_{A10}	L_{A90}	L_{Aeq}	
L01	22/08/2023 16:58 22 C 1.6 m/s NNE	75	68	64	58	62	Traffic Hunter Expressway: 57-75 Insects/Birds audible but not measurable
L02	22/08/2023 17:49 18 C 1.2 m/s ENE	67	64	61	54	58	Traffic Hunter Expressway: 54-65 Train passbys: 55-67

The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and show that existing noise levels are dominated by road traffic noise from the Hunter Expressway as well as passing trains.

Figure 3 Huntlee Residential Development Monitoring Locations and Site Layout

insert

5.0 Traffic Noise Modelling

5.1 Road Traffic Noise Modelling

Road traffic noise predictions were carried out using the UK Department of Transport, Calculation of Road Traffic Noise (CORTN 1988) algorithms incorporated into SoundPLAN (version 8.2) noise modelling software. The modelling allows for traffic volume and mix, type of road surface, vehicle speed, road gradient, reflections off building surfaces, ground absorption and shielding from ground topography and physical barriers.

The algorithm output of CORTN (fundamentally an L_{A10} predictor) has been modified to calculate the relevant L_{Aeq} road traffic noise emission descriptors, as required.

All reported noise level predictions are “façade-corrected”. The predicted noise levels have been adjusted upwards to include a nominal 2.5 dBA reflection within the noise model computation.

The predicted levels are for receiver points 1.5 m and 4.3 m above the external ground level.

In the original United Kingdom version of the CORTN algorithms, all traffic noise “sources” are located 0.5 m above the pavement. This approach is appropriate as a “standard” calculation method and yields reasonable consistency form project to project. The predicted noise levels are considered reasonably accurate for roadway conditions having a clear line of sight from receivers to the traffic.

Where noise barriers (including the edges of cuttings) are present however, the CORTN barrier reduction algorithm would tend to over-predict the reductions for truck engine and exhaust noise components, which have effective source heights above pavement considerably greater than 0.5 m.

For this project therefore, the SoundPLAN traffic noise source “strings” have been modified to incorporate four effective noise sources (and heights) in each carriageway. These comprise a “cars” source with height of 0.5 m above pavement and three “truck” sources at three separate heights representing trucks tyres (0.5 m), truck engines (1.5 m) and truck exhausts (3.5 m).

The truck sources have relative sound power emission levels (compared to total truck sound power) of -5.4 dBA, -2.4 dBA and -8.5 dBA for tyres, engines and exhausts, respectively. These modifications ensure that the noise predictions (particularly in the presence of noise barriers) address the significance of the elevated heights of noise emission from truck engines and exhausts.

Topographic information for the study area was sourced from publicly accessible data provided by the Intergovernmental Committee on Surveying and Mapping as well as pavement heights supplied by the Client.

2015 Road traffic volumes and composition have been sourced from the Hunter Expressway Post Construction Noise Assessment dated 8 September 2016 prepared by AECOM Australia Pty Ltd. The relevant traffic volume and compositions have been increased based on an annual predicted traffic growth of 3% per annum using data from Transport for NSW’s Traffic Volume Viewer to provide road traffic volumes for the years 2023 and 2033.

The assumptions and inputs that have been used for this project are presented in **Table 6**.

Table 6 Design Inputs, Assumptions and Deviations from CoRTN

Input/Assumption/Deviation	Description
Noise Modelling Scenarios	
Current Year (2023) and Future Year (2033)	$L_{Aeq(15hour)}$ daytime (7.00 am to 10.00 pm) and $L_{Aeq(9hour)}$ night-time (10.00 pm to 7.00 am)
Acoustic Parameters	
Pavements corrections: Open graded asphalt: -2.0 dB	Standard correction for OGA.
Ground Absorption: Standard: 50%	Standard correction.
Receiver Heights: First Floor: 1.5 m Second Floor 4.3 m	Standard parameters.
Façade corrections: Reflections: +2.5 dB	Standard correction.
ARRB corrections: Façade: -1.7 dB Free-field -0.7 dB	Adjustments to the model to account for Australian conditions, as opposed to UK conditions where the CoRTN model was developed have been added.
L_{A10} to L_{Aeq} -3dB	Standard correction for road traffic noise
Traffic and Speeds	
Traffic volumes 2023	Based on predicted growth
Hunter Expressway (Eastbound):	15 hour = 8927 Cars, 1828 Heavy 9 hour = 809 Cars, 270 Heavy
Hunter Expressway (Westbound):	15 hour = 7775 Cars, 1707 Heavy 9 hour = 2393 Cars, 598 Heavy
Traffic Volumes 2033	**Based on predicted growth**
Hunter Expressway (Eastbound):	15 hour = 11790 Cars, 2415 Heavy 9 hour = 1069 Cars, 356 Heavy
Hunter Expressway (Westbound):	15 hour = 10268 Cars, 2254 Heavy 9 hour = 3160 Cars, 790 Heavy
Traffic Speeds: Hunter Expressway: 110 km/h	Posted speeds

5.2 Rail Traffic Noise Modelling

No detailed timetabling information was available as part of the study. As such noise modelling has been conducted based on measured rail pass-by noise levels within the study area. Coal freight traffic is the major component of rail traffic in the study area . The 2023 Hunter Valley Corridor Capacity Strategy prepared by the Australian Rail Track Corporation (ARTC) dated September 2023 indicates that coal freight traffic is likely to decline towards the end of 2029 with terminal capacity decreasing from approximately 220 million tonnes per annum (mtpa) to approximately 160 mtpa.

Given the likely reduction in coal freight traffic through the study area by 2033, to provide a conservative assessment, 2033 rail noise was modelled to remain consistent with 2023 noise levels.

5.3 Noise Model Validation

Transport noise levels were predicted for 2023 based on existing rail movements and projected road traffic volumes on the Hunter Expressway. The predicted noise levels were compared to measured noise levels within the study area. The validation of the noise model is a key component of the modelling process. Validation of the model was enabled by carrying out single point receiver calculations at the noise monitoring locations. The results of the single point receiver calculations are provided in **Table 7**.

Table 7 Comparison of Predicted and Measured Transport Noise Levels, 2023

Location	Period	SoundPLAN Prediction	Measured 2023 + 2.5 dBA (Façade Corrected)	Difference (Prediction – Measured)
L01	$L_{Aeq(15hour)}$	57.4 dBA	56.3 dBA	1.0 dBA
	$L_{Aeq(9hour)}$	54.6 dBA	55.5 dBA	-1.0 dBA
L02	$L_{Aeq(15hour)}$	63.8 dBA	63.0 dBA	0.9 dBA
	$L_{Aeq(9hour)}$	61.0 dBA	60.1 dBA	0.9 dBA

There is a strong correlation between the modelled noise levels and the measured (façade corrected) noise levels and as such the noise model is deemed suitable for predicting noise levels at all potentially affected receiver locations.

It is important to note that the modelling process inherently requires a number of assumptions to be made. Whilst every effort has been made to correlate predicted noise levels with measured noise data, it is important to regard the overall predicted noise levels within the generally accepted noise model accuracy of ± 2 dB.

5.4 Transport Traffic Noise Predictions

Noise level predictions are presented as noise contour plots for day and night-time periods for Scenario 2033. The noise contour plots are contained in the following appendices:

- **Appendix C1** – Daytime 2033 – 1.5 m above ground (single-storey dwelling).
- **Appendix C2** – Daytime 2033 – 4.3 m above ground (two-storey dwelling).
- **Appendix C3** – Night-time 2033 – 1.5 m above ground (single-storey dwelling).
- **Appendix C3** – Night-time 2033 – 4.3 m above ground (two-storey dwelling).

The noise contour predictions are external noise levels and have been adjusted (increased by 2.5 dBA to reflect façade noise levels.

The noise reduction to meet relevant internal noise goals and the associated construction categories are provided in **Table 8**.

Table 8 Traffic Noise reduction required to achieve Internal Noise Criteria

Type of Occupancy	Required Noise Reduction	Affected Area	Architectural Treatment
Single Storey and Two-Storey Dwelling			
Habitable Rooms – Daytime	>20 dBA	Where daytime noise is predicted greater than 60 dBA	Non-Standard Construction
	10-20 dBA	Where daytime noise is predicted is predicted to be between 50 and 60 dBA.	Standard Construction – Closed windows
	Up to 10 dBA	Where daytime noise is predicted less than 50 dBA	Standard Construction – Open windows
Sleeping Areas/Bedroom – Night-time	>20 dBA	Where the night-time noise is predicted greater than 55 dBA.	Non-Standard Construction
	10-20 dBA	Where the night-time noise is predicted to be between 45 dBA and 55 dBA	Standard Construction – Closed windows
	Up to 10 dBA	Where the night-time noise is predicted less than 45 dBA	Standard Construction – Open windows
Non-Residential			
Educational institutions, child care centres and Places of Worship	>20 dBA	Where the noise level when in use is predicted to be greater than 60 dBA.	Non-Standard Construction
	10-20 dBA	Where the noise levels when in use are predicted to be between 50-60 dBA.	Standard Construction – Closed windows
	Up to 10 dBA	Where the noise levels when in use is predicted to be less than 50 dBA	Standard Construction – Open windows

6.0 Recommendations

In all instances where windows are required to be closed to achieve internal noise goals, alternative means of achieving the requirement for “comfort ventilation” will need to be considered to enable openings in the external façade (i.e. windows and doors) to remain fully closed during noisy periods. However, this does not prevent the property owner from opening windows and doors during quieter periods.

Generally, to reduce internal noise levels for future residential dwellings, design and construction recommendations include, but are not limited to the following:

- Locate dwellings on each allotment as far as possible from the Hunter Valley Rail Corridor and Hunter Expressway.
- Minimise the size and number of windows in facades facing the Hunter Valley Rail Corridor and Hunter Expressway.
- Locate non-noise sensitive rooms such as the kitchen, storage areas and laundry on the side of the dwelling most exposed to the Hunter Valley Rail Corridor and Hunter Expressway.
- Use construction techniques that focus on sealing gaps around windows, doors, ceiling spaces, etc.
- Use acoustically rated glass on glazing systems.
- Use solid core doors and acoustically effective door seals.

7.0 Vibration

7.1 Road Traffic

The potential for impacts from ground borne traffic vibration is detailed in the RNP, which states:

> *Vehicles operating on a roadway are unlikely to cause a perceptible level of vibration unless there are significant road irregularities, particularly if the affected receiver is more than 20 m from the roadway.*

Given that the closest potentially affected receivers are located approximately 80 m from the hunter expressway, vibration impacts are predicted to be negligible.

7.2 Rail Traffic

Railway vibration is generated by dynamic forces at the wheel-rail interface and will occur, to some degree, even with continuously welded rail and smooth wheel and rail surfaces (due to the moving loads, finite roughness of the surfaces and elastic deformation). Significantly higher vibration levels can occur due to rail and wheel surface irregularities.

The vibration propagates via the sleepers or rail mounts into the ground or track support structure. It then propagates through the ground or structure and may sometimes be felt as tactile vibration by the occupants of buildings.

The primary metrics used to describe ground-borne vibration from train passbys are as follows:

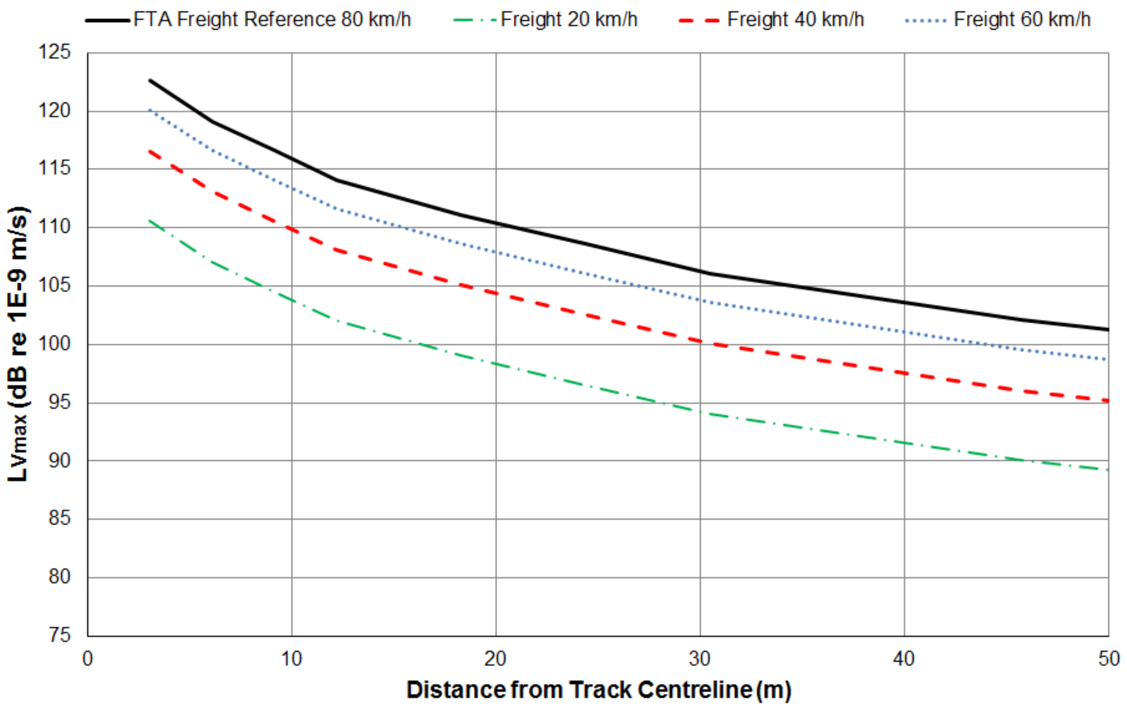
- **LVmax** – the “Maximum Vibration Level” occurring during a train passby event. This is normally defined as the maximum root mean square (rms) vibration level during the train passby average over a one second interval. The vibration level is usually expressed in dBV re 10^{-9} m/s.
- **VDV** – the “Vibration Dose Value” is used to indicate the total vibration exposure during the daytime or night-time period. It is a cumulative measure and indicates the combined effect of all train pasby events within the daytime or night-time period.

The NSW EPA’s *Assessing Vibration – a Technical Guideline* provides a methodology to assess vibration in terms of the VDV.

Use of the LVmax vibration level is advantageous as it allows the variation in individual train passby events to be examined. The LVmax metric can also be compared directly with human response curves to determine whether the train passby vibration levels are likely to be perceived by building occupants.

The US Federal Transit Administration's (FTA's) *"Transit Noise and Vibration Impact Assessment"* report provides indicative vibration levels versus distance for a variety of transport systems including freight and passenger systems. **Figure 4** shows the indicative freight vibration levels at various speeds, assuming a "20log" speed relationship. Passenger train vibration levels are typically around 12 dB less than the freight levels shown in **Figure 4**.

Figure 4 Indicative Freight Vibration Level at Speeds 20 km/h to 80 km/h



SLR has conducted numerous vibration measurements of passenger and freight train passbys on various projects throughout NSW. On the basis of previous measurements, the FTA indicative curves are a reasonable indicator of the typical vibration levels due to passenger and freight trains.

The vibration guideline indicates that the threshold of perception for most people is approximately 0.14 mm/s rms (103 dBV). From the source levels presented in **Figure 4**, it is anticipated that for some train passbys vibration levels would be perceptible at buildings located within approximately 40 m from the nearest track. Given the separation distance of approximately 75 m from the railway to the nearest receivers, vibration levels are likely to be imperceptible, and as such vibration impacts are predicted to be negligible.

8.0 Closure

SLR has undertaken a road traffic noise impact assessment for the proposed Stage 2 of the Huntlee New Town development.

Assessment of the impact of road and rail traffic noise on the proposed development was carried out using a SoundPLAN environmental acoustic model of the site.

Results from the SoundPLAN model have been utilised in determining mitigation measures and construction types suitable for the proposed development.

Vibration levels from road and rail traffic are predicted to be negligible.

Provided the recommendations in this report are implemented, it is expected that dwellings within the development will be able to satisfy the relevant internal noise criteria.

Appendix A Acoustic Terminology

Noise and Vibration Impact Assessment

Huntlee Stage 2

Huntlee Pty Ltd

SLR Project No.: 630.030982.00001

21 June 2024

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being 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 LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2. 'A' Weighted Sound Pressure Level

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

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB 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

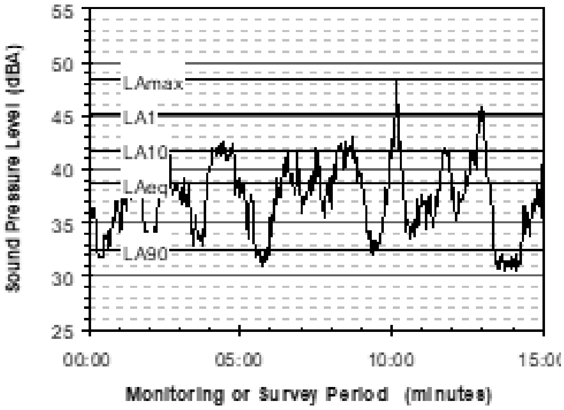
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of 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 LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 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:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 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.

LAeq 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.

5. Frequency Analysis

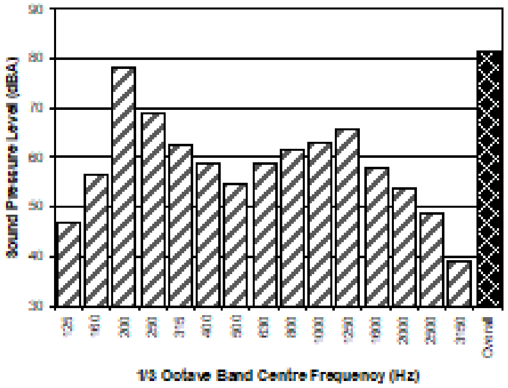
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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 (three 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.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

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 (ie, vertical, longitudinal 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/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

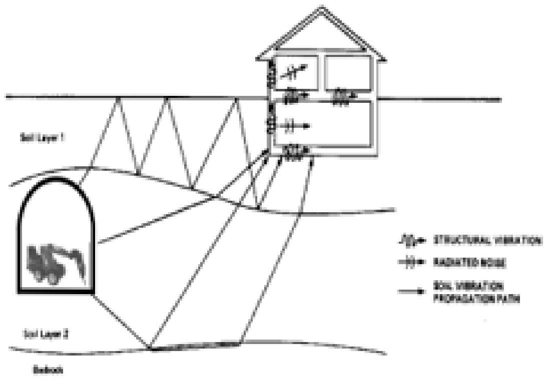
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience 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. 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 an example of 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 Unattended Noise Monitoring - Statistical Ambient Noise Levels

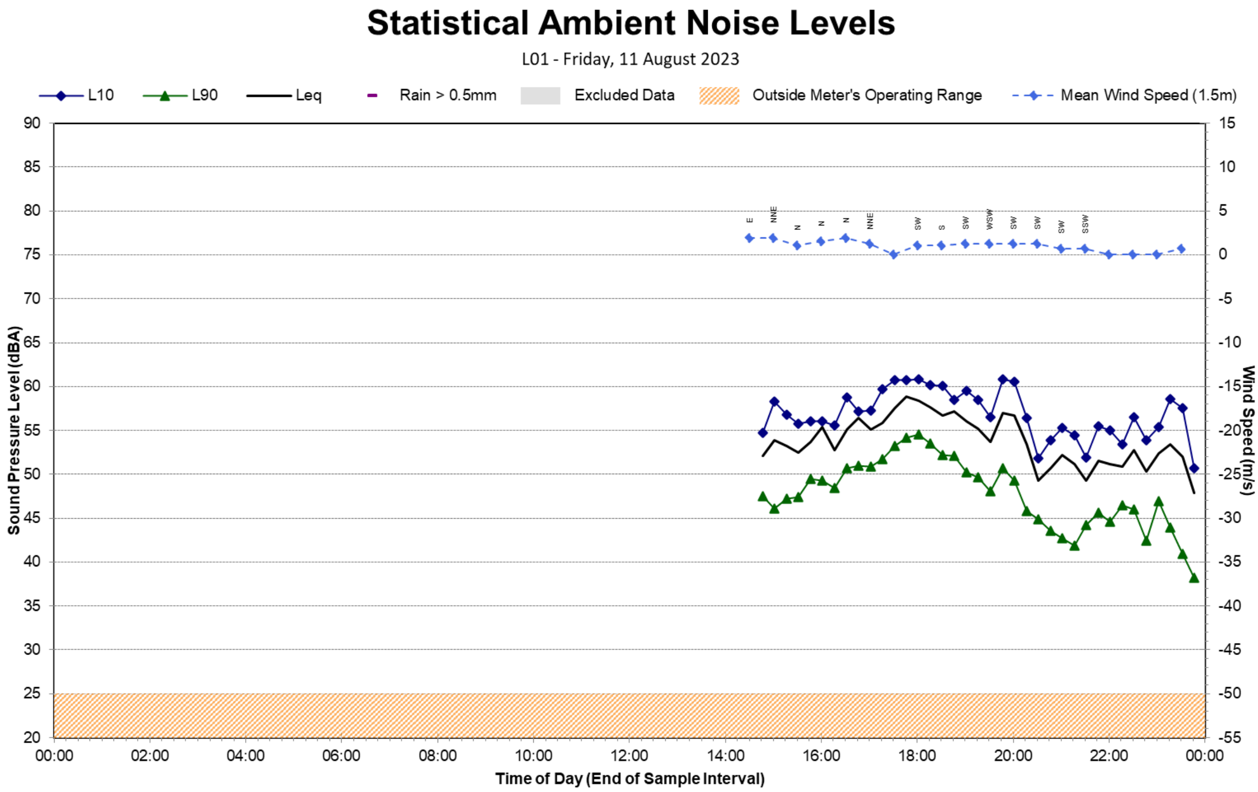
Noise and Vibration Impact Assessment

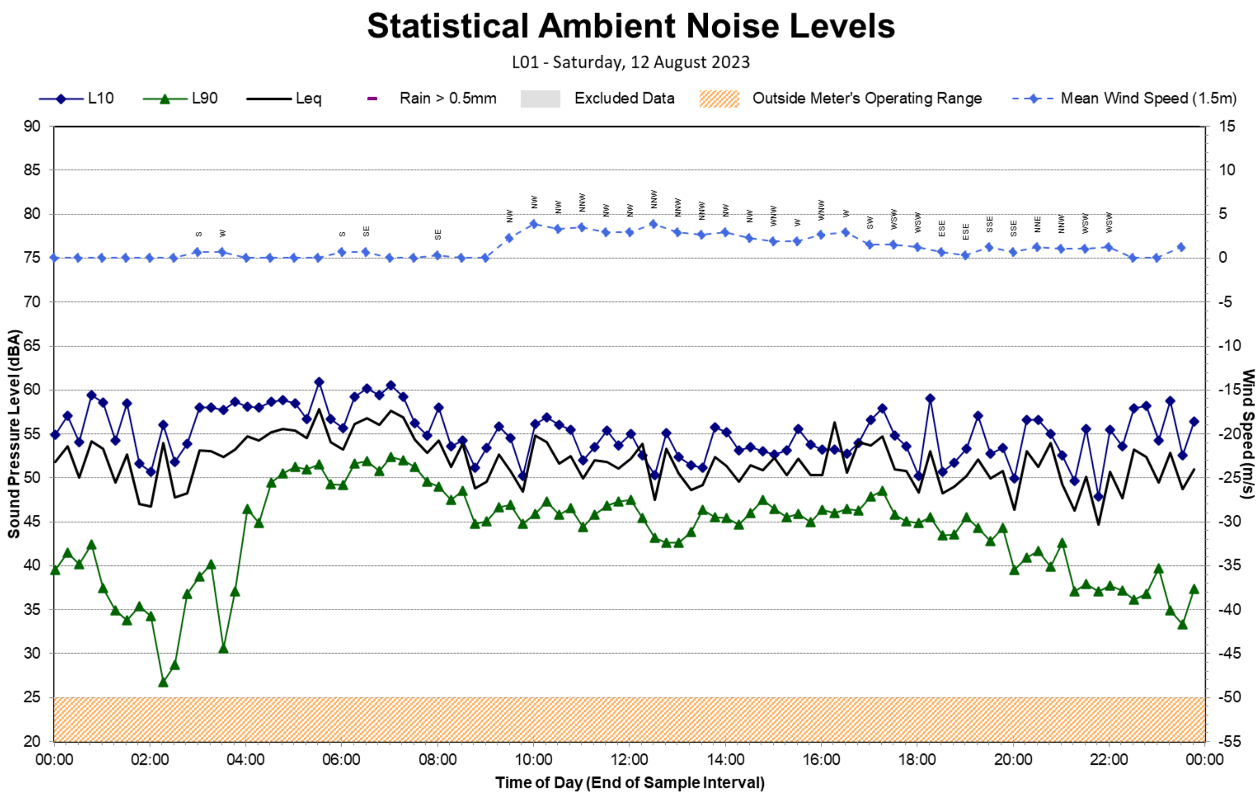
Huntlee Stage 2

Huntlee Pty Ltd

SLR Project No.: 630.030982.00001

21 June 2024

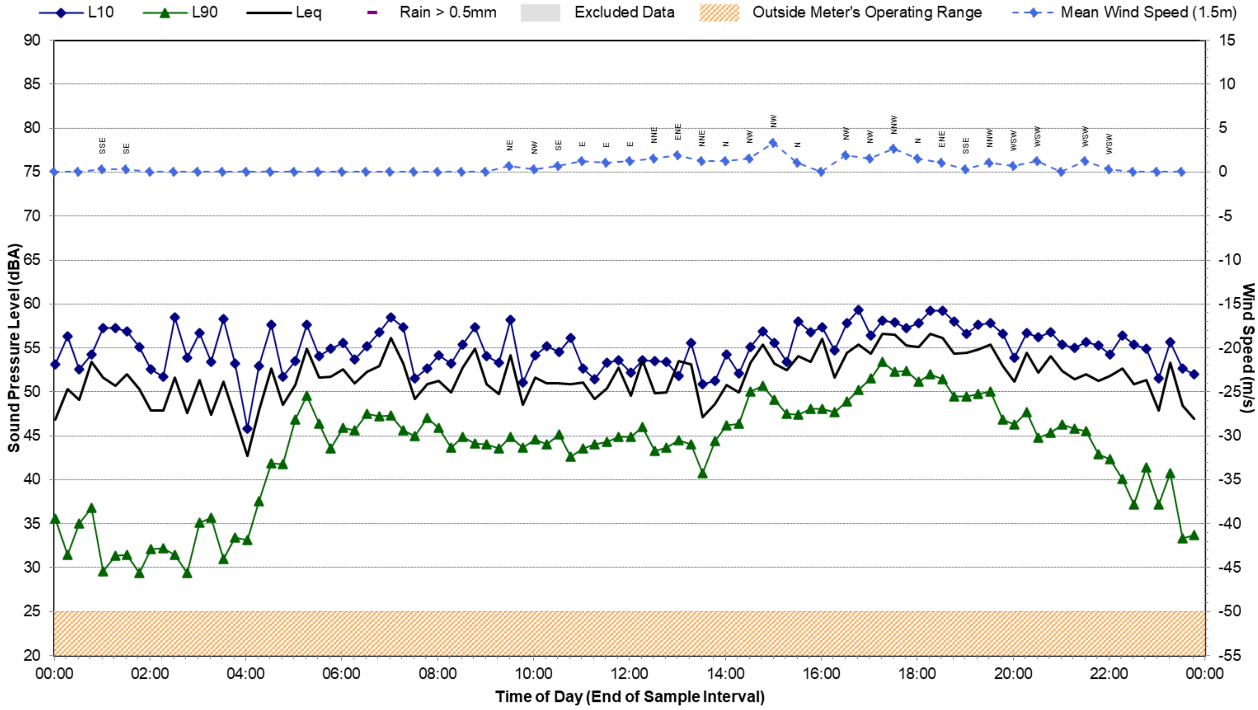

Statistical Ambient Noise Levels
L01 - Friday, 11 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L01 - Saturday, 12 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

SLR

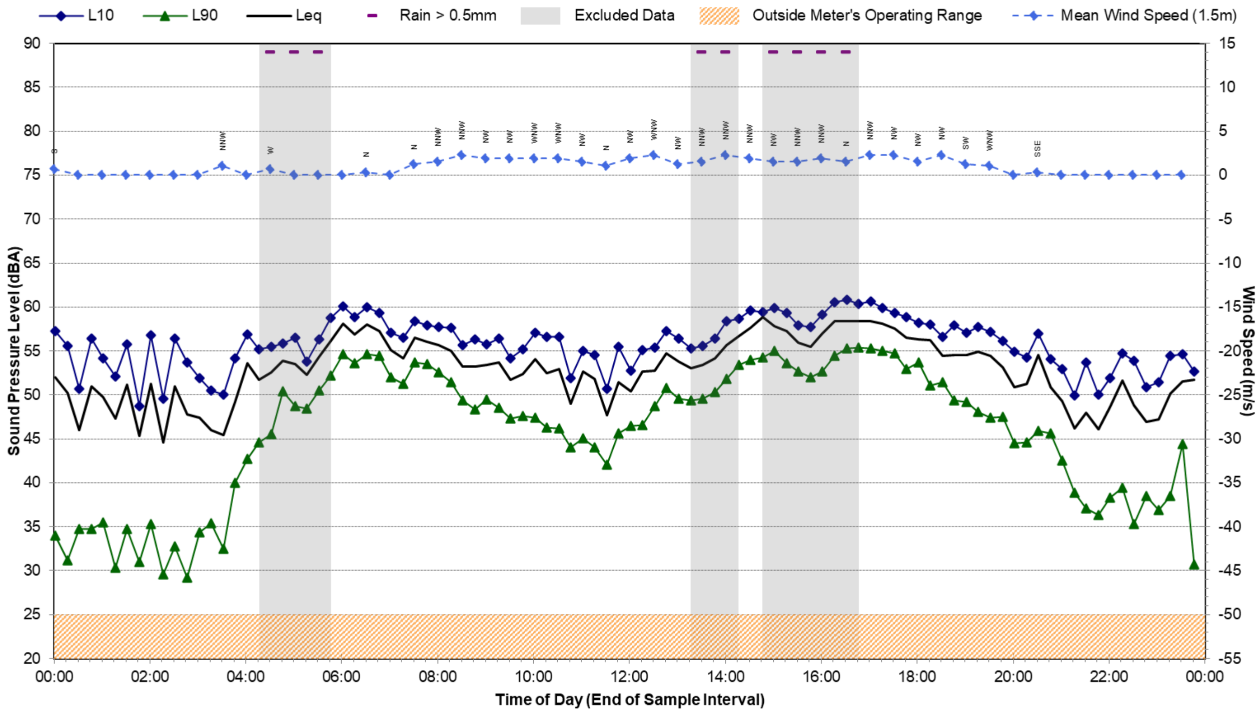
Statistical Ambient Noise Levels

L01 - Sunday, 13 August 2023



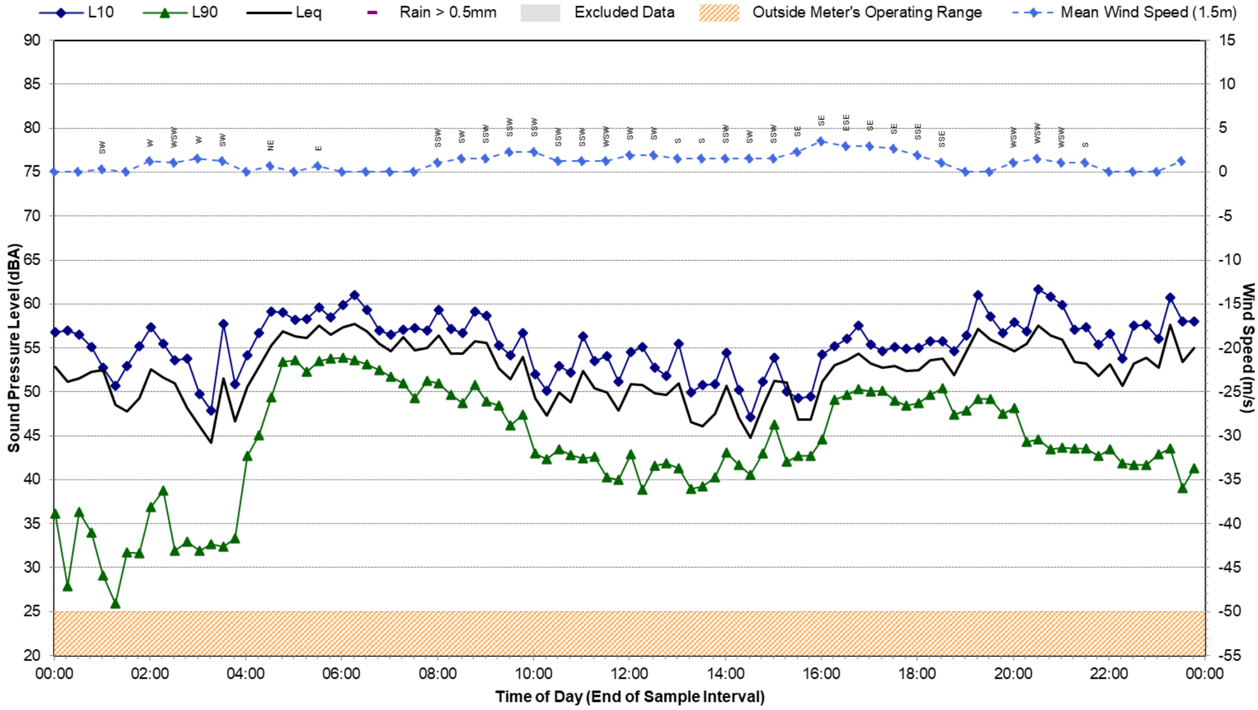
Statistical Ambient Noise Levels

L01 - Monday, 14 August 2023



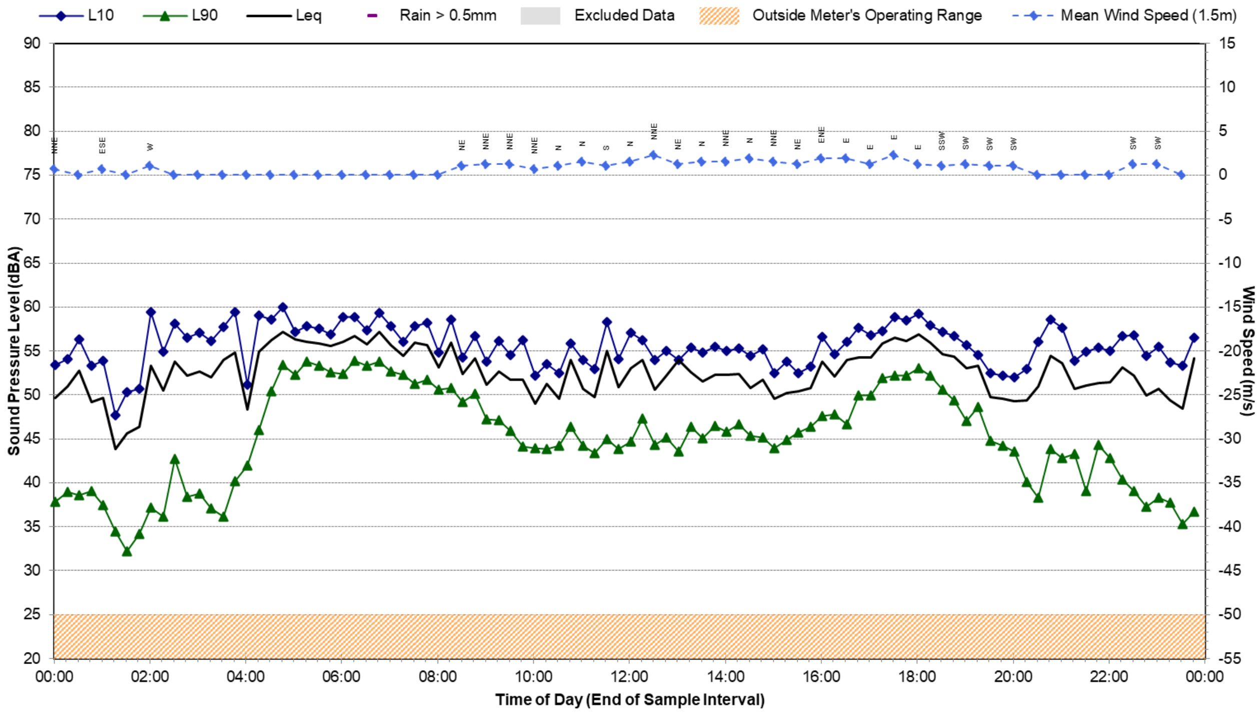
Statistical Ambient Noise Levels

L01 - Tuesday, 15 August 2023



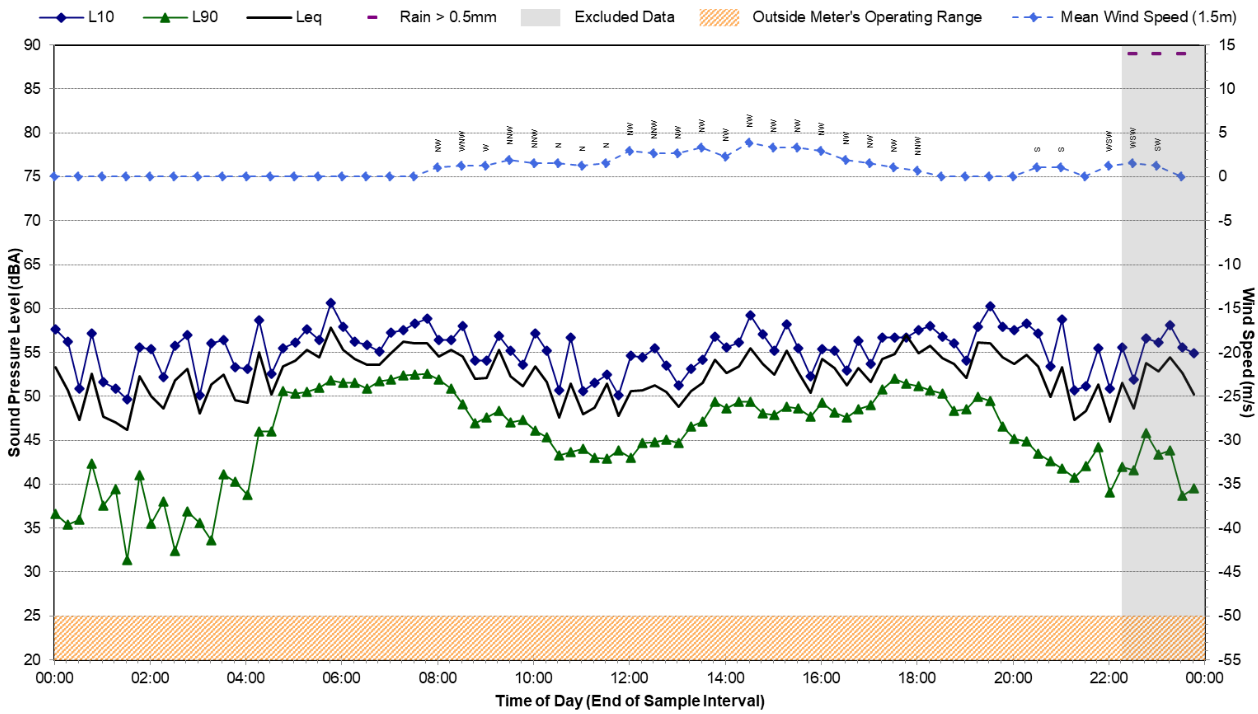
Statistical Ambient Noise Levels

L01 - Wednesday, 16 August 2023



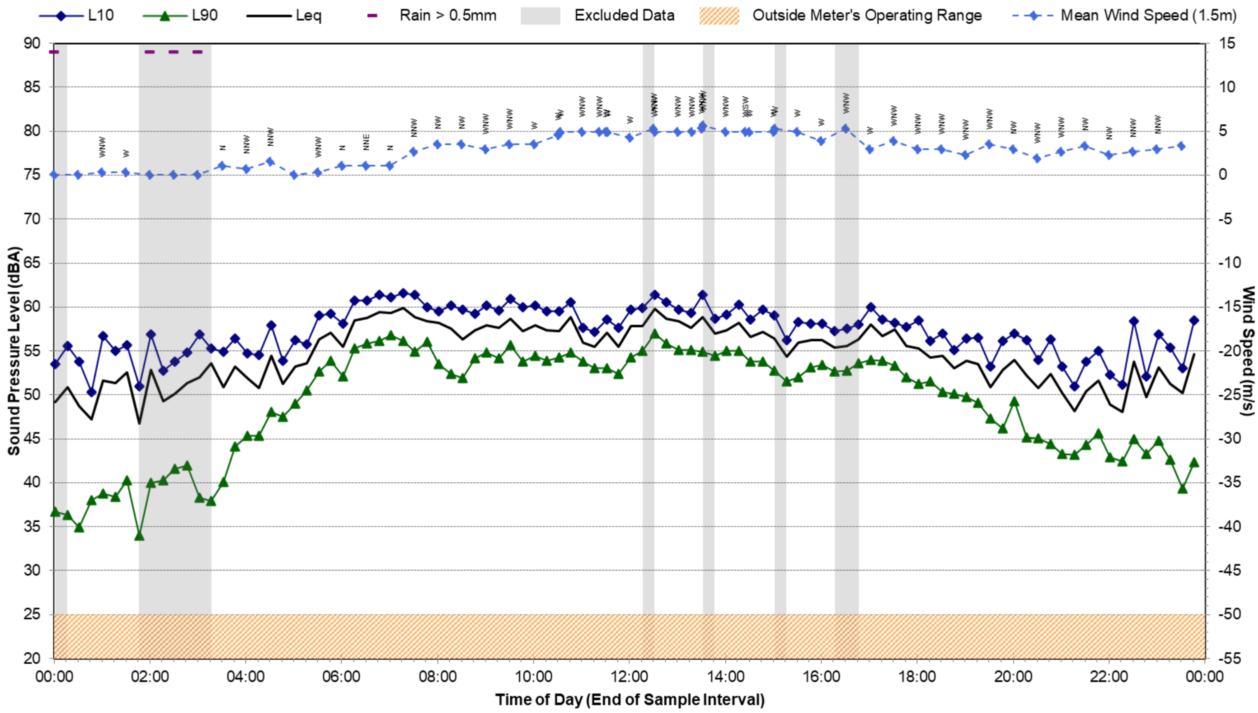
Statistical Ambient Noise Levels

L01 - Thursday, 17 August 2023



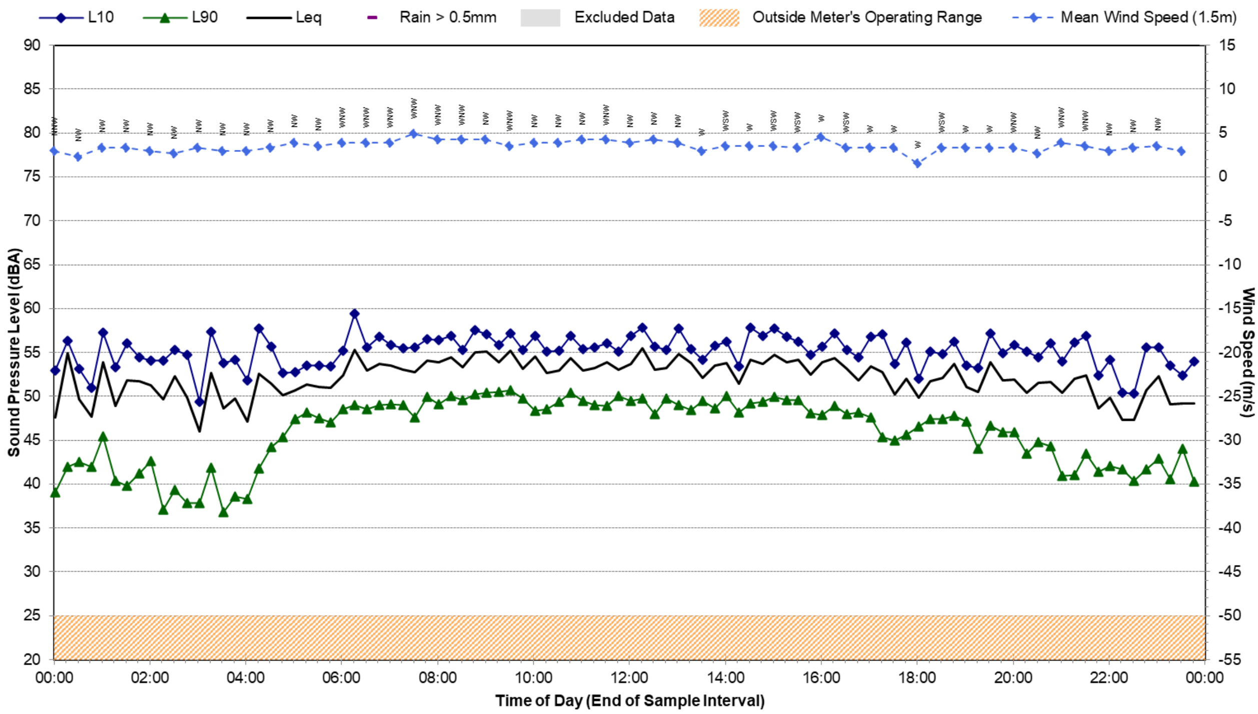
Statistical Ambient Noise Levels

L01 - Friday, 18 August 2023



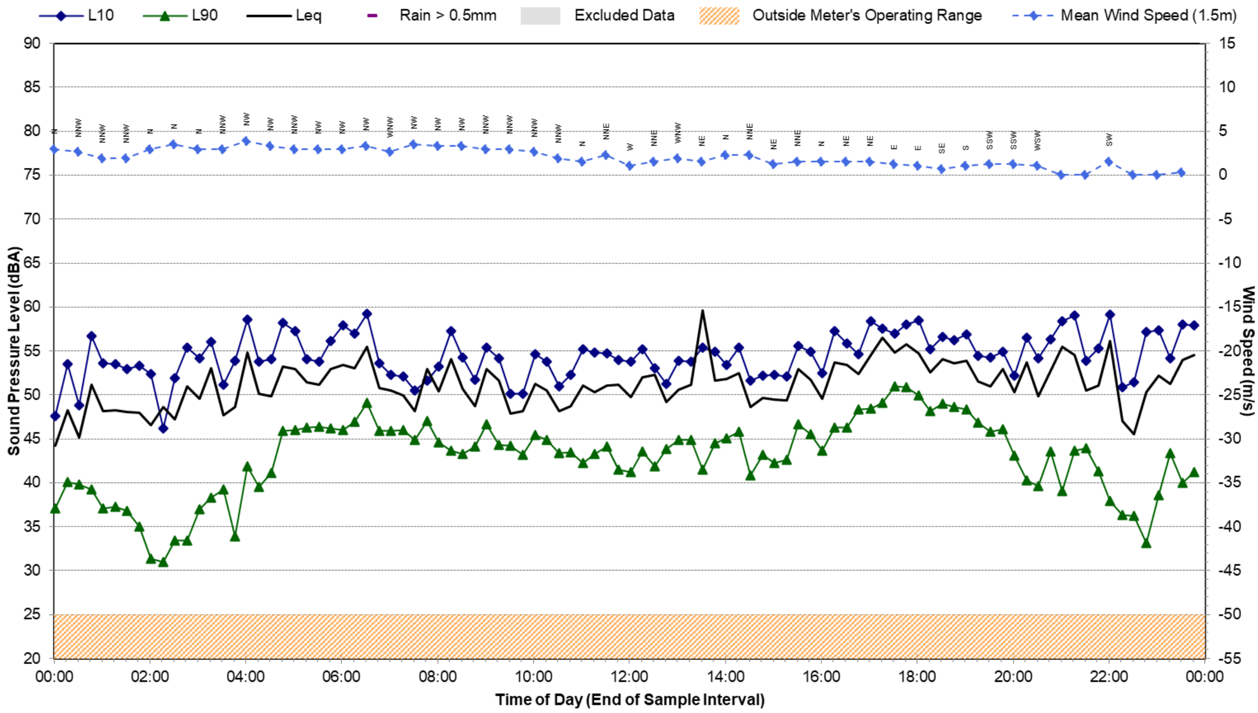
Statistical Ambient Noise Levels

L01 - Saturday, 19 August 2023



Statistical Ambient Noise Levels

L01 - Sunday, 20 August 2023



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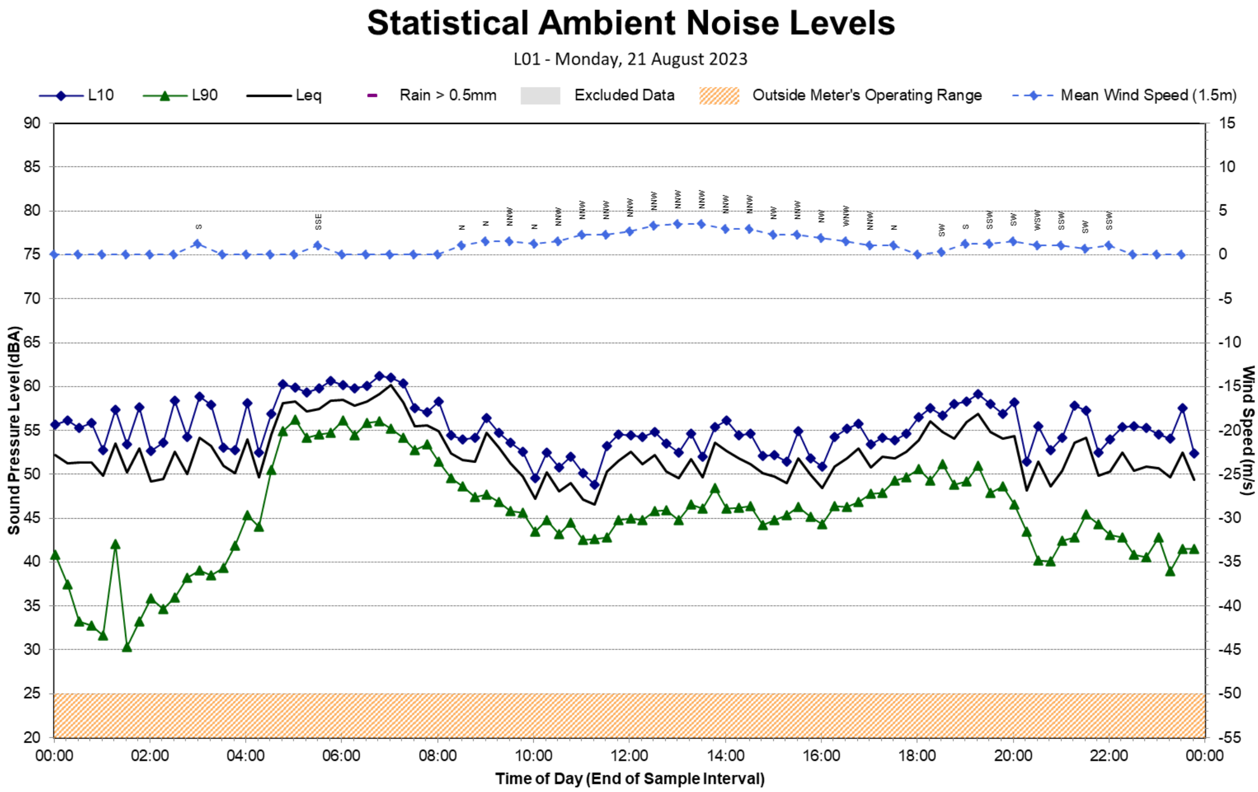
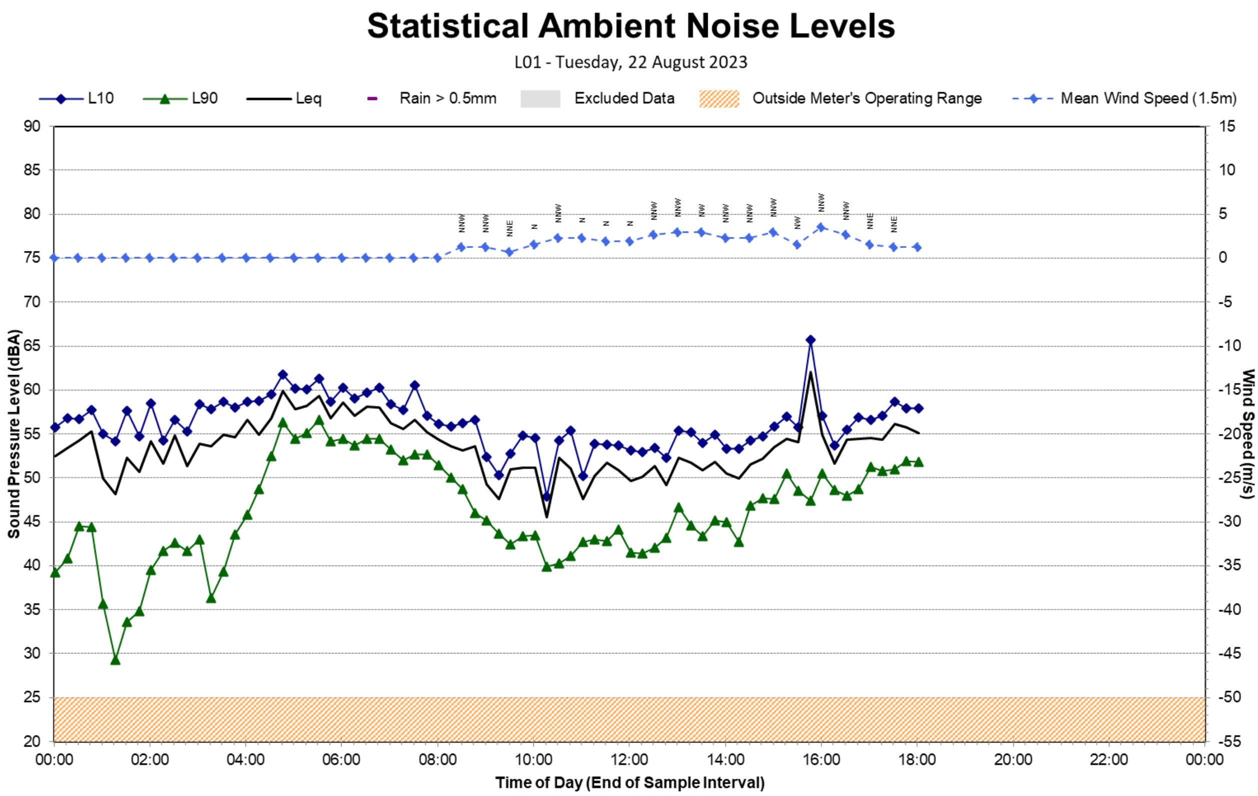
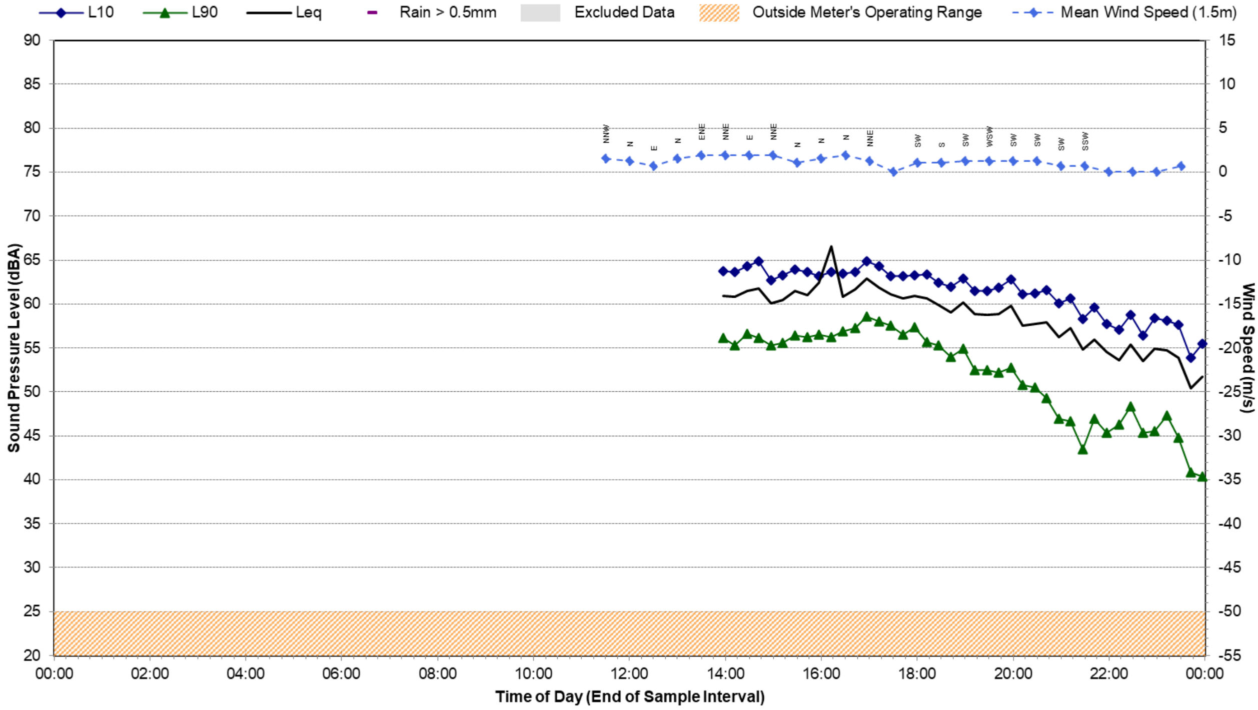

Statistical Ambient Noise Levels
L01 - Monday, 21 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L01 - Tuesday, 22 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

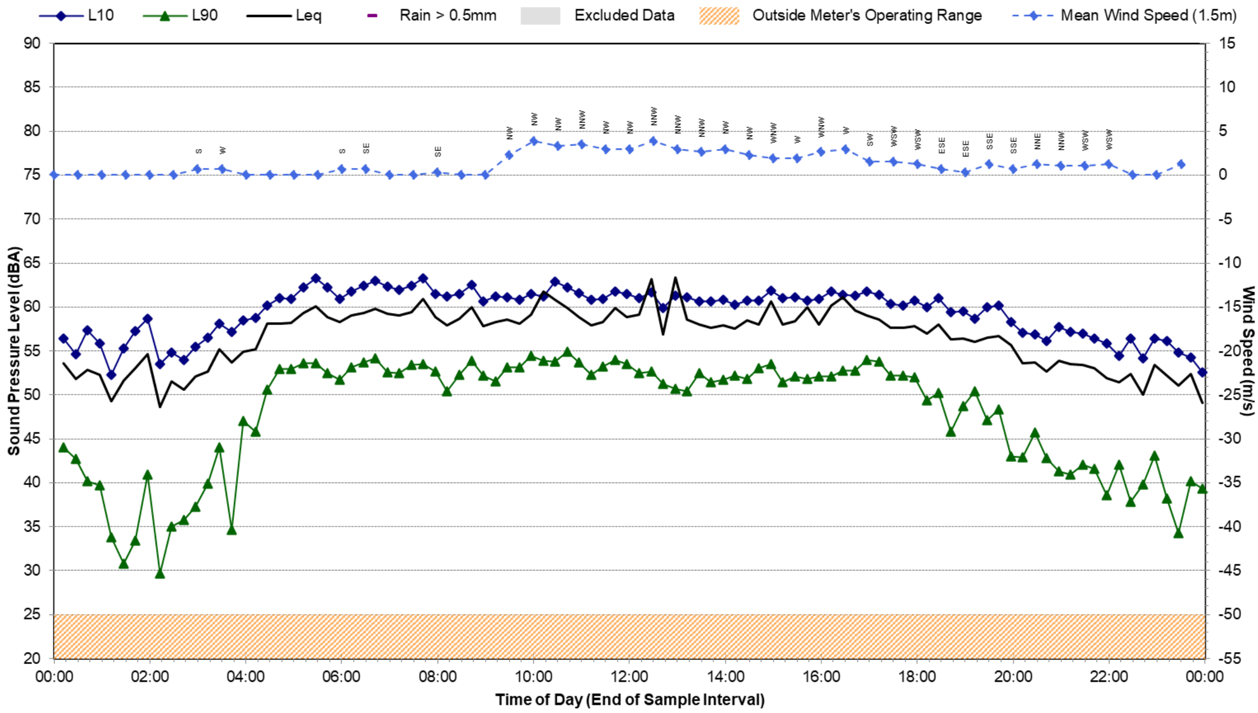
Statistical Ambient Noise Levels

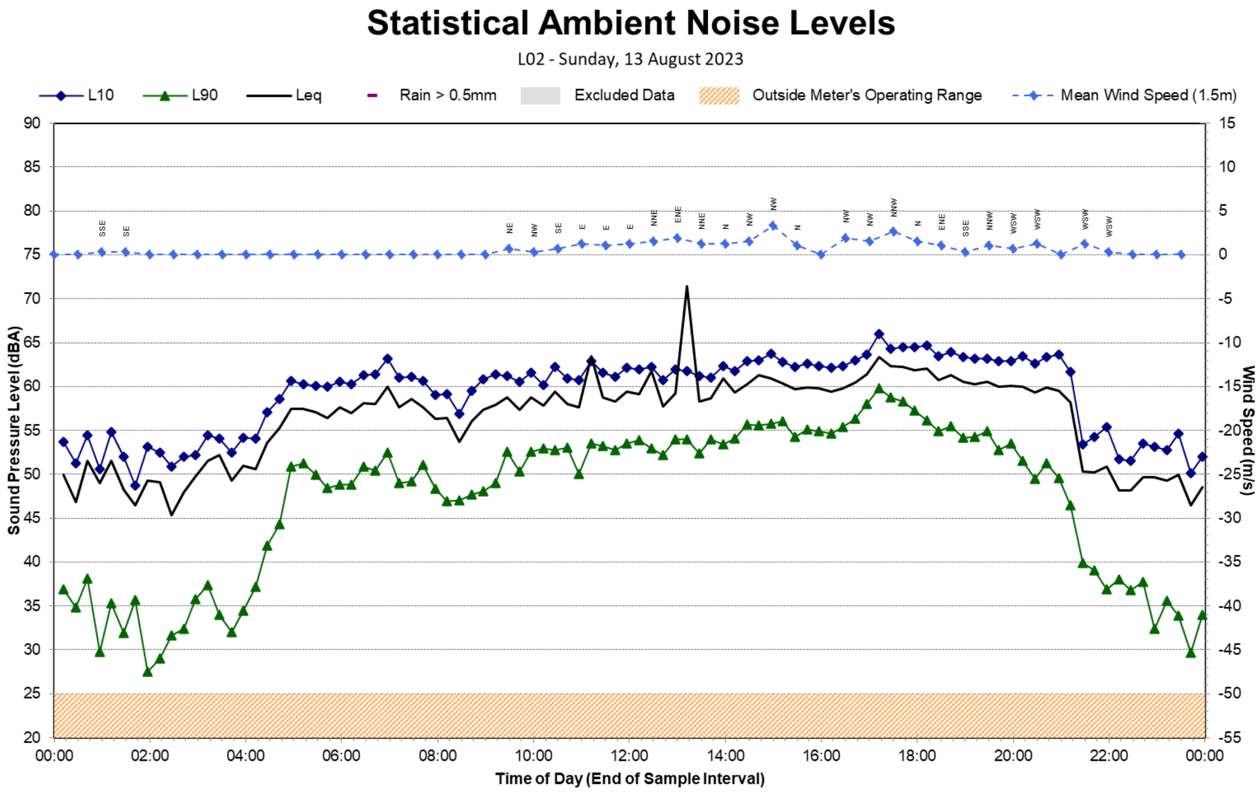
L02 - Friday, 11 August 2023

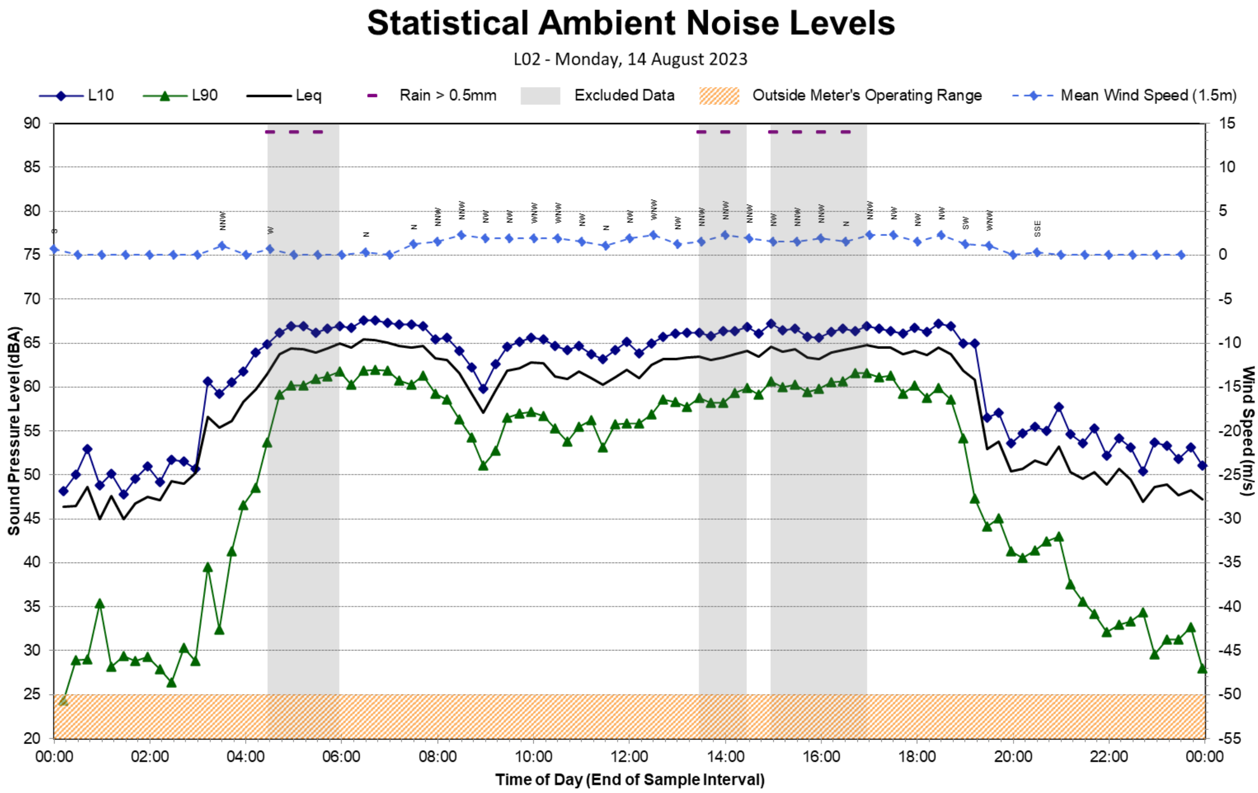


Statistical Ambient Noise Levels

L02 - Saturday, 12 August 2023

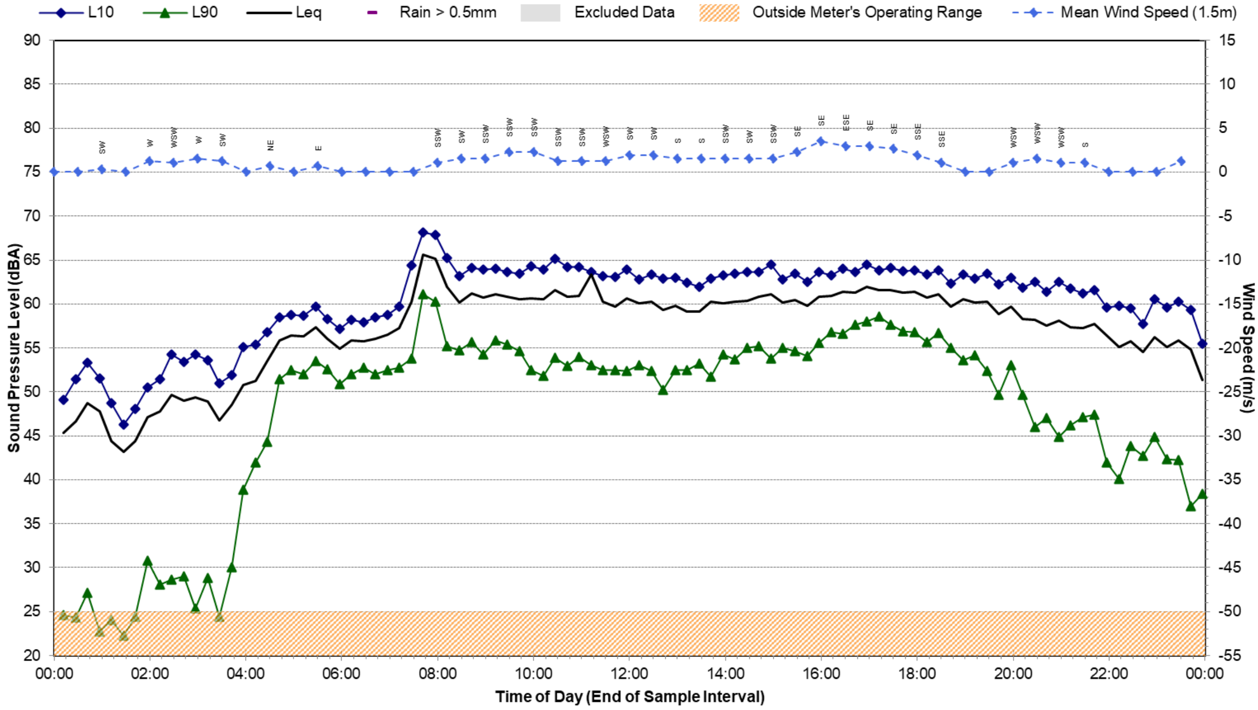



Statistical Ambient Noise Levels
L02 - Sunday, 13 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Monday, 14 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

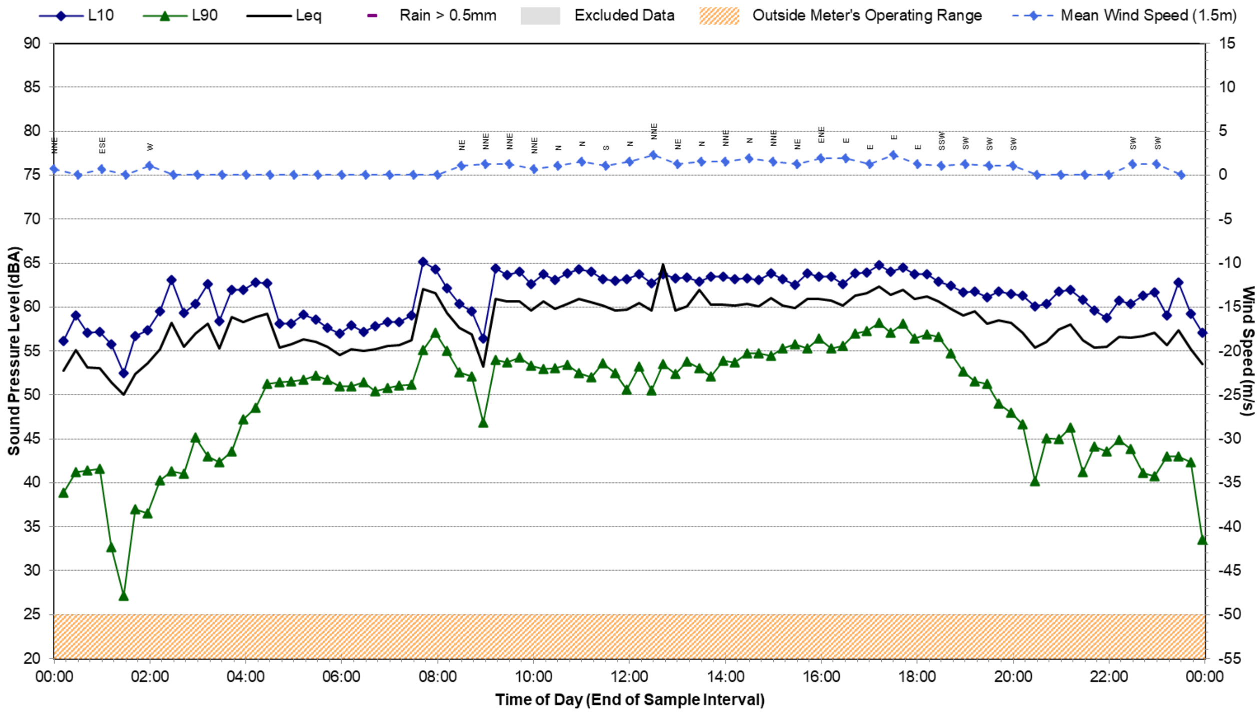
Statistical Ambient Noise Levels

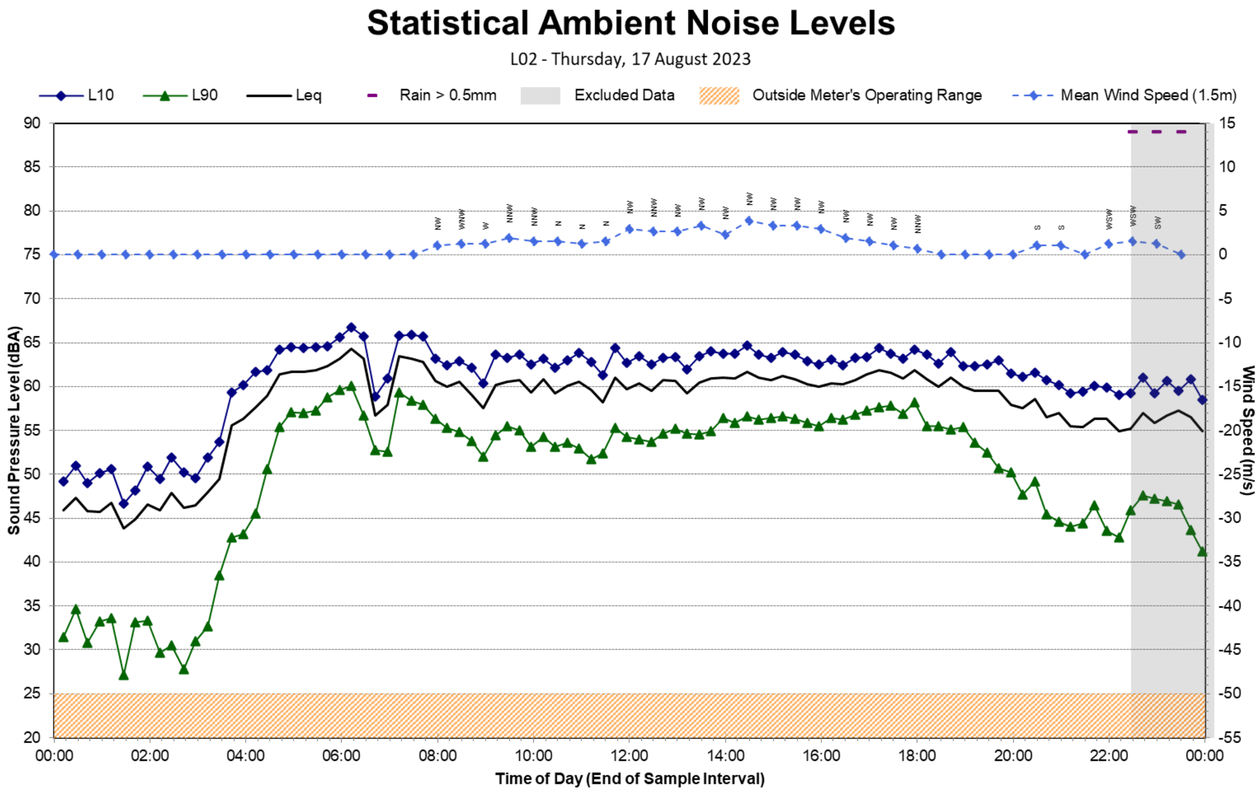
L02 - Tuesday, 15 August 2023

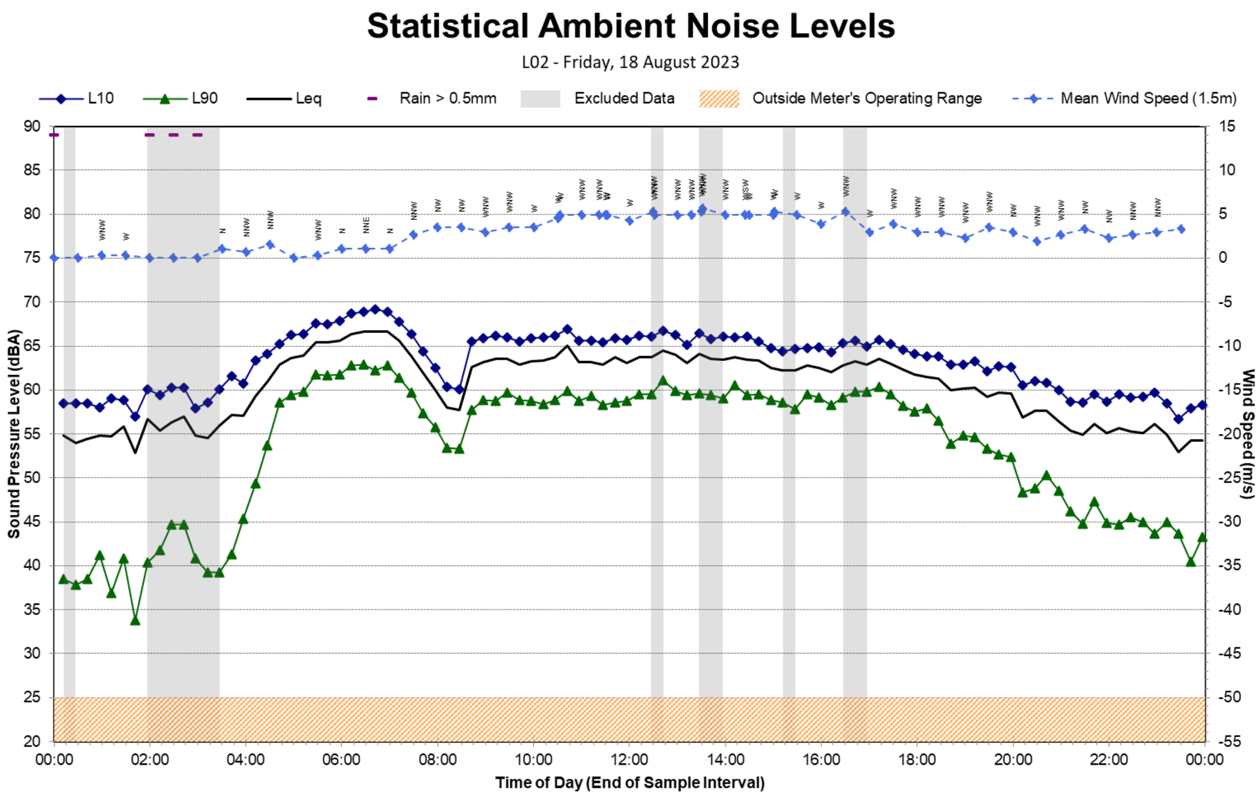


Statistical Ambient Noise Levels

L02 - Wednesday, 16 August 2023

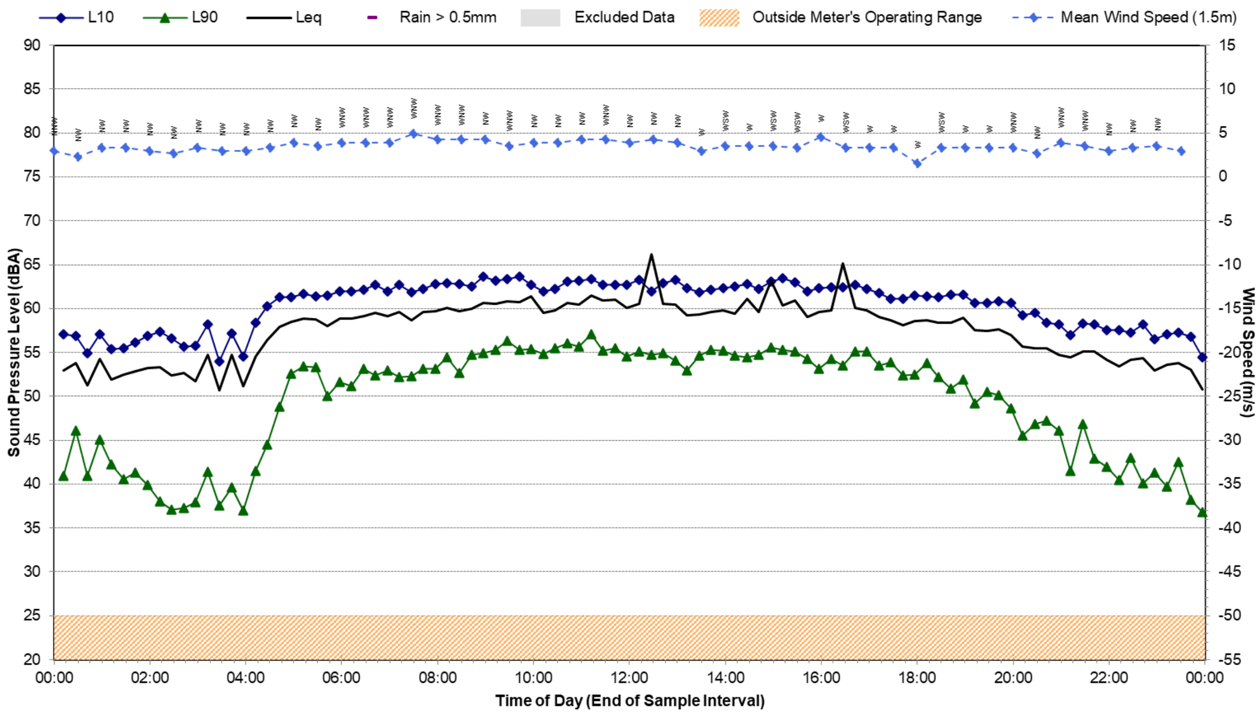



Statistical Ambient Noise Levels
L02 - Thursday, 17 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - Friday, 18 August 2023
L10
L90
Leq
Rain > 0.5mm
Excluded Data
Outside Meter's Operating Range
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

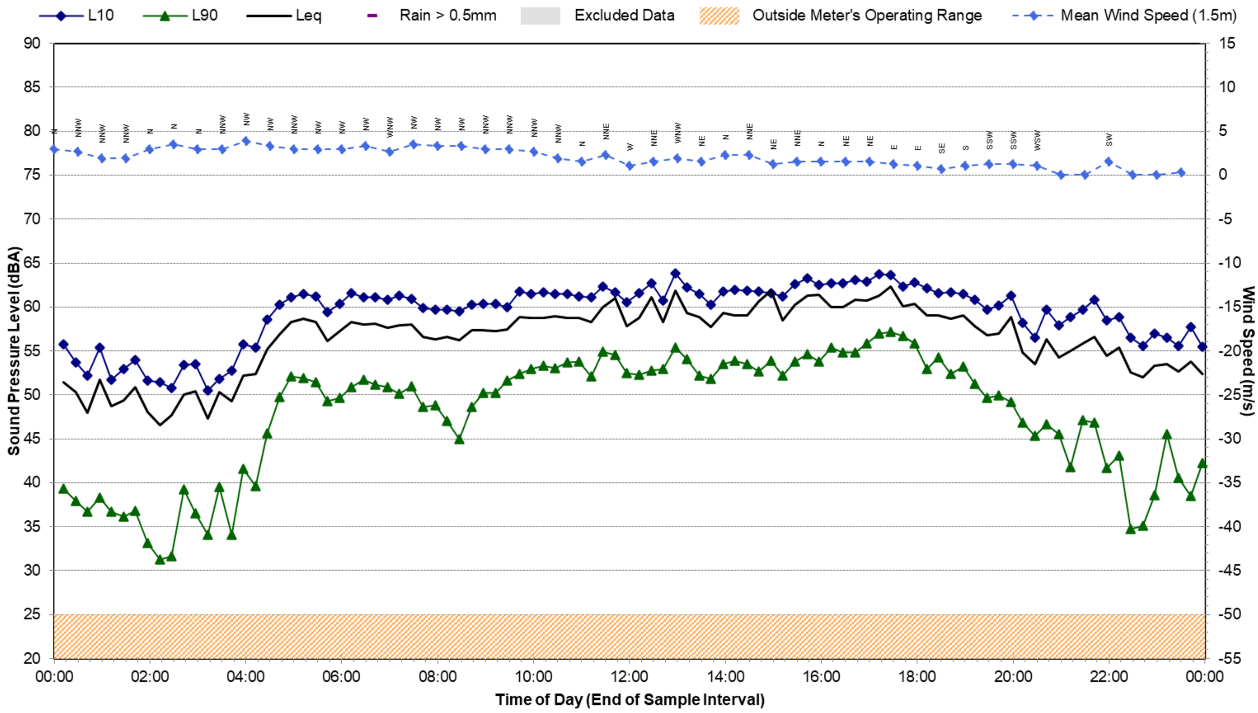
Statistical Ambient Noise Levels

L02 - Saturday, 19 August 2023



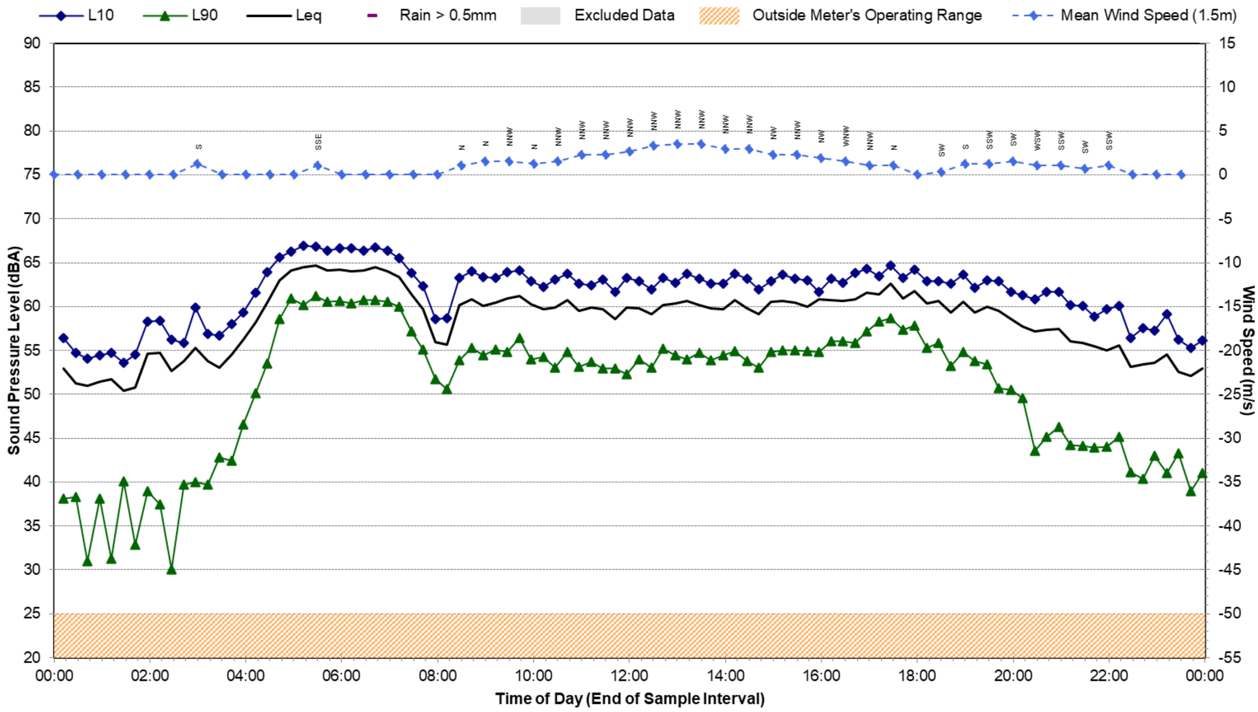
Statistical Ambient Noise Levels

L02 - Sunday, 20 August 2023



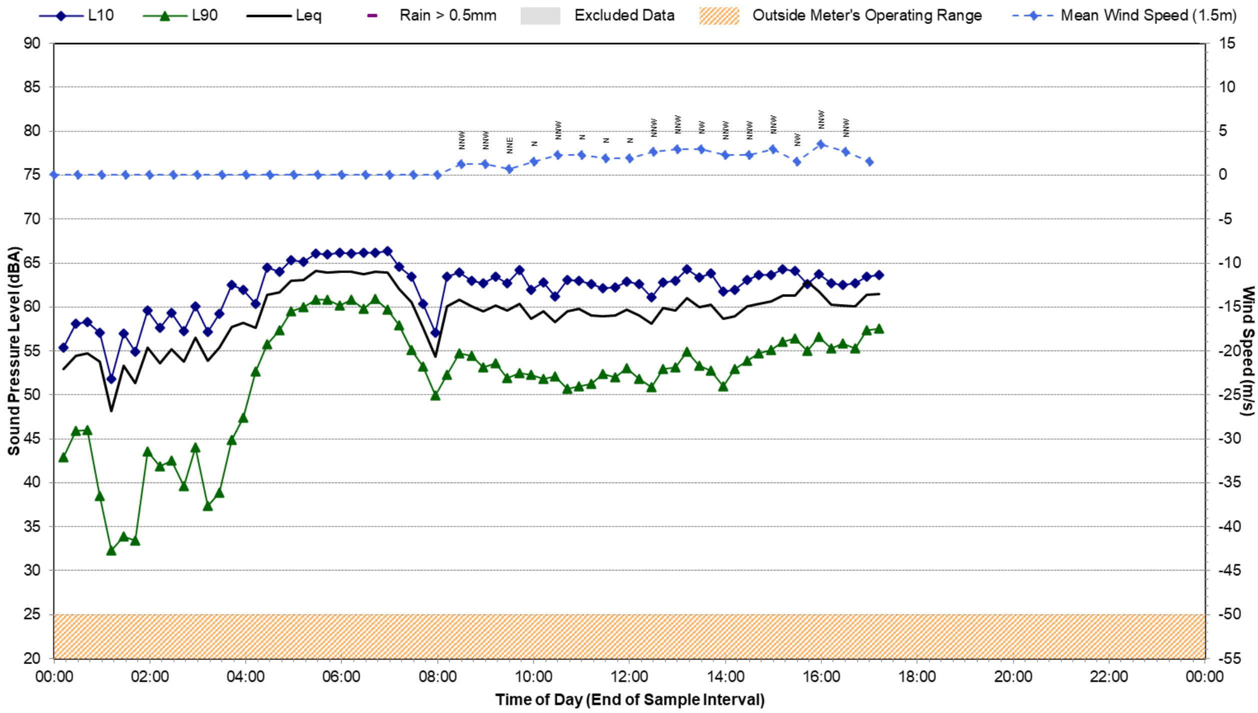
Statistical Ambient Noise Levels

L02 - Monday, 21 August 2023



Statistical Ambient Noise Levels

L02 - Tuesday, 22 August 2023



Appendix C Noise Contours 2033 Daytime and Night-Time

Noise and Vibration Impact Assessment

Huntlee Stage 2

Huntlee Pty Ltd

SLR Project No.: 630.030982.00001

21 June 2024

SLR

Making Sustainability Happen