Transport for NSW

Sydney Terminal Building Revitalisation

Noise and Vibration Impact Assessment

February 2023

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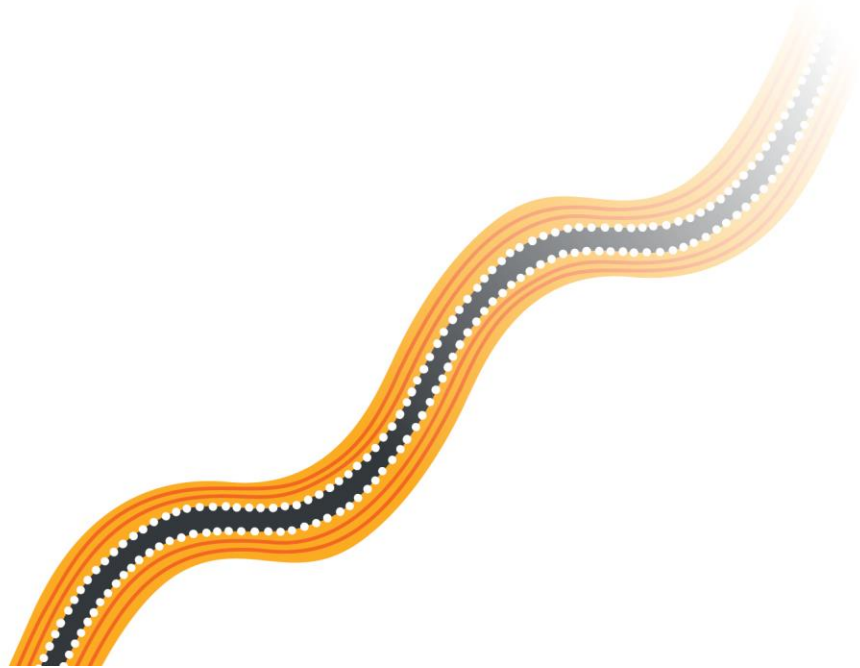
Acknowledgement of Country

We respectfully acknowledge the Traditional Custodians of the land of Central Precinct and the Sydney Terminal Building, the Gadigal. From time immemorial, this Country has been a place where people come to connect and reconnect. We pay our respects to all Aboriginal people who have journeyed and will journey through this place and acknowledge their ongoing connection to Country and culture. We pay our respects to members of the Stolen Generations and their descendants for whom the Sydney Terminal Building will always hold significance. We acknowledge that Platform One played a key role in Aboriginal children being removed from their families and communities.



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Abbreviations

Abbreviation	Definition
Attended noise monitoring	Operator attended noise monitoring which is completed to determine the various contributors to the noise environment of an area. It is usually done over a short period, such as 15 minutes.
AvaTG	*Assessing Vibration: a technical guideline*
CEMP	Construction Environmental Management Plan
CNVS	Construction Noise and Vibration Standard (Transport for NSW, 2019)
CNVMP	Construction Noise and Vibration Management Plan
dB	Decibel
dBA	Decibel, A-weighted
DEC	Department of Environment and Conservation (now EPA)
DECC	Department of Environment and Climate Change (now EPA)
DECCW	Department of Environment, Climate Change and Water (now EPA)
EPA	Environment Protection Authority
HNA	Highly noise affected. Relates to construction noise levels of ≥75 dBA and is the point above which there may be strong community reaction to noise construction noise levels.
ICNG	Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)
INP	Industrial Noise Policy (Environmental Protection Authority, 2000) (Superseded)
LAeq	The average noise level during a measurement period, such as the daytime or night-time
LAFmax	The maximum noise level measured during a monitoring period, using 'fast' weighting
LGA	Local government area
mm/s	Millimetres per second
NATA	National Association of Testing Authorities
NCA	Noise Catchment Area
NML	Noise Management Level
NpfI	Noise Policy for Industry (Environmental Protection Authority, 2017)
OOH	Out of Hours
OOHW	Out of Hours Work
PPV	Peak Particle Velocity
RBL	Rating Background Level. This is the background noise level measured at a particular location. The method for calculating the RBL is defined in the NPfI.
RMS	Root Mean Square

Abbreviation	Definition
RNP	Road Noise Policy
SEARs	Secretary's Environmental Assessment Requirements Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning, Industry and Environment under section 5.16 of the Environmental Planning and Assessment Act 1979 (NSW).
SSI	State significant infrastructure. Major transport and services infrastructure considered to have State significance as a result of size, economic value or potential impacts.
Standard construction hours	Monday to Friday 7 am to 6 pm and Saturdays from 8 am to 1 pm
SWL	Sound Power Level
VC	Vibration Criterion
VDV	Vibration Dose Value

Definitions

Term	Definition
Attended noise monitoring	Operator attended noise monitoring which is completed to determine the various contributors to the noise environment of an area. It is usually done over a short period, such as 15 minutes.
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own.
Heavy vehicles	A heavy vehicle is classified as a Class 3 vehicle (a two-axle truck) or larger, in accordance with the Austroads Vehicle Classification System.
Noise intensive equipment	Some construction equipment can be particularly noisy and can cause excessive annoyance. This includes items such as rockbreakers and concrete saws
Realistic worst-case scenarios	Realistic worst-case construction scenarios have been developed to assess the potential impacts from the proposal. These scenarios are based on the noisiest items of equipment which would likely be required to complete the work.
Standard construction hours	Monday to Friday 7 am to 6 pm and Saturdays from 8 am to 1 pm
Unattended noise monitoring	Noise monitoring which is typically completed over a seven day period using unattended noise monitoring equipment. The equipment is left in a certain location to measure the existing background noise levels during the daytime, evening and night-time.

1. Introduction

1.1 Purpose of this Report

This report documents the noise and vibration impact assessment conducted to support the Sydney Terminal Building Revitalisation ('the project'). The assessment was completed to support the Environmental Impact Statement (EIS) and address the relevant Secretary's Environmental Assessment Requirements (SEARs), outlined in **Section 1.3**.

This technical paper presents indicative noise and vibration impacts for the purpose of planning approval and is not intended to be used for any other purpose.

The report uses specific acoustic terminology. An explanation of common terms is included in **Appendix A.**

1.2 Project Overview

The project comprises the revitalisation of the Sydney Terminal Building and its public domain interfaces, Eddy Avenue Colonnade, Eddy Avenue Plaza and the Western Forecourt at Central Station (the project). The project would provide:

- Improved pedestrian connections and integration with the adjacent public domain areas
- Improved lighting, wayfinding, safety and accessibility
- Improved customer amenity, public art and interpretation
- Improved activation of spaces, including high quality retail and community uses that are complementary to the function of the transport interchange
- Heritage conservation and enhancement.

These works would be undertaken as priority works as part of the wider and longer-term Central Precinct Renewal Program. The project is located on Gadigal Country of the Eora Nation, in Haymarket, in the City of Sydney local government area (LGA).

A summary of the key features of the project is provided in **Table 1**.

Table 1 Project Summary

Project Element	Summary
Description	The project comprises the revitalisation of the Sydney Terminal Building and its public domain interfaces, Eddy Avenue Colonnade, Eddy Avenue Plaza and Western Forecourt at Central Station.
Construction	
Construction footprint	About three hectares (see **Figure 1**)
Timeframe	Construction for the project is expected to commence in Q3 2023 and take about three years to complete. This is subject to planning approval, funding availability, weather conditions and any unforeseen events.
Workforce	The construction workforce is expected to be an average of 100 per day over a three year period with an estimated peak of 200 being anticipated.

Construction ancillary facilities	Construction worker parking, site compounds and materials will be located within the western loading dock and Western Forecourt, with access from Pitt Street. Additional site staff facilities and storage areas would be provided from the existing facilities in the Sydney Trains Yard.
Sydney Terminal Building	• Demolition of awning and escalators on the eastern side of the Sydney Terminal Building • Removal of all redundant and ageing services, non-loadbearing walls, fit-outs, mezzanine floors and associated support structures within the back of house area of the Sydney Terminal Building • Removal of concrete floor and associated services to restore the Booking Hall to its original double height space • Western loading dock modification and strip-out works • Replacement of roof sheeting to the Grand Concourse and Porte Cochere • Realignment of the light rail track under the Porte Cochere of the Sydney Terminal Building to enable platform widening and water proofing corrective works.
Eddy Avenue Plaza	• Excavation of the eastern side of Eddy Avenue Plaza and re-grade ground level for improved pedestrian access (remove existing level difference across plaza) • Demolition of the brick retaining wall in the centre of Eddy Avenue Plaza • Demolition of ramp adjacent to the rail line behind the existing retail shops.
Western Forecourt	• Strengthening works to support the Western Forecourt.
Central Electric Building	• Demolition of mezzanine within the Central Electric Building.
Tree removal	Trees requiring removal include six London Plane Trees and two Tuckeroo trees in Eddy Avenue Plaza. These will be replaced as per the Transport Biodiversity Policy
Property	The project is located on land owned by the NSW Government or City of Sydney Council. No property acquisition would be required as part of the project.
Capital investment	$350M
Operation	
Operational footprint	About two hectares (see **Figure 2**)
Sydney Terminal Building	• New access and egress points, including escalators and lifts between the Grand Concourse and ground level at Eddy Avenue and Eddy Avenue Plaza • New lifts and stairs between the Grand Concourse and upper levels of the Sydney Terminal Building • Adaptive re-use, additions and alterations of retail space at the Grand Concourse and ground level of the Sydney Terminal Building • New amenities and relocation of existing amenities at the Grand Concourse and ground level of the Sydney Terminal Building • Reinstatement of the original Booking Hall's double height ceiling space • New multipurpose space in the existing ground level of the Sydney Terminal Building • New finishes to the Grand Concourse roof and flooring • Improved roofing for natural lighting to the Porte Cochere over the existing light rail stop • New awning over the eastern balcony of the Sydney Terminal Building, adjacent to Eddy Avenue Plaza

	• Widening of Eddy Avenue footpath between Pitt Street and Eddy Avenue Plaza • Market-style retail activation within the western loading dock • Reconfiguration of the northwest corner of the Sydney Terminal Building and colonnade adjacent to Pitt Street, including creation of a new public access to the western loading dock from Pitt Street and Eddy Avenue • Public domain improvements.
Eddy Avenue Plaza	• Additional retail spaces within Eddy Avenue Plaza including a new two storey retail building • New lifts and escalators to provide access to the Central Electric Building and the Grand Concourse from Eddy Avenue Plaza • New landscaping and paving reflecting a Connecting with Country approach. • Public seating in Eddy Avenue Plaza.
Central Electric Building	• New retail space on Level 1 and activation of the rooftop of the Central Electric Building.
Operational ancillary facilities and infrastructure	• New wayfinding and signage • Upgrading of lighting, closed circuit television (CCTV) and passenger information systems.
Utilities	• Adjustment, protection and upgrade of existing utilities within the Sydney Terminal Building. • Relocation of transformer rooms within the Sydney Terminal Building • Relocation of fire hydrant boosters.
Operation of the project	Operation of the project will not result in any change of the primary use of the station as a transport interchange. Any operational changes that arise from the project are expected to be beneficial changes related to accessibility, wayfinding, and safety. The project also aims to address current Sydney Light Rail operations at the Central Station light rail platform where a two-stage drop-off and pick-up arrangement exists. By widening the platform to alleviate congestion issues, it is intended to simplify operations to a single drop-off and pick-up arrangement.

Figure 1 Construction Footprint

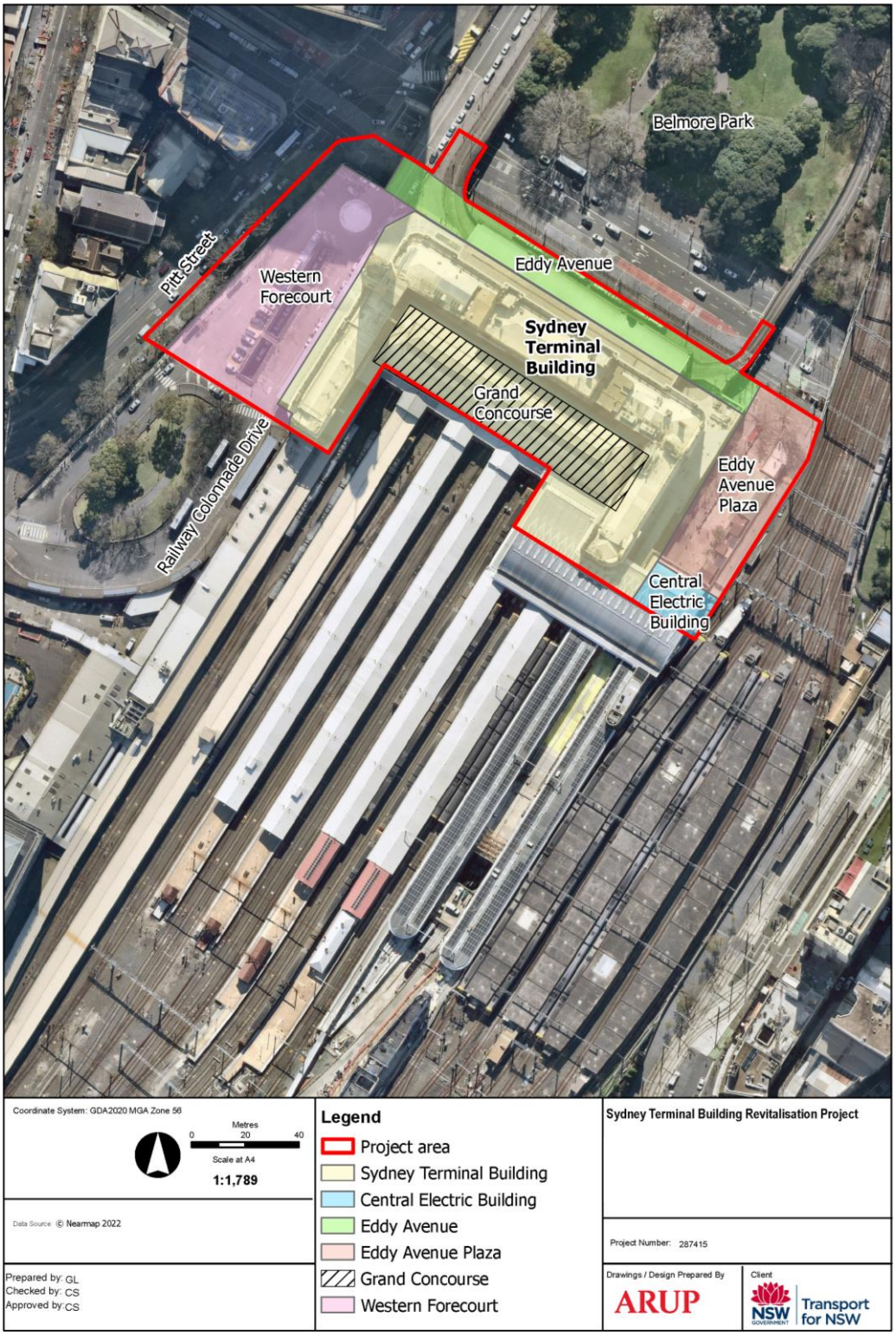


Figure 2 Operational Footprint

1.3 Secretary's Environmental Assessment Requirements

The SEARs were issued by the NSW Department of Planning and Environment (DPE) on 17 October 2022. **Table 2** outlines the SEARs relevant to noise and vibration and where these requirements are assessed in this report.

Table 2 SEARs Relevant to Noise and Vibration

Secretary's Environmental Assessment Requirements	Where Addressed
1. Construction and operational noise and vibration (including mechanical plant) impacts in accordance with relevant NSW noise and vibration guidelines.	**Section 5** and **Section 6**
2. The assessment of **construction noise and vibration** must address:	
(a) the nature of construction activities and related noise characteristics using typical and worst-case scenarios, including high noise generating activities;	**Section 4.1.1**
(b) intensity and duration of noise (both air and ground borne) and vibration impacts. This must include consideration of extended construction impacts associated with ancillary facilities (and the like) and construction fatigue;	**Section 5**
(c) the identification and nature of receivers, existing and proposed, during the construction period;	**Section 2**
(d) the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage);	**Section 3.4.1**
(e) the nature of the impact and the sensitivity of receivers and level of impact including for out of hours works;	**Section 5**
(f) the need to balance timely conclusion of noise and vibration generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	**Section 4.1.1** and **Section 8**
(g) noise impacts of out-of-hours works (including utility works and works associated with the SSI including those undertaken under another assessment pathway), possible locations where out-of-hours works would be undertaken, the activities that would be undertaken, the estimated duration of those activities and justification for these activities in terms of the Interim Construction Noise Guideline (DECCW, 2009);	**Section 5**
(h) sleep disturbance (including the number of noise-awakening events);	**Section 5**
(i) a cumulative noise and vibration assessment inclusive of impacts from the proposal, including concurrent construction activities within the proposal and the construction of other relevant development in the vicinity of the proposal;	**Section 7**
(j) details and analysis of the predicted effectiveness of mitigation measures to adequately manage identified impacts, including impacts as identified in (h);	**Section 8**
(k) any potential residual noise and vibration impacts following application of mitigation measures; and	**Section 8**
(l) a description of how receiver feedback received during the preparation of the EIS has been taken into account (and would be taken into account post exhibition of the EIS) in the design of mitigation measures, including any tailored mitigation, management and communication strategies for sensitive receivers.	**Section 8**
3.The process for community engagement should be included or referenced in the noise and vibration assessment as part of the mitigation strategy and assessment.	**Section 8**

2. Existing Environment

2.1 Study Area

The project is located at Sydney Central Station, with nearby receivers in the suburbs of Haymarket, Surry Hills, Ultimo, Redfern, and Chippendale. The surrounding area includes the existing Sydney Trains and light rail corridors, which stop at Central Station. Major nearby roads include Elizabeth Street and Pitt Street, which carry traffic to and from the Sydney Central Business District (CBD). The station is currently being upgraded to support the metro service, which is due to be operational from 2024.

The noise and vibration study area was defined to include the extent of locations where receivers may be potentially impacted by noise and/or vibration from the project.

Existing noise levels in the study area are relatively high (compared to smaller urban or suburban environments) and generally dominated by transport such as rail, light rail and major roads. Urban noise associated with the Sydney CBD also influences the existing noise environment. While noise levels are typically lower at night due to reduced activity, train and bus movements, and other night-time traffic still contribute to the background noise environment. Given the station's role, ambient noise is also affected by such activity on weekends.

A large proportion of the receivers closest to the project are of commercial use, particularly on major roads and in areas zoned as mixed use. Several hotels and other short-stay accommodation are near to the project. Residential receivers near to the project are generally scattered apartment buildings. Lower density residential receivers are generally set back several rows of buildings from the project.

Most of buildings immediately adjacent to the project are multistorey, with five or more floors. Large building structures provide shielding to receivers which are further back.

The assessment of impacts from the project uses Noise Catchment Areas (NCAs) to describe different receiver areas surrounding the project. NCAs are also used to apply appropriate criteria for groups of residential receivers, based on the existing background noise levels.

The noise and vibration study area, NCAs, and surrounding receivers are shown in **Figure 3**.

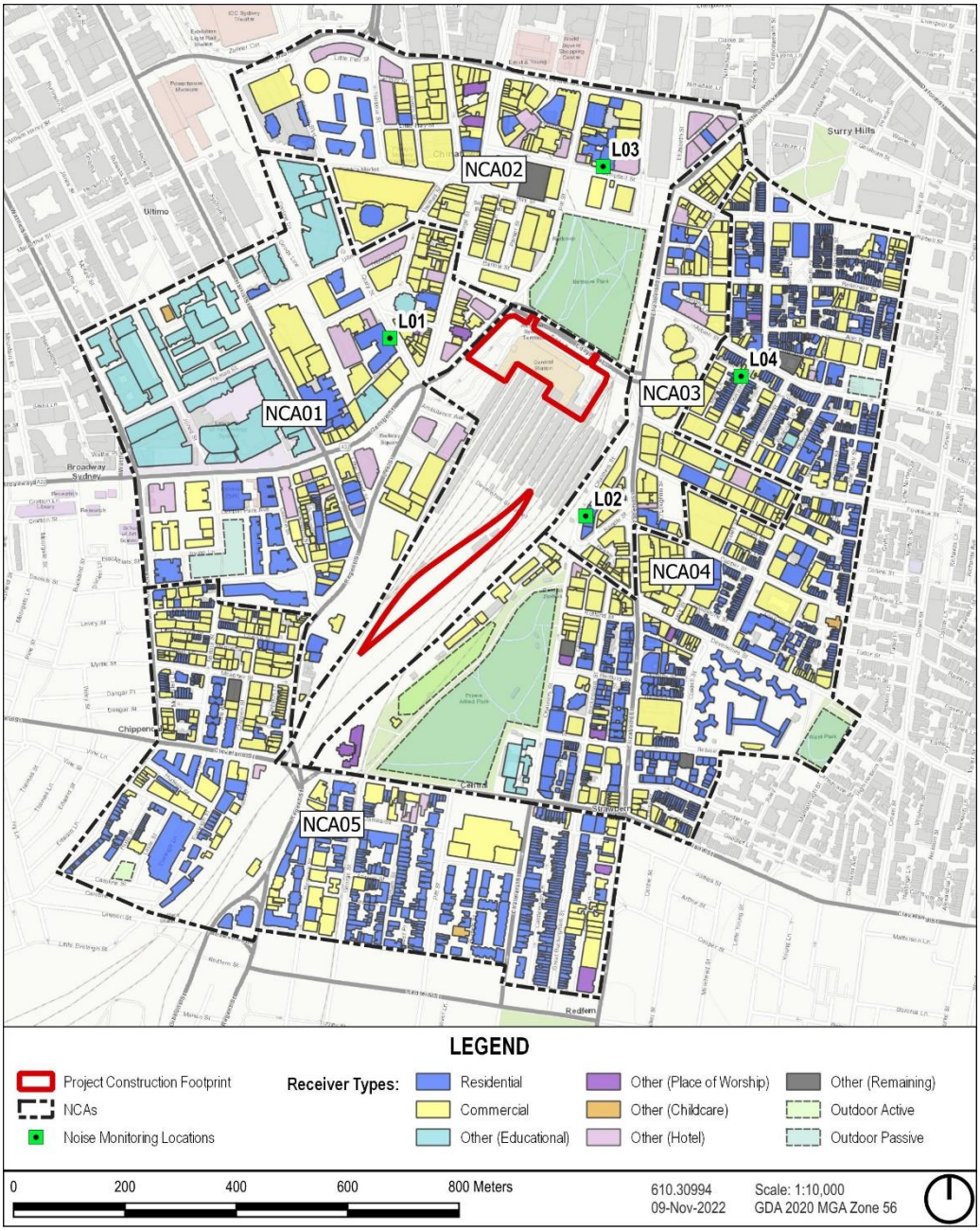


Figure 3 Study Area and Surrounding Receivers

2.2 Sensitive Receivers

Receivers potentially sensitive to noise and vibration have been categorised as residential buildings, commercial/industrial buildings, or 'other sensitive' land uses which includes educational institutions, child care centres, hotels, places of worship, outdoor recreation areas, etc.

The noise and vibration assessment identifies the likely maximum impacts from the project for receivers in the study area. Some buildings contain more than one use, such as residential apartments that have commercial uses on the ground floor. Where this occurs, buildings have been categorised based on the most noise sensitive use type identified in the building.

The sensitive receivers in each NCA are described in **Table 3**.

Table 3 Noise Catchment Areas

NCA	Description
NCA01	This catchment is located to the west of the project. The closest receivers are generally commercial but also include several hotels and place of worship receivers. TAFE NSW Ultimo and the University of Technology Sydney occupy a large portion of the NCA located more distant to the west of the project. The closest residential receivers are apartment buildings around 150 metres from the project. Residential receivers in this catchment have relatively high existing background noise levels.
NCA02	This catchment area is located to the north of the project. The closest receivers are generally commercial but also include Belmore Park directly north of the project and the Capitol Theatre around 200 metres north of the project. The closest residential receivers are apartment buildings around 300 metres north of the project on Campbell Street. Residential receivers in this catchment have relatively high existing background noise levels.
NCA03	This catchment is located east of the project. The closest receivers are generally commercial. The closest residential receivers are apartment buildings around 150 metres northeast of the project on Elizabeth Street and southeast of the project on Chalmers Street. Residential receivers in this catchment have relatively high existing background noise levels.
NCA04	This catchment is located east of the project, more distant than NCA03. This catchment includes residential areas with a significant proportion of lower density housing, generally in the form of one or two storey terraces. The closest residential receivers are around 250 metres east of the project. Residential receivers in this catchment are generally more distant from major infrastructure and the urban hum of the Sydney CBD, resulting in comparatively lower existing background noise levels.
NCA05	This catchment is located to the south of the project. The catchment is relatively distant from Central Station and potential noise impacts from the project are expected to be limited to the Sydney Trains Yard ancillary area. The closest residential receivers are around 150metres from the Sydney Trains Yard and are around 600 metres south of the main work at Central Station. Residential receivers in this catchment are generally more distant from major infrastructure and the urban hum of the Sydney CBD, resulting in comparatively lower existing background noise levels.

Detailed views of each NCA and 'other sensitive' receivers are shown in **Appendix B**.

2.2.1 New Developments

A review of recently approved potentially noise and vibration sensitive developments in the study area has been completed and the identified developments have been included in the assessment, where appropriate. This resulted in the following:

- The Adina Hotel and Sydney Railway Square YHA – identified as currently closed (i.e. currently not noise sensitive and not included in this assessment) due to the Western Gateway sub-precinct development at the time of the project construction
- 55-59 Wentworth Avenue – approved development application for a 20-storey hotel / residential building which is currently under construction and conservatively assumed to be open (a noise sensitive receiver) at the time of the project and included in the assessment
- Inner City Highschool – recently constructed 13 storey educational building included in the assessment.

2.3 Existing Noise Monitoring Survey

Unattended ambient noise monitoring was completed in the noise and vibration study area between 11 October and 1 November 2022. The measured noise levels have been used to determine the existing noise environment and to set criteria to assess the potential impacts from the project.

The ambient noise monitoring locations were selected with reference to the procedures outline in the Noise Policy for Industry (NPfI, Environmental Protection Authority, 2017). Monitoring was conducted during a regular (non-holiday) period for a minimum of 14 days at each location and excluded extraneous noise such as adverse weather. The measured existing noise levels are representative of residential receivers in each NCA that would likely be most affected by the construction of the project.

The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time. All equipment carried current National Association of Testing Authorities (NATA) calibration certificates and the calibration was checked before and after the monitoring.

The results of the noise monitoring have been processed with reference to the NPfI to exclude noise from extraneous events and/or data affected by adverse weather conditions, such as strong wind or rain (measured at Observatory Hill Weather Station), to establish representative existing noise levels for each NCA.

The monitoring results are summarised in **Table 4** and shown in **Figure 3**. Descriptions of each monitoring location and the measured noise environment, together with graphs of the daily measured noise levels, are also in **Appendix C**.

Table 4 Summary of Noise Monitoring Results

NCA	Location ID	Address	Noise Level (dBA)[1,2]					
			Background Noise (RBL)			Average Noise (LAeq)		
			Day	Evening	Night	Day	Evening	Night
NCA01	L01	107-121 Quay Street, Haymarket	57	57	50	64	63	60
NCA02	L02	303-321 Castlereagh Street, Haymarket	59	58	53	62	61	59
NCA03	L03	38 Chalmers Street, Surry Hills	53	53	48	61	61	59
NCA04	L04	201 Commonwealth Street, Surry Hills	50	49	44	59	57	55

Note 1: The RBL and L_{Aeq} noise levels have been determined with reference to the procedures in the NPfI.

Note 2: Daytime is 7am to 6pm, evening is 6pm to 10pm and night-time is 10pm to 7am.

Short-term attended noise monitoring was completed at each ambient monitoring location. The attended measurements allow the contributions of the various noise sources at each location to be determined. The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and show that existing noise levels are relatively high on a 24/7 basis, and are typically dominated by road and rail transportation noise sources, along with general urban hum.

3. Policy and Planning Context

The guidelines used to assess construction noise and vibration impacts from the project are listed in **Table 5**. The guidelines aim to protect the community and environment from excessive noise and vibration impacts as projects are constructed.

Table 5 Noise and Vibration Guidelines

Guideline/Policy name	Where guideline used
Guidelines and Policy for Assessment	
Construction Noise and Vibration Strategy (CNVS) (Transport for NSW, 2019)	Assessment and management of construction noise and vibration from Transport Infrastructure and Place projects
Interim Construction Noise Guideline (ICNG), (Department of Environment and Climate Change, 2009)	Assessment of construction noise (CNVS refers ICNG for construction noise)
Road Noise Policy (RNP) (Department of Environment, Climate Change and Water, 2011)	Assessment of construction traffic noise (CNVS refers RNP for construction traffic noise)
Noise Policy for Industry (NPfI) (Environmental Protection Authority, 2017)	Assessment of operational/industrial noise
Other Referenced Guidelines and Policy	
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces
Guideline for Child Care Centre Acoustic Assessment Version 2.0 (GCCCAA) (Association of Australasian Acoustical Consultants, 2013)	Contains reference noise criteria for child care centres
Assessing Vibration: a technical guideline (AVaTG) (Department of Environment and Conservation, 2006)	Assessment of human response to construction vibration (CNVS refers to AVaTG for human perception vibration)
BS7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993	Screening assessment of vibration impacts (cosmetic damage) to sensitive buildings and structures (CNVS refers to BS7385-2 for cosmetic damage vibration)
DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999	Screening assessment of vibration impacts (cosmetic damage) to vibration sensitive heritage buildings and structures, where the structure is found to be unsound (CNVS refers to DIN 4150-3 for heritage vibration)
Work Health and Safety Regulations, 2017	Legislation for employer noise management for construction workers

3.1 Construction Airborne Noise Guidelines

The ICNG is used to assess and manage impacts from construction noise on residences and other sensitive land uses in NSW.

The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers based on the existing background noise in the area. The 'worst-case' noise levels from construction of a project are predicted and then compared to the NMLs in a 15-minute assessment period to determine the likely impact of the project.

The NMLs are not mandatory limits, however, where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions should be investigated.

3.1.1 Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in **Table 6**.

Table 6 ICNG NMLs for Residential Receivers

Time of Day	NML $L_{Aeq(15minute)}$	How to Apply
Standard construction hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq(15minute) is greater than the noise affected level, the proponent should apply all feasible and reasonable work 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 (HNA) level represents the point above which there may be strong community reaction to noise.
		• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:
		  • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences.
		  • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside standard construction hours:	Noise affected RBL + 5 dB	• 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 dB above the noise affected level, the proponent should negotiate with the community.

Note 1: The RBL is the Rating Background Level and the ICNG refers to the calculation procedures in the Industrial Noise Policy (INP, Environmental Protection Authority, 2000). The INP has been superseded by the NPfI. The RBLs have been determined in accordance with the calculation procedures outlined in the NPfI.

The ICNG recommends work to be completed during standard construction hours where possible (see Section ***[CS]*** 5.3.11 of the EIS). More stringent requirements are placed on work that is required to be completed outside of standard construction hours (i.e. during the evening or night-time) which reflects the greater sensitivity of communities to noise impacts during these periods.

Sleep Disturbance

Major infrastructure projects often require certain work to be completed during the night-time. Where night work is located close to residential receivers there is potential for sleep disturbance impacts.

The ICNG lists five categories of work that might be required to be undertaken outside the standard construction hours:

- The **delivery of oversized equipment or structures** that require special arrangements to transport on public roads
- **Emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
- **Maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- **Public infrastructure work** that shortens the length of the project and are supported by the affected community
- Work where a proponent demonstrates and justifies **a need to operate outside the recommended standard hours**.

Where construction work is planned to extend over more than two consecutive nights, the ICNG recommends that an assessment of sleep disturbance impacts should be completed. Given the intention to carry out night work (see Section ***[CS]*** 5.3.11of the EIS) sleep disturbance impacts have been assessed in **Section 5**.

The most current method for assessing sleep disturbance from NSW transport infrastructure projects is contained in the NPfI. Although the NPfI sleep disturbance criteria relate to industrial noise, they are considered relevant for reviewing potential impacts from construction noise. The NPfI defined sleep disturbance criteria is 52 dBA L_{AFmax} or the prevailing background level plus 15 dB, whichever is the greater.

The ICNG also refers to the NSW *Environmental Criteria for Road Traffic Noise* (ECRTN) for assessing the potential of sleep disturbance impacts. The ECRTN has since been superseded by the NSW EPA *Road Noise Policy* (RNP), which concludes the following regarding research on sleep disturbance:

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

The above guidance results in the following:

- The 'sleep disturbance screening level' of the higher of 52 dBA or RBL +15 dB (external), which is used to identify receivers where there is potential for sleep disturbance.
- Where the sleep disturbance screening level is predicted to be exceeded, further assessment may be required to determine if the 'awakening reaction' level of L_{Amax} 55 dB (internal) is likely to be exceeded. The awakening reaction level is the level above which sleep disturbance may occur.

Summary of Residential NMLs

The residential NMLs for the project have been determined using the results from the unattended ambient noise monitoring (see **Section 2.3**) and are shown in **Table 7**.

Table 7 Residential Receiver Construction NMLs

NCA	Representative background monitoring location	NML $L_{Aeq(15minute)}$ – dBA				Sleep disturbance L_{Amax} - dBA		Highly Noise Affected $L_{Aeq(15minute)}$ – dBA
		Standard construction (RBL +10 dB)	Out of hours (RBL +5 dB)			Screening level (52 dBA or RBL +15 dB whichever is higher)	Awakening reaction[2]	
		Daytime	Daytime[1]	Evening	Night-time			
NCA01	L01	67	62	62	55	65	75	75
NCA02	L02	69	64	63	58	68	75	
NCA03	L03	63	58	58	53	63	75	
NCA04 & NCA05	L04	60	55	54	49	59	65	

Note 1: Daytime out of hours is 7am to 8am and 1pm to 6pm on Saturday, and 8am to 6pm on Sunday and public holidays.

Note 2: Awakening reaction level is based on 55 dBA internal. A 20 dB facade loss has been assumed for fixed windows in NCA01, NCA02 and NCA03 where the closest residential receivers are apartment buildings in a relatively high existing noise environment. A conservative 10 dB facade loss has been assumed for open windows in NCA04 and NCA05 which include low density residential receivers.

The noise monitoring locations were selected to measure background noise levels representative of the potentially most affected receivers in each NCA. These locations would likely be most affected during construction of the project and while background noise levels may be lower at receivers which are further back from the project. Previous experience and measurement data indicate construction noise tends to reduce at a faster rate than background noise with increasing distance. The worst-case noise impacts are, therefore, generally at the front row receivers and control the mitigation requirements.

3.1.2 'Other Sensitive' Land Uses and Commercial Receivers

Non-residential land uses have been identified in the study area. These include commercial properties and 'other sensitive' land uses such as hotels, educational institutes, and outdoor recreation areas. The NMLs for 'other sensitive' receivers are shown in **Table 8**.

Table 8 NMLs for 'Other Sensitive' Receivers

Land Use	Noise management level $L_{Aeq(15minute)}$ (dBA) (applied when the property is in use)	
	Internal	External
ICNG 'other sensitive' receivers		
Classrooms at schools and other educational institutions	45	55[1]
Places of worship	45	55[1]
Active recreation areas (characterised by sporting activities and activities which generate noise)	-	65
Passive recreation areas (characterised by contemplative activities that generate little noise)	-	60
Commercial	-	70
Industrial	-	75
Non-ICNG 'other sensitive' receivers		
Hotel – daytime & evening[3]	50	70[2]
Hotel – night-time[3]	40	60[2]
Court House[3]	35	55[2]
Theatre / auditorium[3] (when in use)	30	50[2]
Child care centres – sleeping areas[4]	40	50[1]

Note 1: It is assumed that these receivers have windows partially open for ventilation which results in internal noise levels being around 10 dB lower than the external noise level.

Note 2: It is assumed that these receivers have fixed windows which conservatively results in internal noise levels being around 20 dB lower than the external noise level.

Note 3: Taken from AS2107.

Note 4: Taken from the GCCCAA.

3.2 Construction Traffic Noise Guidelines

The potential impacts from construction traffic associated with the project when travelling on public roads are assessed under the RNP.

An initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than 2.0 dB due to construction traffic. Where this is considered likely, further assessment is required using the RNP base criteria shown in **Table 9**.

Table 9 RNP Criteria for Assessing Construction Traffic on Public Roads

Road category	Type of project/land use	Assessment criteria (dBA)	
		Daytime (7 am - 10 pm)	Night-time (10 pm - 7 am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	LAeq(15hour) 60 (external)	LAeq(9hour) 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	LAeq(1hour) 55 (external)	LAeq(1hour) 50 (external)

Where the criteria are exceeded, the project would consider the use of all feasible and reasonable mitigation and management measures to minimise the impacts. The potential project related construction traffic impacts are assessed in **Section 5.6**.

3.3 Construction Ground-Borne Noise Guidelines

Construction work can cause ground-borne (or regenerated) noise impacts in nearby buildings when vibration intensive equipment is in use. Vibration can be transmitted through the ground and into nearby buildings, which can then create audible noise impacts inside the building.

Ground-borne noise NMLs are applicable where ground-borne noise levels are likely to be higher than airborne noise levels, which can occur where work is internal or where noise is shielded by other structures. The potential ground-borne noise from vibration intensive activities associated with the project are assessed in **Section 5.5**.

The internal ground-borne noise NMLs used in the assessment for residential receivers are shown in **Table 10**.

Table 10 Construction Ground-borne NMLs

Period	Residential (Internal), dBA $L_{Aeq(15minute)}$
Daytime	45
Evening	40
Night-time	35

The ICNG does not provide ground-borne noise NMLs for ‘other sensitive’ receivers. For these receivers, the ICNG internal airborne noise NMLs listed in **Table 8** have been used to identify potential ground-borne noise impacts from the project.

3.4 Construction Vibration Guidelines

The effects of vibration from construction work can be divided into three categories:

- Those in which the occupants of buildings are disturbed (**human comfort**). People can sometimes perceive vibration impacts when vibration generating construction work is located close to occupied buildings. Vibration from construction work tends to be intermittent in nature and AVaTG provides criteria for intermittent vibration based on the Vibration Dose Value (VDV), as shown in **Table 11**. While the construction activities for the project are generally not expected to result in continuous or impulsive vibration impacts, criteria are provided in **Table 12**.
- Those where building contents may be affected (**building contents**). People perceive vibration at levels well below those likely to cause damage to building contents. For most receivers, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents. Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes or medical imaging equipment, are in buildings near to construction work. Vibration limits for the operation of sensitive scientific and medical equipment should be taken from manufacturer's data. Where this is not available the Vibration Criterion (VC) curves shown in **Table 13** can be used.
- Those where the integrity of the building may be compromised (**structural/cosmetic damage**). If vibration from construction work is sufficiently high, it can cause cosmetic damage to elements of affected buildings. Industry standard cosmetic damage vibration limits are specified in British Standard BS 7385 and German Standard DIN 4150. The limits are shown in **Table 14** and **Table 15**.

Table 11 Human Comfort Vibration – Vibration Dose Values for Intermittent Vibration

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical working areas (e.g. operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods and is dependent on the level of vibration as well as the duration.

Table 12 Human Comfort Vibration – Preferred and Maximum Weighted Root Mean Square Values for Continuous and Impulsive Vibration Acceleration (m/s2) 1–80 Hertz (Hz)

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration					
Critical working areas[1]	Day or night-time	0.0050	0.0036	0.010	0.0072
Residential	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
Workshops	Day or night-time	0.04	0.029	0.080	0.058
Impulsive Vibration					
Critical working areas[1]	Day or night-time	0.0050	0.0036	0.010	0.0072
Residential	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Note 1: Such as operating theatres or precision laboratories where sensitive operations are occurring. No such areas have been identified in the study area.

Table 13 VC Curves for Vibration Sensitive Equipment

Criterion Curve	Max Level (µm/sec, RMS)[1]	Detail Size (microns)[2]	Description of Use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note 1: Table reproduced from the CNVS

Note 2: As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz.

Note 3: The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given take into account the observation requirements of many items depend upon the detail size of the process.

Table 14 Cosmetic Damage – BS 7385 Transient Vibration Values for Minimal Risk of Damage

Group	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

Note 1: Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values may need to be reduced by up to 50%.

Table 15 Cosmetic Damage – DIN 4150 Guideline Values for Short-term Vibration on Structures

Group	Type of structure	Guideline values vibration velocity (mm/s)				
		Foundation, all directions at a frequency of			Topmost floor, horizontal	Floor slabs, vertical
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified as Group 1 or 2 **and** are of great intrinsic value (e.g. heritage listed buildings)	3	3 to 8	8 to 10	8	20[1]

Note 1: It may be necessary to lower the relevant guideline value markedly to prevent minor damage.

3.4.1 Heritage Buildings or Structures

Heritage listed buildings and structures should be considered on a case-by-case basis but as noted in BS 7385 should not be assumed to be more sensitive to vibration, unless structurally unsound. Where a heritage building is deemed to be sensitive, the more stringent DIN 4150 Group 3 guideline values in **Table 15** can be applied.

The project is located within the Stage Heritage Register (SHR) listed Sydney Terminal and Central Railway Stations Group, which includes underground rail tunnels and utilities. The nearby Christ Church St Laurence Anglican Church and Pipe Organ are also SHR listed and are located around 75 metres west of the Sydney Terminal Building and 30 metres west of the Western Forecourt. The heritage listed items in close proximity to the project are shown in **Figure 4**.

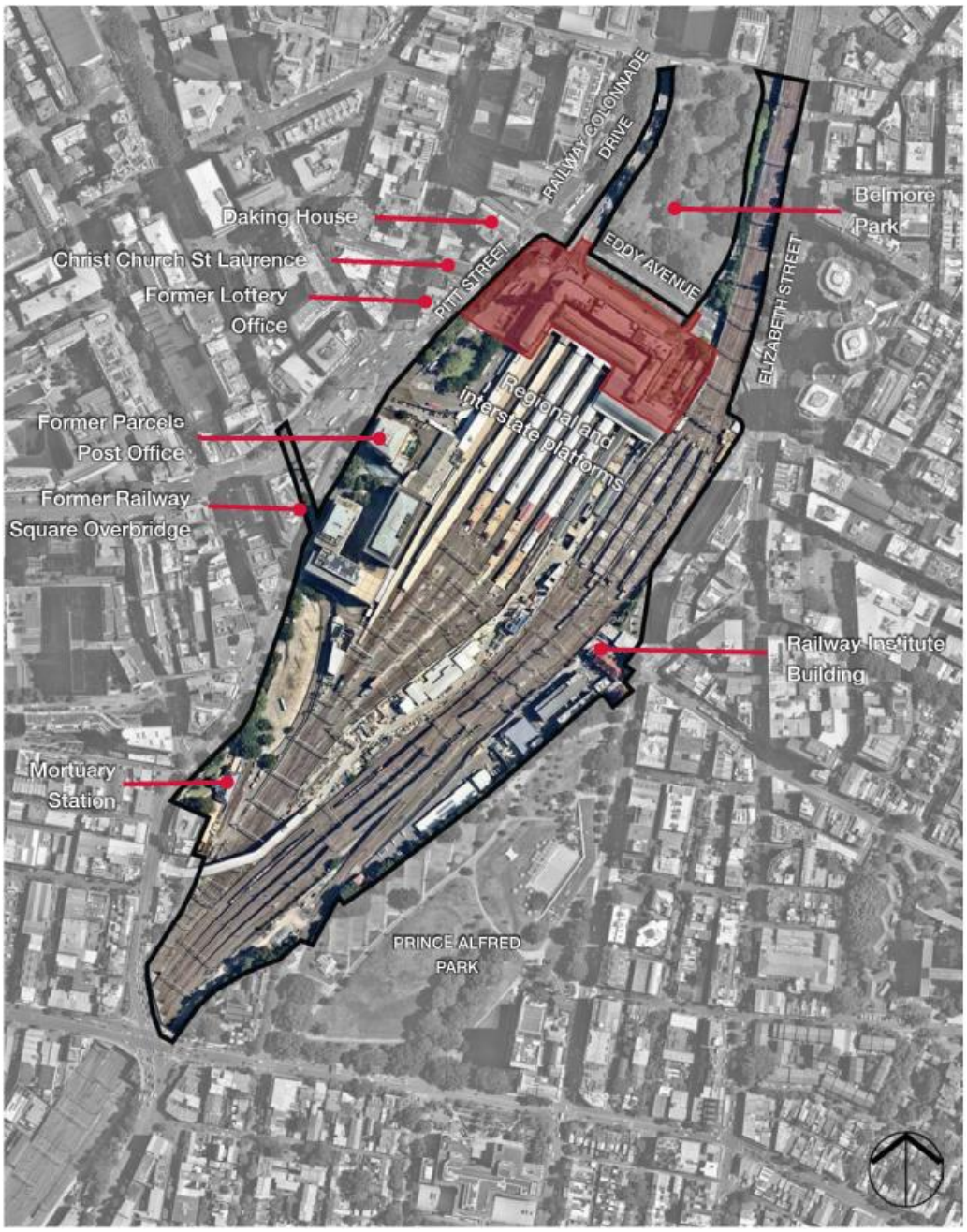


Figure 4 Heritage Items in Proximity to the Project (Project Operational Footprint Shaded Red)

3.4.2 Minimum Working Distances for Vibration Intensive Work

Minimum working distances for typical vibration intensive construction equipment are provided in the TfNSW *Construction Noise and Vibration Strategy* (CNVS) and are shown in **Table 16**.

The minimum working distances are for both cosmetic damage (from BS 7385 and DIN 4150) and human comfort (from the NSW EPA Vibration Guideline). They are calculated from empirical data which suggests that where work is further from receivers than the quoted minimum distances then impacts are not considered likely.

Table 16 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant item	Rating/Description	Minimum distance		
		Cosmetic damage		Human response (NSW EPA Guideline)
		Residential and light commercial (BS 7385)	Heritage items[1] (DIN 4150, Group 3)	
Vibratory roller	<50 kN (1–2 tonne)	5 m	11 m	15 m to 20 m
	<100 kN (2–4 tonne)	6 m	13 m	20 m
	<200 kN (4–6 tonne)	12 m	25 m	40 m
	<300 kN (7–13 tonne)	15 m	31 m	100 m
	>300 kN (13–18 tonne)	20 m	40 m	100 m
	>300 kN (>18 tonne)	25 m	50 m	100 m
Small hydraulic hammer	300 kg (5 to 12 t excavator)	2 m	5 m	7 m
Medium hydraulic hammer	900 kg (12 to 18 t excavator)	7 m	15 m	23 m
Large hydraulic hammer	1,600 kg (18 to 34 t excavator)	22 m	44 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	5 m to 40 m	20 m
Piling rig – bored	≤ 800 mm	2 m (nominal)	5 m	4 m
Jackhammer	Hand held	1 m (nominal)	3 m	2 m

Note 1: Minimum working distances for heritage items that have been identified as structurally unsound or otherwise particularly sensitive to vibration. These distances have been calculated based on the 2.5 mm/s PPV criteria from DIN 4150 and the cosmetic damage minimum working distances presented in the CNVS with reference to BS 7385.

The vibration intensive equipment assessed for the project are detailed in **Section 4.1.2**.

The minimum working distances are indicative and will vary depending on the particular item of equipment and local geotechnical conditions. The distances apply to cosmetic damage of typical buildings under typical geotechnical conditions.

Heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. Where heritage buildings and structures are found to be structurally unsound, a more conservative cosmetic damage objective of 2.5 mm/s Peak Particle Velocity (PPV) (from DIN 4150) would be considered. No structurally unsound heritage buildings or structures have been identified in the noise and vibration study area.

3.5 Operational Noise Guidelines

The NPfI was released in 2017 and sets out the requirements for the assessment and management of operational noise from industry in NSW.

The NPfI defines how to determine ‘trigger levels’ for noise emissions from industrial developments. Where a development is likely to exceed the trigger levels at existing noise sensitive receivers, feasible and reasonable noise management measures are required to be considered to reduce the impacts.

There are two types of trigger levels – one to account for 'intrusive' noise impacts and one to protect the 'amenity' of particular land uses:

- The **intrusiveness** of an industrial noise source is generally considered acceptable if the L_{Aeq} noise level of the source, measured over a period of 15-minutes, does not exceed the representative background noise level by more than 5 dB. Intrusive noise levels are only applied to residential receivers. For other receiver types, only the amenity levels apply.
- To limit continual increases in noise levels from the use of the intrusiveness level alone, the ambient noise level within an area from all industrial sources should remain below the recommended **amenity** levels specified in the NPfI for that particular land use.

Intrusive and amenity noise levels are not used directly as regulatory limits. They are used to assess the potential impact of noise, assess feasible and reasonable mitigation options and subsequently determine achievable noise requirements.

The NPfI provides guidance on assigning residential receiver amenity noise categories based on the site-specific features shown in **Table 17**.

Table 17 Residential Receiver Amenity

Receiver Category	Typical Planning Land Use Zoning	Typical Existing Background Noise Levels (RBL)	Description
Rural	RU1 – primary production RU2 – rural landscape RU4 – primary production small lots R5 – large lot residential E4 – environmental living	Daytime <40 dBA Evening <35 dBA Night <30 dBA	Rural – an area with an acoustical environment that is dominated by natural sounds, having little or no road traffic noise and generally characterised by low background noise levels. Settlement patterns would be typically sparse. Note: Where background noise levels are higher than those presented due to existing industry or intensive agricultural activities, the selection of a higher noise amenity area should be considered.
Suburban residential	RU5 – village RU6 – transition R2 – low density residential R3 – medium density residential E2 – environmental conservation E3 – environmental management	Daytime <45 dBA Evening <40 dBA Night <35dBA	Suburban – an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.
Urban residential	R1 – general residential R4 – high density residential B1 – neighbourhood centre (boarding houses and shop-top housing) B2 – local centre (boarding houses) B4 – mixed use	Daytime >45 dBA Evening >40 dBA Night >35 dBA	Urban – an area with an acoustical environment that: • Is dominated by 'urban hum' or industrial source noise, where urban hum means the aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources • Has through-traffic with characteristically heavy and continuous traffic flows during peak periods • Is near commercial districts or industrial districts • Has any combination of the above.

Amenity noise categories for the surrounding receivers have been determined with reference to the NPFI. The assessment is shown in **Table 18**.

Table 18 Residential Receiver Amenity Category Assessment

NCA	Land Use Zoning	Existing Background Noise Levels RBL (dBA)[1]			Resulting Amenity Classification	Discussion
		Day	Eve	Night		
NCA01	B4 – Mixed Use B8 – Metropolitan Centre Zone	57	57	50	Urban	The area surrounding the project is zoned as a mix of urban classifications. B8 and D zonings are not listed in the NPfI, however, they are considered to be comparable to urban zoning. The existing noise levels are relatively high and are controlled by continuous road traffic flows, noise from infrastructure and urban hum. Therefore, residences surrounding the project have been classified as urban.
NCA02	B8 – Metropolitan Centre Zone	59	58	53	Urban	
NCA03	B4 – Mixed Use	53	53	48	Urban	
NCA04	R1 – General Residential B4 – Mixed Use	50	49	44	Urban	
NCA05	R1 – General Residential B4 – Mixed Use D – Sustainable Mixed Use Development	50	49	44	Urban	

Note 1: See **Section 2.3** and **Appendix C** for background noise levels.

3.5.1 Project Noise Trigger Levels

Industrial noise from the project may include operational sources such as additional mechanical plant. The trigger levels for industrial noise from the project are summarised in **Table 19**. They are based on the previously measured background noise levels, where appropriate. The Project Noise Trigger Levels (PNTL) are the most stringent of the intrusiveness and amenity trigger level for each period and are shaded in grey below.

Table 19 Project Noise Trigger Levels

Receiver Type	Period	Amenity Noise Level L_{Aeq} (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels $L_{Aeq(15minute)}$ (dBA)	
			RBL[1]	L_{Aeq}(period)	Intrusiveness	Amenity[2,3]
NCA01 Residential	Day	60	57	64	62	58
	Evening	50	57	63	62	51[4]
	Night	45	50	60	55	48[4]
NCA02 Residential	Day	60	53	61	58	58
	Evening	50	53	61	58	49[4]
	Night	45	48	59	53	47[4]
NCA03 Residential	Day	60	53	61	58	58
	Evening	50	53	61	58	49[4]
	Night	45	48	59	53	47[4]
NCA04 & NCA05 Residential	Day	60	50	59	55	58
	Evening	50	49	57	54	48
	Night	45	44	55	49	43[4]

Receiver Type	Period	Amenity Noise Level L_{Aeq} (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels $L_{Aeq(15minute)}$ (dBA)	
			RBL[1]	L_{Aeq}(period)	Intrusiveness	Amenity[2,3]
Hotel	Day	65	-	-	-	58
	Evening	55	-	-	-	50
	Night	50	-	-	-	48
Educational[5]	When in use	50	-	-	-	48
Place of Worship[5]	When in use	50	-	-	-	48
Active Recreation Area	When in use	50	-	-	-	48
Passive Recreation Area	When in use	55	-	-	-	53
Commercial premises	When in use	65	-	-	-	63

Note 1: RBL = Rating Background Level.

Note 2: The recommended amenity noise levels have been reduced by 5 dB, where appropriate, to give the project amenity noise levels due to other sources of industrial noise being present in the area, as outlined in the NPfI.

Note 3: The project amenity noise levels have been converted to a 15-minute level by adding 3 dB, as outlined in the NPfI.

Note 4: The measured L_{Aeq} noise level was dominated by existing road traffic noise and exceeds the recommended amenity noise level by 10 dB or more, therefore, the 'high traffic project amenity noise level' is the existing $L_{Aeq(traffic)}$ noise level minus 15 dB, as outlined in the NPfI.

Note 5: The criterion is specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been assumed these receivers have windows partially open for ventilation which results in internal noise levels being around 10 dB lower than the external noise level.

3.5.2 Corrections for Annoying Noise Characteristics

Sources of industrial noise can cause greater annoyance where they contain certain characteristics, such as tonality, intermittency or dominant low-frequency content. The NPfI specifies the following modifying factor corrections, shown in **Table 20**, which are to be applied where annoying characteristics are present. The corrections are to be added to the noise level at the receiver before comparison with the PNTLs.

Table 20 NPfI Modifying Factor Corrections

Factor	Assessment/Measurement	When to Apply	Correction[1]
Tonal noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by the levels defined in the NPfI.	5 dB[2]
Low-frequency noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements	Measure/assess source contribution C and A weighted Leq,t levels over same time period. Correction to be applied where the C minus A level is 15 dB or more and the level to which the thresholds defined in the NPfI are exceeded.	2 or 5 dB[2]

Factor	Assessment/Measurement	When to Apply	Correction[1]
Intermittent noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level	The source noise heard at the receiver varies by more than 5 dB and the intermittent nature of the noise is clearly audible. The NPfI further defines intermittent noise as noise where the level suddenly drops/increases several times during the assessment period, with a noticeable change in source noise level of at least 5 dB, for example, equipment cycling on and off. The intermittency correction is not intended to be applied to changes in noise level due to meteorology.	5 dB[3]
Maximum adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated.	Maximum correction of 10 dB[2] (excluding duration correction)

Note 1: Corrections to be added to the measured or predicted levels.

Note 2: Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

Note 3: Adjustment to be applied to night-time only.

4. Methodology

4.1 Construction Noise Assessment Methodology

4.1.1 Airborne Noise Methodology

A noise model of the study area has been used to predict noise levels from the construction of the project to the surrounding receivers. The model uses ISO 9613 algorithms in SoundPLAN software to predict noise levels at external building facades and outdoor recreation areas.

Local terrain, receiver buildings and structures were digitised in the noise model to develop a three-dimensional representation of the construction sites and surrounding areas. Details of the noise modelling parameters used in the assessed are summarised in **Table 21**.

Table 21 Noise Model Inputs and Parameters

Input Parameter	Source of Data
Ground topography	The noise model includes a 'digital ground model' which is an accurate 3D representation of the terrain in the study area. The ground model was generated from 1 m LIDAR contours.
Buildings, receiver locations and floors	The buildings in the noise model were generated from a third-party database based on satellite imagery and a combination of automated and manual processing to identify building attributes. The model predicts noise to every facade of every identified receiver in the assessment area using the following heights: • Floor heights – 2.8 m • Ground floor receiver height – 1.5 m • Subsequent receiver heights – 1.5 m + 2.8 m times floor number (e.g. 4.3 m, 7.1 m, etc.)
Construction sources	Construction noise sources were modelled at a height of 1.5 m above the local ground surface. Construction work was modelled in discrete areas to represent the likely area that typical construction work for a particular scenario would be spread across.
Ground absorption	A ground absorption factor of 50% was used in the model.

The results of this assessment consider the highest predicted noise level at each receiver building from each work location. Therefore, the result at each receiver building is representative of the most impacted floor and facade within that building for each work scenario.

The assessment results are presented in terms of the number of receiver buildings that are predicted to be impacted. Given the multi-use nature of most buildings in the noise and vibration study area, the number of impacted individuals is expected to be substantially higher.

Construction Activities

Representative scenarios have been developed to assess the likely impacts from the construction activities. The scenarios cover a range of work, including high noise generating activities, that are considered to represent the expected peak and typical stages of construction.

The assessment uses ‘realistic worst-case’ scenarios to determine the impacts from the noisiest 15-minute periods that are likely to occur for each work scenario, as required by the ICNG. The impacts represent construction noise levels without mitigation applied.

The assessment is generally considered conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

Noise intensive construction would also not occur continuously, and it is expected that there would be relatively long periods where construction noise levels are much lower than the realistic worst-case levels presented in this assessment. There would also be times when work is not audible at receivers due to less noisy items of equipment being used or where work is in distant or shielded parts of the project.

Construction has been assessed individually for the various areas of the project based on the work locations and the areas of receivers that may be impacted. The construction areas at Central Station are shown in **Figure 5**. The Sydney Trains Yard ancillary construction area is located to the south of the station, as shown in **Figure 3**.

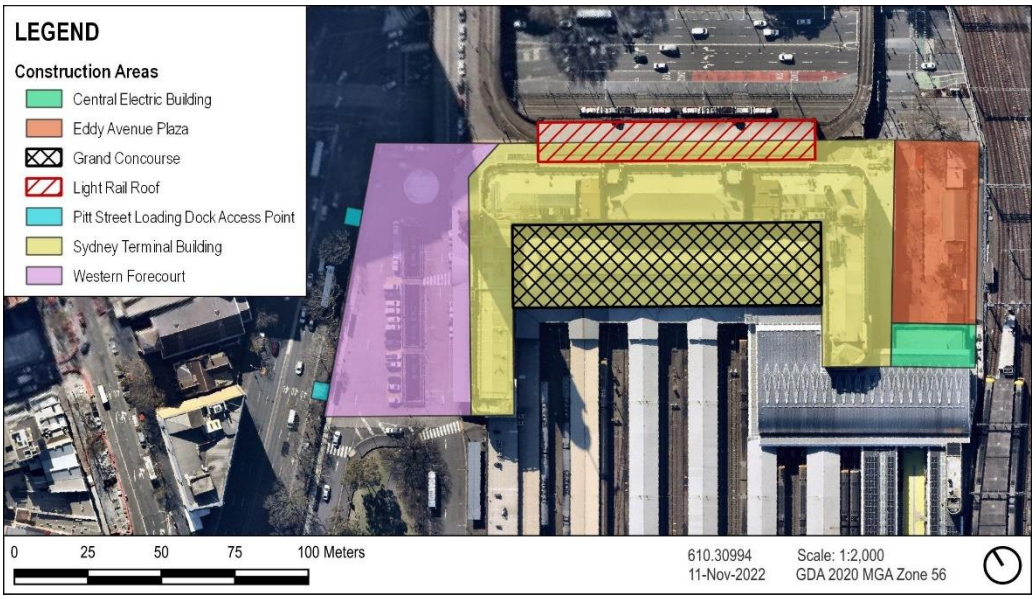


Figure 5 Construction Areas

Several construction scenarios at the Sydney Terminal Building would be located internally and would have reduced noise emissions to the surrounding receivers. Work within the Pitt Steet Loading Dock would also be internal, with notable construction noise emission only expected through the loading dock access points shown in **Figure 5**. For internal construction work the noise sources have been modelled at the relevant external facades with a 10 dB reduction in noise levels to represent partially closed facade elements.

The assessed construction noise scenarios are described in **Table 22**. Equipment lists for each scenario and sound power level data is provided in **Appendix D**.

Table 22 Construction Scenario Descriptions

Scenario	Description	Internal / External
All locations		
Deliveries and load out	This work would include: • Deliveries of materials, services, plant, equipment, etc • Load out of materials, soil/fill, redundant services, plant, equipment, etc. This work would require trucks movements and loading/unloading activity. Deliveries would access Eddy Avenue Plaza, the Central Electric Building and the Sydney Terminal Building via the Eddy Avenue Plaza. Deliveries would access the Pitt Street loading dock directly via Pitt Street. Deliveries would access the Western Forecourt via Railway Colonnade Drive off Pitt Street. Deliveries would access Sydney Trains Yard via the Sydney Yard Access Bridge off Regent Street (this was constructed as part of Sydney Metro City & Southwest).	External
Sydney Terminal Building		
Demolition and hazmat removal	This work would include: • Removal of hazardous materials • Demolition of plaster boards, walls, stripping of services, partitions and floor finishes • Structural penetrations of walls/ceiling/floors, mezzanine removal, scabbling existing floor. This work represents a peak scenario (i.e. noise intensive) and would include equipment such as concrete saws, jackhammers and vacuum trucks. A range of less noisy supporting equipment would also be required, such as hand tools and dust extractors.	Internal and External
Excavation	This work would include excavation for new back of house rooms, lift/escalator pits and stair bases. This work would require equipment such as mini excavators and loaders.	Internal and External
Concrete work	This work would include: • Construction of new slab on ground • Construction of new lift/ escalator pits • Construction of new stair /bases • Make good to structure • Strengthening as required. This work would require equipment such as concrete trucks, pumps and agitators.	Internal and External
Installation of services	This work would include the installation of new services, infrastructure and plant, lifts, escalators, base build, commissioning, switch over. This work would require equipment such as grinders, drop saws, cranes and elevated working platforms. The work would be internal only, noise emissions would be reduced by the building facade.	Internal
Roof construction – Grand Concourse	Replacement of roof sheeting to the Grand Concourse and Porte Cochere. This work would include a range of activities specific to this location: • Site establishment • Remove existing roof sheets • Install new purlins • Install new roof sheets • Install new ceiling fittings. This work would include equipment such as crawler cranes, elevated working platforms, grinders and various hand tools.	External

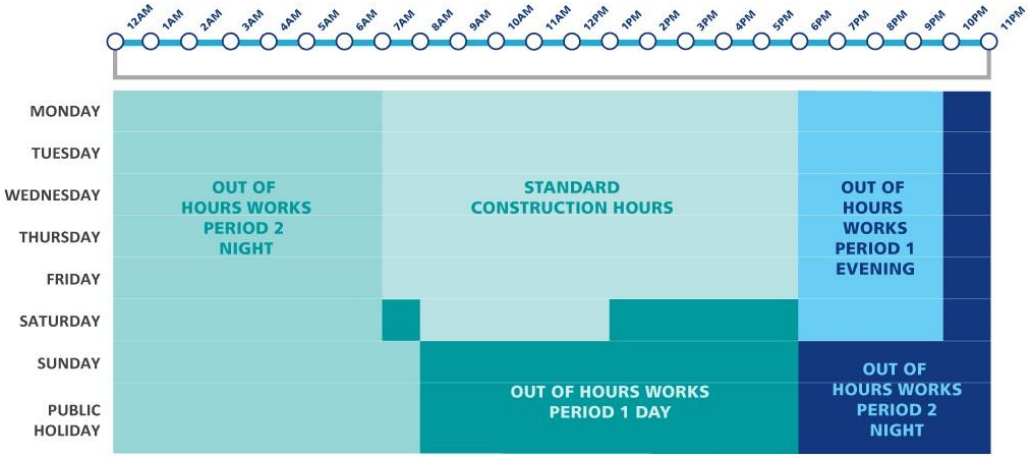
Scenario	Description	Internal / External
Grand Concourse work	This work would include removal of existing pavement, make good to existing slab, install terrazzo, excavation, planter/kiosk. This work represents a peak scenario (i.e. noise intensive) and would include equipment such as jackhammers and concrete saws.	External
Roof construction – Light rail skylight	This work includes modification to the existing light rail roof structure to install a skylight. This work would include equipment such as crawler cranes, elevated working platforms, grinders and various hand tools.	External
Facade refurbishment	This work includes refurbishment of existing facade/ windows, removal of existing awning and install new awning. This work would include equipment such as crawler cranes, elevated working platforms, sand blasting and pressure washing.	External
Eddy Avenue Plaza and Central Electric Building		
Demolition	This work would include: • Site establishment, demolition of existing buildings, and remove existing retaining wall/paving/landscaping • Excavation, scaffolding, bracing and propping, demolish existing ramp. This work represents a peak scenario (i.e. noise intensive) and would include equipment such as rockbreakers, concrete saws, jackhammers and vacuum trucks. A range of less noisy supporting equipment would also be required, such as hand tools and dust extractors.	Internal and External
Concrete work	This work would include: • Construction of new lift pit • Construction of new reinforced concrete wall • Make good to Central Electric structure • Central Electric roof work • Construction of new building structures, lift pit, stair bases, and facade work. This work would include equipment such as concrete trucks, pumps and agitators.	Internal and External
Installation of services	This work would include the installation of new services, plant, lifts, base build and commissioning. This work would require equipment such as grinders, drop saws, cranes and elevated working platforms. The work would be internal only, noise emissions would be reduced by the building facade.	Internal
Paving and landscaping	This work would include new paving and landscaping for the Eddy Avenue Plaza. The work would include equipment such as excavators, loaders and grinders.	External
Pitt Street Loading Dock		
Demolition and hazmat removal	This work would include: • Removal of hazardous materials • Clearing and stripping services • Decommissioning of redundant existing services and plant • Mezzanine removal and demolish floor. This work would include noise intensive equipment such as rockbreakers, concrete saws, jackhammers and vacuum trucks. However, the work is only required internal to the loading dock. A range of less noisy supporting equipment would also be required, such as hand tools and dust extractors.	Internal

Scenario	Description	Internal / External
Western Forecourt		
Western forecourt strengthening	This work would include the strengthening of the existing Western Forecourt structure. This work would include equipment such as welders, grinders, elevated working platforms and cranes.	External

Construction Working Hours

Construction of the project would be carried out during standard construction hours where possible. Standard construction hours are defined in the ICNG and shown in **Table 23**.

Table 23 Standard Construction Hours[1, 2, 3]



Note 1: Taken from the *Construction Noise and Vibration Strategy* (TfNSW, 2019).

Note 2: Standard Construction Hours are Monday to Friday 7am to 6pm and Saturdays from 8am to 1pm, as defined in the ICNG.

Note 3: Work outside of Standard Construction Hours is defined as 'Out-of-Hours Work' (OOHW) and can be divided into two periods of sensitivity. OOHW Period 1 relates to evening (and weekend daytime) work, and OOHW Period 2 relates to night-time (and weekend evening) work.

Project specific constraints require evening and night-time work for some construction activities. A summary of the proposed construction hours for the project is shown in **Table 24**.

Table 24 Construction Scenarios and Working Hours

Scenario	Estimated Duration[1]	Hours of Work			
		Standard Daytime	Day OOH[2]	Evening	Night-time
All Locations (around 36 months total)					
Deliveries and load out	Project duration	✓	✓	✓	✓
Sydney Terminal Building (around 27 months total)					
Demolition and hazmat removal	18 months	✓	-	-	-
Excavation	10 months	✓	-	-	-
Concrete work	18 months	✓	✓	✓	✓
Installation of services	19 months	✓	✓	✓	✓
Roof construction – Grand Concourse	17 months	✓	✓	✓	✓

Scenario	Estimated Duration[1]	Hours of Work			
		Standard Daytime	Day OOH[2]	Evening	Night-time
Grand Concourse work	17 months	✓	✓	✓	✓
Roof construction – Light Rail	5 months	✓	✓	✓	✓
Facade refurbishment	20 months	✓	✓	✓	✓
Eddy Avenue Plaza and Central Electric Building (around 18 months total)					
Demolition	2 months	✓	✓	✓	✓
Concrete work	5 months	✓	-	-	-
Installation of services	3 months	✓	-	-	-
Paving and landscaping	3 months	✓	-	-	-
Pitt Street Loading Dock (around 3 weeks total)					
Demolition and hazmat removal	3 weeks	✓	-	-	-
Western Forecourt (around 6 months total)					
Western forecourt strengthening	6 months	✓	✓	✓	✓

Note 1: Durations are indicative and would be confirmed by the construction contractor.

Note 2: OOH = out-of-hours. Daytime out-of-hours is Saturday between 7 am to 8 am and 1 pm to 6 pm, on Sunday and public holidays between 8 am to 6 pm.

Certain would be undertaken out of hours to minimise disruptions to customers, pedestrians, motorists, nearby sensitive receivers, and to ensure the safety of railway workers and operational assets. Deliveries would also be required out of hours to support this work.

This is consistent with the ICNG recognition of public infrastructure work being required out of hours to minimise disruption to services, support worker safety and shorten the length of the project.

Construction Schedule

Subject to planning approval, project construction is planned to commence in late 2023. The total duration of the project construction work is expected to be around three years. The indicative construction program for the project is shown in **Table 25**.

Table 25 Indicative Construction Program

Construction stage	2023		2024				2025				2026	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Site establishment and low impact work												
Eddy Avenue Plaza												
Substation Relocations												
Central Electric Building												
Grand Concourse												
Sydney Terminal Building												
Western Forecourt and Loading Dock												
Light rail track slew	This item of work is reliant on Sydney Light Rail schedule of possessions or shutdowns											

4.1.2 Ground-borne Noise and Vibration Assessment Methodology

The main vibration generating equipment are likely to be hydraulic hammers required for demolition work. Small excavators with hydraulic hammers may be used for work at Eddy Avenue Plaza, the Central Electric Building, and the Pitt Street Loading Dock. Work inside the Sydney Terminal Building would be limited to jackhammers, as required.

Ground-borne noise

Ground-borne noise refers to the 'rumble-like' noise generated from the vibration of the building's internal surfaces. Ground-borne noise is only required to be assessed where ground-borne noise levels are higher than the corresponding airborne noise levels.

Potential construction noise impacts are expected to be mainly airborne, however some receivers adjacent to the project may have internal spaces which do not have windows or facades facing the construction and could result in ground-borne noise levels during vibration intensive work being the dominant construction noise in these spaces. Similarly, when work is inside the Sydney Terminal Building or Pitt Street Loading dock the airborne noise transmission path to surrounding receivers may be obstructed such that ground-borne noise becomes the dominant construction noise source at nearby receivers. Therefore, ground-borne noise from vibration intensive construction work has been assessed.

The ground-borne noise assessment is based on the following key assumptions:

- Vibration source levels are conservatively assumed based on the CNVS minimum working distances for cosmetic damage (see **Table 16**)
- Hydraulic hammers used for external demolition are up to 300 kg in size
- Hydraulic hammers have a crest factor of 4
- Receiver buildings have a vibration reduction of 5 dB between the ground surface and building foundation (conservatively assumed based on typical residential construction, noting that large buildings with greater mass are expected to have a greater coupling loss)

- Receiver buildings have a vibration amplification of 10 dB due to the potential floor resonances.

Vibration

The potential impacts during vibration intensive work have been assessed using the CNVS minimum working distances for cosmetic damage and human response shown in **Table 16**. The assessment identifies structures which are within the minimum working distances based on the construction scenarios with vibration intensive equipment as shown in **Table 26**.

Table 26 Vibration Intensive Equipment

Scenario	Vibration intensive equipment	Minimum working distance		
		Cosmetic damage	Heritage items	Human response
Demolition Sydney Terminal Building (external) Eddy Avenue Plaza Central Electric Building Pitt Street Loading Dock	Medium hydraulic hammer (Around 300 kg hammer on a 5 to 12 tonne excavator)	7 m	15 m	23 m
Demolition Sydney Terminal Building (internal)	Jackhammer	1 m (nominal)	3 m	2 m

4.2 Construction Traffic

The potential impacts from construction traffic on public roads have been predicted using the *Calculation of Road Traffic Noise* (CORTN) algorithm.

Where the criteria are found to be exceeded, feasible and reasonable mitigation and management measures should be considered.

4.3 Operational Assessment Methodology

4.3.1 Operational Noise Sources

Operation of the project would not result in any change of the primary use of the station as a transport interchange. Any operational changes that arise from the project are expected to be limited to relatively minor changes related to retail activation, accessibility, wayfinding and safety.

Industrial noise emissions from the station are not expected to notably change due to the project. The potential sources of operational noise are summarised in **Table 27**.

Table 27 Potential Operational Noise Sources

Potential Operational Noise Source	Description	Detailed Assessment Completed
Mechanical Plant	The project includes removal of redundant services/equipment in back of house areas. The project also includes installation and operation of new services such as HVAC plant, lifts and escalators. At this stage specific lift and escalator systems have not been selected. However, given this type of source generally has relatively low noise emissions and the area has a high existing background noise environment, it is anticipated that such equipment is unlikely to result in operational noise impacts, or where impacts are expected they could be relatively easily mitigated during detailed design through the selection of appropriate equipment. The project also has potential for modifications to existing noise producing plant such as the reconfiguration of HVAC system components, however where internal plant reconfiguration is required by the project it is unlikely to result in any substantial change to the total industrial noise emission from the station. Additional external noise producing plant proposed at roof level has been assessed in this report to determine the potential for noise impacts at nearby receivers.	Yes – for additional plant
Pitt Street Loading Dock	The project includes market style activation within the western loading dock to create a new publicly accessible space. This new space would be located inside the station, behind the Pitt Street front retail buildings. There is no proposed change to the industrial use of the space (i.e. loading dock operation) and no change to the operational noise emissions is expected.	No
Coach Terminal	The project includes strengthening work to upgrade the load capacity of the Western Forecourt to support emergency vehicles and coach/bus loading. There is no proposed change to the typical use of the space in terms of the number of bus services and no change to operational noise emissions is expected.	No
Retail Operation and Patron Noise	The project includes new and enhanced retail spaces within the Sydney Terminal Building, Eddy Avenue Plaza and the Central Electric Building. The assessment of noise emissions from individual retail tenancies is typically included in tenancy specific Develop Applications. Additionally, given the nature of the area as a transport and commercial hub it is not expected that typical retail and/or patron noise would notably impact the surrounding background noise environment.	No

The potential operational noise levels from the proposed external roof plant for the Sydney Terminal Building have been predicted to the surrounding receivers using the ISO 9613 algorithms in SoundPLAN software. The model includes ground topography, receiver buildings and representative worst-case noise sources from the project. The operational noise modelling parameters are consistent with the construction noise model, shown in **Table 21**.

The assessed mechanical plant items are summarised in **Table 28** and are based on the concept design at the time of this assessment. This assessment provides an indicative summary of the potential mechanical plant noise impacts from the project. Final plant items and locations are subject to change as the project progresses.

Table 28 Mechanical Plant Details

Noise Source	Sound Power Level (dBA)[1]	Location
Air Cooled Chiller	91	1x Northwest roof 1x East roof
Suction Centrifugal Pump (chilled water and hot water)	68-70	8x Northwest roof 4x East Roof
Kitchen Exhaust Fan[2]	103-109	2x Northwest roof 4x Northeast roof
Toilet Exhaust Fan[2]	95	1x Northwest roof 1x Northeast roof

Note 1: Sound power level data was provided by Aurecon based on concept stage mechanical design and typical equipment specifications.

Note 2 Modelled exhaust fan noise levels include attenuators, ducting sections and bends as per the preliminary mechanical drawings for the project. This results in a noise level reduction of around 25-30 dB at the duct exhaust points.

It is conservatively assumed that the proposed plant will operation on a 24/7 basis. The potential impacts have been determined by comparing the predicted worst-case noise levels to the NPfI PNTLs in a 15-minute assessment period.

4.3.2 Corrections for Annoying Noise Characteristics

The proposed mechanical plant is not expected to produce annoying characteristic (i.e. tonality, low-frequency noise or intermittency) at the nearest receivers based on the equipment type, receiver distances of at least 100 metres, and previous measurements of similar equipment.

4.3.3 Noise Sources with Potential for Sleep Disturbance

The proposed mechanical plant is expected to operate continuously on a 24/7 basis. Variation in noise emission may occur due to different load conditions, however, this would be unlikely to cause impulsive noise (i.e. sudden drops/increases several times in the 15 minute assessment period). Therefore, maximum noise level events are not expected.

4.3.4 Weather Conditions

Operational noise has been assessed using ISO 9613 prediction algorithms. This includes conditions representative of moderately noise enhancing weather, including source to receiver wind. This methodology is considered representative of the worst-case potential noise enhancing weather, in accordance with the requirements of the NPfI.

5. Construction Impact Assessment

5.1 Summary of Key Findings

- Daytime construction airborne noise impacts at residential receivers are generally only predicted at the closest few receivers (i.e. less than 10), when peak work is required externally. For most of construction work, daytime airborne noise levels are predicted to comply with the management levels at all residential receivers.
- Night-time construction airborne noise impacts at residential receivers are predicted to be more widespread due to the lower existing noise environment. Worst-case night-time impacts at residential receivers are predicted when peak work is being completed externally at the Sydney Terminal Building, Eddy Avenue Plaza and the Central Electric Building. Night-time work at the Sydney Terminal Building is expected to last up to 20 months for various scenarios. Night-time work at Eddy Avenue Plaza and the Central Electric Building would be relatively short-term and is expected to take around two months.
- Many of the receivers closest to the project are commercial or 'other sensitive' such as hotels, places of worship, educational receivers and outdoor passive recreation areas. Theses receivers are predicted to be impacted by construction noise during most work scenarios when noisy activities are being completed nearby.
- Typical scenarios such as 'deliveries and load out' are predicted comply with the management levels at all receivers during the daytime and are predicted to have relatively minor impacts at the closest few receivers during the night-time period. Peak scenarios such as 'demolition and hazmat removal', which use noise intensive equipment such as rockbreakers and concrete saws, are predicted to result in higher impacts, particularly during the night-time period, with intermittent impacts potentially lasting for around 22 months in total.
- Sleep disturbance impacts are predicted at the closest residential receivers when peak work is required during the night-time.
- No ground-borne noise impacts are predicted at the surrounding receivers from vibration intensive construction work.
- All surrounding receivers are beyond the cosmetic damage and human comfort minimum working distances for vibration intensive equipment.
- There is potential for vibration impacts at the Sydney Terminal and Central Railway Stations Group SHR listed area, given the project is within the heritage area.

5.2 Construction Airborne Noise at Surrounding Receivers

The following assessment shows the predicted noise impacts based on the exceedance of the NML, as per the categories in **Table 29** which are taken from the CNVS (see **Section 8.3** for further detail).

Table 29 NML Exceedance Bands and Corresponding CNVS Perception Categories

CNVS Perception Category	NML Exceedance		Impact colouring
	Daytime	Out of hours	
n/a	No exceedance	No exceedance	
Noticeable	-	1 to 5 dB	
Clearly Audible	1 to 10 dB	6 to 15 dB	
Moderately Intrusive	11 to 20 dB	16 to 25 dB	
Highly Intrusive	> 20 dB	> 25 dB	

For most activities, it is expected that the construction noise levels would frequently be lower than predicted, as the noise levels presented in this report are based on the worst-case scenario when construction is at the closest point to each receiver.

The assessment is generally considered conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios. There would frequently be periods when construction noise levels are much lower than the worst-case levels predicted as well as times when no equipment is in use.

5.2.1 Detailed Airborne Noise Impacts

The following sections present a detailed assessment of the likely worst-case predicted noise impacts from the various areas of project construction. Impacts are presented in terms of the number of receiver buildings and outdoor areas predicted to exceed the NMLs.

The construction work assessed in this section is categorised as ‘peak’ and ‘typical’ scenarios based on sound the power level of the equipment and the work location. For example, construction work is considered to be ‘peak’ when it is required external to the project buildings and is more exposed to surrounding receivers. This represents the wort-case potential scenario, particularly when high noise generating activities such as demolition are required.

The work is considered ‘typical’ when it is inside the project buildings which would have reduced noise impacts at the surrounding receivers. ‘Typical’ work represents the noise levels that are more likely to be produced for the majority of the project construction.

Sydney Terminal Building

The Sydney Terminal Building work would commence with the removal of redundant services and building fabric followed by a staged fit out. Work would also include the revitalisation of the Grand Concourse, including restoration of the roof structure

The first phases of work represented by ‘demolition and hazmat removal’ and ‘excavation’ scenarios would occur during standard daytime hours. All subsequent work, such as ‘concrete work’ and ‘facade refurbishment’ would be required outside of standard hours. Work would be required at the ground level and the Grand Concourse level (level one relative to Eddy Avenue).

The predicted airborne noise impacts are summarised in **Table 30** and **Table 31** for residential receivers and commercial/‘other sensitive’ receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers when the work is at its closest.

Daytime noise impacts at residential receivers are only predicted during 'demolition and hazmat removal' when noise intensive work is required externally, which is expected to last around 18 months. The worst-case daytime noise impacts for this scenario are shown in **Figure 6**.

The highest night-time noise impacts are predicted during 'Grand Concourse work', an activity that is expected to last around 17 months. The worst-case night-time noise impacts from this scenario are shown in **Figure 7**. The noise impacts during typical night-time work are shown in **Figure 8** for the 'installation of services' scenario, an activity expected to last around 19 months. This shows the range of impacts predicted from construction at the Sydney Terminal Building.

Table 30 Sydney Terminal Building Summary of Residential NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																			
		HNA[1]	With NML Exceedance																		
			Standard Daytime			Out-of-Hours Work[2]															
						Daytime OOH				Evening				Night-time				Sleep Disturbance			
			1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB
Deliveries and load out (External) – Typical	Project duration	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	2	-	-	-
Demolition and hazmat removal (External) - Peak	18 months	-	10	-	-	n/a															
Demolition and hazmat removal (Internal) - Typical		-	-	-	-																
Excavation (External) – Peak	10 months	-	-	-	-																
Excavation (Internal) – Typical		-	-	-	-																
Concrete work (External) – Peak	18 months	-	1	-	-	5	1	-	-	9	1	-	-	57	10	-	-	10	2	-	-
Concrete work (Internal) – Typical		-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Installation of services (Internal) – Typical	19 months	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
Roof construction – Grand Concourse (External) – Peak	17 months	-	-	-	-	2	-	-	-	3	-	-	-	21	4	-	-	5	-	-	-
Grand Concourse work (External) – Peak	17 months	-	1	-	-	7	1	-	-	9	1	-	-	105	11	-	-	16	1	-	-
Roof construction – Light Rail (External) – Peak	5 months	-	-	-	-	3	-	-	-	5	-	-	-	35	5	-	-	5	1	-	-
Facade refurbishment (External) – Peak	20 months	-	-	-	-	4	-	-	-	6	-	-	-	45	6	-	-	10	2	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Note 1: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 2: OOH = out of hours.

Table 31 Sydney Terminal Building Summary of Commercial and 'Other Sensitive' NML Exceedances

Scenario	Estimated Duration	Number of Impacted Receiver Buildings with NML Exceedance																				
		Commercial			Educational			Hotel (Day)			Hotel (Night)				Place of Worship			Theatre			Outdoor Passive		
		1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Deliveries and load out (external) – Typical	Project duration	-	-	-	1	-	-	-	-	-	2	-		-	1	-	-	-	-	-	1	-	-
Demolition and hazmat removal (External) - Peak	18 months	9	-	-	4	1	-	3	-	-	n/a				2	-	1	2	-	-	-	1	-
Demolition and hazmat removal (Internal) - Typical		-	-	-	1	-	-	-	-	-					-	1	-	-	-	-	1	-	-
Excavation (External) – Peak	10 months	-	-	-	1	-	-	-	-	-					-	1	-	-	-	-	1	-	-
Excavation (Internal) – Typical	10 months	-	-	-	-	-	-	-	-	-					1	-	-	-	-	-	-	-	-
Concrete work (External) – Peak	18 months	-	-	-	2	1	-	1	-	-	3	3		-	-	1	-	1	-	-	1	-	-
Concrete work (Internal) – Typical		-	-	-	1	-	-	-	-	-	1	-		-	1	-	-	-	-	-	-	-	-
Installation of services (Internal) – Typical	19 months	-	-	-	1	-	-	-	-	-	2	-		-	1	-	-	-	-	-	1	-	-
Roof construction – Grand Concourse (External) – Peak	17 months	-	-	-	3	-	-	-	-	-	2	1		-	1	-	-	1	-	-	-	-	-
Grand Concourse work (External) – Peak	17 months	-	-	-	3	-	-	-	-	-	2	-		-	1	-	-	1	-	-	-	-	-
Roof construction – Light Rail (External) – Peak	5 months	-	-	-	1	-	-	-	-	-	1	1		-	1	-	-	1	-	-	1	-	-
Facade refurbishment (External) – Peak	20 months	-	-	-	3	-	-	1	-	-	1	3		-	-	1	-	1	-	-	1	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

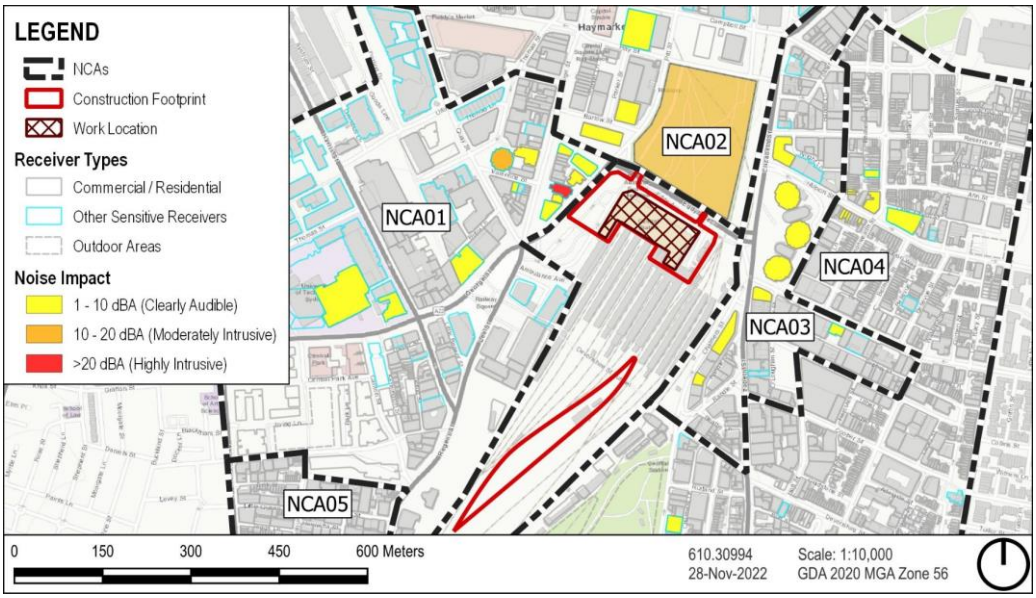


Figure 6 Sydney Terminal Building Daytime Noise Impacts – Demolition and Hazmat Removal (External)

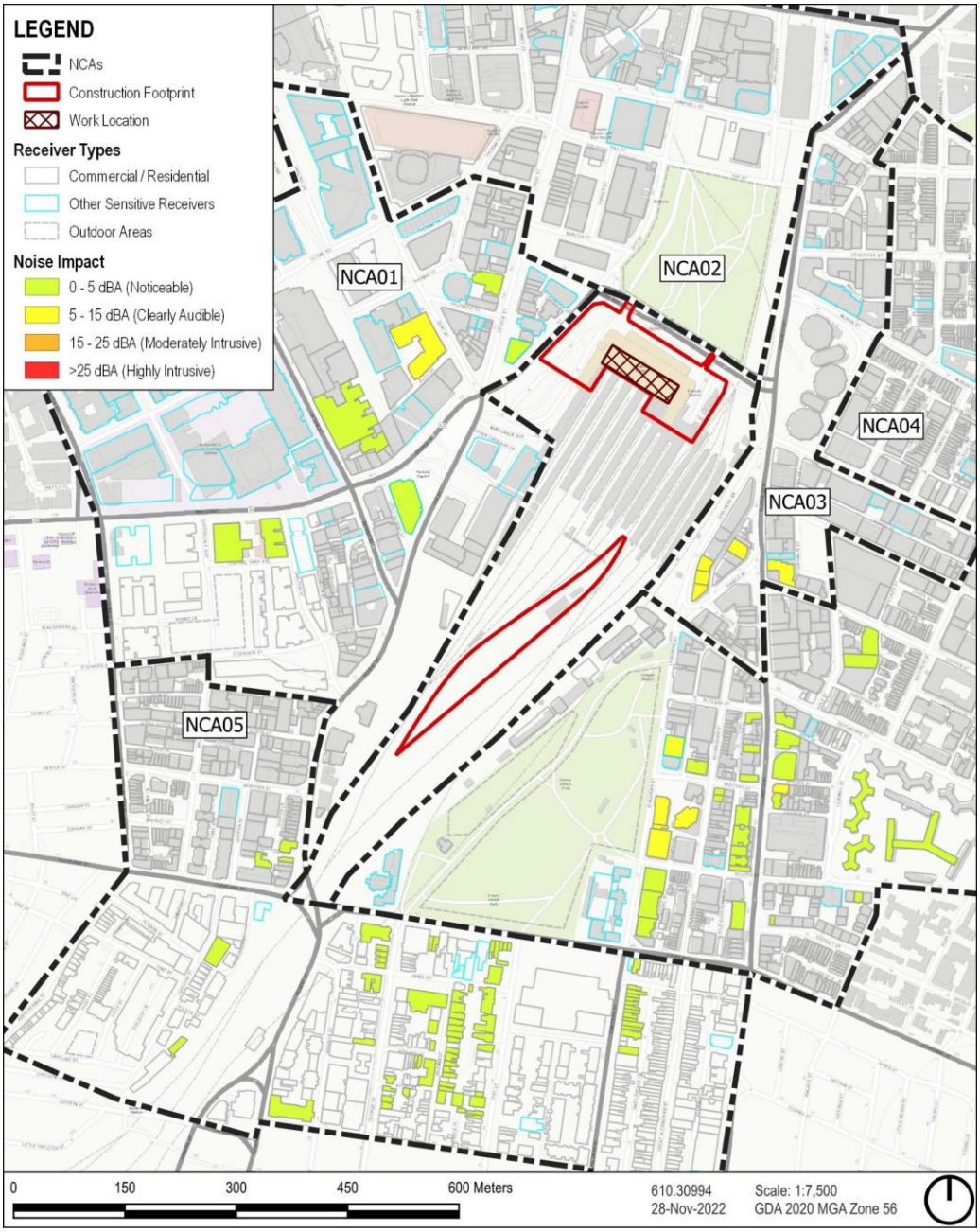


Figure 7 Sydney Terminal Building Night-time Airborne Noise Impacts – Grand Concourse Work (External)

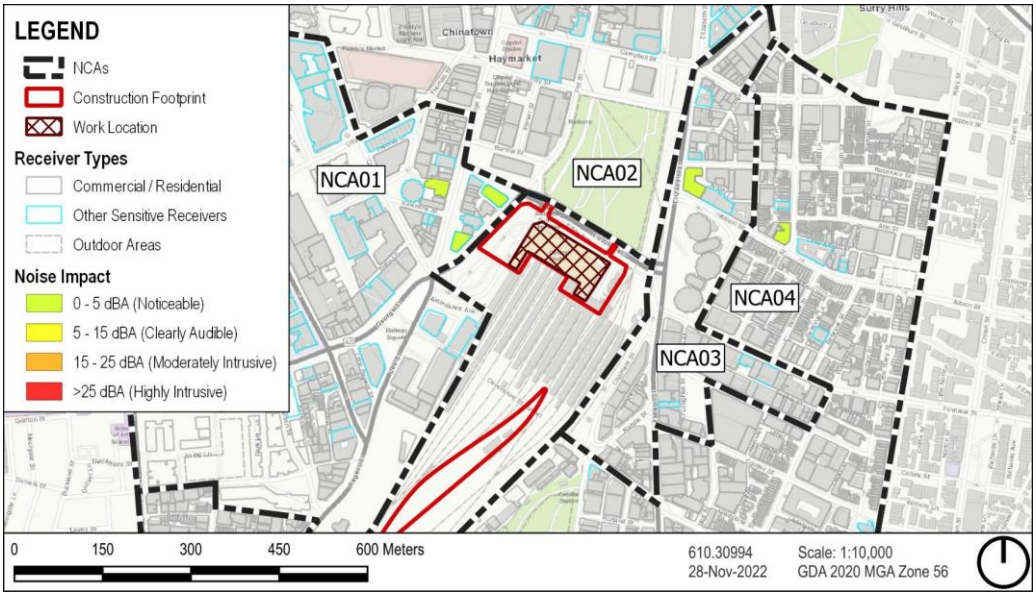


Figure 8 Sydney Terminal Building Night-time Airborne Noise Impacts – Installation of Services (Internal)

The construction airborne noise assessment at the Sydney Terminal Building shows the following:

- Daytime impacts at residential receivers are only predicted during the 'demolition and hazmat removal', 'concrete work' and 'Grand Concourse work' scenarios when work is required externally. These activities are expected to last for around 18 months each. Worst-case impacts are predicted to be 'clearly audible' (1-10 dB) at up to 10 of the closest residential receivers. The impacted receivers include one apartment building on west of the project in NCA01, six apartment buildings east of the project in NCA03 and some residences more distant to the east of the project in NCA04.
- The worst-case night-time impacts at residential receivers are predicted during the 'Grand Concourse work' scenario when work is required externally, an activity that is expected to last for around 18 months. 'Clearly audible' (6-15 dB) impacts are predicted at up to 11 residential receivers and 'noticeable' (0-5 dB) are predicted at up to 105 receivers. During other external work such as 'roof construction' and 'facade refurbishment', similar noise levels are predicted however less residential receivers are impacted. During typical 'deliveries and load out' and all internal work, impacts are predicted to be substantially less, with 'noticeable' (1-5 dB) impacts at a small number of the closest residential receivers and compliant noise levels all more distant receivers.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted when they are in use and noisy construction work is being competed at the Sydney Terminal Building. Worst-case 'highly intrusive' and 'moderately intrusive' impacts are predicted at:
    - 'Highly intrusive' (>20 dB) at Christ Church St Laurence, immediately west of the project in NCA01.
    - 'Moderately intrusive' (11-20 dB) at one University Technology Sydney building, west of the project in NCA01.

- ‘Moderately intrusive’ (11-20 dB) at Belmore Park, immediately north of the project in NCA02.
- Moderately intrusive’ (6-15 dB) during the night-time at the Sydney Central YHA Hostel, Wake Up! Sydney Hostel and 790 on George Backpackers, west of the project in NCA01.

- The above figures show a number of isolated receivers which are distant from the project are predicted to be impacted, whereas closer receivers are not. This generally occurs where the impacted receivers are taller than the surrounding buildings so that they have a direct line of site to the project over the intervening buildings. Distant ‘other sensitive’ receivers are also more likely to be impacted during the daytime period due to the NMLs for these receiver categorise being more stringent than the NMLs for surrounding commercial and residential receivers.
- The highest impacts are predicted during peak work, such as during ‘demolition and hazmat removal’ or ‘concrete work’. The predicted worst-case impacts are only expected to occur intermittently when noise intensive equipment is being used externally. The impacts are predicted to substantially reduce during typical work which does not require noise intensive equipment and/or is located inside the station.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 8**.

Eddy Avenue Plaza and Central Electric Building

Work at Eddy Avenue Plaza would involve adaptive reuse, additions, and alterations of retail space within Eddy Avenue Plaza including a new two storey retail building adjacent to the rail line. The Eddy Avenue Plaza would also be levelled providing better access and pedestrian flow through the plaza and to the Sydney Terminal Building.

The Central Electric Building would be repurposed to allow for new retail space on Level 1 and on the rooftop. New access points to the Central Electric Building would be created between the new two storey retail space in Eddy Avenue Plaza and the Grand Concourse level of the Sydney Terminal Building.

Demolition would first be required outside of standard construction hours. This would take around two months to complete. The following phases of work, represented by the’ concrete work’, ‘installation of services’ and ‘paving and landscaping’ scenarios would occur during standard daytime hours over a period of around 11 months.

The predicted airborne noise impacts are summarised in **Table 32** and **Table 33** for residential receivers and commercial/‘other sensitive’ receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers when the work is at its closest.

Daytime noise impacts at residential receivers are only predicted during ‘demolition’ when noise intensive work is required externally. The worst-case daytime noise impacts from this scenario are shown in **Figure 9**.

The worst-case night-time noise impacts are predicted during ‘demolition’. The night-time noise impacts from this scenario are shown in **Figure 10** when work is external and **Figure 11** when work is internal. This shows the range of impacts predicted from construction at Eddy Avenue Plaza and the Central Electric Building.

Table 32 Eddy Avenue Plaza and Central Electric Building Summary of Residential NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																			
		HNA[1]	With NML Exceedance																		
			Standard Daytime			Out-of-Hours Work[2]															
						Daytime OOH				Evening				Night-time				Sleep Disturbance			
			1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB
Deliveries and load out (External) - Typical	Project duration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Demolition (External) – Peak	2 months	-	7	-	-	48	7	-	-	54	12	-	-	104	66	-	-	28	6	-	-
Demolition (Internal) – Typical		-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-
Concrete work (External) – Peak	5 months	-	-	-	-	n/a															
Concrete work (Internal) – Typical		-	-	-	-																
Installation of services (Internal) – Typical	3 months	-	-	-	-																
Paving and landscaping (External) – Peak	3 months	-	-	-	-																

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Note 1: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 2: OOH = out of hours.

Table 33 Eddy Avenue Plaza and Central Electric Building Summary of Comsectionmercial and 'Other Sensitive' NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																					
		Commercial			Educational			Hotel (Day)			Hotel (Night)				Place of Worship			Theatre			Outdoor Passive		
		1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Deliveries and load out (External) - Typical	Project duration	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-
Demolition (External) – Peak	2 months	5	-	-	2	-	-	-	-	-	6	1	-	-	1	-	-	2	-	-	-	1	-
Demolition (Internal) – Typical		-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	1	-	-
Concrete work (External) – Peak	5 months	-	-	-	-	-	-	-	-	-	n/a				-	-	-	1	-	-	1	-	-
Concrete work (Internal) – Typical		-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-	-
Installation of services (Internal) – Typical	3 months	-	-	-	-	-	-	-	-	-					-	-	-	-	-	-	-	-	-
Paving and landscaping (External) – Peak	3 months	-	-	-	-	-	-	-	-	-					-	-	-	1	-	-	1	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

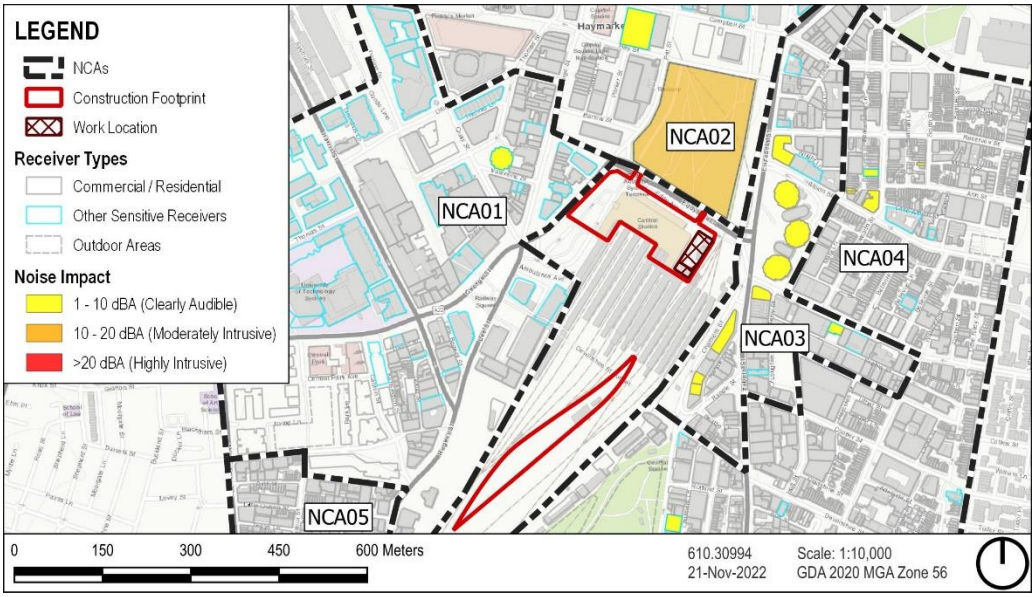


Figure 9 Eddy Avenue Plaza and Central Electric Building Daytime Noise Impacts – Demolition (External)

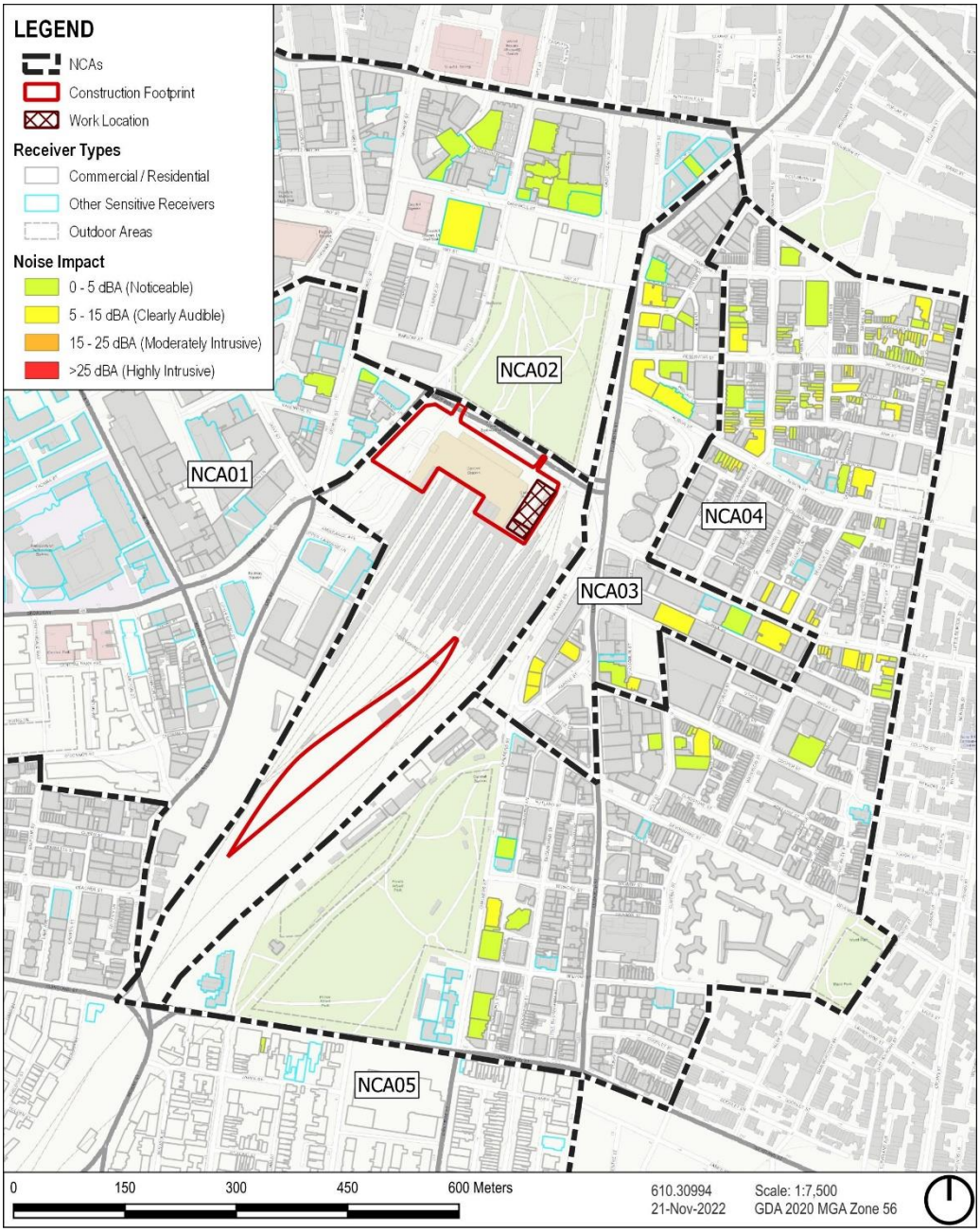


Figure 10 Eddy Avenue Plaza and Central Electric Building Night-time Noise Impacts – Demolition (External)

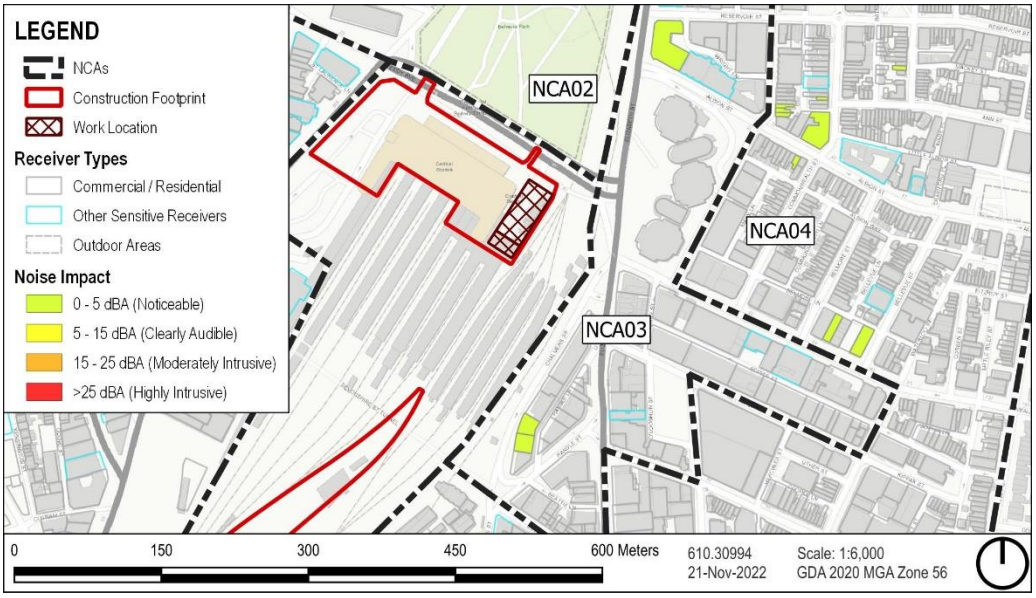


Figure 11 Eddy Avenue Plaza and Central Electric Building Night-time Noise Impacts – Demolition (Internal)

The construction airborne noise assessment at Eddy Avenue Plaza and the Central Electric Building shows the following:

- Daytime impacts at residential receivers are only predicted during the 'demolition' scenario when work is required externally, an activity which is expected to last for around two months. Worst-case impacts are predicted to be 'clearly audible' (1-10 dB) at up to seven of the closest residential receivers. These receivers include three apartment buildings east of the project in NCA03 and some residences more distant to the east of the project in NCA04.
- The worst-case night-time impacts at residential receivers are predicted during the 'demolition' scenario when work is required externally, an activity which is expected to last for around two months. 'Clearly audible' (6-15 dB) impacts are predicted at up to 66 residential receivers and 'noticeable' (1-5 dB) are predicted at up to 104 more distant receivers. When the work is inside the existing buildings in Eddy Avenue Plaza and the Central Electric Building, impacts are predicted to substantially reduce with 'noticeable' (1-5 dB) impacts at 12 receivers and compliant noise levels all more distant receivers. 'Deliveries and load out' work is predicted to comply with the management levels at all surrounding receivers.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted when they are in use and noisy construction work is occurring at Eddy Avenue Plaza and the Central Electric Building. Worst-case 'moderately intrusive' (11-20 dB) impacts are predicted at Belmore Park, immediately north of the project in NCA02.
- The above figures show a number of isolated receivers which are distant from the project are predicted to be impacted, whereas closer receivers are not. This generally occurs where the impacted receivers are taller than the surrounding buildings so that they have a direct line of site to the project over the intervening buildings. Distant 'other sensitive' receivers are also more likely to be impacted during the daytime period due to the NMLs for these receiver categorise being more stringent than the NMLs for surrounding commercial and residential receivers.

- The highest impacts are predicted during peak work, such as during 'demolition and hazmat removal' or 'concrete work'. The predicted worst-case impacts are only expected to occur intermittently when noise intensive equipment is being used externally. The impacts are predicted to substantially reduce during typical work which does not require noise intensive equipment and/or is located inside the station.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 8**.

Western Forecourt and Pitt Street Loading Dock

Work at the Western Forecourt would involve strengthening to upgrade the load capacity of the Western Forecourt to support emergency vehicles and coach/bus loading, an activity that is expected to take around six months.

Work at the Pitt Street Loading Dock would involve modification and removal of redundant services/equipment to allow market-style retail activation within the loading dock, an activity that is expected to take around three weeks.

Construction ancillary facilities such as site compounds for plant, equipment and material storage would also be located within the Western Forecourt and Pitt Street Loading Dock. This activity is represented by the 'deliveries and load out' scenario, which is expected to be required for the duration of the project.

The predicted airborne noise impacts are summarised in **Table 34** and **Table 35** for residential receivers and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers when the work is at its closest.

Daytime noise impacts are only predicted at 'other sensitive' receivers. The worst-case daytime noise impacts from 'demolition and hazmat removal' are shown in **Figure 12**.

Worst-case night-time noise impacts are predicted during 'Western Forecourt strengthening'. The night-time noise impacts from this scenario are shown in **Figure 13**.

Table 34 Western Forecourt and Pitt Street Loading Dock Summary of Residential NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																			
		HNA[1]	With NML Exceedance																		
			Standard Daytime			Out-of-Hours Work[2]															
						Daytime OOH				Evening				Night-time				Sleep Disturbance			
			1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB
Deliveries and load out (External) – Typical	Project duration	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-
Demolition and hazmat removal (Internal) – Typical	3 weeks	-	-	-	-	n/a															
Western forecourt strengthening (External) – Peak	6 months	-	-	-	-	1	-	-	-	1	-	-	-	1	1	-	-	1	-	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Note 1: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 2: OOH = out of hours.

Table 35 Western Forecourt and Pitt Street Loading Dock Summary of Commercial and 'Other Sensitive' NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																		
		Commercial			Educational			Hotel (Day)			Hotel (Night)				Place of Worship			Outdoor Passive		
		1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Deliveries and load out (External) – Typical	Project duration	1	-	-	1	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
Demolition and hazmat removal (Internal) – Typical	3 weeks	2	-	-	2	-	-	2	-	-	n/a				-	-	1	-	-	-
Western forecourt strengthening (External) - Peak	6 months	-	-	-	2	-	-	1	-	-	2	2	-	-	-	1	-	1	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

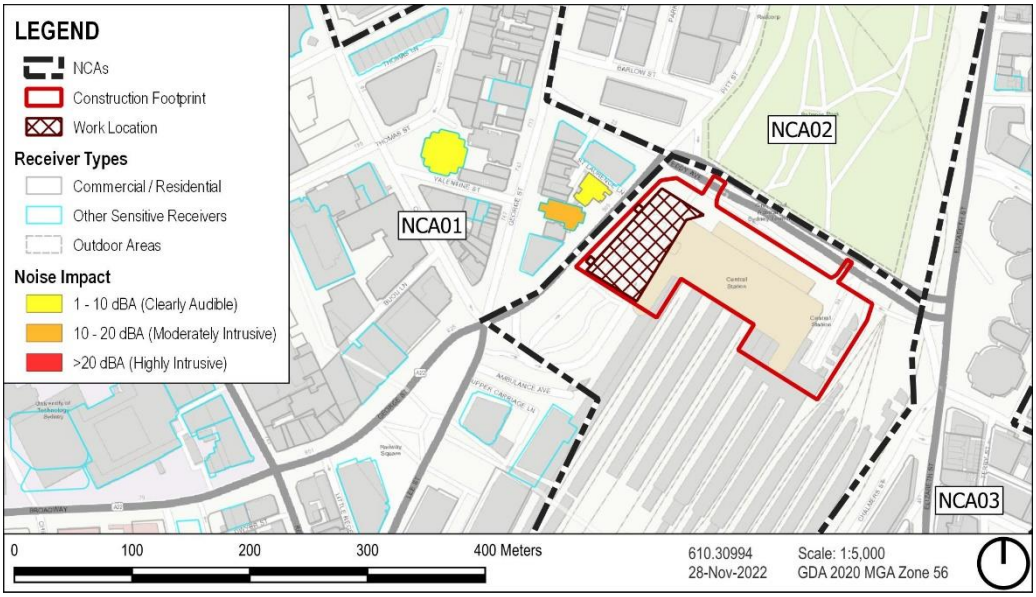


Figure 12 Pitt Street Loading Dock Daytime Noise Impacts – Demolition and Hazmat Removal (Internal)

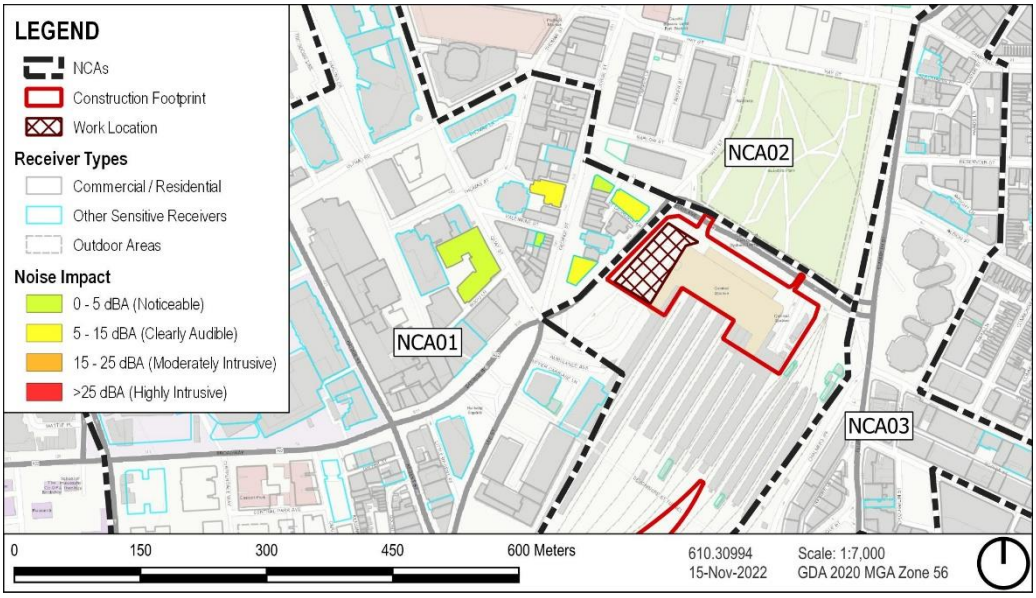


Figure 13 Western Forecourt Night-time Noise Impacts – Western Forecourt Strengthening (External)

The construction airborne noise assessment at the Western Forecourt and the Pitt Street Loading Dock shows the following:

- Work during standard daytime hours is predicted to comply with the management levels at all residential receivers.
- The worst-case night-time impacts at residential receivers are predicted during the 'Western Forecourt strengthening' scenario, an activity that is expected to last for around 6 months. 'Clearly audible' (6-15 dB) worst-case impacts are predicted at the nearest residential receiver and 'noticeable' (1-5 dB) impacts are predicted at one more distant receiver. During typical 'deliveries and load out' work' worst-case impacts are predicted to be 'noticeable' (1-5 dB) at the closest residential receiver.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted when they are in use and noisy construction work is occurring at the Western Forecourt. Worst-case 'moderately intrusive' (6-15 dB) impacts are predicted during the night-time at the Sydney Central YHA Hostel, immediately west of the project in NCA01.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 8**.

Sydney Trains Yard

Construction staff amenities and equipment and plant storage would also be provided in the Sydney Trains Yard. This work is represented by the 'deliveries and load out' scenario that would be required outside of standard construction hours, an activity that is expected to be required for the duration of the project.

The predicted airborne noise impacts are summarised in **Table 36** and **Table 37** for residential receivers and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers when the work is at its closest.

The night-time noise impacts are shown in **Figure 14.**

Table 36 Sydney Trains Yard Summary of Residential NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																				
		HNA[1]	With NML Exceedance																			
			Standard Daytime			Out-of-Hours Work[2]																
						Daytime OOH				Evening				Night-time				Sleep Disturbance				
			1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB
Deliveries and load out (External) - Typical	Project duration	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	7	-	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

Note 1: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 2: OOH = out of hours.

Table 37 Sydney Trains Yard Summary of Commercial and 'Other Sensitive' NML Exceedances

Scenario	Estimated Duration	Number of Receiver Buildings																				
		Commercial			Educational			Hotel (Day)			Hotel (Night)				Place of Worship			Theatre			Outdoor Passive		
		1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-5 dB	6-15 dB	16-25 dB	>25 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Deliveries and load out (External) – Typical	Project duration	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

Key to Impacts	Noticeable	Clearly Audible	Moderately Intrusive	Highly Intrusive

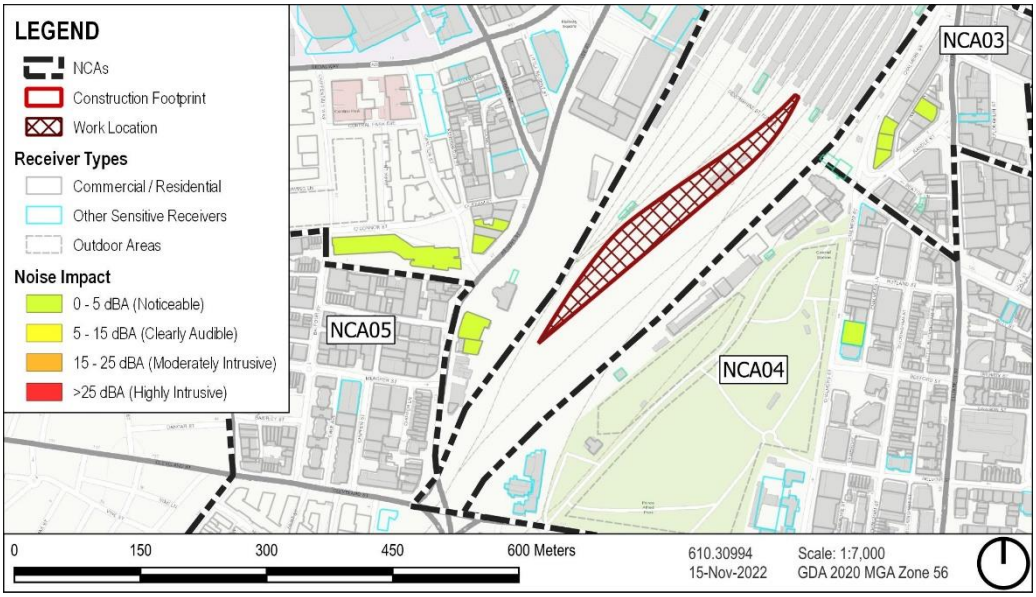


Figure 14 Sydney Trains Yard Night-time Noise Impacts – Deliveries and Load Out (External)

The construction airborne noise assessment at the Sydney Trains Yard shows the following:

- During the daytime, work at the Sydney Trains Yard is predicted to comply with the management levels at all residential receivers.
- During the night-time, worst-case impacts are predicted to be 'noticeable' (1-5 dB) at up to nine of the closest residential receivers.
- 'Clearly audible' (1-10 dB) impacts are predicted at the Tom Mann Theatre, east of the project in NCA03, when it is in use and noisy construction work is occurring at the Sydney Trains Yard.
- Supporting work at the Sydney Trains Yard is expected to be required for the duration of the project.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 8**.

5.2.2 Highly Noise Affected Residential Receivers

No residential receivers are predicted to be highly noise affected from the project construction work.

5.2.3 Sleep Disturbance

A sleep disturbance assessment has been completed and is summarised in **Table 30**, **Table 32**, **Table 34** and **Table 36** for the separately assessed construction locations. The assessment predicts worst-case exceedances of the sleep disturbance screening criteria at:

- Up to 12 of the residential receivers closest to work at the Sydney Terminal Building
- Up to 50 of the residential receivers closest to work at Eddy Avenue Plaza and the Central Electric Building

- One residential receiver closest to work at the Western Forecourt
- Up to seven of the residential receivers closest to work at the Sydney Trains Yard.

The majority of exceedances of the sleep disturbance screening criteria are predicted to be relatively minor in magnitude, being only 1-5 dB above the sleep disturbance screening level.

Maximum noise events that are predicted to exceed the sleep disturbance screening level have been assessed in further detail in **Table 38**.

Table 38 Detailed Maximum Noise Level Assessment

NCA	Maximum Noise Level L_{Amax} (dBA)			Comments
	Awakening Reaction	Predicted Maximum Noise Levels	Existing Maximum Noise Levels	
NCA01	75	73	75-85	Maximum noise levels are predicted to be below the 'awakening reaction' level at all receivers in NCA01, NCA02, NCA03 and NCA05. Maximum noise levels in NCA04 are predicted to potentially be marginally above the 'awakening response' level by 1-4 dB at nine of the closest receivers in NCA04. This is, however, only expected to occur during the 'demolition' scenario when work is required externally at Eddy Avenue Plaza and the Central Electric Building. The unattended noise monitoring showed that existing maximum noise levels were measured to frequently be greater than 70 dB at all monitoring locations. Project construction related maximum noise levels are likely to be similar in magnitude or lower than existing maximum noise levels.
NCA02	75	67	70-80	
NCA03	75	74	75-85	
NCA04	65	69	70-80	
NCA05	65	59	70-80	

The results show that construction maximum noise events are generally predicted to be below the 'awakening reaction' level. Minor exceedances of 1-4 dB are predicted at nine of the closest residential receivers in NCA04, however, this is only expected to occur during the 'demolition' scenario when work is required externally at Eddy Avenue Plaza and the Central Electric Building. This scenario is expected to last for about two months.

It is noted that the noise monitoring shows existing night-time maximum noise levels in the range of 70 to 80 dB frequently occur in NCA04, which is greater than the worst-case predicted project related construction maximum noise levels. As such, the significance of the minor exceedances of the sleep awakening reaction level is considered relatively low. The impacts would be mitigated using measures in **Section 8** and no specific mitigation measures are considered necessary to address these impacts.

The assessment is based on receiver buildings. The number of individuals that would potentially be subject to exceedances of the sleep disturbance screening criteria is expected to be greater.

The number of potential night-time awakenings during the work would depend on several factors, including the type of equipment being used, the duration of the noisy external work and the background noise levels at the time of the work. Further investigation of the potential for awakenings would be completed as the project progresses and detailed construction planning information becomes available.

5.2.4 'Other Sensitive' Receivers

Assessment of construction noise impacts on 'other sensitive' receivers has been completed and is summarised in **Table 31**, **Table 33**, **Table 35**, and **Table 37** for the separately assessed construction locations.

Impacts at 'other sensitive' receivers are predicted for most work scenarios when noisy activities are being completed, due to their proximity to the project. A number of hotel, educational and place of worship receivers are adjacent the project and have a direct line of site to the construction work locations.

It is noted that the criteria for 'other sensitive' receivers, based on the ICNG methodology, are absolute noise levels rather than a relative exceedance of the existing background noise levels. For example, place of worship and educational receivers have an external NML of 55 dBA and hotels have an external NML of 60 dBA during the night-time. The background noise survey summarised in **Section 2.3** indicates that existing noise levels in the study area are regularly at this level. Therefore, it is expected that the subjective level of impact at such receivers would likely be lower than the impacts presented in this assessment.

Construction scenarios resulting in night-time impacts at hotels are generally also predicted to have impacts at the closest residential receivers. Therefore, mitigation measures applied to manage the residential impacts would also manage the impacts to night-time amenity at nearby hotels.

The proposed mitigation measures to minimise and manage the predicted impacts at 'other sensitive' receivers are discussed in **Section 8**.

5.3 Construction Airborne Noise at Central Station

The project requires the use of noise intensive equipment, such as concrete saws or jackhammers, during certain stages of the work inside the Sydney Terminal Building. The use of noise intensive equipment in an enclosed reverberant space may result in potential noise impacts on people in and around the station building. This could include construction workers, staff in commercial areas, office workers, commuters, rough sleepers, etc.

The NSW Work Health and Safety Regulation 2017 includes a $L_{Aeq(8\ hour)}$ noise limit of 85 dBA, which sets a noise limit over an eight hour period.

The potential construction noise impacts on rough sleepers is considered further in the Social Impact Assessment (see Section ***[CS]*** 13.2 of the EIS).

The potential for occupational health and safety noise impacts would be further reviewed by the construction contractor as the project progresses.

5.4 Construction Ground-borne Noise Impacts

Ground-borne noise impacts have been predicted based on a small hydraulic hammer (300 kg) for demolition work at Eddy Avenue Plaza, the Central Electric Building and Pitt Street Loading Dock.

The predicted ground-borne noise levels based on distance from the relevant work are shown in **Figure 15**.

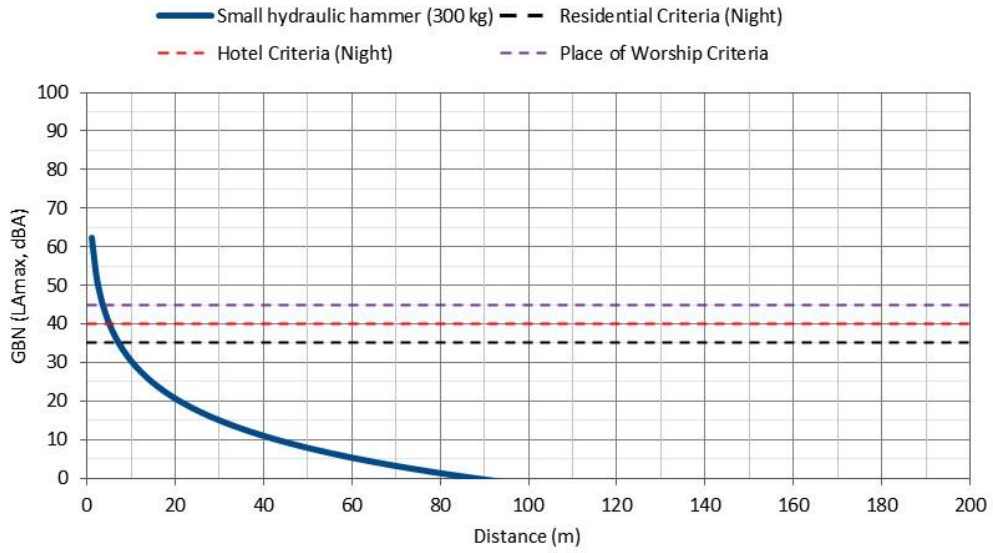


Figure 15 Modelled Ground-borne Noise Levels versus Distance

The receivers surrounding the project are sufficiently distant from the construction work for no ground-borne noise impacts to be predicted.

It is, however, noted that ground-borne noise levels may be audible within the commercial and commuter areas of Central Station when vibration intensive work occurs and the station is open to the public. Internal ground-borne noise at Central Station would vary depending on the location of the vibration producing work relative to the receiver space(s). **Figure 15** shows that worst-case ground-borne noise levels could be around 60 dBA in areas immediately adjacent to or underneath vibration intensive work. Ground-borne noise of this magnitude may cause annoyance, however, it is noted as being similar to existing L_{Aeq} noise levels in the area surrounding the station (see **Section 2.3**).

5.5 Construction Vibration

Minimum offset distances for the vibration intensive equipment required to complete the work are shown in **Figure 16**.

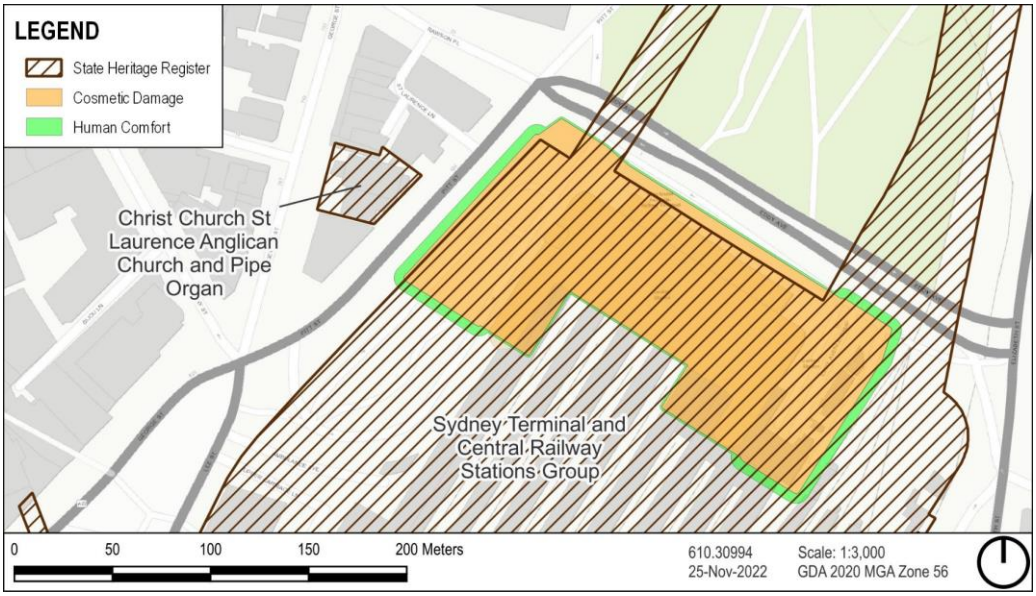


Figure 16 Construction Vibration Assessment

All surrounding receivers are beyond the minimum working distances for cosmetic damage and human comfort.

Due to the nature of the project, structures within the Sydney Terminal and Central Railway Stations Group heritage area, including tunnels and existing rail infrastructure, are within the cosmetic damage minimum working distance.

BS 7385 recommends a 25 mm/s PPV criteria to avoid cosmetic damage for reinforced or framed structures, industrial and heavy commercial buildings. It is considered unlikely that the proposed construction equipment would induce this level of vibration outside of the areas it is directly interacting with as part of the construction work. Cosmetic damage is, therefore, considered unlikely to occur at the station (where existing elements are of structurally sound condition).

BS 7385 also notes that structures below ground, such as rail tunnels, are generally known to sustain higher levels of vibration and are resistant to damage from unless in very poor condition.

Notwithstanding, attended vibration measurements are recommended to be completed at the start of new vibration intensive work to confirm the vibration levels produced by the equipment are appropriate.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 8**. If elements of the heritage item are found to be structurally unsound, specific additional mitigation measures should be applied to avoid vibration impacts.

5.5.1 Vibration Sensitive Equipment

The only receiver identified near the project with potential vibration sensitive equipment is the Sydney Dental Hospital. The receiver is around 100 metres southeast of the project at 2 Chalmers Street, Surry Hills and may have CT scanners or other sensitive medical equipment which may require assessment against the VC-A criteria (see **Table 13**). The Sydney Dental Hospital is, however, considered sufficiently distant from the project for construction vibration levels to be expected to comply with VC-A criteria.

More distant receivers at the University of Technology Sydney may also have vibration sensitive equipment. However, the university buildings are around 500 metres from the project and are not expected to be impacted by vibration.

5.6 Construction Traffic

Construction related traffic has the potential to temporarily increase road traffic noise levels at receivers that are near to haulage routes.

The construction workforce would average 100 workers per day and have an estimated peak of 200 workers per day over the three year construction period. Workers would predominately use light vehicles. Construction heavy vehicles would be required for deliveries and removal of waste.

Indicative construction traffic volumes on the proposed construction haulage routes are detailed in **Table 39**.

Table 39 Indicative Construction Traffic Volumes

Vehicle Type	Number of Vehicles Per Day	Roads Likely to be Used
Heavy vehicles	30	Eddy Avenue Pitt Street Railway Colonnade Drive Regent Street
Light vehicles	50	

The above shows that project would require relatively low numbers of construction traffic compared to the high existing volumes on major roads in the area (see the Traffic, transport and access assessment).

Project related construction traffic is not expected to result in a noticeable increase in road traffic noise impacts (which is defined as an increase of greater than 2.0 dB).

6. Operational Impact Assessment

A summary of the predicted operational noise levels from the new mechanical plant at the Sydney Terminal Building at the nearest sensitive receivers is shown in **Figure 17**. The predicted noise levels are shown **Table 40** and compared to the most stringent nigh-time PNTLs where relevant.

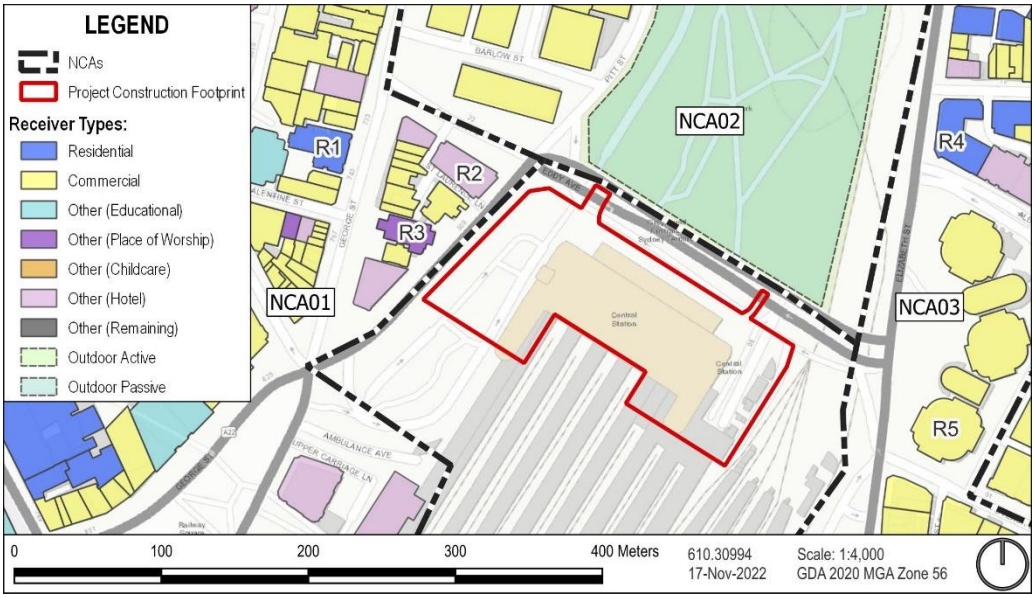


Figure 17 Operational Noise Assessed Receivers

Table 40 Operational Noise Assessment

Receiver ID	Receiver Location	Noise Level $L_{Aeq(15minute)}$ (dBA)			Compliance
		Noise Criteria	Predicted[1]	Exceedance	
R1	NCA01 closest residential receiver (743-755 George Street)	48 (night)	38	-	Yes
R2	NCA01 closest hotel receiver (Sydney Central YHA Hostel)	48 (night)	44	-	Yes
R3	NCA01 closest place of worship receiver (Christ Church St Laurence)	48 (when in use)	34	-	Yes
R4	NCA03 closest residential receiver (242-254 Elizabeth Street)	47 (night)	34	-	Yes
R5	NCA03 closest commercial receiver (300 Elizabeth Street)	63 (when in use)	32	-	Yes

Note 1: The predicted noise levels represent the most affected floor at each receiver.

The assessment indicates that noise from the proposed mechanical plant is predicted to comply with the PNTLs at the closest sensitive receivers and therefore is also expected to comply at all more distant receivers.

The potential for operational noise impacts should be reviewed as the project progresses when the potential noise sources are known. Selection of mechanical plant should consider the equipment sound power levels with reference to the noise criteria at nearby receivers and avoid sources with annoying characteristics (i.e. tonality, low frequency and intermittency), where possible.

7. Cumulative Construction Impacts

The Department of Planning, Industry and Environment, Cumulative Assessment Guidelines for State Significant Projects (DPIE, 2021) defines cumulative impacts as:

Cumulative impacts are a result of incremental, sustained and combined effects of human action and natural variations over time and can be both positive and negative. They can be caused by the compounding effects of a single project or multiple projects in an area, and by the accumulation of effects from past, current and future activities as they arise.

Where concurrent construction work is being completed near to a particular area, the worst-case construction noise levels could theoretically increase by around 3 dB (i.e. a logarithmic adding of two sources of noise at the same level). The likelihood of worst-case noise levels being generated by two different work activities at the same time is, however, considered low and rather than increase construction noise levels, the impact of concurrent construction work would generally be limited to a potential increase in the duration, and annoyance, of noise impacts on the affected receivers.

Additionally, successive work in a particular area may result in consecutive impacts (i.e. 'construction fatigue') at the surrounding receivers due to construction work being in the area for an extended period. Mitigation measures aimed at short-term construction work may be less effective where receivers are affected by longer duration impacts from several projects.

Construction of the project has the possibility of interacting with the construction activities of a number of other nearby projects. Major nearby projects are listed in **Table 41**.

Table 41 Nearby Major Developments

Development	Detail	Interface / Potential Cumulative Impact
Central Precinct Renewal Program (CPRP)	The project forms part of the wider CPRP. It includes the following key projects: Central State Significant Precinct (SSP) rezoning proposal. The rezoning proposal aims to deliver a technology and innovation precinct by enabling development over and adjacent to the railway lines at Central Station, providing new jobs, homes and open space. Western Gateway involves the development of the associated sub-precinct to support the delivery of Tech Central. It will include a mix of company headquarters, apartments, and retail. Former Prince Alfred Substation Adaptive Reuse Project involves creating a new space for tech and creative industries or start-ups. Early Activation Work | EDDY is a project that will allow 12 to 18 month leases to be taken on Eddy Avenue, Eddy Avenue Plaza, and the Grand Concourse for retail and dining spaces.	The Western Gateway sub-precinct describes three zones between the existing rail corridor and Lee Street, south of the project. Each of the three zones have submitted development applications including proposed demolition and redevelopment work which may result in cumulative impacts for receiver west of the project in NCA01.
Sydney Metro City and Southwest	The Sydney Metro City and Southwest platforms are below the intercity rail Platforms 13, 14, and 15. This project is currently under construction and is expected to be open in 2024.	Construction in the same work area as the project may result in cumulative and/or consecutive impacts depending on the timing of the work.

Development	Detail	Interface / Potential Cumulative Impact
More Trains More Services program	The More Trains More Services (MTMS) program will support new suburban and intercity services. It involves reconfiguring Platforms 9 to 14 and other adjustments to allow more trains per hour. The first phase on Platforms 5 to 8 has just finished.	Construction noise from the MTMS program is expected to be relatively minor compared to the project. Noisy work is unlikely to occur in the same area as the project at the same time. Cumulative impacts are not expected.
Tech Central	Tech Central is the biggest innovation district of its kind in Australia. It covers seven suburbs; Haymarket, Ultimo, Surry Hills, Camperdown, Darlington, North Eveleigh, and South Eveleigh. The district will provide technology company space and affordable space for start-ups and scaleups over the coming years.	The only part of Tech Central currently expected to interact with the construction of the project is the Western Gateway sub-precinct, as noted above.

The potential for cumulative noise and vibration impacts would be reviewed as the project progresses and detailed work schedules are available. Specific management and mitigation measures designed to address potential impacts would be developed and used to minimise the impacts as far as practicable, in consultation with the affected community, as outlined in **Section 8**.

8. Mitigation and Management Measures

The ICNG acknowledges that due to the nature of construction work it is inevitable that there would be noise and vibration impacts where construction activities are near to sensitive receivers. The results of this assessment identify exceedances of the relevant management levels at times during construction. Therefore, feasible and reasonable mitigation and measures should be implemented to manage the impacts, where appropriate.

8.1 Construction Noise and Vibration Strategy Standard Mitigation Measures

Transport's CNVS provides guidance on the mitigation of construction noise and vibration impacts. The CNVS provides a list of best practice standard mitigation measures which should be applied by the project where appropriate. The CNVS standard mitigation measures are shown in **Appendix E** and include measures such as requiring construction contractors to complete site inductions to make workers aware of any noise and vibration specifics on the project and completing regular monitoring to check noise and vibration levels are as expected.

8.2 Specific Mitigation Measures

Specific construction mitigation measures recommended for the project are listed in **Table 42**. These measures include a Construction Noise and Vibration Management Plan (CNVMP) that would be prepared to provide the framework and mechanisms for the management and mitigation of all potential construction noise and vibration impacts from the project.

Table 42 Recommended Specific Mitigation Measures

Ref	Impact / Uncertainty	Environmental Management Measure	Timing
NV01	Impact | Operational mechanical plant and equipment	The selection and treatment of air-cooled chillers and centrifugal pumps for the hot water system on the roof of the Sydney Terminal Building and exhaust fans will be evaluated during detailed design to ensure noise emission levels are within criteria.	Detailed design
NV02	Impact | Construction noise and vibration	A Construction Noise and Vibration Management Plan (CNVMP) will be prepared as part of the Construction Environmental Management Plan (CEMP). The plan will: • Identify nearby sensitive receivers • Describe the activities, construction equipment and work that will be completed and quantify resulting impacts at sensitive receivers • Include noise and vibration management criteria and relevant licence and approval conditions • Include measures to manage noise and vibration and minimise the potential for impacts during construction, aligned with the results of community consultation, and consistent with the management approach and mitigation measures in the Construction Noise and Vibration Strategy (CNVS) (Transport for NSW, 2019) • Set out requirements for noise and vibration monitoring • Set out procedures for handling complaints • Provide details on how respite would be applied where ongoing high impacts are seen at certain receivers in accordance with the CNVS • Include any requirements contained within the Central SSP and supporting technical documents where applicable. The CNVMP will consider cumulative construction impacts and the likelihood for 'construction fatigue' from consecutive projects in the areas which have substantial night-time work.	Pre-construction
NV03	Impact | Construction noise	Where noise impacts are predicted, the work should be scheduled for standard construction hours, where possible. If it is not possible then the activities should be completed as early as possible in each work shift. Appropriate respite will be introduced in accordance with the CNVS.	Construction
NV04	Impact | Construction noise	Specific consultation will be carried out with nearby sensitive health facilities, educational and place of worship receivers. Noise intensive work that is predicted to impact such receivers will be scheduled outside of particularly sensitive periods, such as exams or religious services, where possible. Hotels and temporary accommodation will be included in the consultation where predicted (night-time) noise impacts may impact the amenity of guests.	Construction
NV05	Impact | Construction noise and vibration	Monitoring will be carried out at the start of new noise and vibration intensive activities to confirm that actual levels are consistent with the predictions and that appropriate mitigation measures from the CNVS have been implemented.	Construction

Ref	Impact / Uncertainty	Environmental Management Measure	Timing
NV06	Impact | Heritage items	The following measures will be implemented for significant heritage fabric within the Sydney Terminal and Central Railway Stations Group heritage area, including tunnels and existing rail infrastructure, where vibration generating activities cannot take place without maintaining the safe working distances set out in the CNVS: • Dilapidation / condition surveys will be carried out before and after work. Survey will include details of any structurally elements that are found to be structurally unsounds and/or considered to be particularly sensitive to vibration • Where any structures are considered structurally unsound or particularly sensitive to vibration, the more stringent DIN 4150 Group 3 guideline values will be applied • Attended vibration monitoring will be carried out at the start of any new vibration intensive work activity that cannot take place at a safe working distance to confirm the vibration levels produced by the equipment are appropriate • Further attended and/or unattended monitoring will be carried out wherever vibration intensive equipment is required near to structurally unsound infrastructure and/or locations particularly sensitive to vibration. • The potential for vibration impacts on heritage structures will be reviewed during detailed design when construction planning is available.	Construction
NV07	Impact | Internal noise	Where noisy construction is occurring and the station is open to the public, station patrons, staff in commercial areas and other members of the public may be impacted. The following measures should be implemented where feasible and reasonable to manage noise impacts within Central Station: The following measures will be implemented to manage noise impacts within the project area: • Schedule noise intensive work for off-peak commuter times when the area is less busy. • Use the minimum practical size of equipment including silenced compressors, generators and dust extractors, when noisy work is required while the station is open • Use path control, such as mobile hoarding, to isolate noise intensive activities from publicly accessible locations. This may include work within the Sydney Terminal Building and Eddy Avenue Plaza.	Construction
NV08	Uncertainty | Construction noise and vibration	Location and activity specific noise and vibration impact assessments will be carried out where: • There is the potential to result in noise levels above 75 dBA at any sensitive receiver • Work is scheduled outside of standard construction hours and likely to result in noise levels in greater than the relevant NML • Activities have the potential to exceed relevant criteria for vibration. The assessments will confirm the predicted impacts at the relevant receivers to help with the selection of appropriate management measures, consistent with the requirements of the CNVS.	Construction
CL02	Impact | Cumulative construction noise	Potential cumulative noise and vibration impacts will be reviewed as the project progresses and detailed work schedules are available. Specific management and mitigation measures designed to address potential impacts will be developed and used to minimise the impacts as far as practicable, in consultation with the affected community.	Pre-construction / construction

8.3 Construction Noise and Vibration Strategy Additional Mitigation Measures

Where noise impacts remain after the use of standard mitigation measures, the CNVS recommends additional mitigation measures are investigated, where feasible and reasonable. Descriptions of the CNVS additional mitigation measures are shown in **Appendix E**. The CNVS defines how additional mitigation measures are applied based on the level of impact above the relevant management levels. The CNVS approach for the application of additional mitigation is shown in **Table 43** and **Table 44** for noise and vibration impacts, respectively.

Table 43 CNVS Triggers for Additional Airborne Noise Mitigation Measures

Time Period	Receiver Perception	dBA Above RBL	dBA Above NML	Additional Management Measures[1]
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[2], DR[2]
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

Note 1: PN = Project notification, SN = Specific notification, individual briefings, or phone call, V = Verification monitoring, AA = Alternative accommodation, DR = Duration Reduction RO = Project specific respite offer, RP = Respite Period.

Note 2: Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

Table 44 CNVS Triggers for Additional Vibration Mitigation Measures

Time Period	Receiver Perception	Vibration Management Level	Additional Management Measures[1]
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

Note 1: 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.

The categories of NML exceedances used in the assessment in **Chapter 5** are consistent with the CNVS categories for determining additional mitigation. Based on the worst-case assessment in this report, the following CNVS additional mitigation measures may be appropriate for the project:

- Project notification and verification monitoring for noise intensive external work required outside of standard construction hours
- Specific notification and verification monitoring at the closest 'other sensitive' receivers, including hotels, places of worship and educational facilities.

It is noted that the assessment in this report presents worst-case noise impacts prior to the application of mitigation. It is expected that the impacts would be reduced through the use of the recommended measures. As the project progresses, the CNVMP and further assessments would determine the requirement for potential additional feasible and reasonable mitigation measures to address residual construction noise and vibration impacts.

8.4 Mitigation Effectiveness and Residual Impacts

The CNVS standard mitigation measures and the recommended specific mitigation measures are expected to reduce the predicted noise and vibration impacts as far as practicable. It is difficult to quantify the effectiveness of the mitigation measures given the majority are management measures which provide a benefit other than a direct noise level reduction.

Based on the assessment in this report, it is expected that there will be some residual exceedances of the NMLs after the implementation of standard and specific mitigation measures. Residual impacts are generally expected to be relatively minor in magnitude (i.e. around 1-10 dB). The CNVMP would review the predicted impacts and determine appropriate additional mitigation measures as the project progresses.

8.5 Community Engagement

Community engagement prior to the exhibition of the EIS has included engagement with businesses within 100 metres of the project area regarding potential for noise impacts during the business surveys. Businesses and residential receivers were also targeted via the project newsletter which was distributed 500 metres from the project area and invited feedback via the project email or response to a community survey.

The results of the engagement included two nearby businesses indicating that project construction noise would likely impact them. One respondent expressed a preference for noise intensive construction work to be conducted at night when businesses are closed and to minimise construction traffic. These preferences have been considered in the design of the recommended mitigation measures in **Section 8**, in conjunction with the needs and preferences of nearby residential receivers.

Ongoing engagement would be conducted as per the Community and stakeholder engagement plan for the project.

9. Conclusion

This report has been prepared to address the project SEARs in relation to the assessment of noise and vibration impacts of the project. The report describes the existing noise environment surrounding the project and outlines the methodology and assessment of impacts from the construction and operation of the project. Where impacts are predicted, appropriate mitigation measures have been recommended to mitigate and manage the impacts.

The project would involve construction work at the Sydney Terminal Building, Eddy Avenue Plaza, the Central Electric Building, the Western Forecourt and the Pitt Street Loading Dock. The Sydney Trains Yard would also be used as an ancillary construction area.

Representative work scenarios detailing construction activities and equipment have been developed to assess the potential construction noise impacts of the project. The assessment identifies that potential noise impacts during the daytime and out of hours periods are likely when noisy work is being completed. Impacts are also identified at various 'other sensitive' receivers in the study area.

Construction ground-borne noise and vibration has been assessed based on the hydraulic hammers identified in the construction scenarios. No surrounding receivers are within the recommended minimum working distances for human comfort and cosmetic damage.

Consistent with other major infrastructure projects in urban areas, noise impacts during construction are unavoidable, particularly where work requires the use of noise intensive equipment near to sensitive receivers. A range of feasible and reasonable mitigation measures have been recommended to control the potential construction noise and vibration impacts.

Operational noise levels from additional mechanical plant on the Sydney Terminal Building roof have been assessed and are expected to result in noise levels that comply with the relevant criteria at all receivers.

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 4,000 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 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

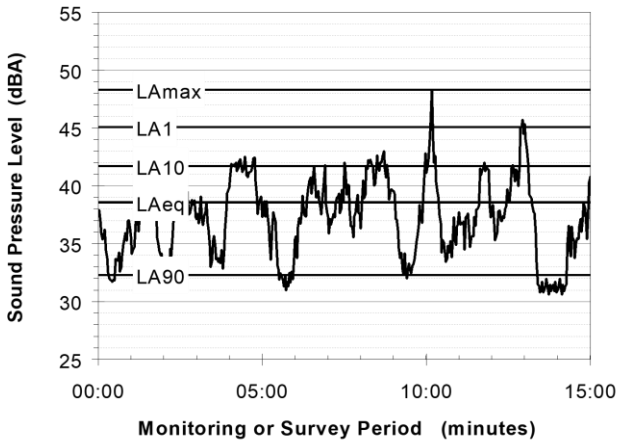
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

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

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

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

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

5 Tonality

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

6 Impulsiveness

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

7 Frequency Analysis

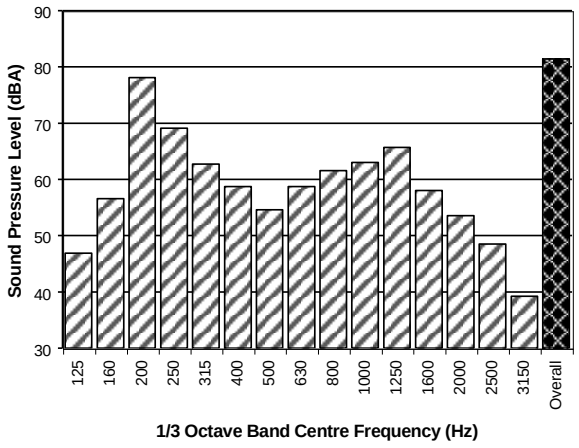
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

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

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

9 Human Perception of Vibration

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

10 Over-Pressure

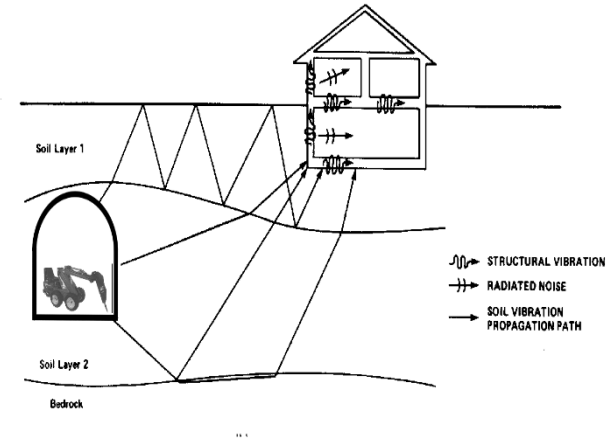
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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

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

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

The following figure presents 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:

Detailed Receiver Mapping

Figure 1 NCA01

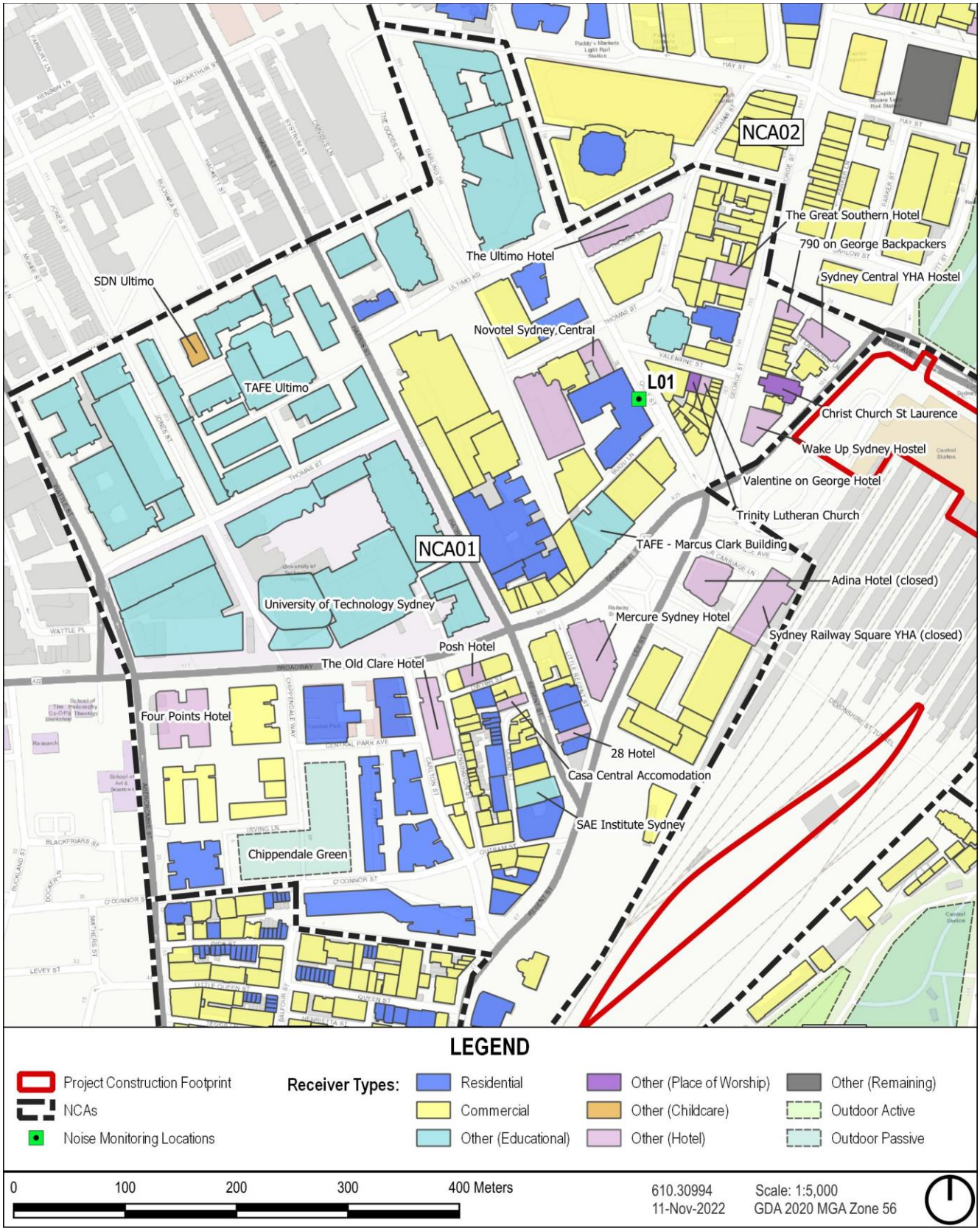


Figure 2 NCA02

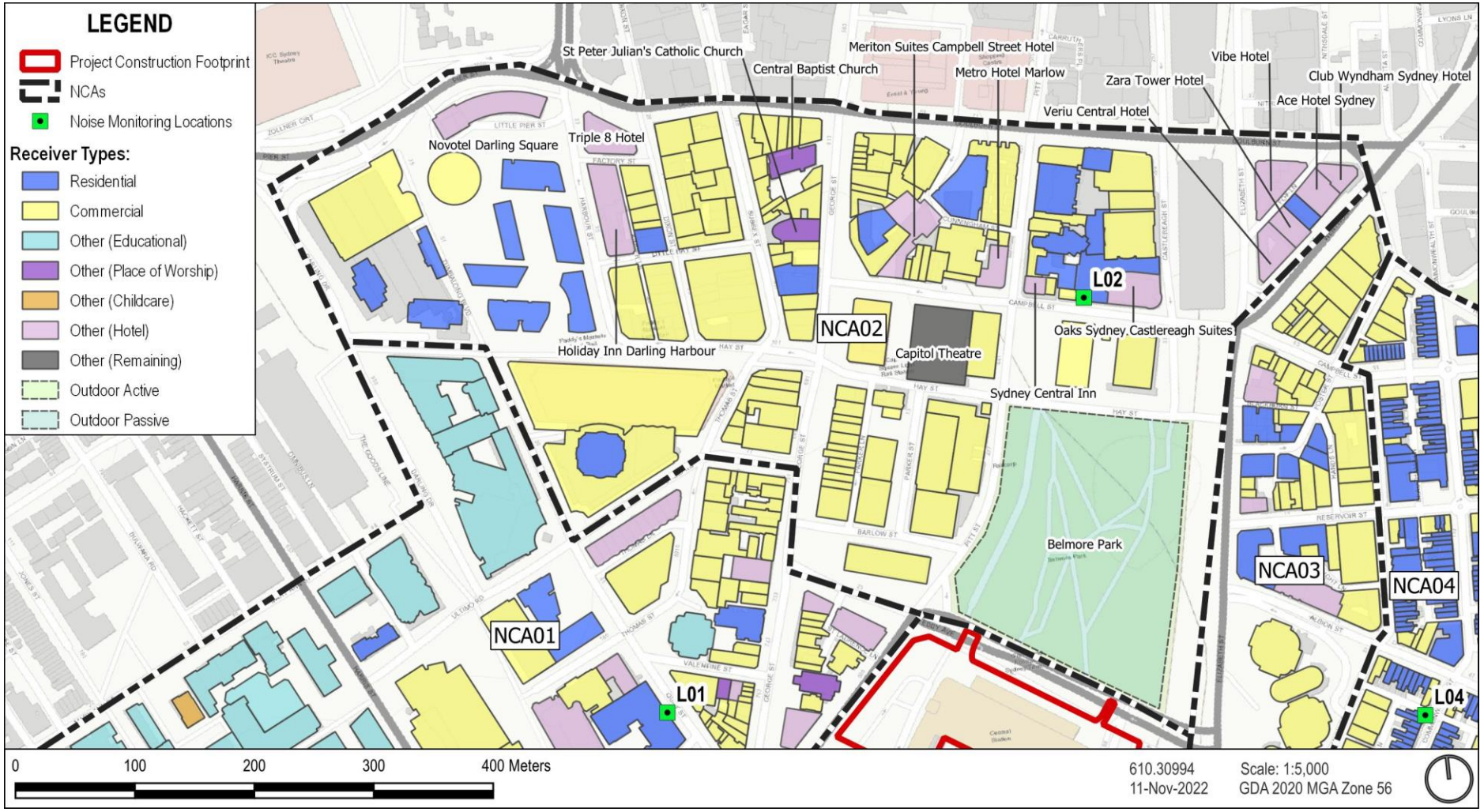


Figure 3 NCA03 and NCA04

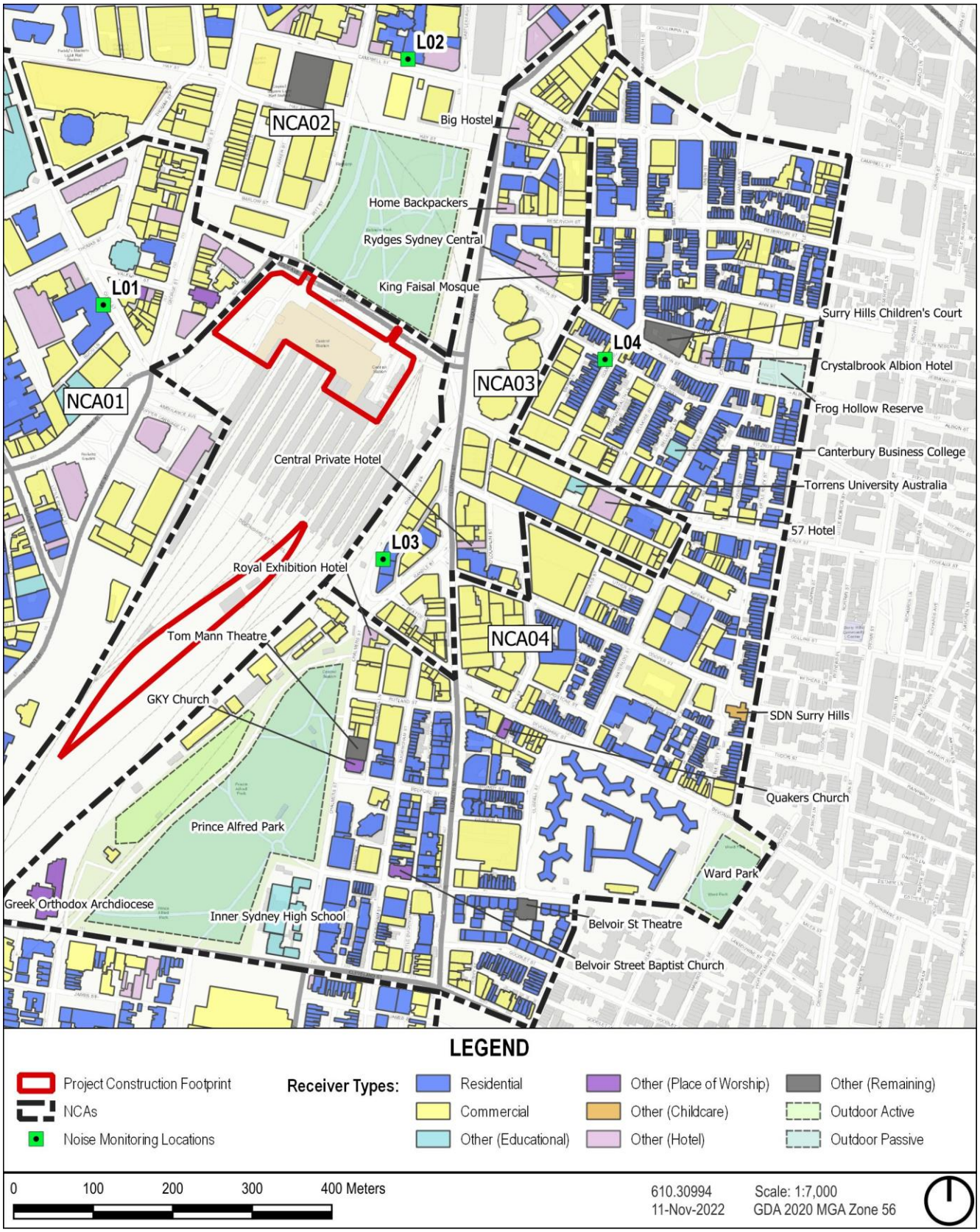
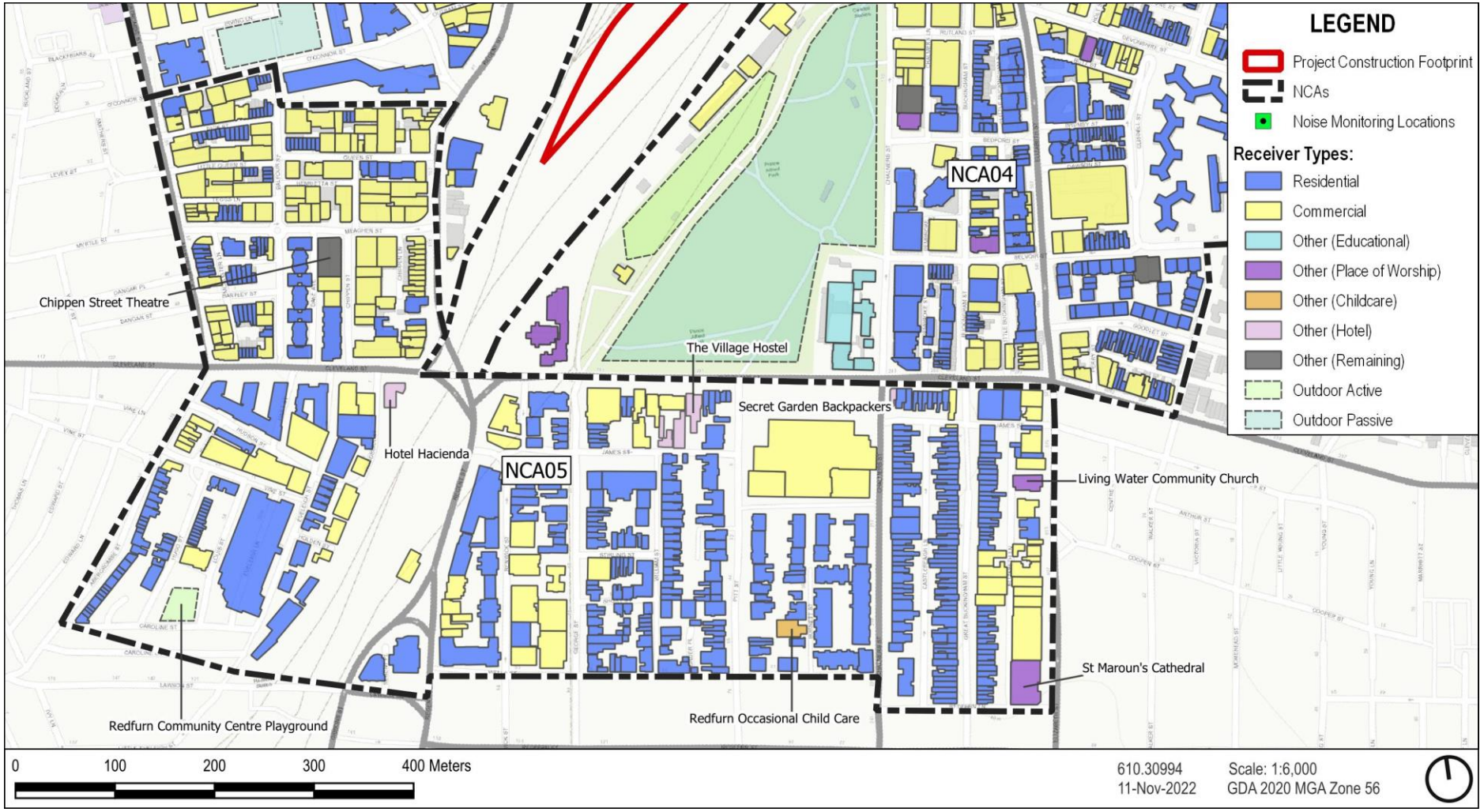


Figure 4 NCA05



Appendix C:

Ambient Noise Monitoring Results

Noise Monitoring Location	L.01
Noise Monitoring Address	107-121 Quay Street, Haymarket

Logger Device Type: Svantek 977, Logger Serial No: 98070
Sound Level Meter Device Type: Brüel and Kjær 2250L, Sound Level Meter Serial No: 3005904

Ambient noise logger deployed on level 2 balcony of a northeast facing unit at 107-121 Quay Street, Haymarket. Logger located at balcony edge with view over Quay Street and Central Station to the southeast.

Attended noise measurements indicate the ambient noise environment at this location is influenced by road traffic noise and pedestrian activity including loading/unloading vehicles.

Recorded Noise Levels (L_{Amax}) 11/10/2022:

Light vehicle road traffic noise: 65-70 dBA
Heavy vehicle road traffic noise: 69-73 dBA
Truck reversing beeper: 70 dBA
Pedestrian with hand trolley: 68 dBA

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L_{10}	L_1
Daytime	57	64	67	71
Evening	57	63	55	70
Night-time	50	60	61	69

Ambient Noise Logging Results – RNP Defined Time Periods

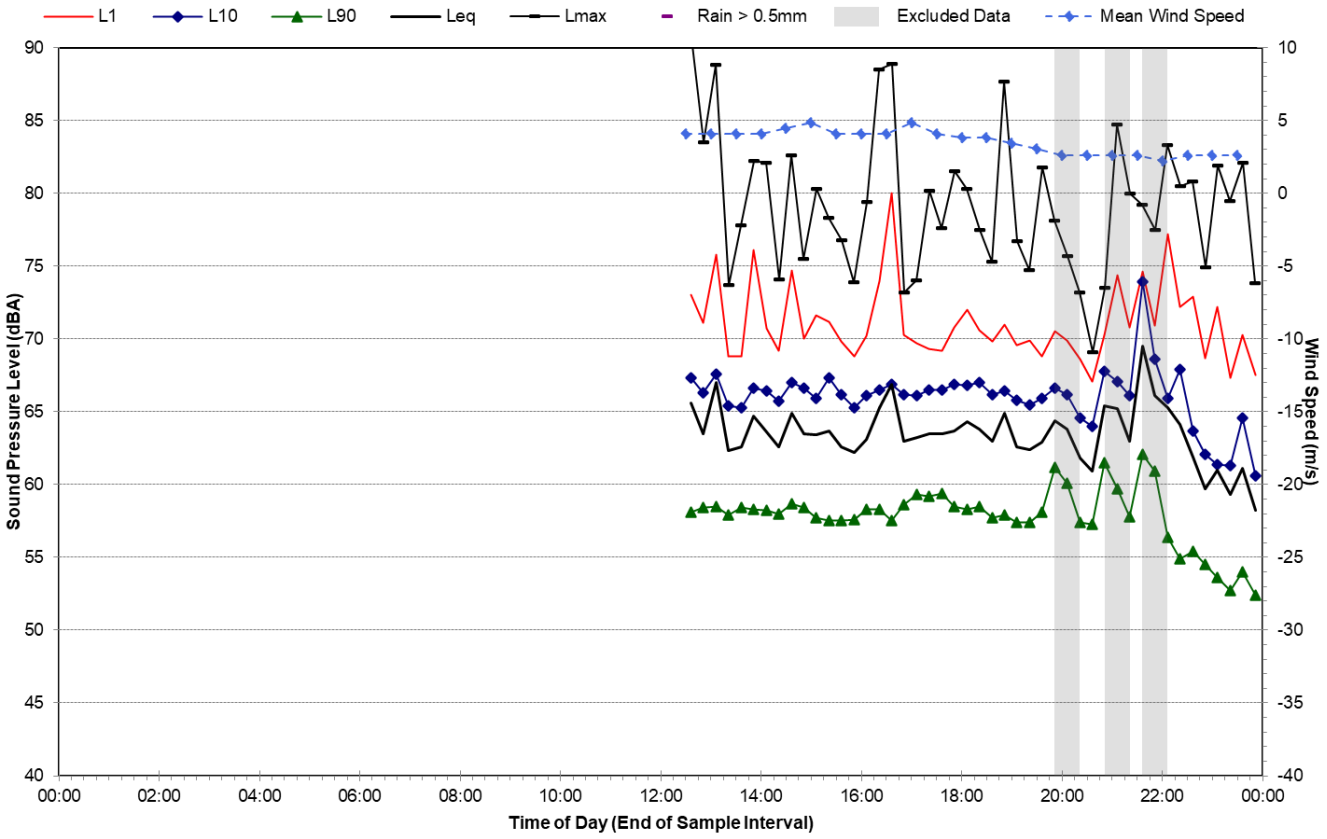
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	64	69
Night-time (10pm-7am)	60	68

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
11/10/2022	11:57	59	63	74

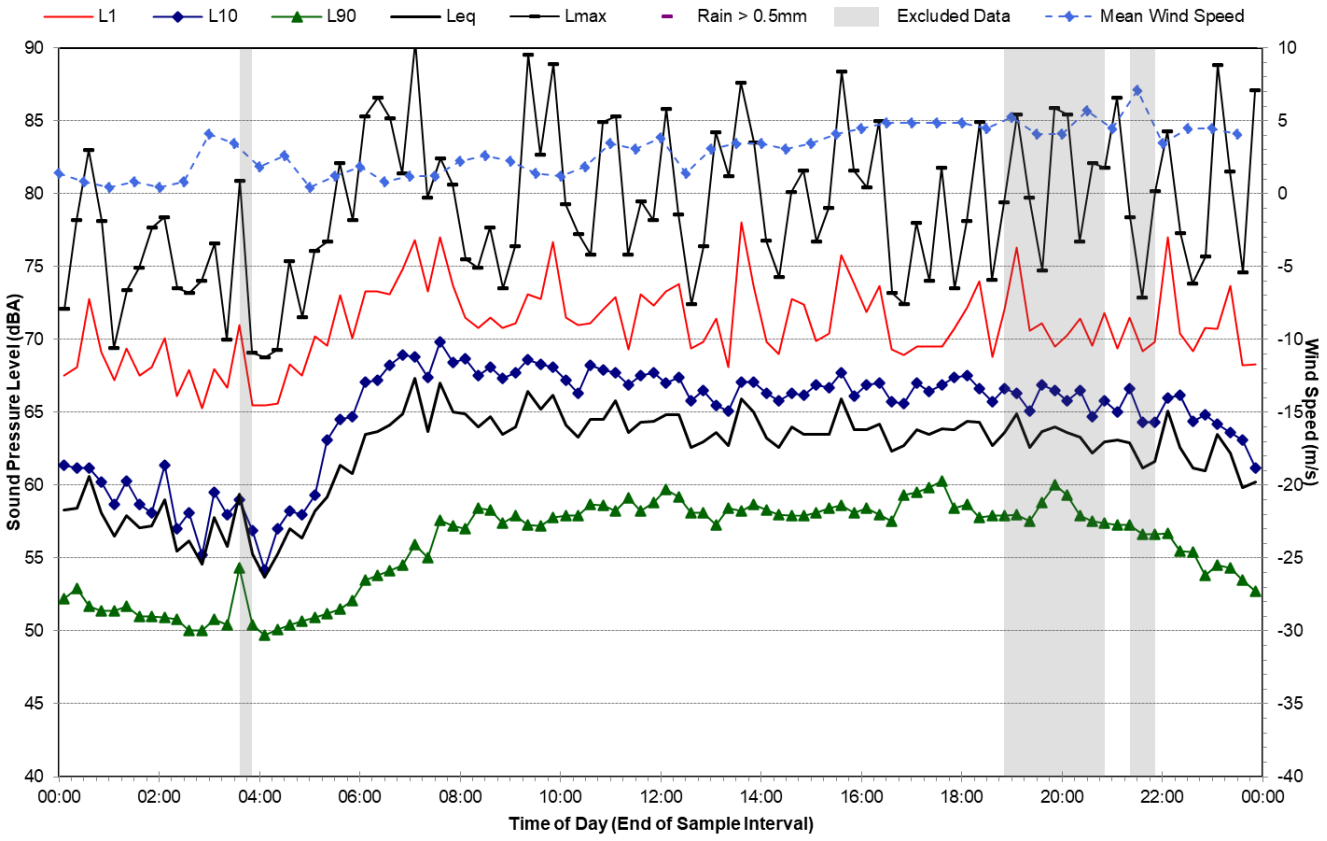
Statistical Ambient Noise Levels

107-121 Quay Street - Tuesday, 11 October 2022



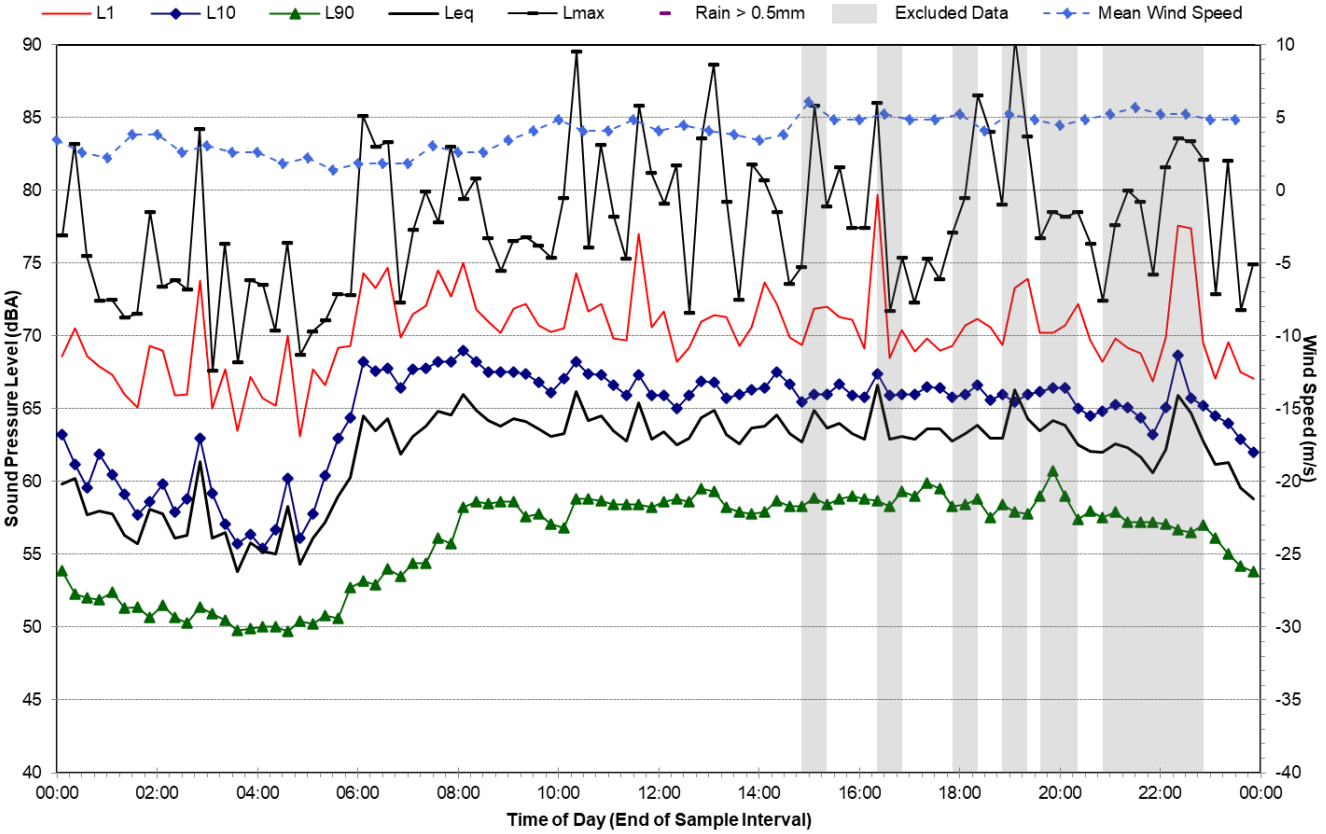
Statistical Ambient Noise Levels

107-121 Quay Street - Wednesday, 12 October 2022



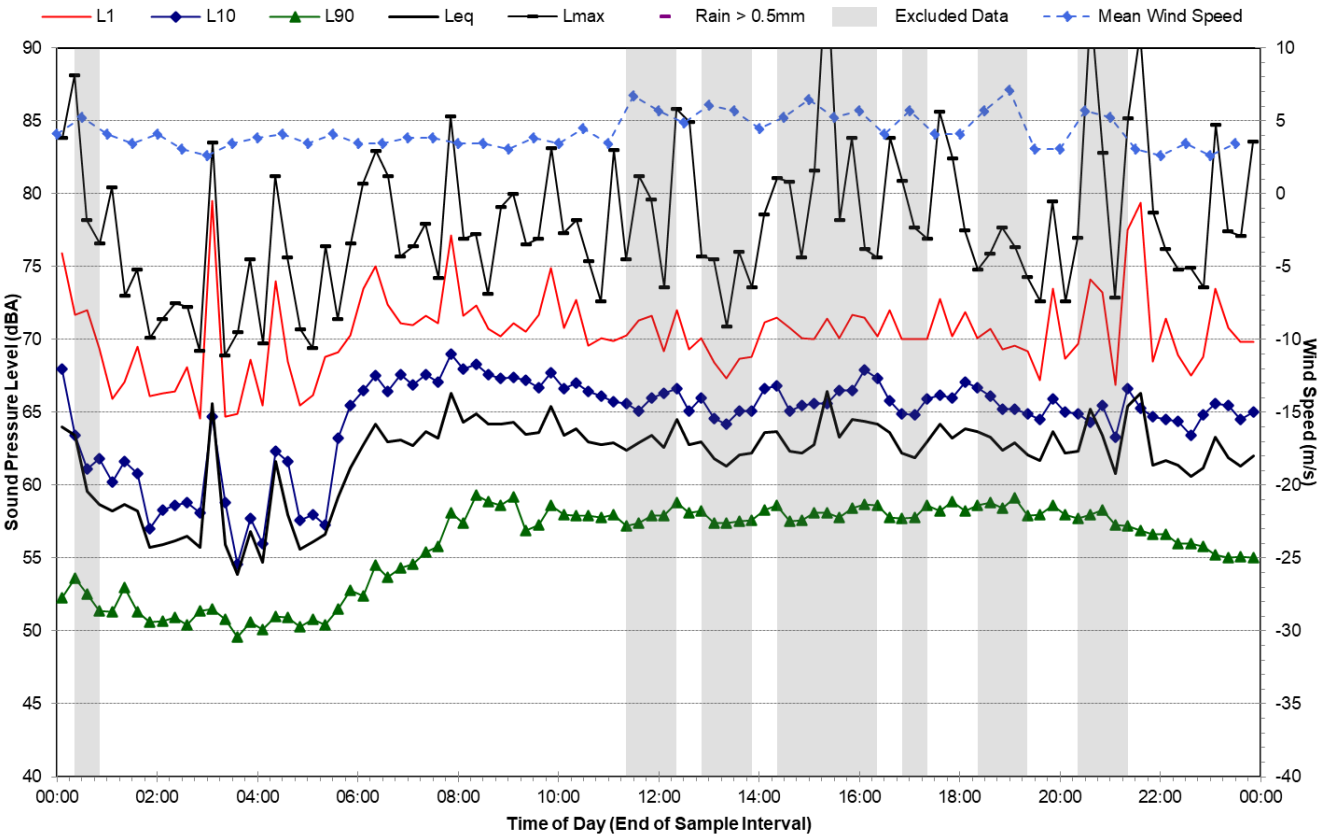
Statistical Ambient Noise Levels

107-121 Quay Street - Thursday, 13 October 2022



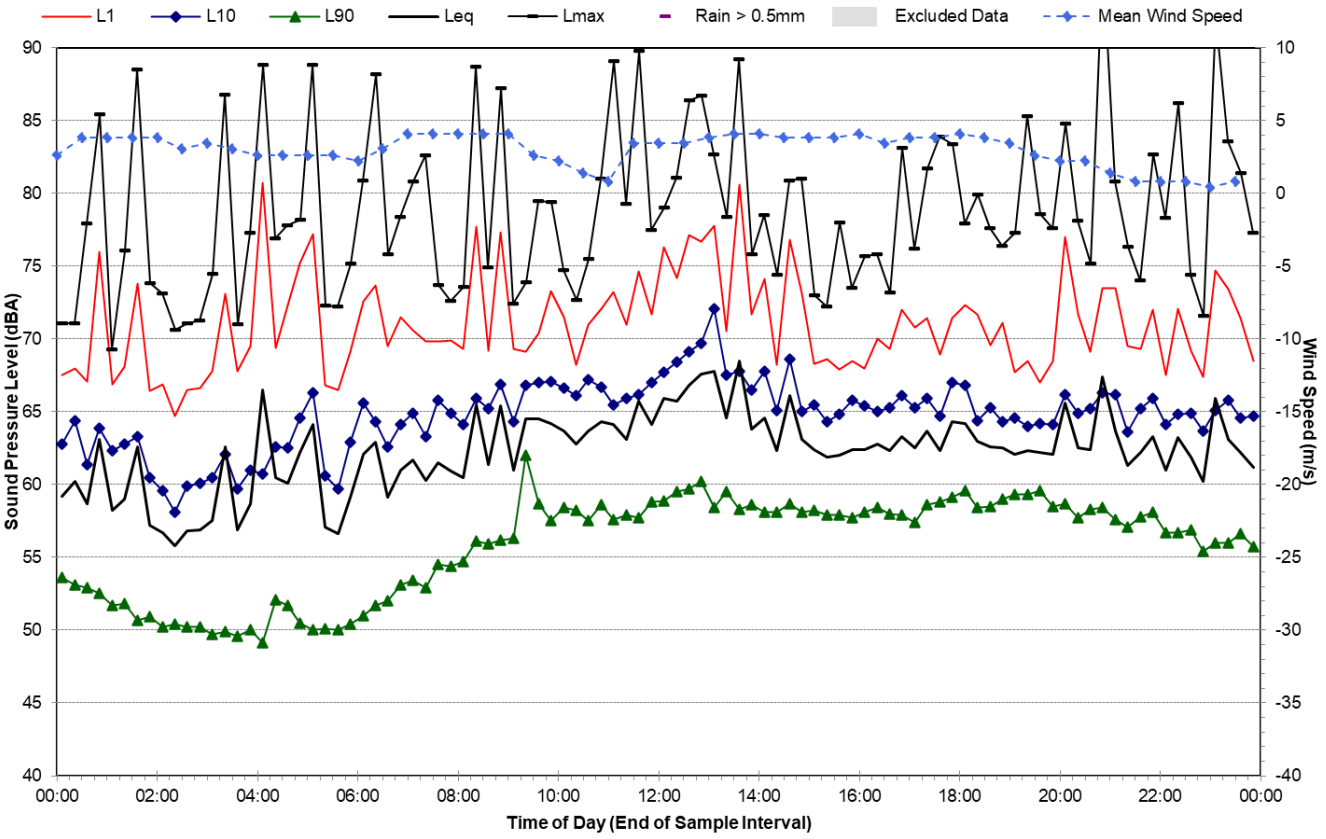
Statistical Ambient Noise Levels

107-121 Quay Street - Friday, 14 October 2022



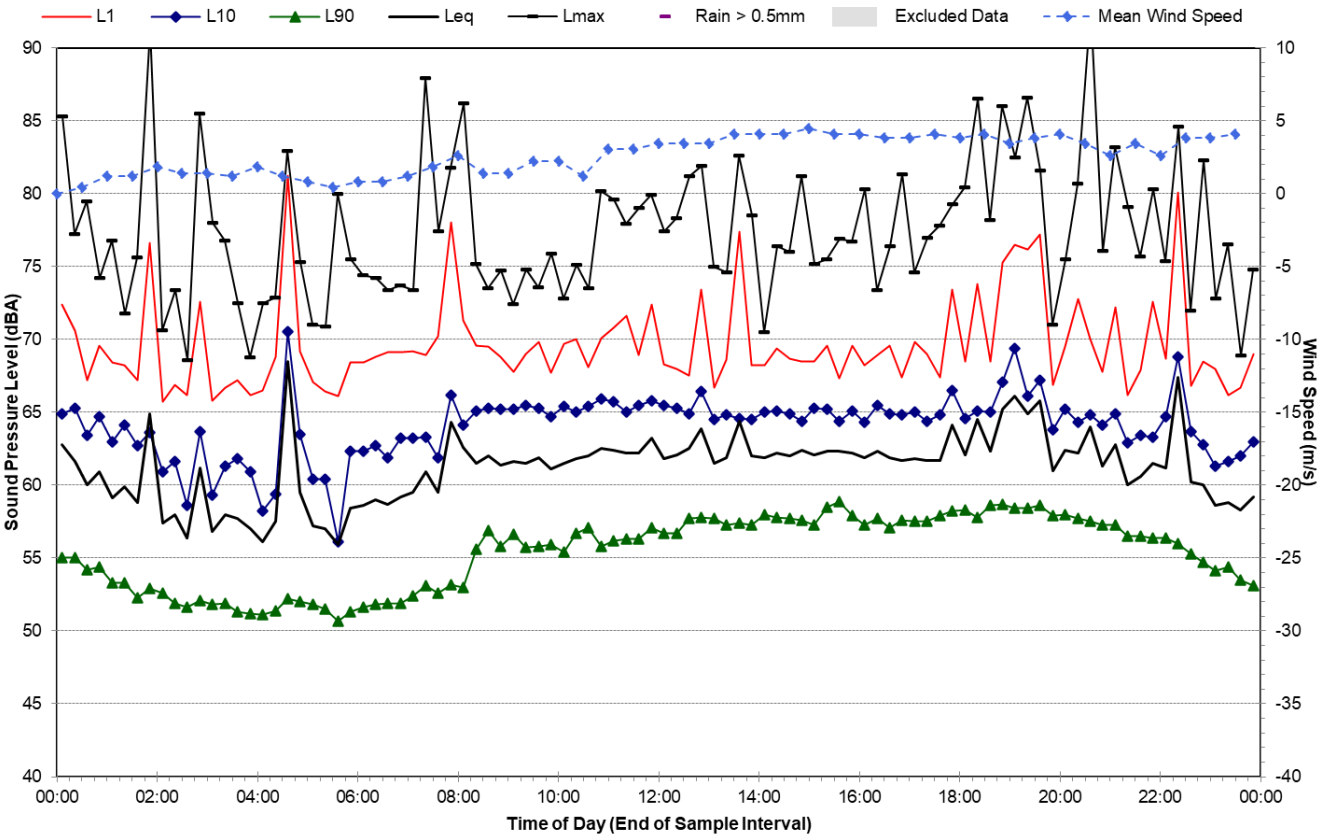
Statistical Ambient Noise Levels

107-121 Quay Street - Saturday, 15 October 2022



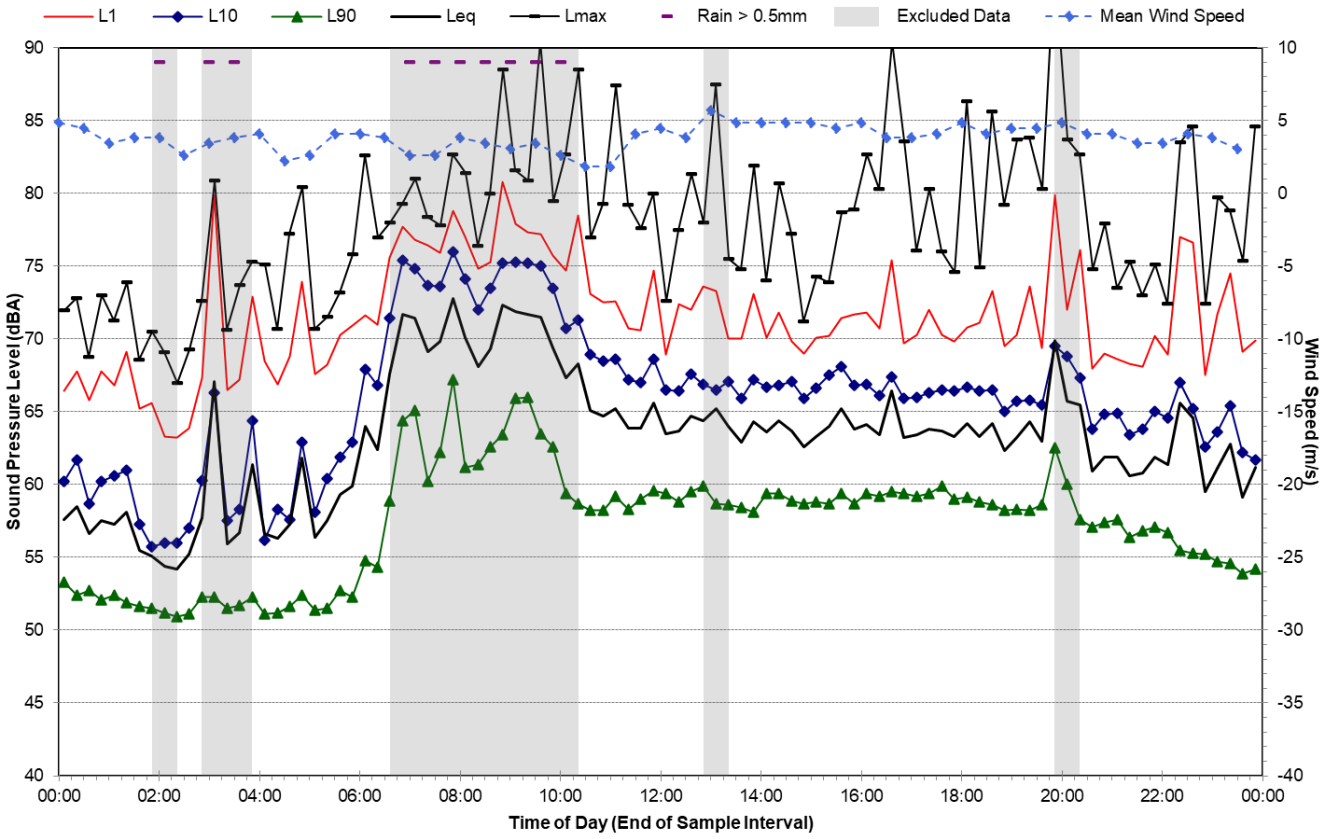
Statistical Ambient Noise Levels

107-121 Quay Street - Sunday, 16 October 2022



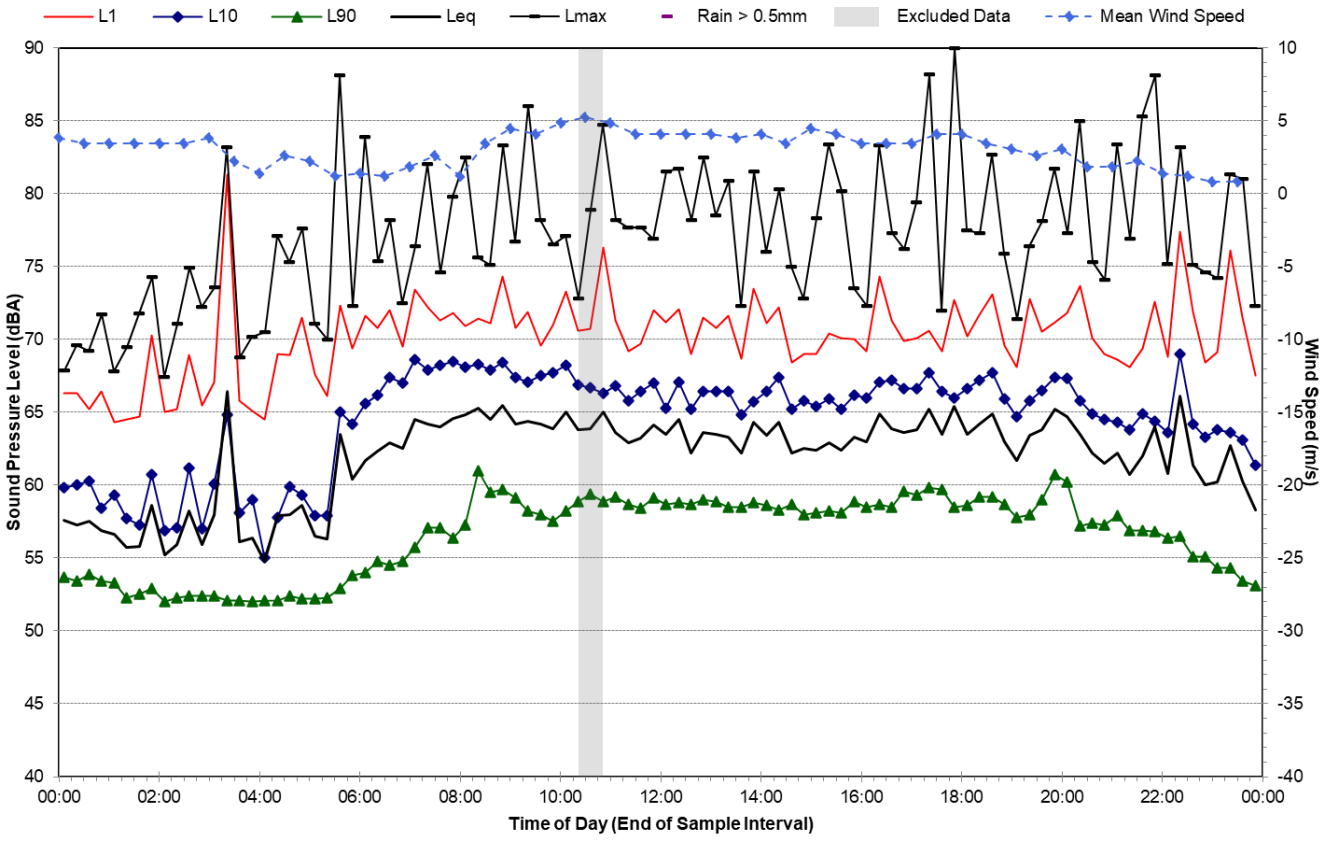
Statistical Ambient Noise Levels

107-121 Quay Street - Monday, 17 October 2022



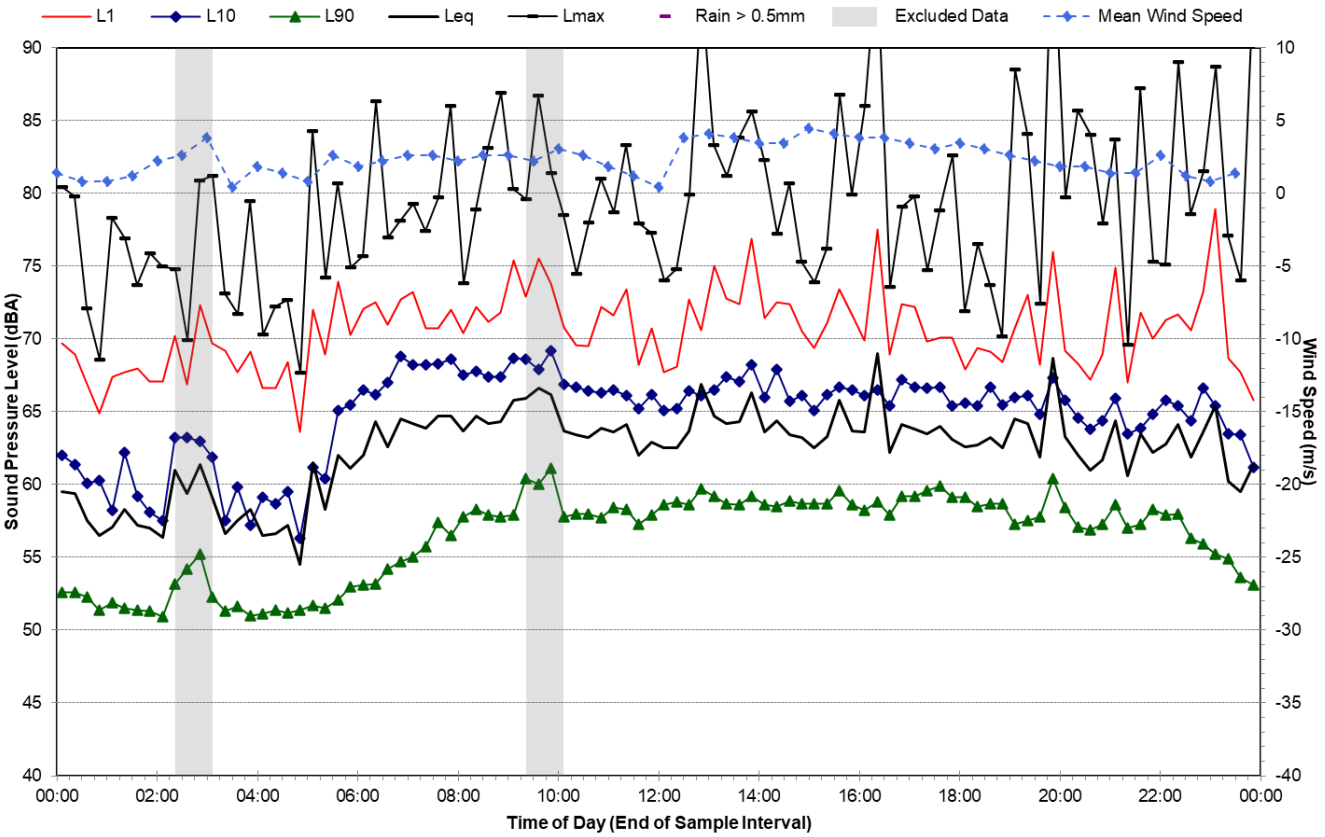
Statistical Ambient Noise Levels

107-121 Quay Street - Tuesday, 18 October 2022



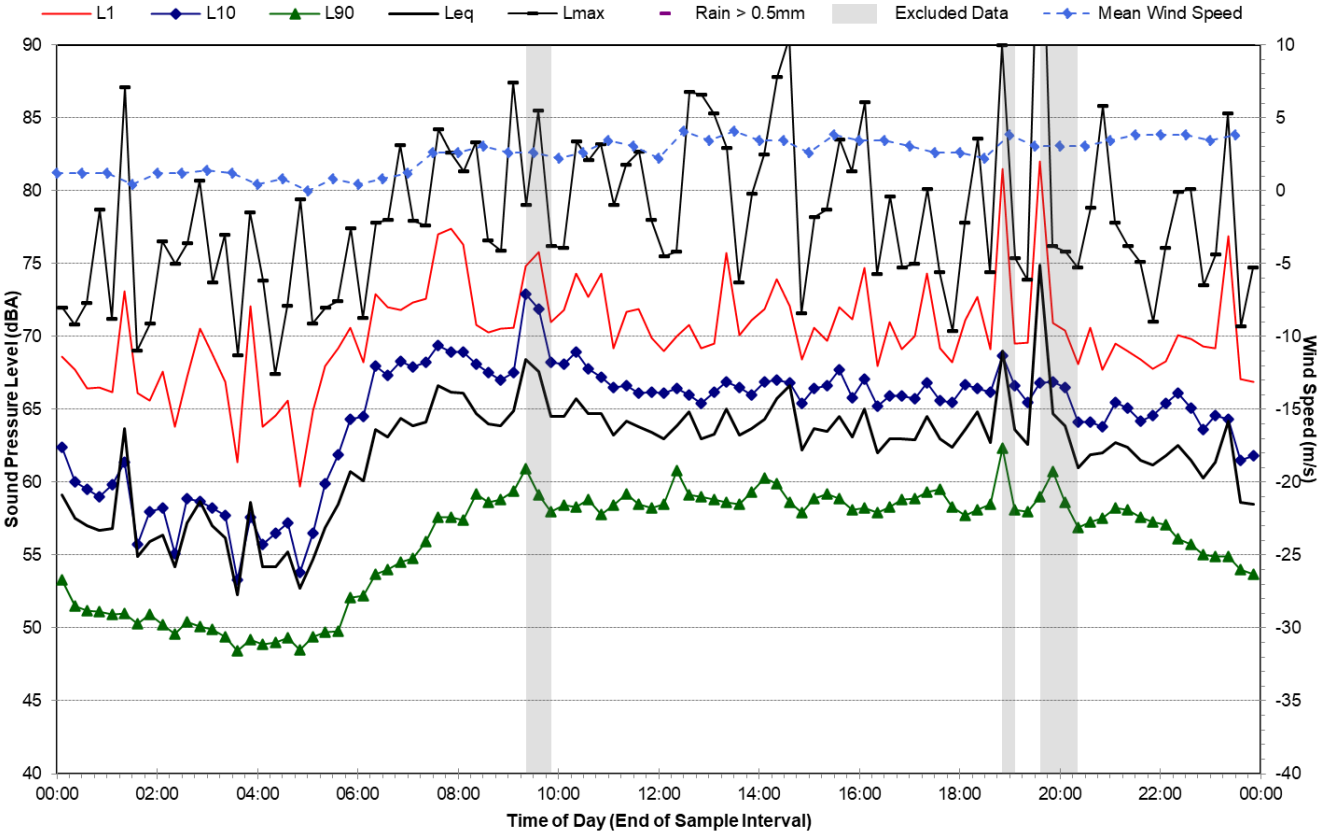
Statistical Ambient Noise Levels

107-121 Quay Street - Wednesday, 19 October 2022



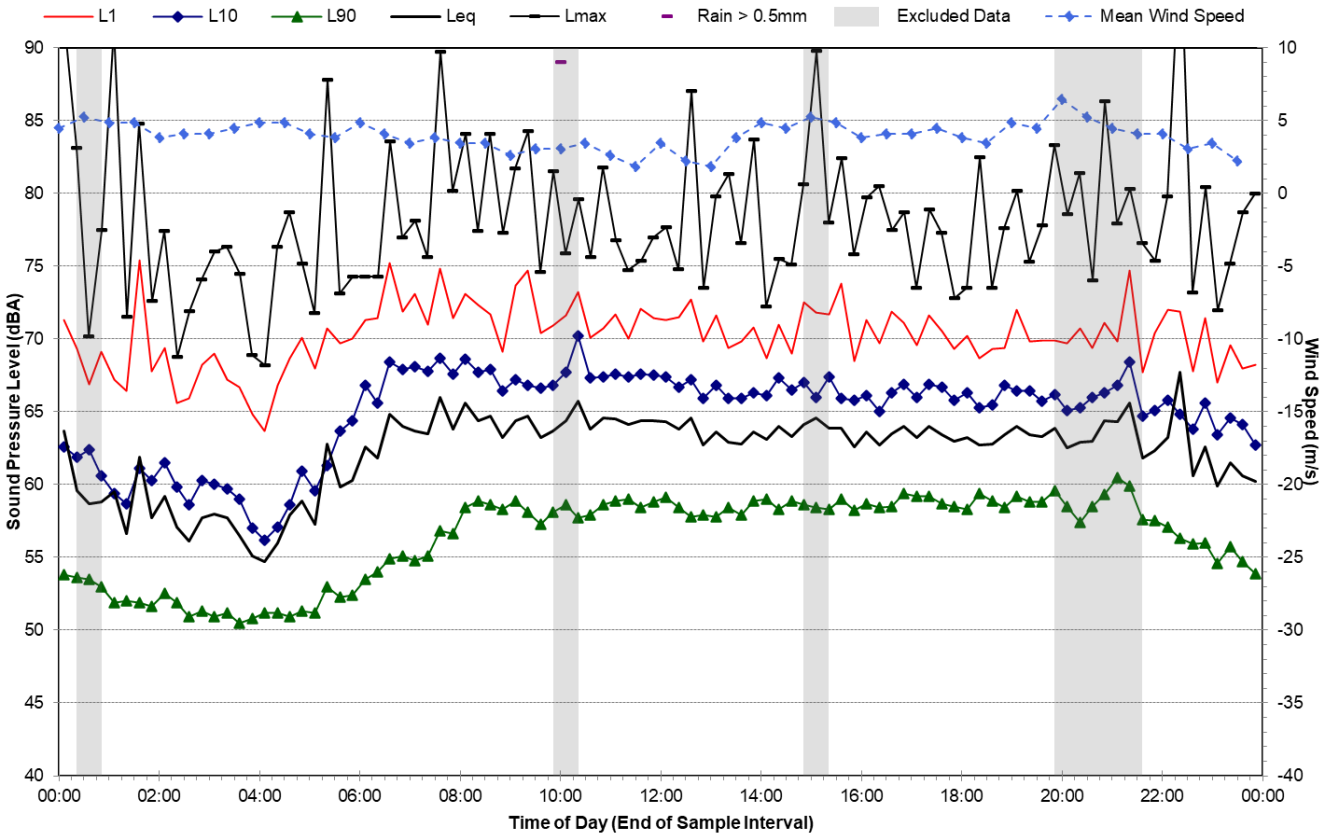
Statistical Ambient Noise Levels

107-121 Quay Street - Thursday, 20 October 2022



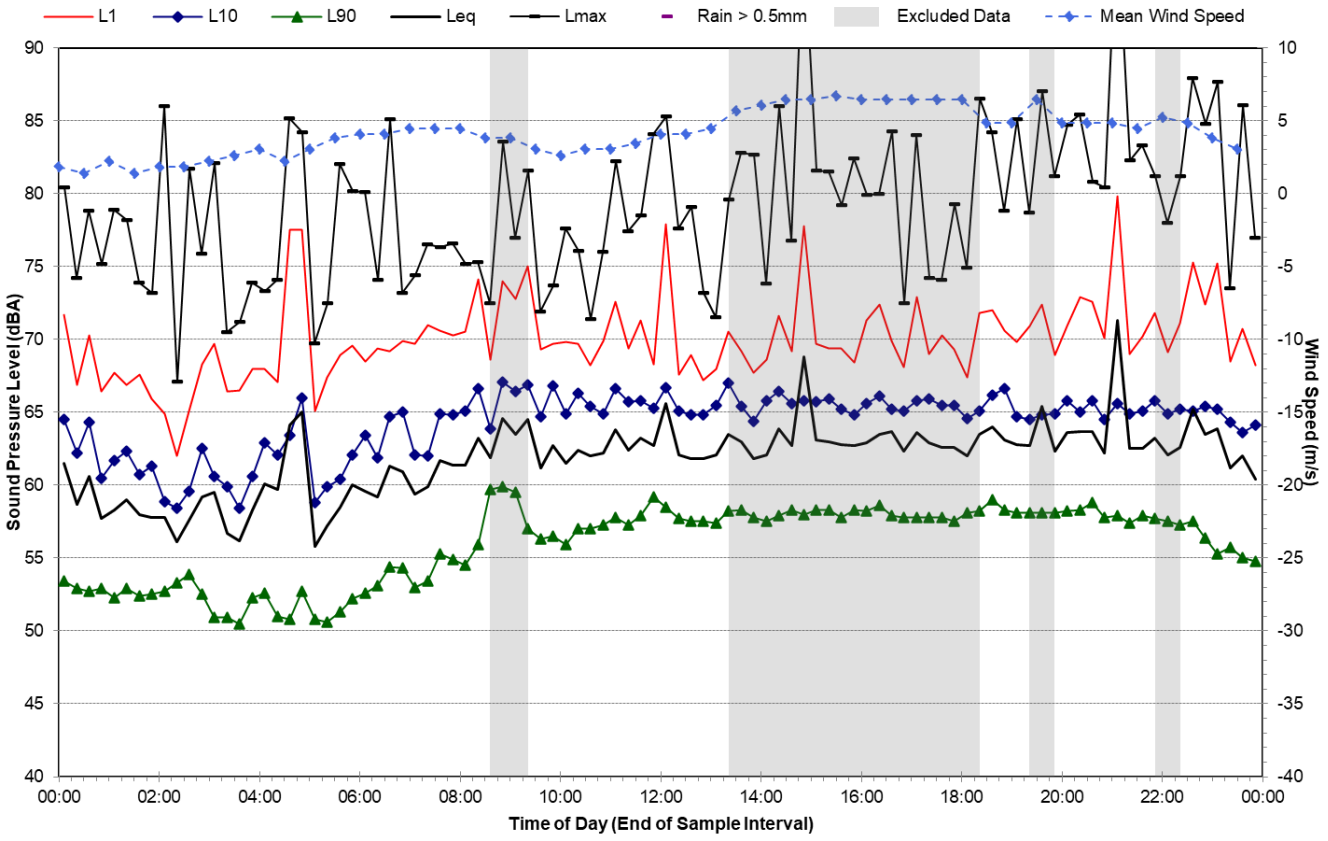
Statistical Ambient Noise Levels

107-121 Quay Street - Friday, 21 October 2022



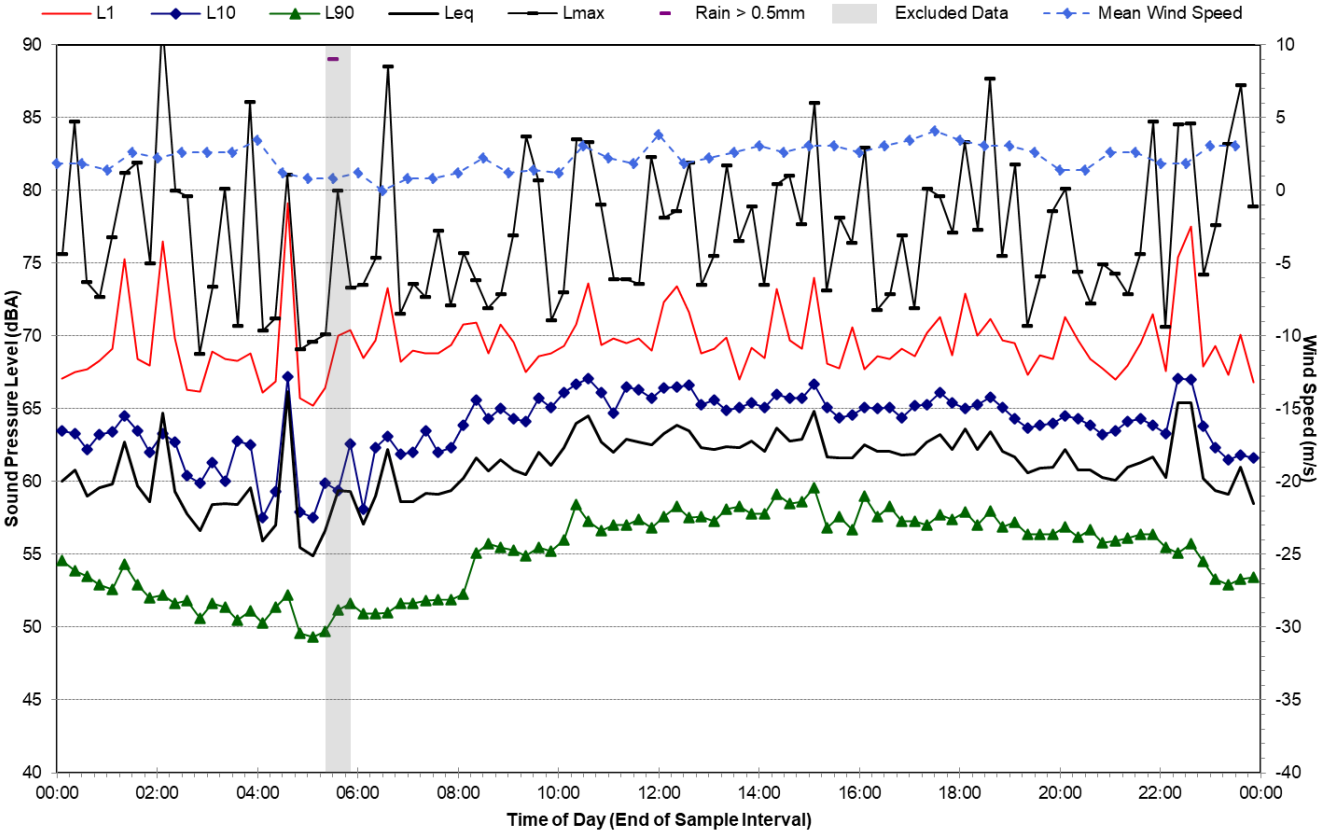
Statistical Ambient Noise Levels

107-121 Quay Street - Saturday, 22 October 2022



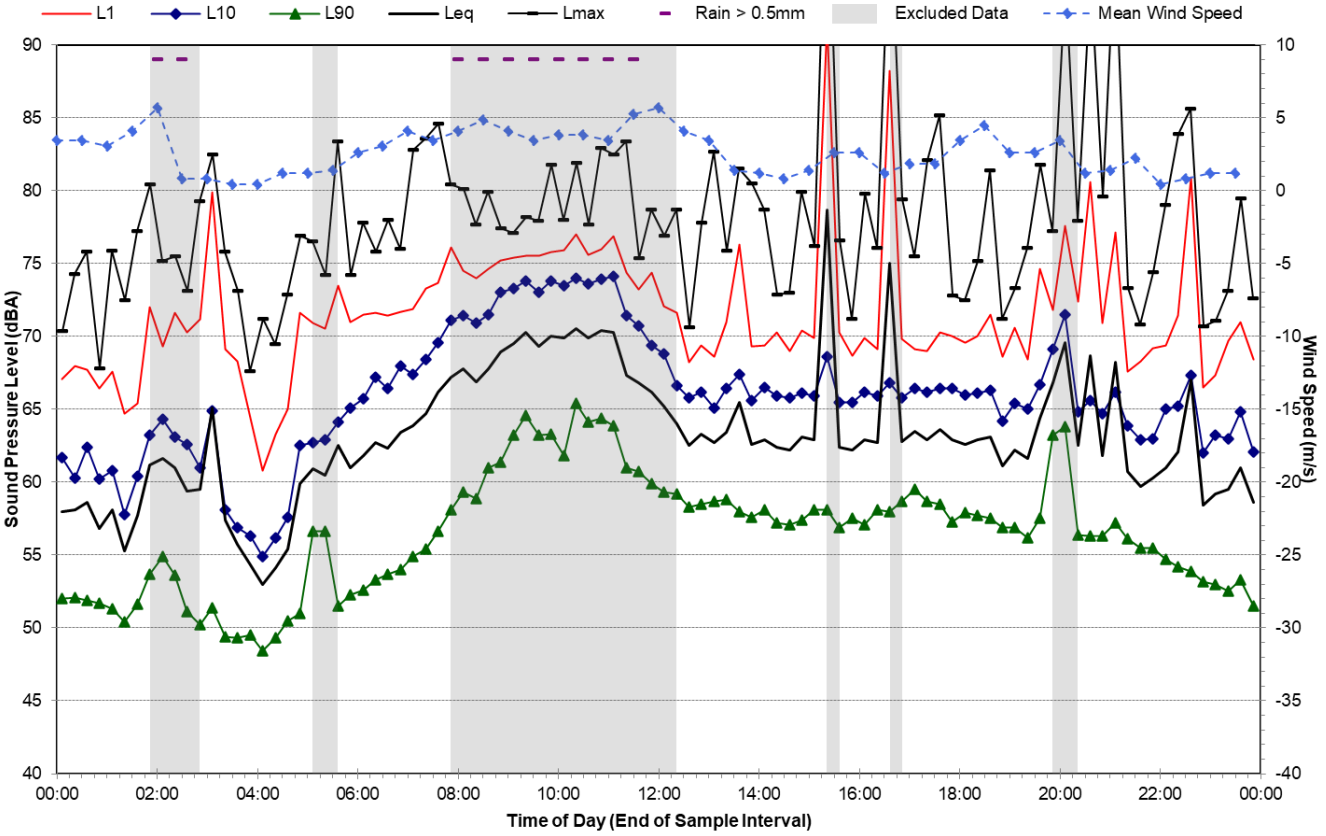
Statistical Ambient Noise Levels

107-121 Quay Street - Sunday, 23 October 2022



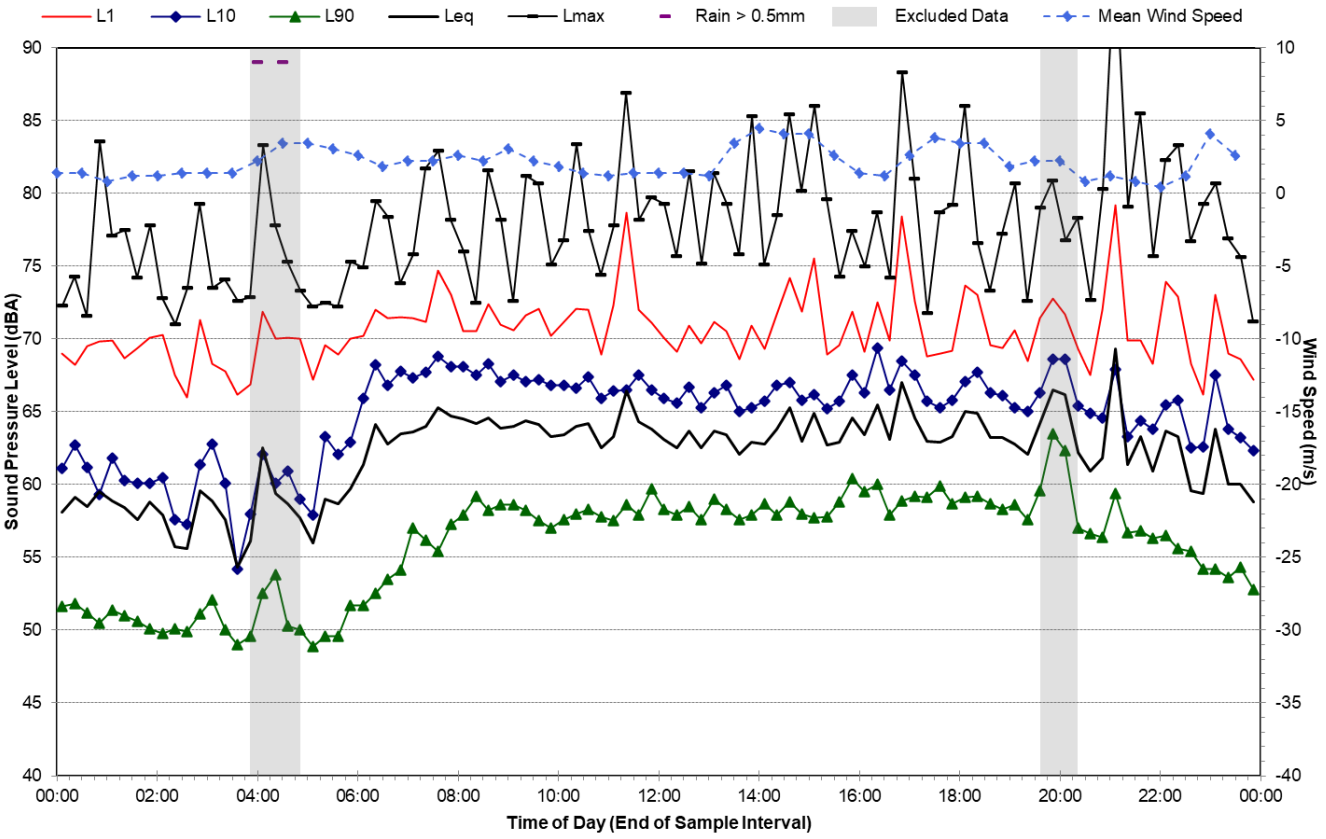
Statistical Ambient Noise Levels

107-121 Quay Street - Monday, 24 October 2022



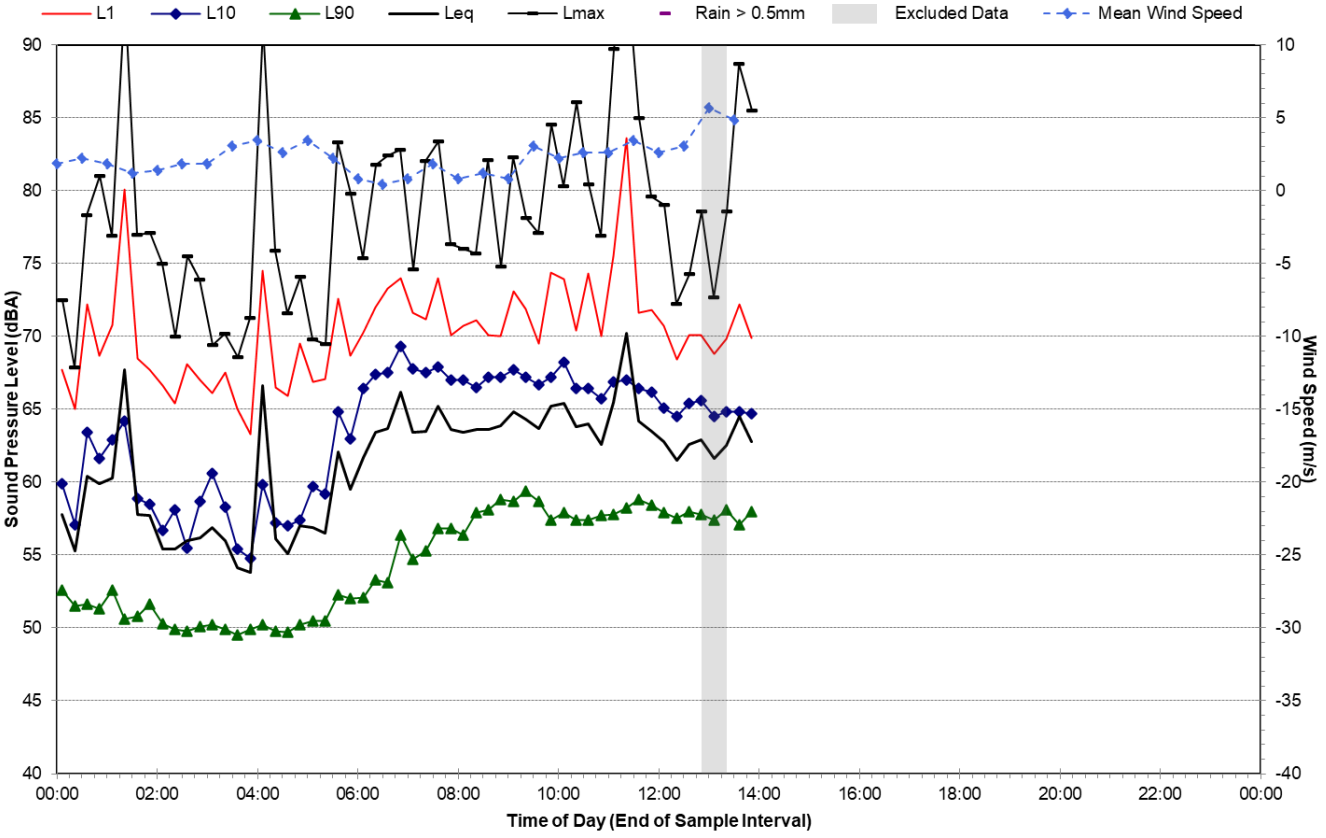
Statistical Ambient Noise Levels

107-121 Quay Street - Tuesday, 25 October 2022



Statistical Ambient Noise Levels

107-121 Quay Street - Wednesday, 26 October 2022



Noise Monitoring Location	L.02	Map of Noise Monitoring Location
Noise Monitoring Address	303-321 Castlereagh Street, Haymarket	

Logger Device Type: Svantek 958A, Logger Serial No: 81111
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3008204

Ambient noise logger deployed at level 6 roof terrace of 303-321 Castlereagh Street, Haymarket. Logger located with view over Campbell Street to the south.

Attended noise measurements indicate the ambient noise environment at this location is influenced by road traffic noise, heavy rail, light rail and industrial hum.

Recorded Noise Levels (L_{Amax}) 19/10/2022:

Road traffic noise: 58-64 dBA
Heavy rail: 65 dBA
Light rail: 58-62 dBA
Horn: 81 dBA
Distant construction: 55-60 dBA
Mechanical plant: 58 dBA

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L_{10}	L_1
Daytime	59	62	64	68
Evening	58	61	62	66
Night-time	53	59	60	64

Ambient Noise Logging Results – RNP Defined Time Periods

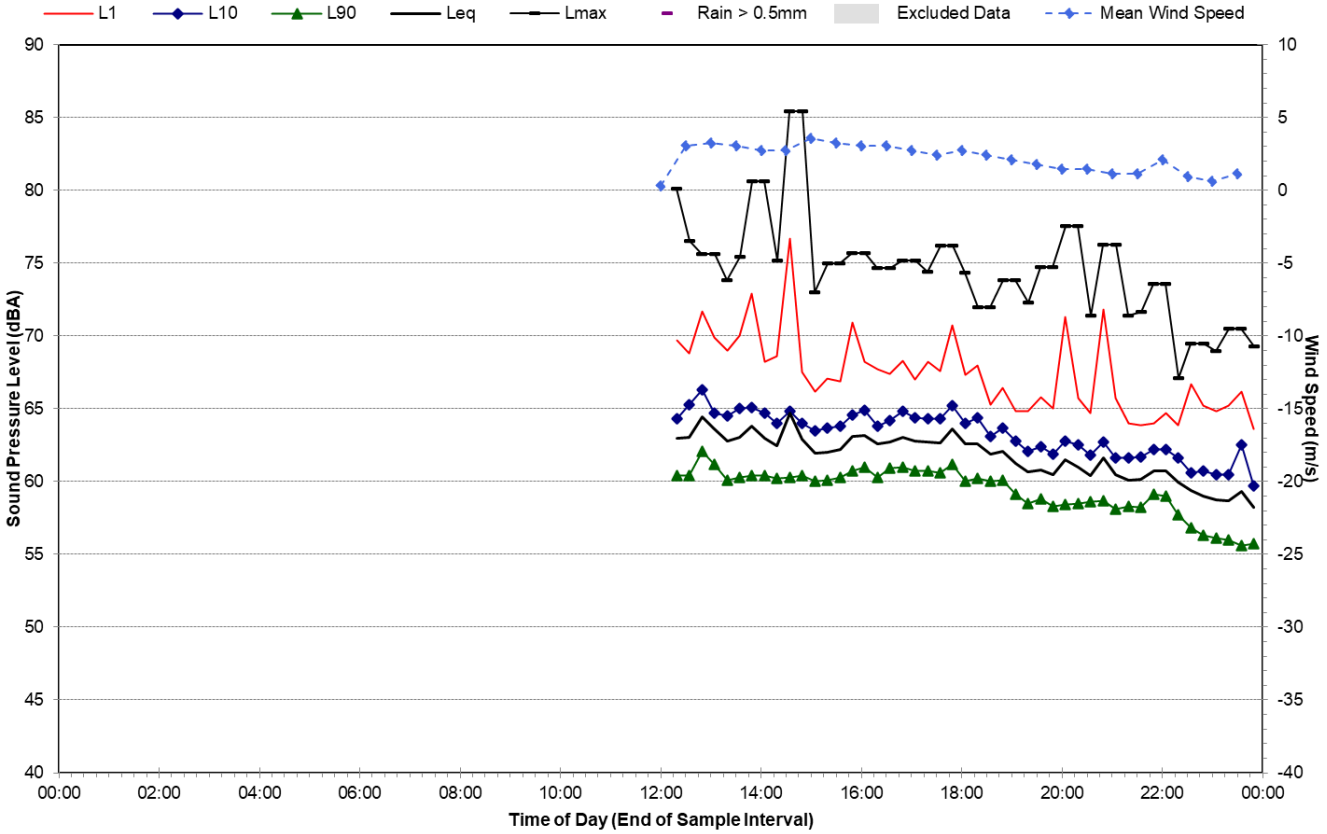
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	62	67
Night-time (10pm-7am)	59	64

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
19/10/2022	11:45	59	61	81

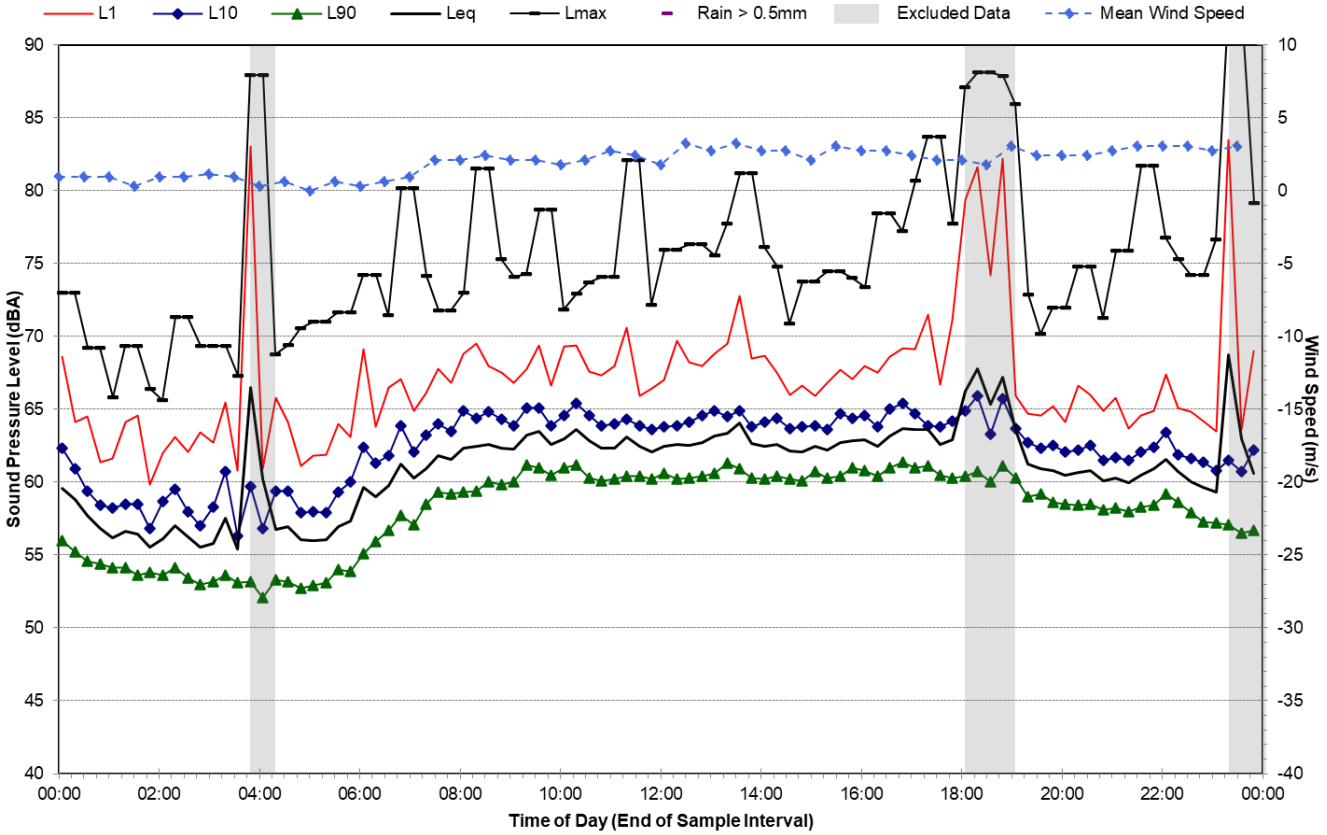
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Wednesday, 19 October 2022



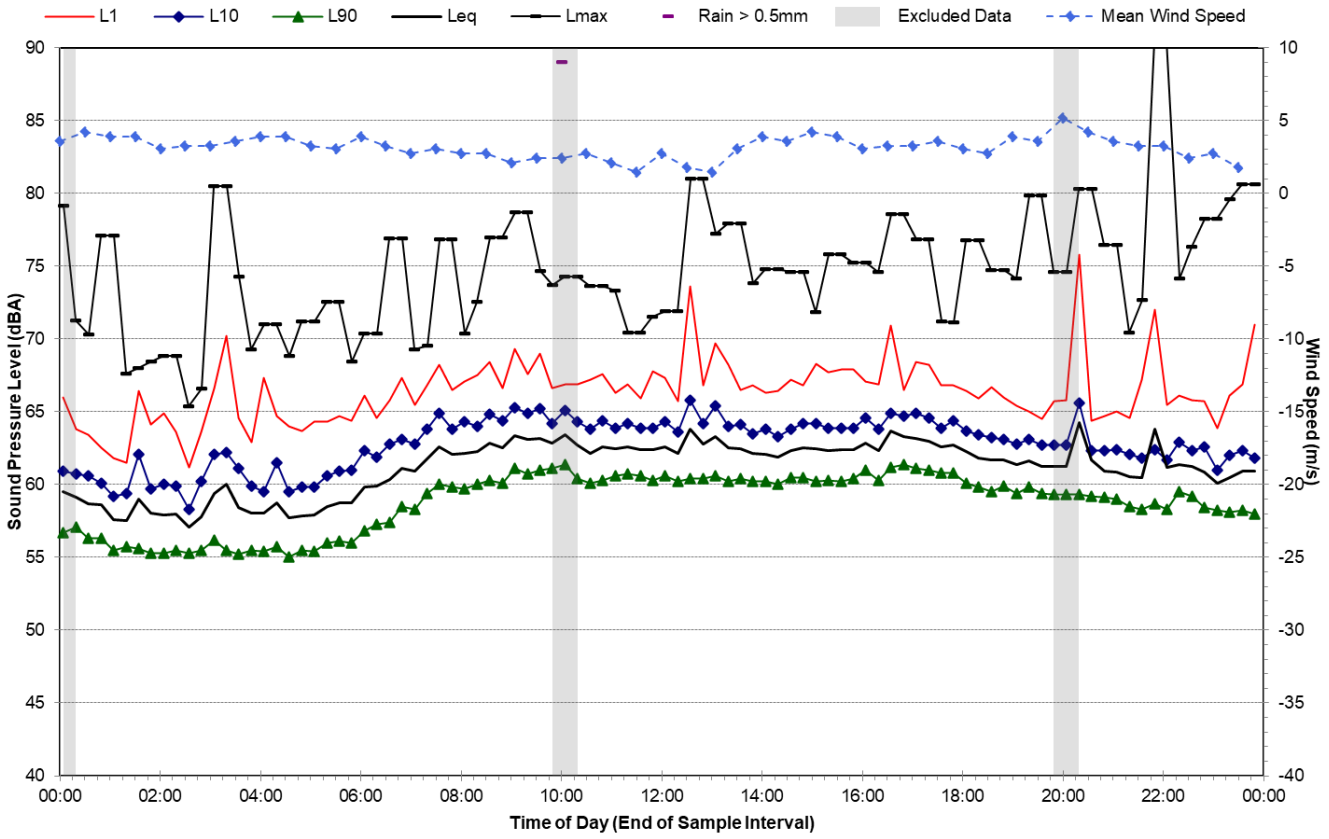
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Thursday, 20 October 2022



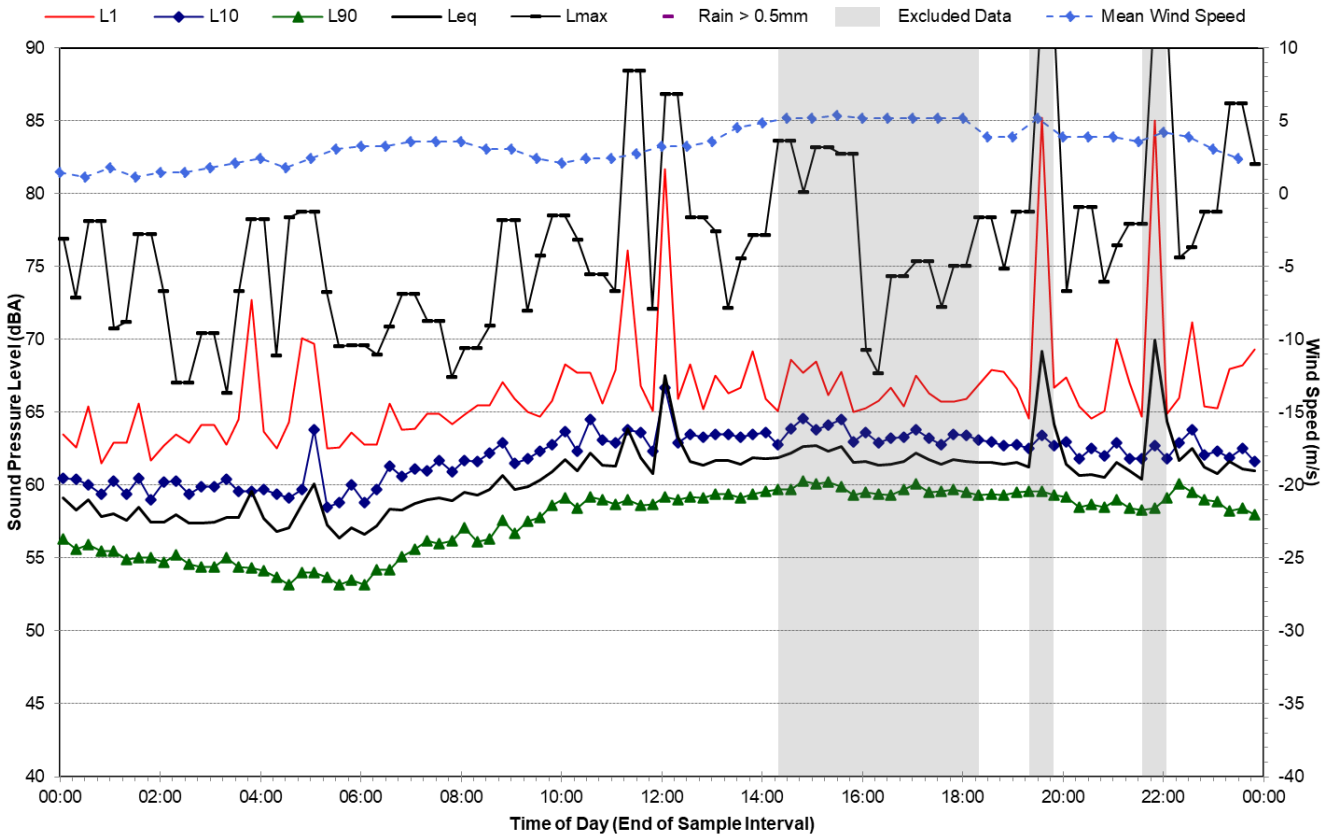
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Friday, 21 October 2022



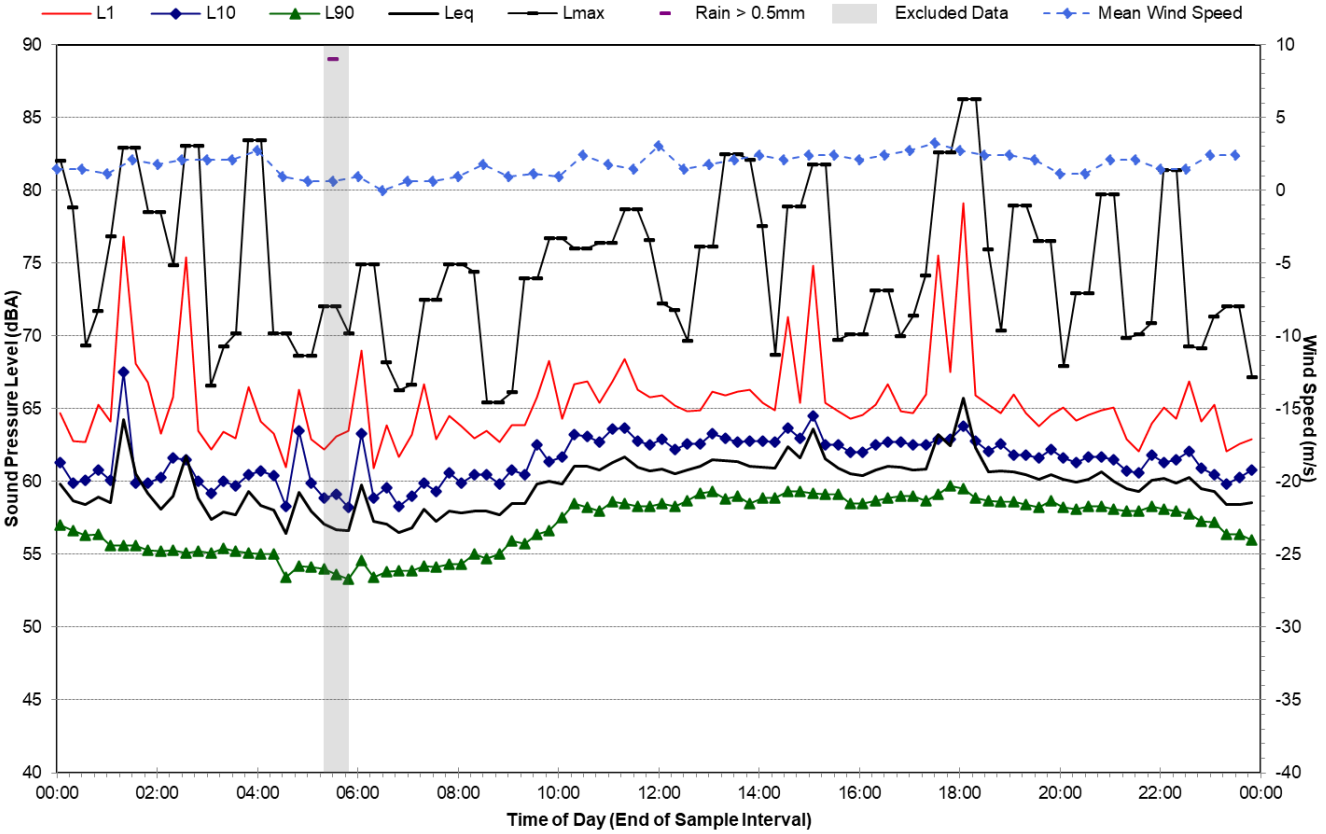
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Saturday, 22 October 2022



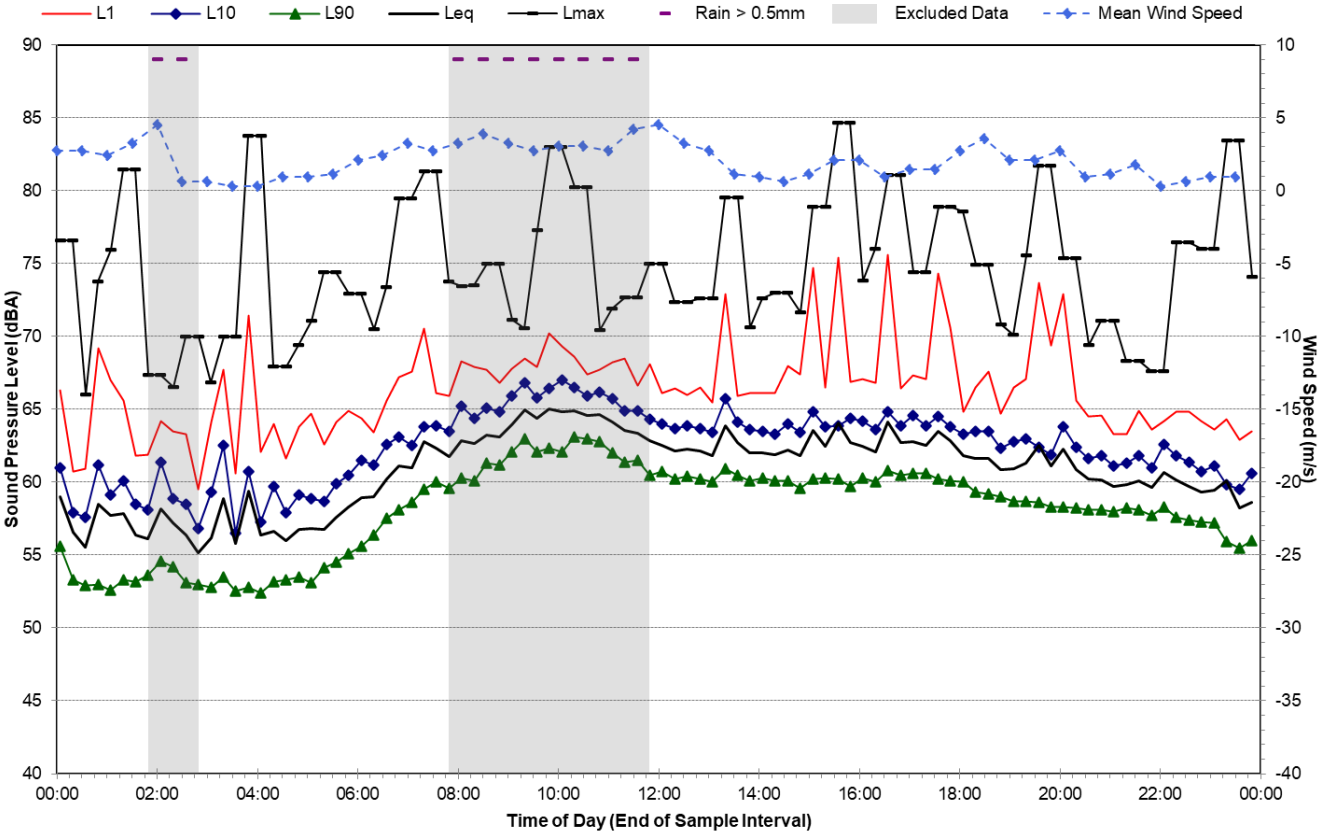
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Sunday, 23 October 2022



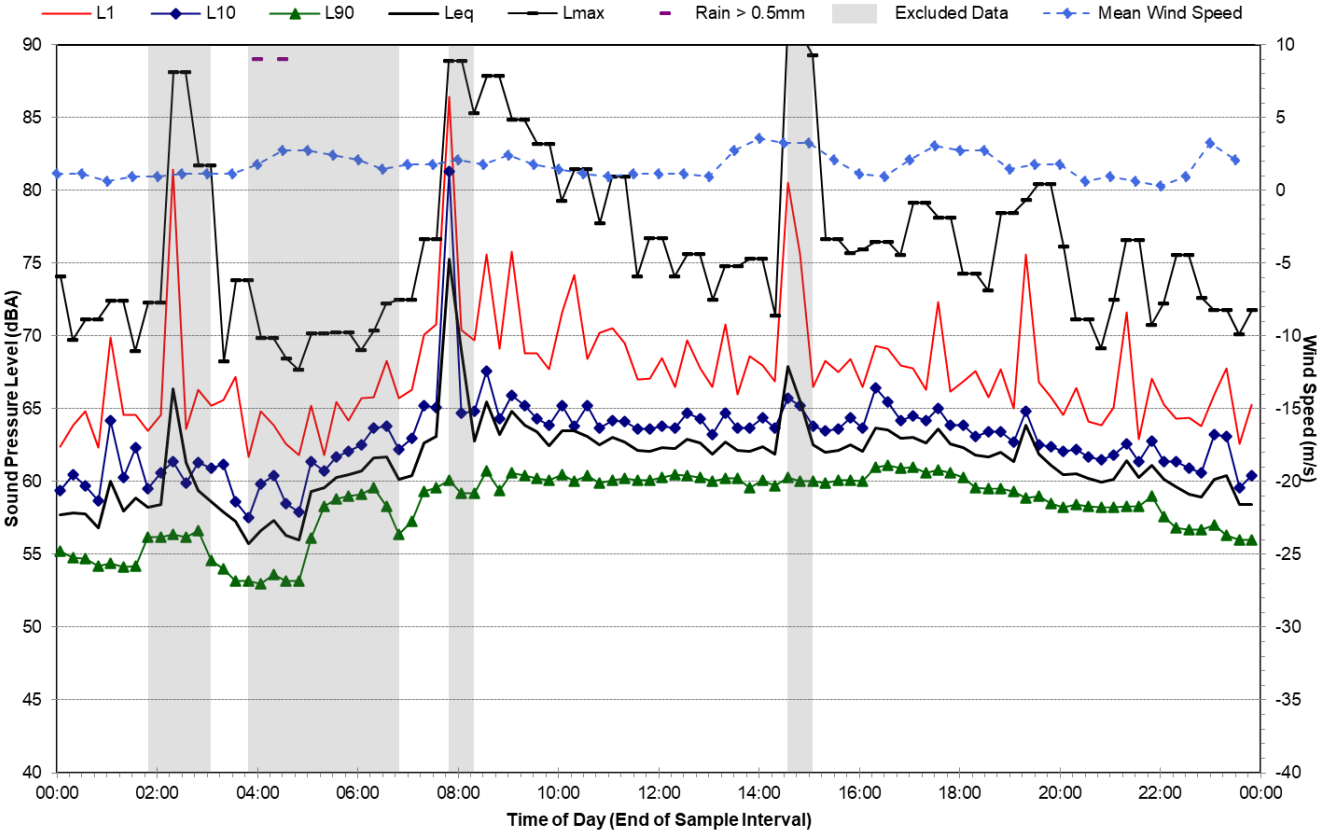
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Monday, 24 October 2022



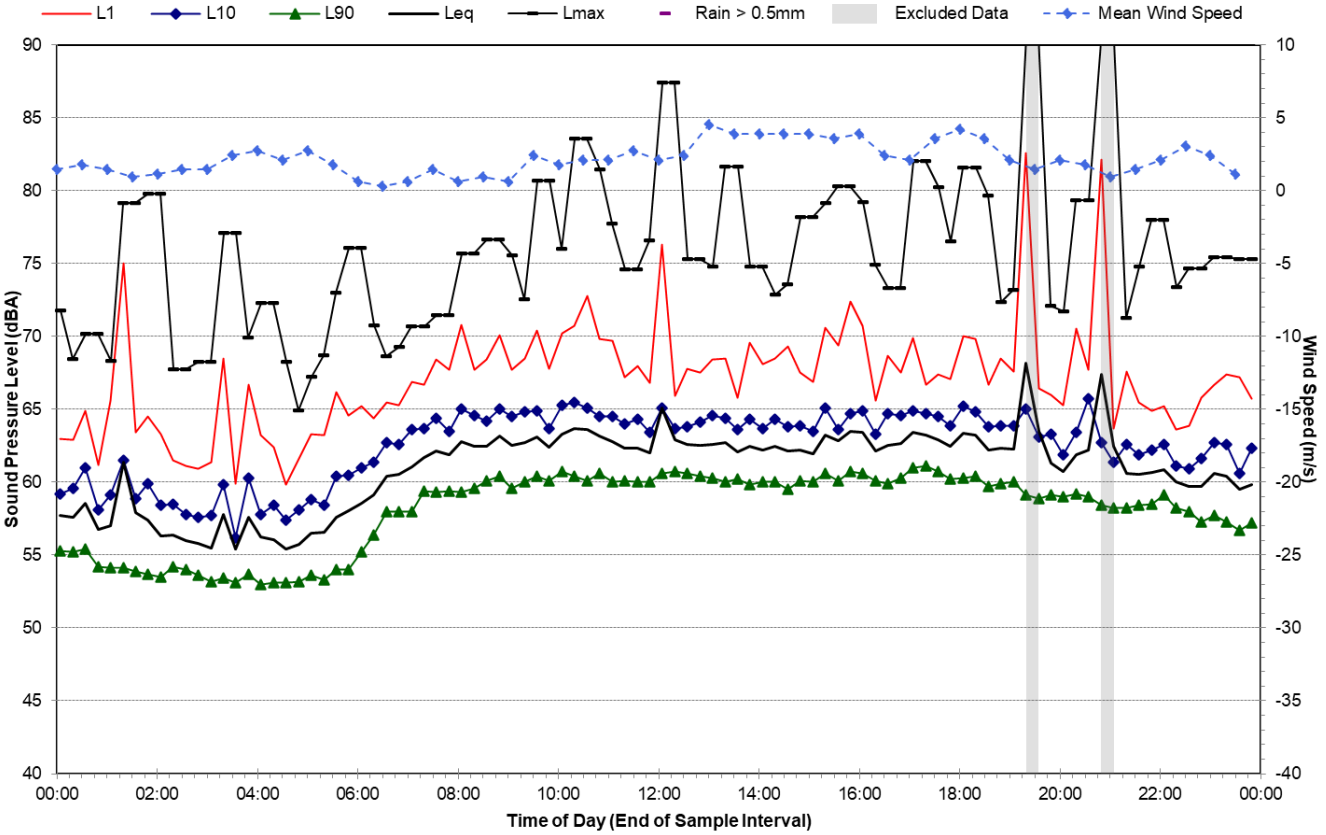
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Tuesday, 25 October 2022



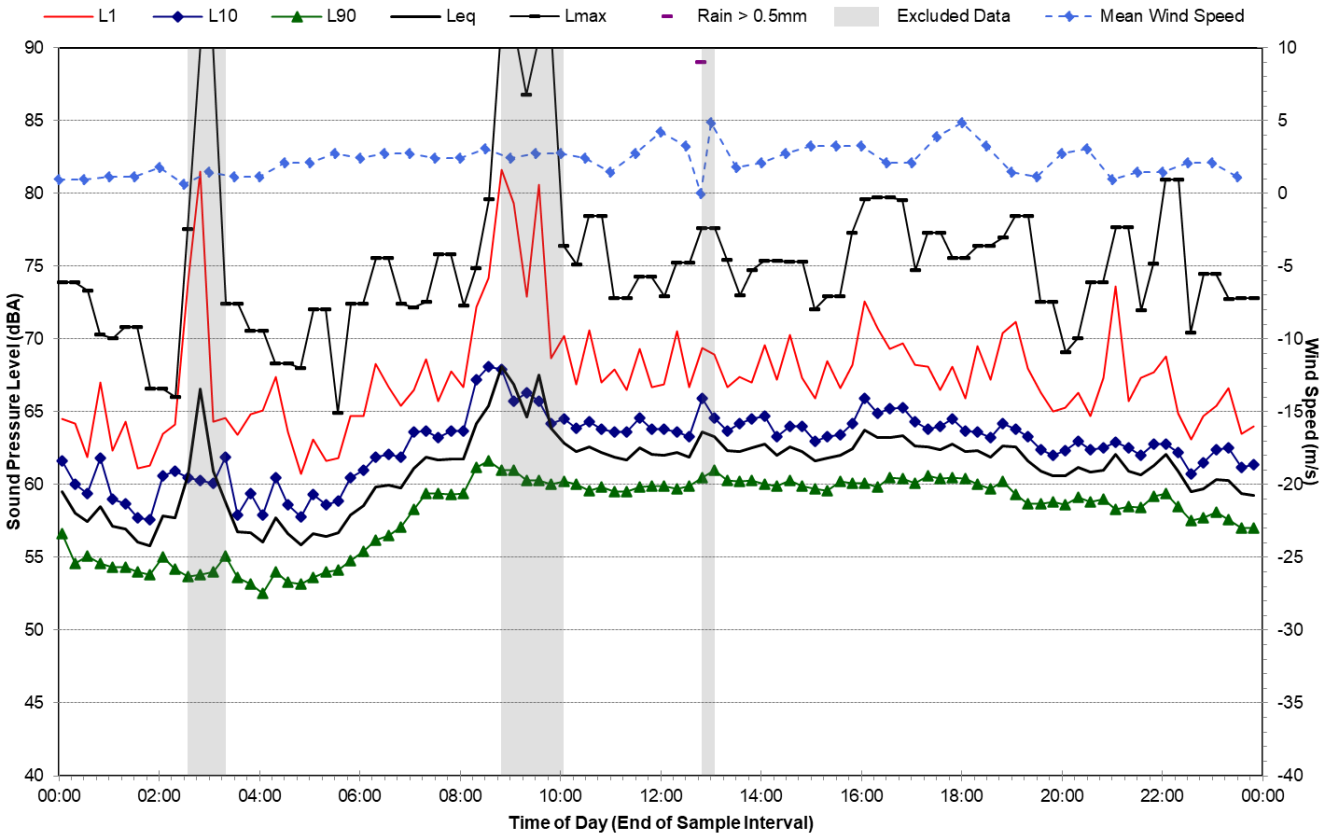
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Wednesday, 26 October 2022



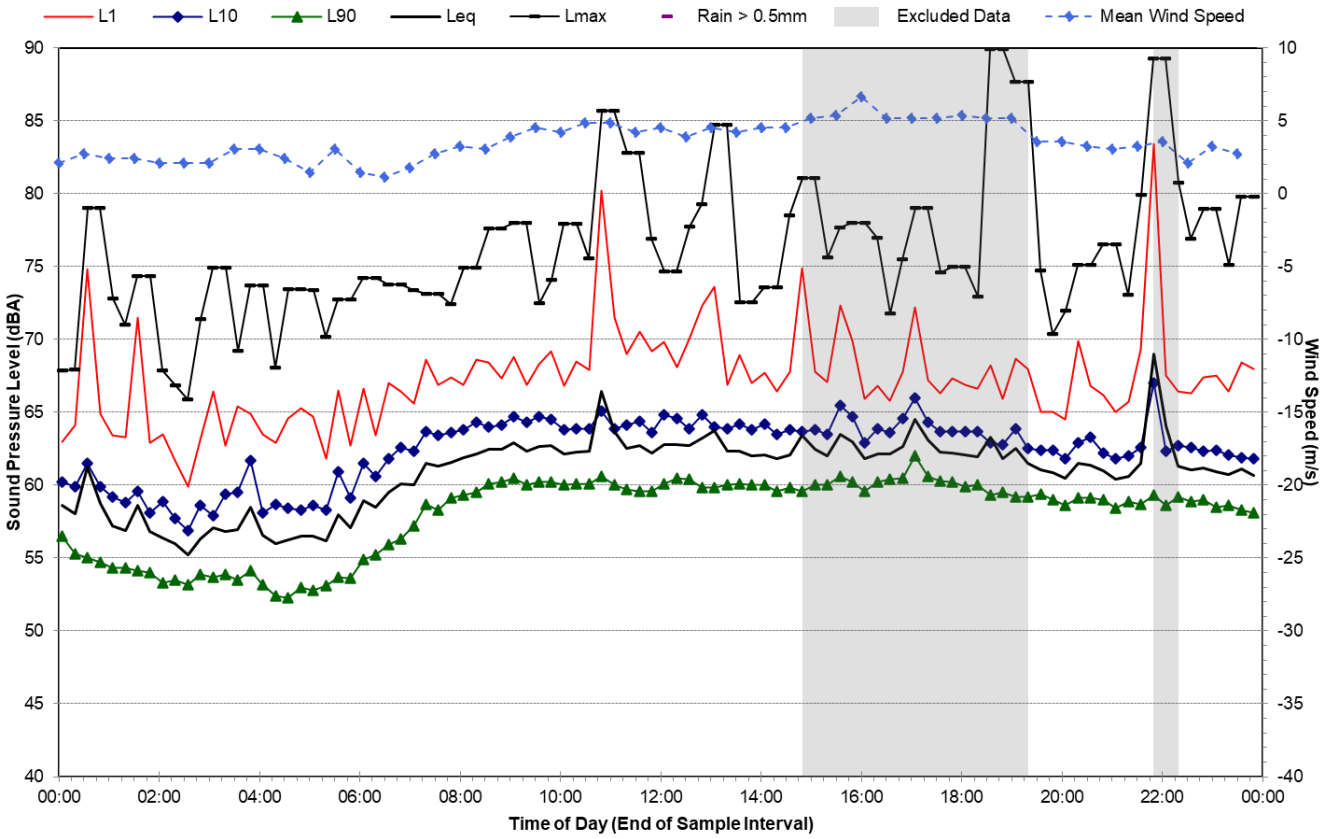
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Thursday, 27 October 2022



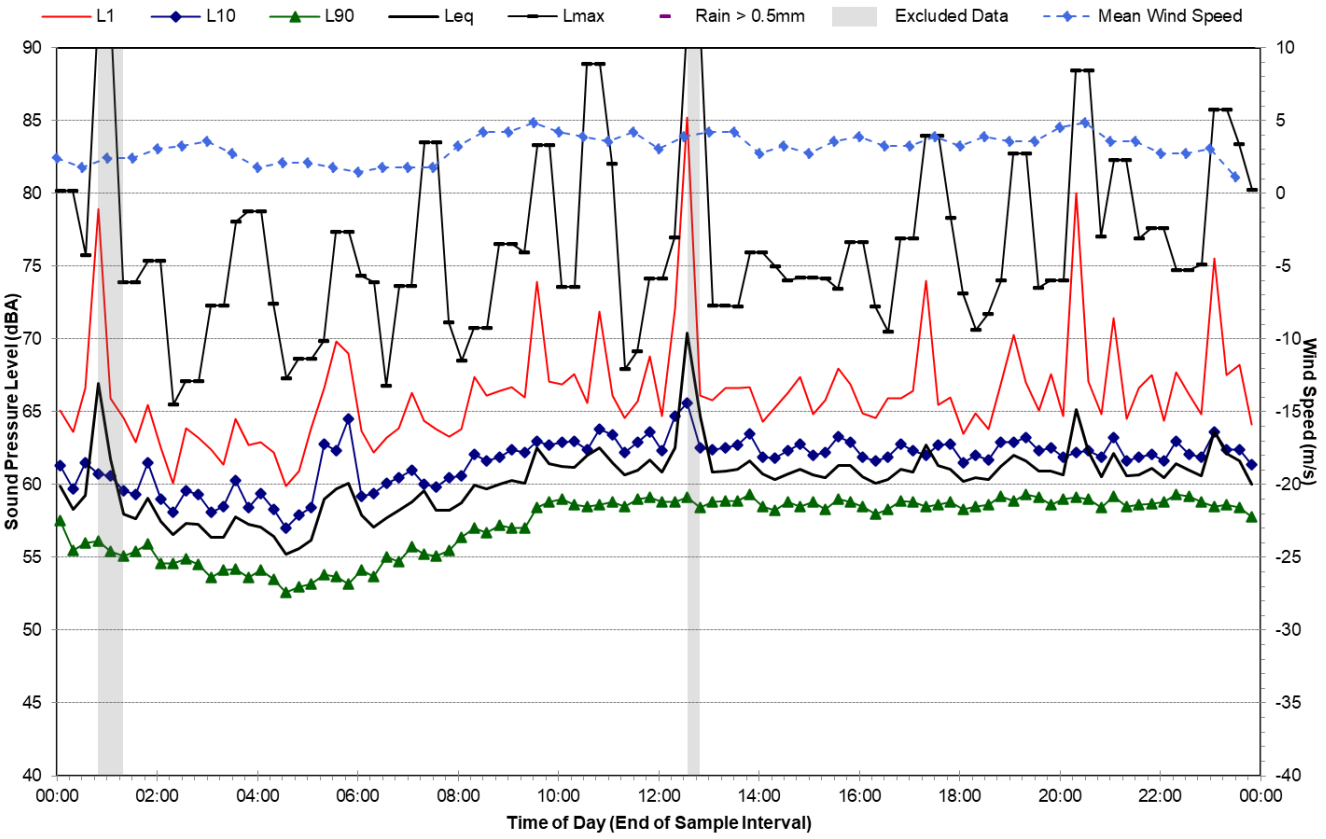
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Friday, 28 October 2022



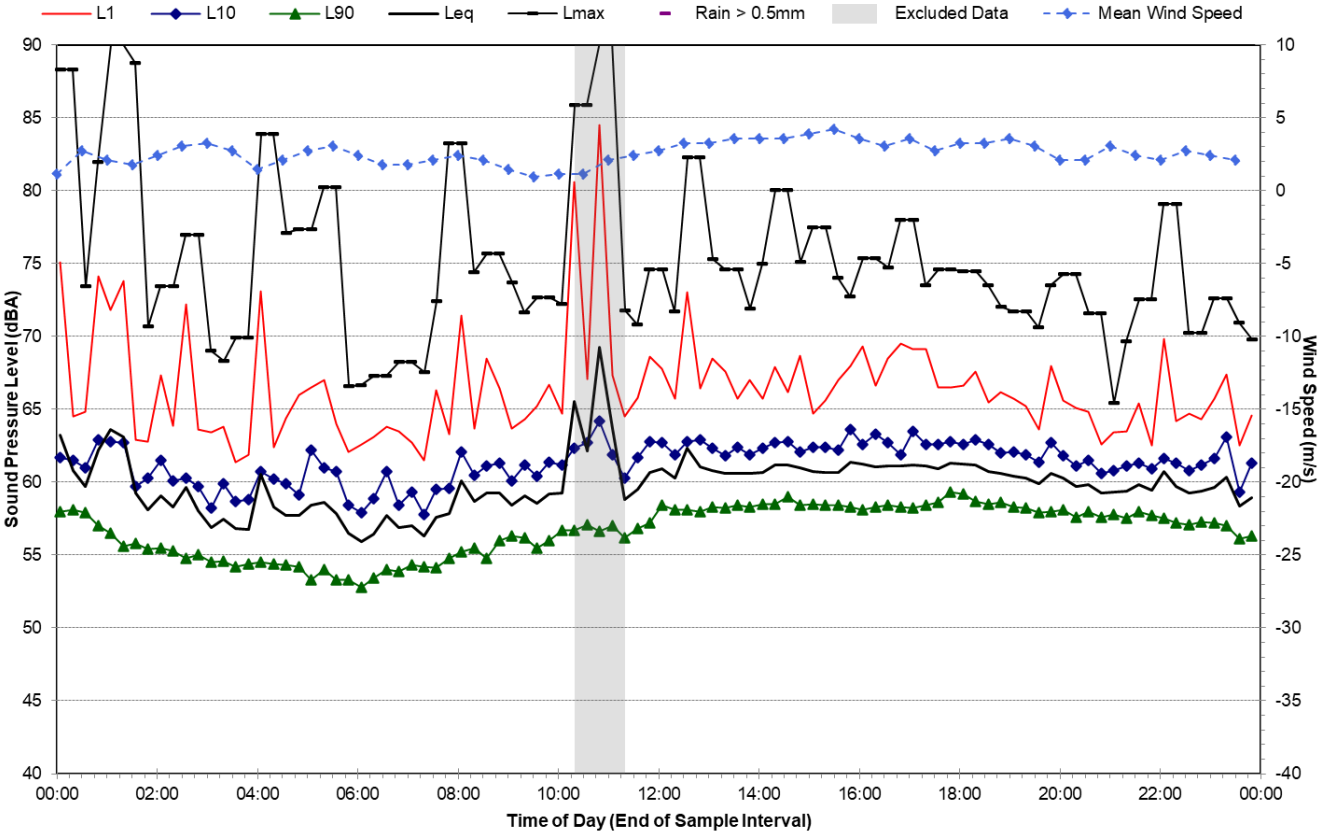
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Saturday, 29 October 2022



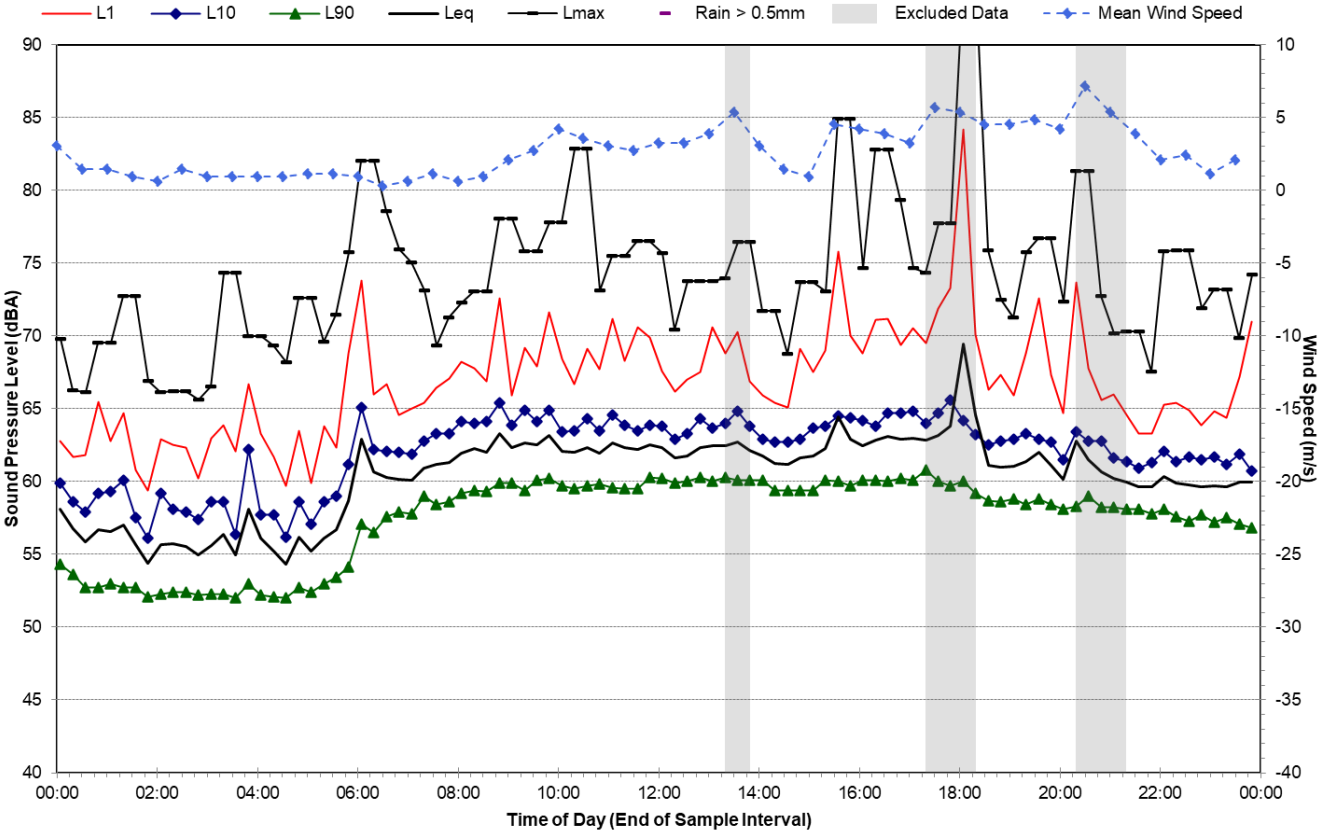
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Sunday, 30 October 2022



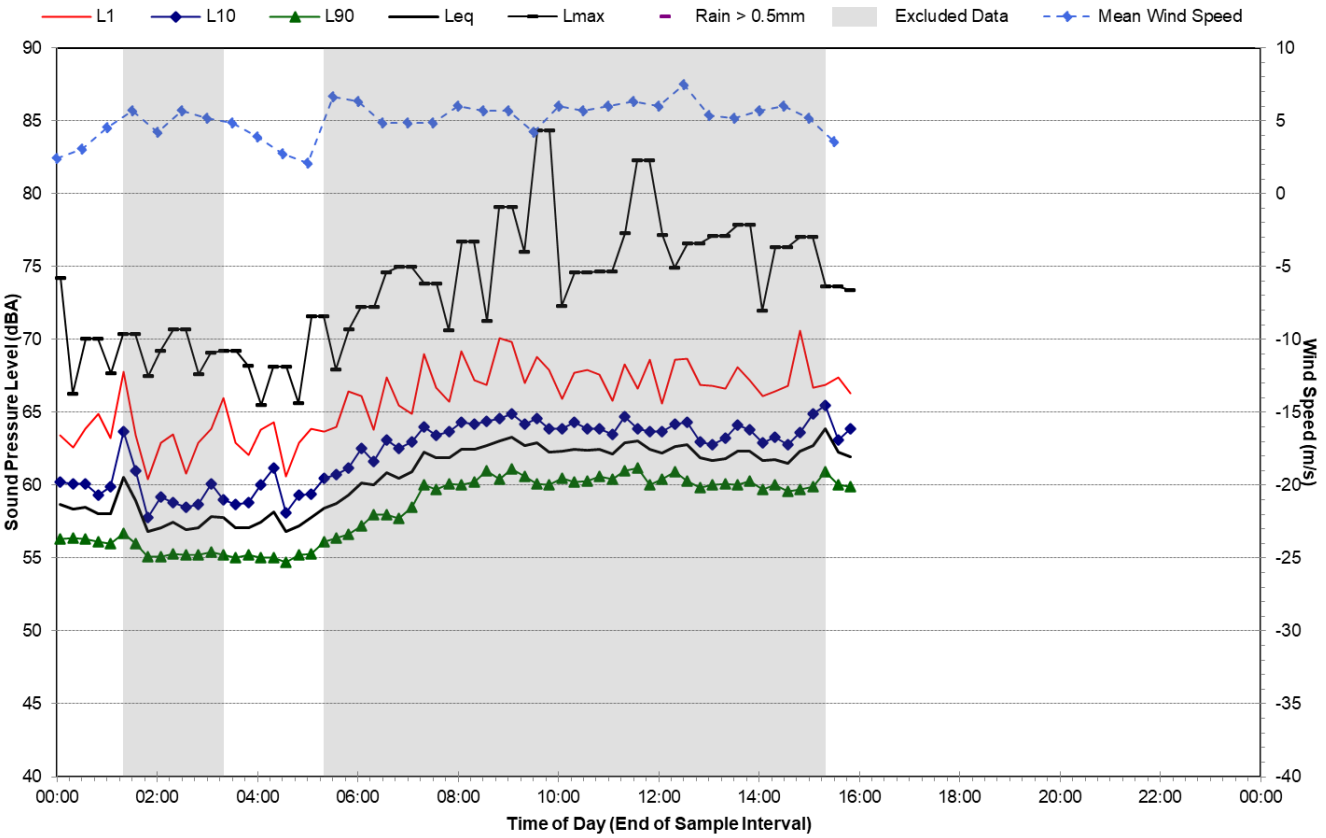
Statistical Ambient Noise Levels

303-321 Castlereagh Street - Monday, 31 October 2022



Statistical Ambient Noise Levels

303-321 Castlereagh Street - Tuesday, 1 November 2022



Noise Monitoring Location	L.03
Noise Monitoring Address	38 Chalmers Street, Surry Hills

Logger Device Type: Svantek 957, Logger Serial No: 20665
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3005904

Ambient noise logger deployed on level 1 calcony of west facing unit at 38 Chalmers Street, Surry Hills. Logger located at balcony edge with view over light rail to Central Station platforms.

Attended noise measurements indicate the ambient noise environment at this location is influenced by light rail operation.

Recorded Noise Levels (LAmax) 11/10/2022:
Light rail noise: 63-65 dBA
Aircraft noise: 60 dBA

Map of Noise Monitoring Location

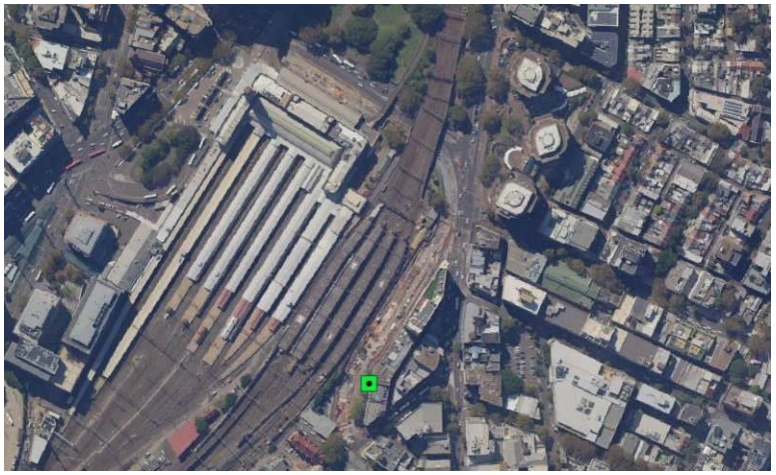


Photo of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	53	61	63	68
Evening	53	61	63	68
Night-time	48	59	61	67

Ambient Noise Logging Results – RNP Defined Time Periods

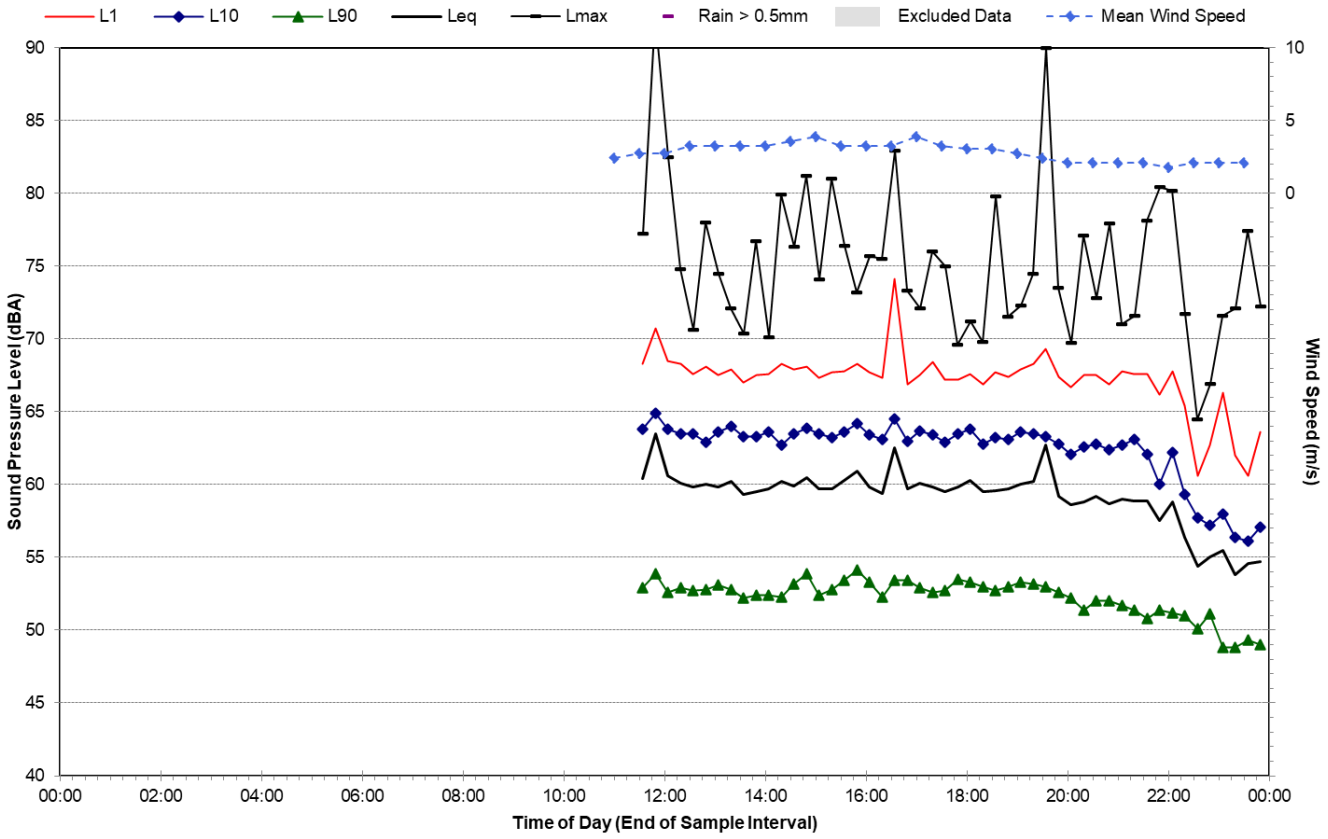
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	61	62
Night-time (10pm-7am)	59	62

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
11/10/2022	10:20	54	60	78

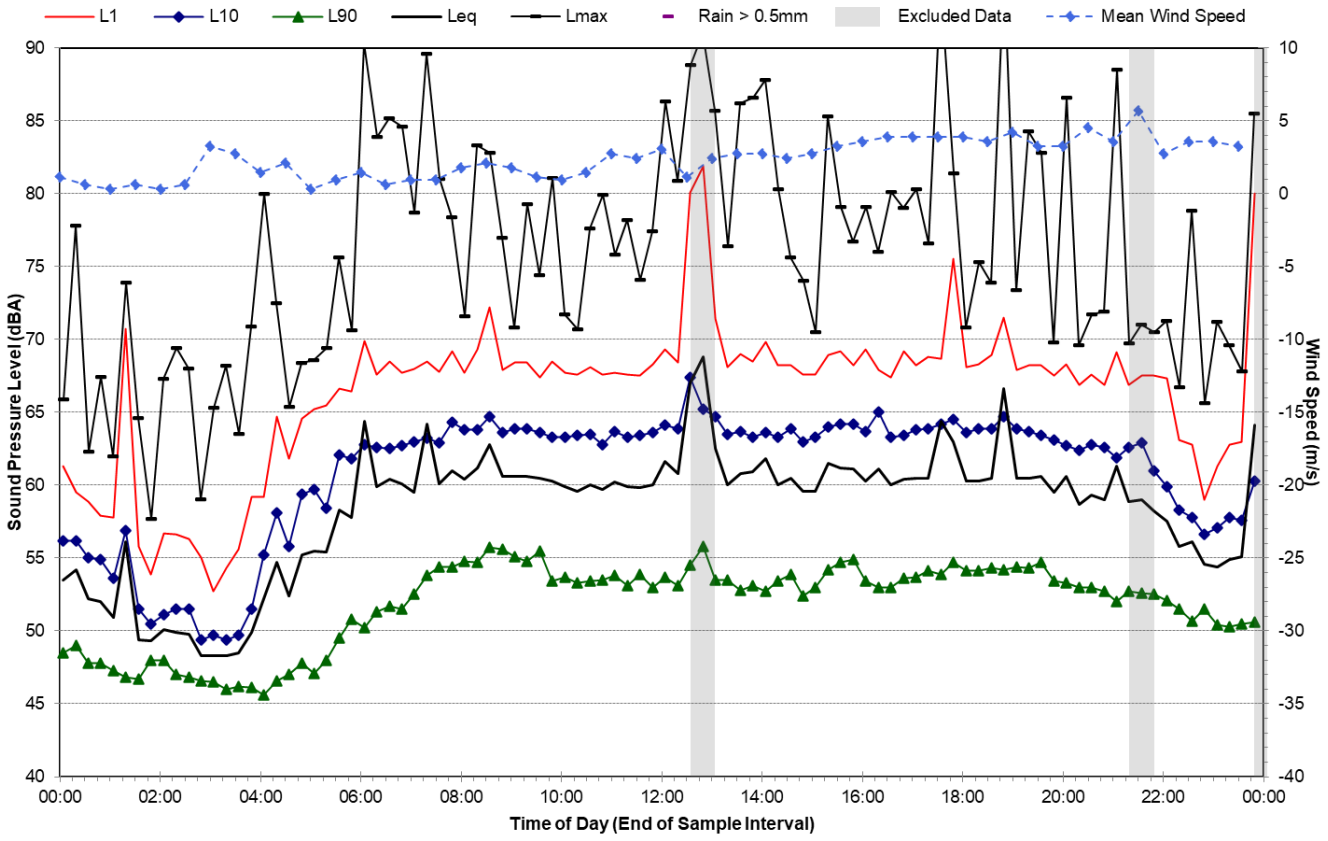
Statistical Ambient Noise Levels

38 Chalmers Street - Tuesday, 11 October 2022



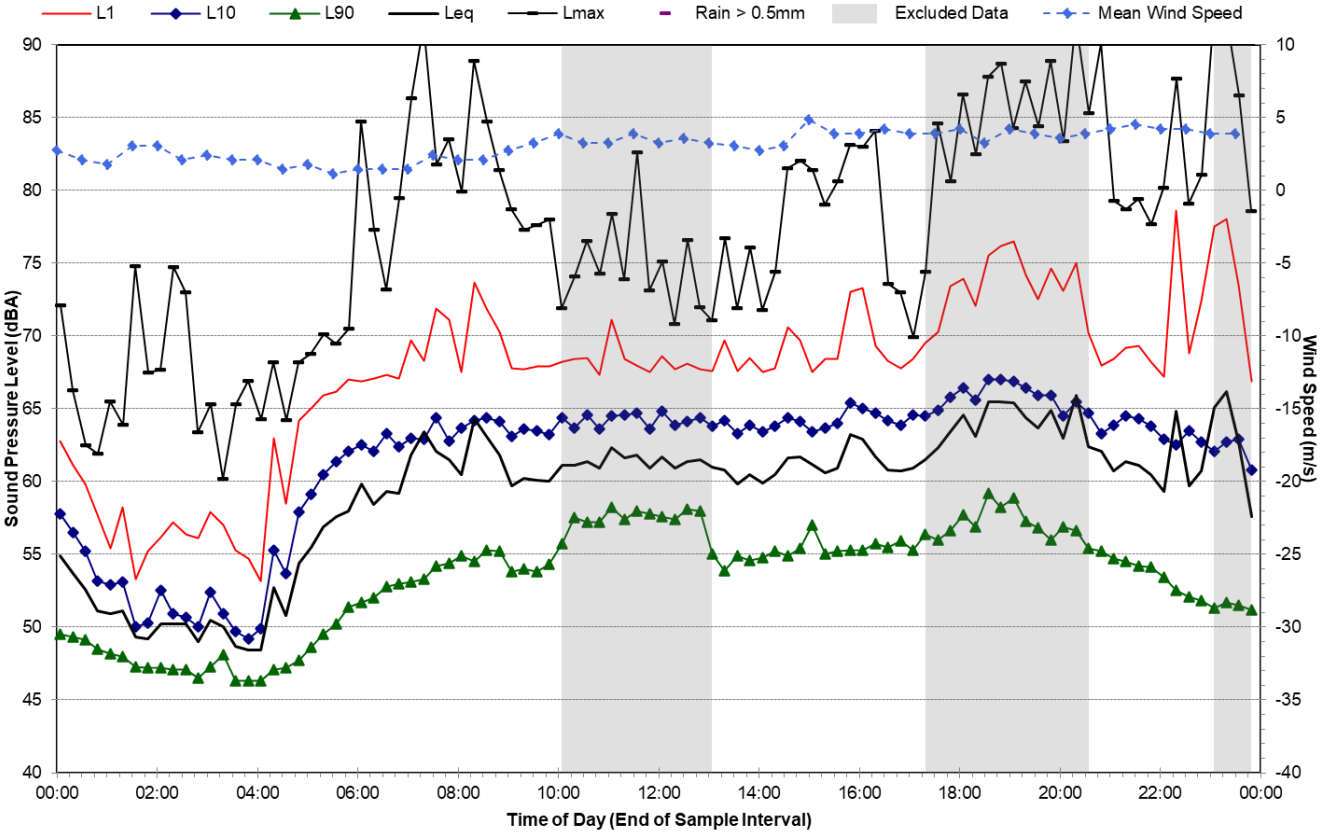
Statistical Ambient Noise Levels

38 Chalmers Street - Wednesday, 12 October 2022



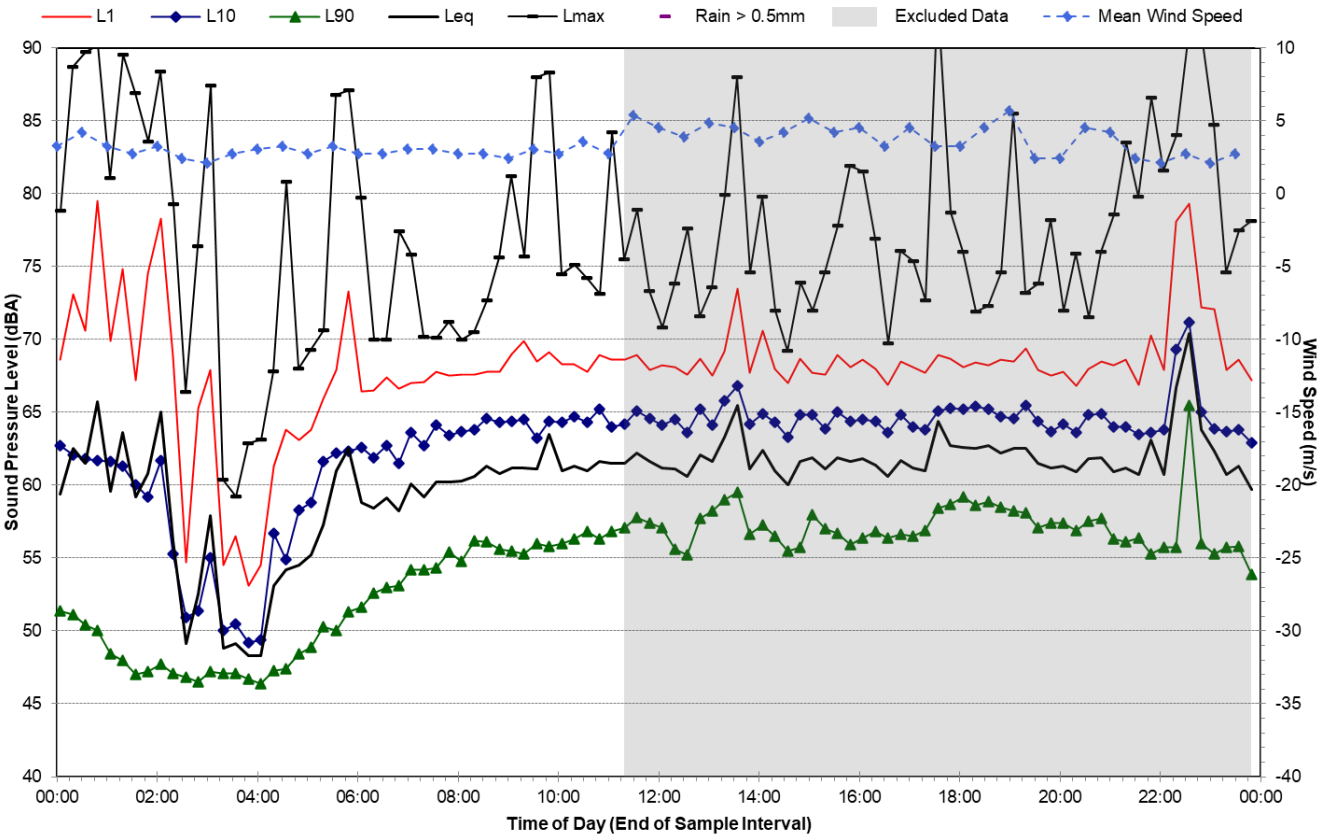
Statistical Ambient Noise Levels

38 Chalmers Street - Thursday, 13 October 2022



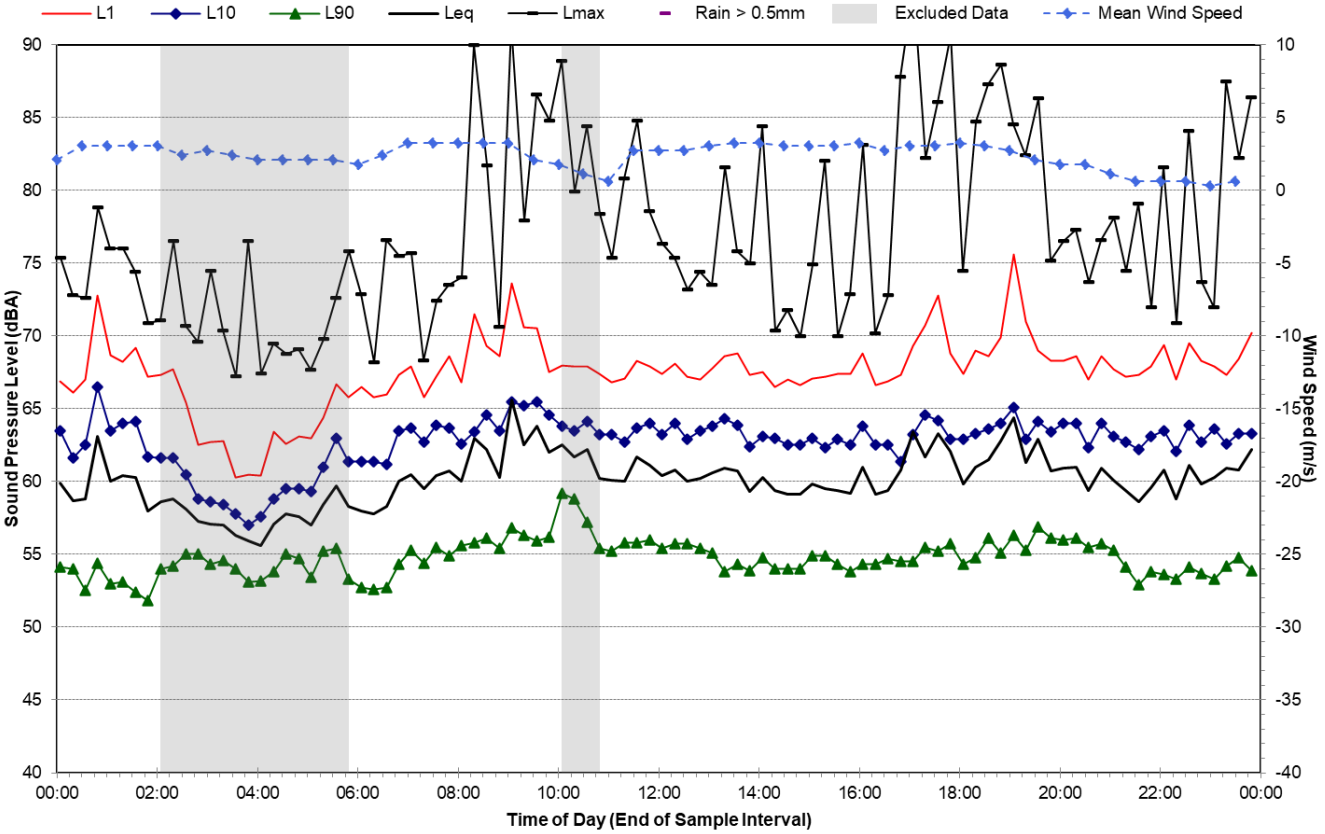
Statistical Ambient Noise Levels

38 Chalmers Street - Friday, 14 October 2022



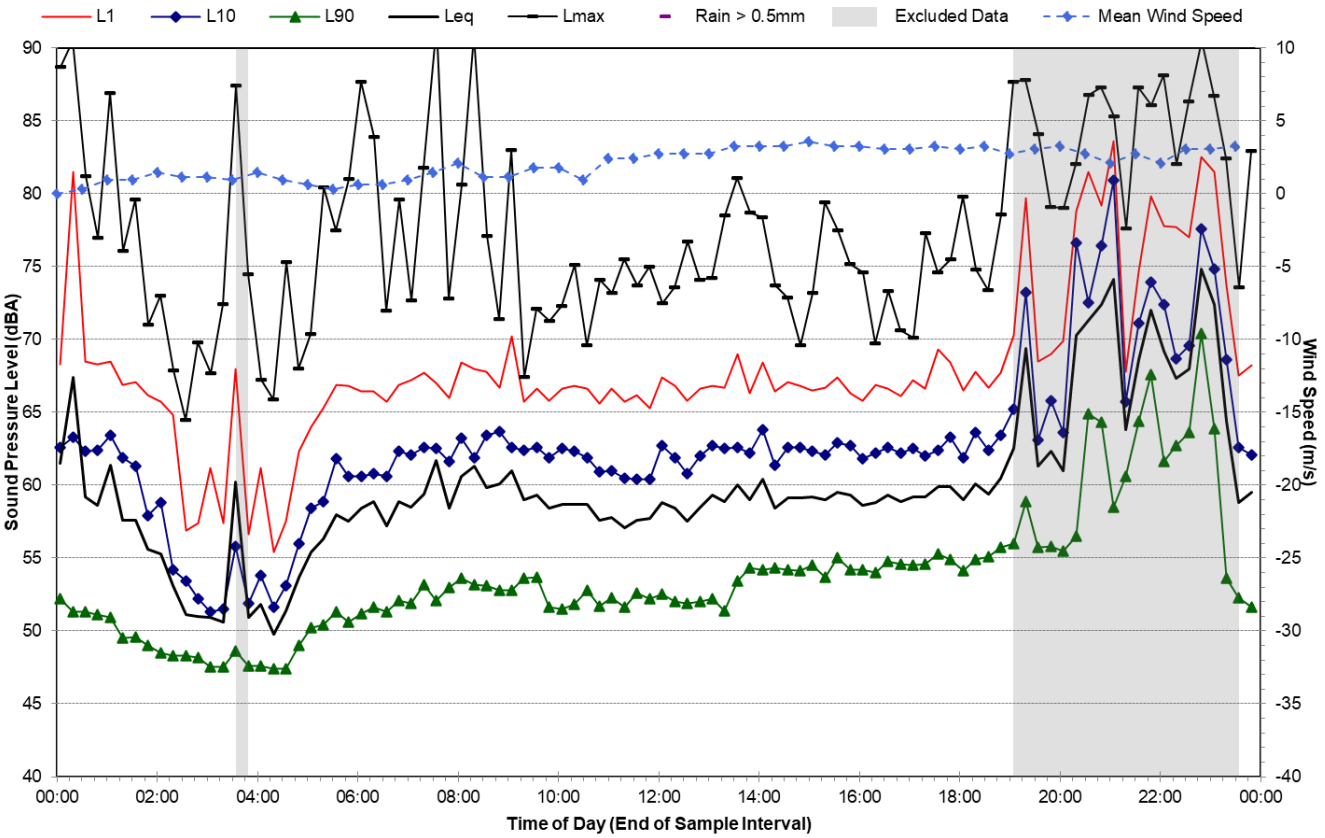
Statistical Ambient Noise Levels

38 Chalmers Street - Saturday, 15 October 2022



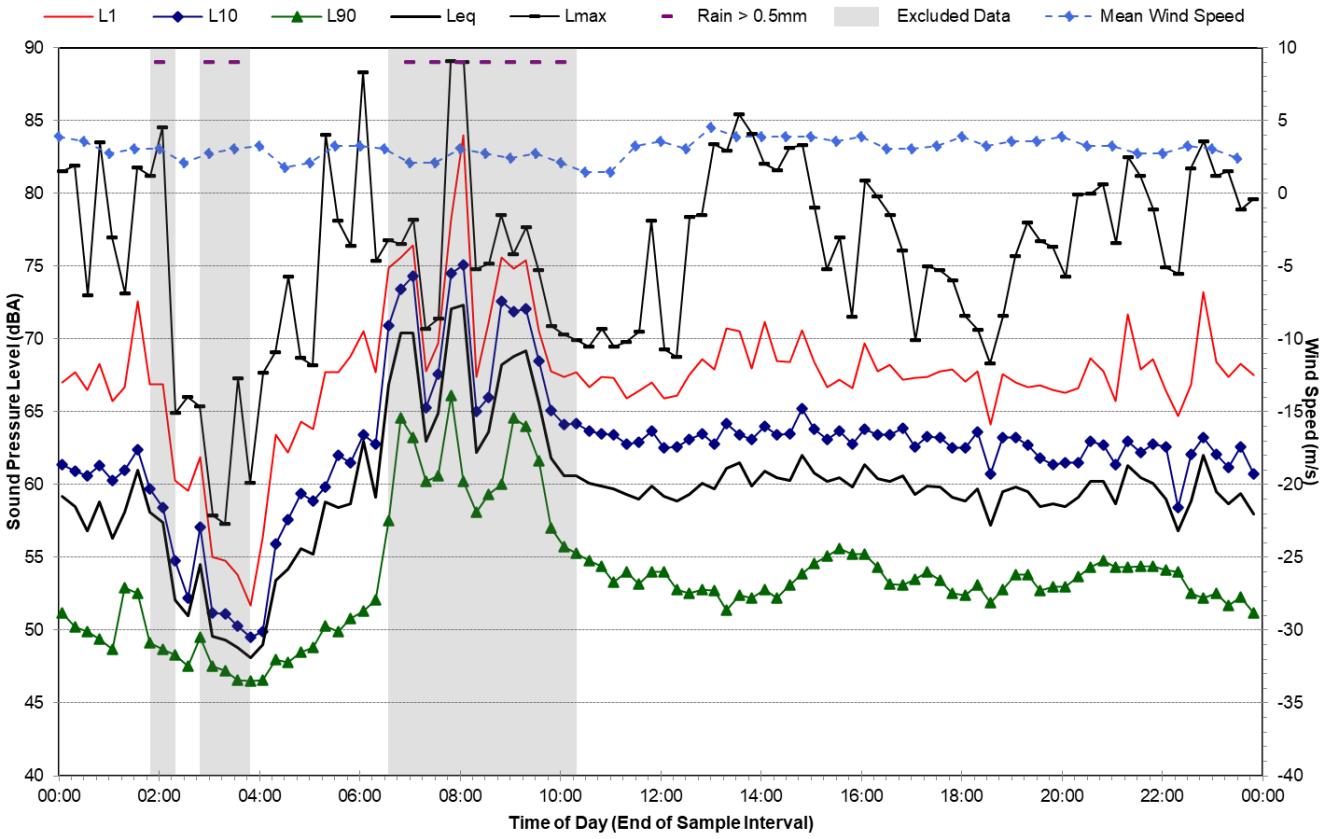
Statistical Ambient Noise Levels

38 Chalmers Street - Sunday, 16 October 2022



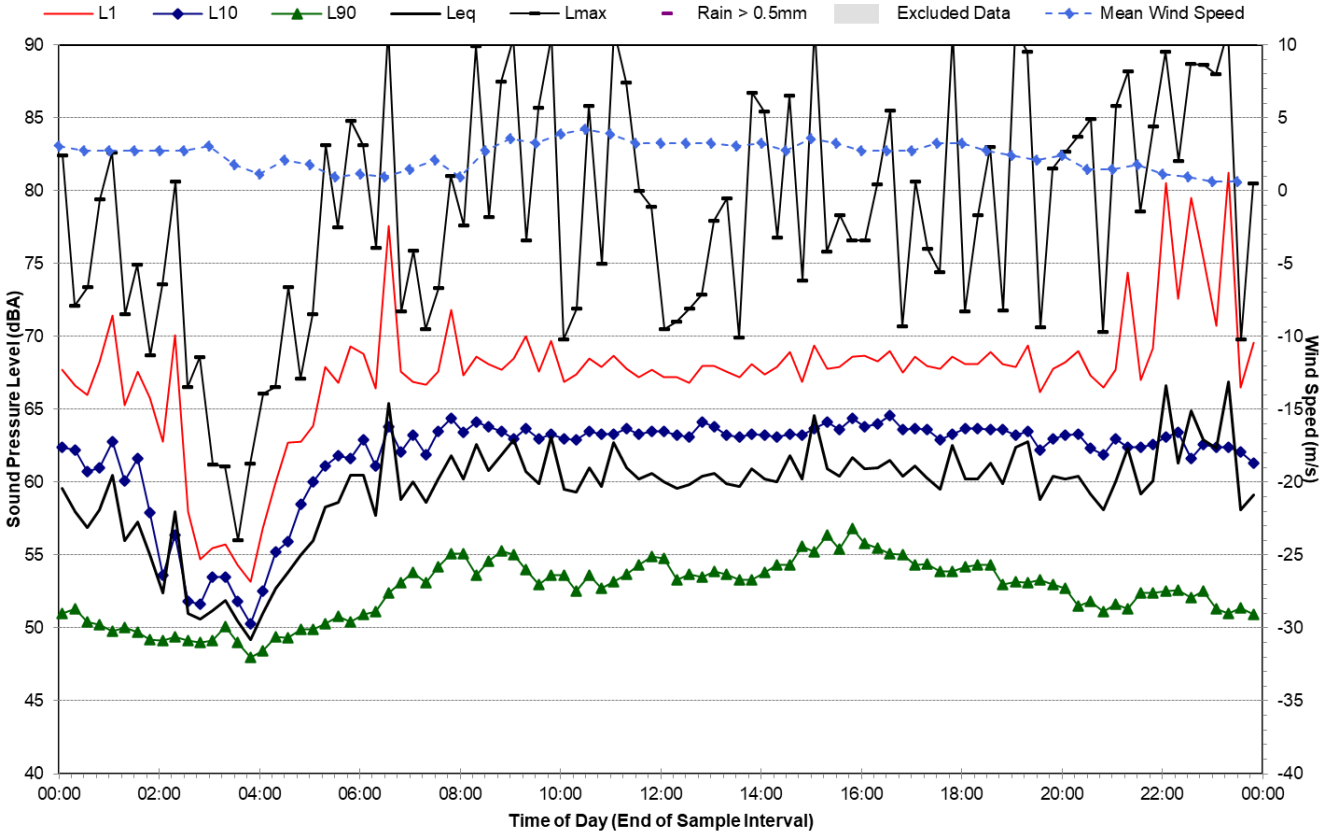
Statistical Ambient Noise Levels

38 Chalmers Street - Monday, 17 October 2022



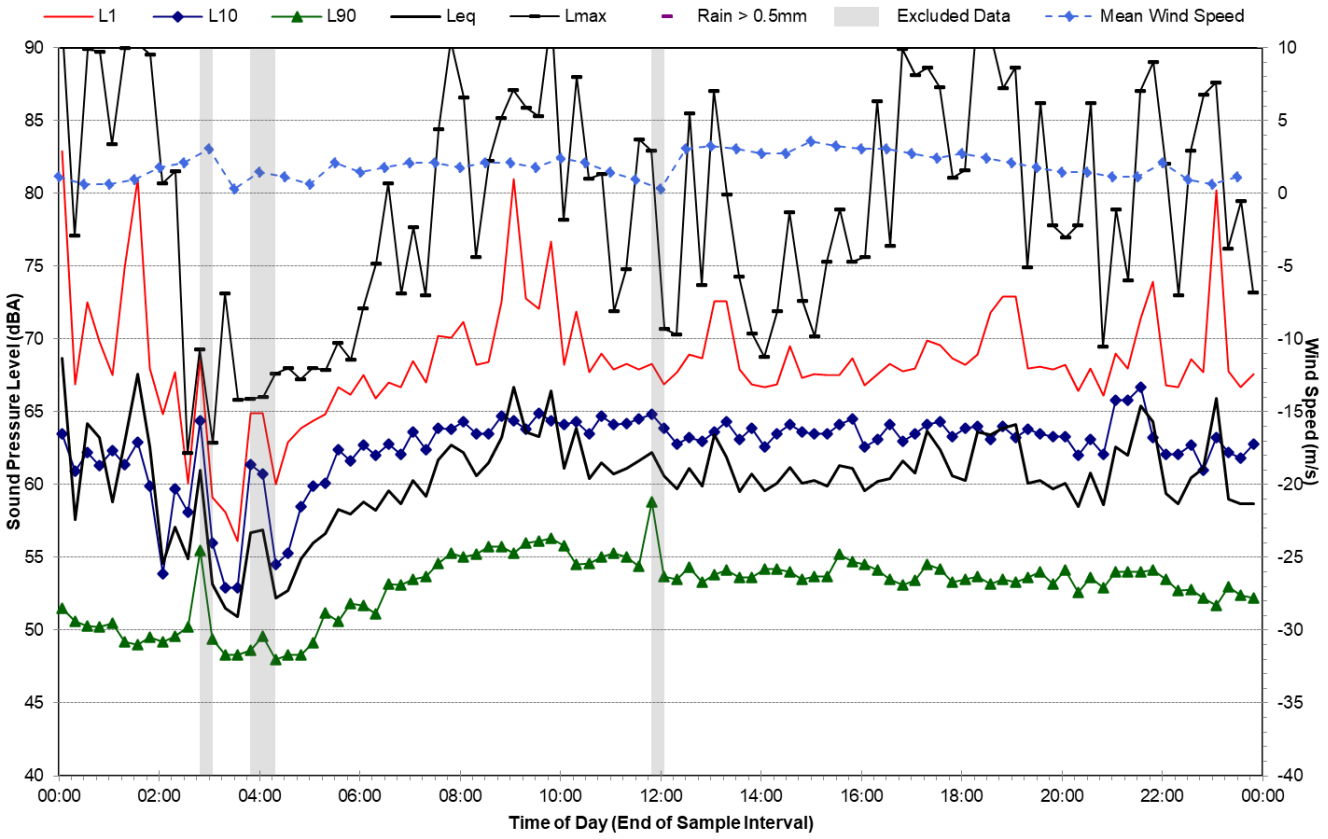
Statistical Ambient Noise Levels

38 Chalmers Street - Tuesday, 18 October 2022



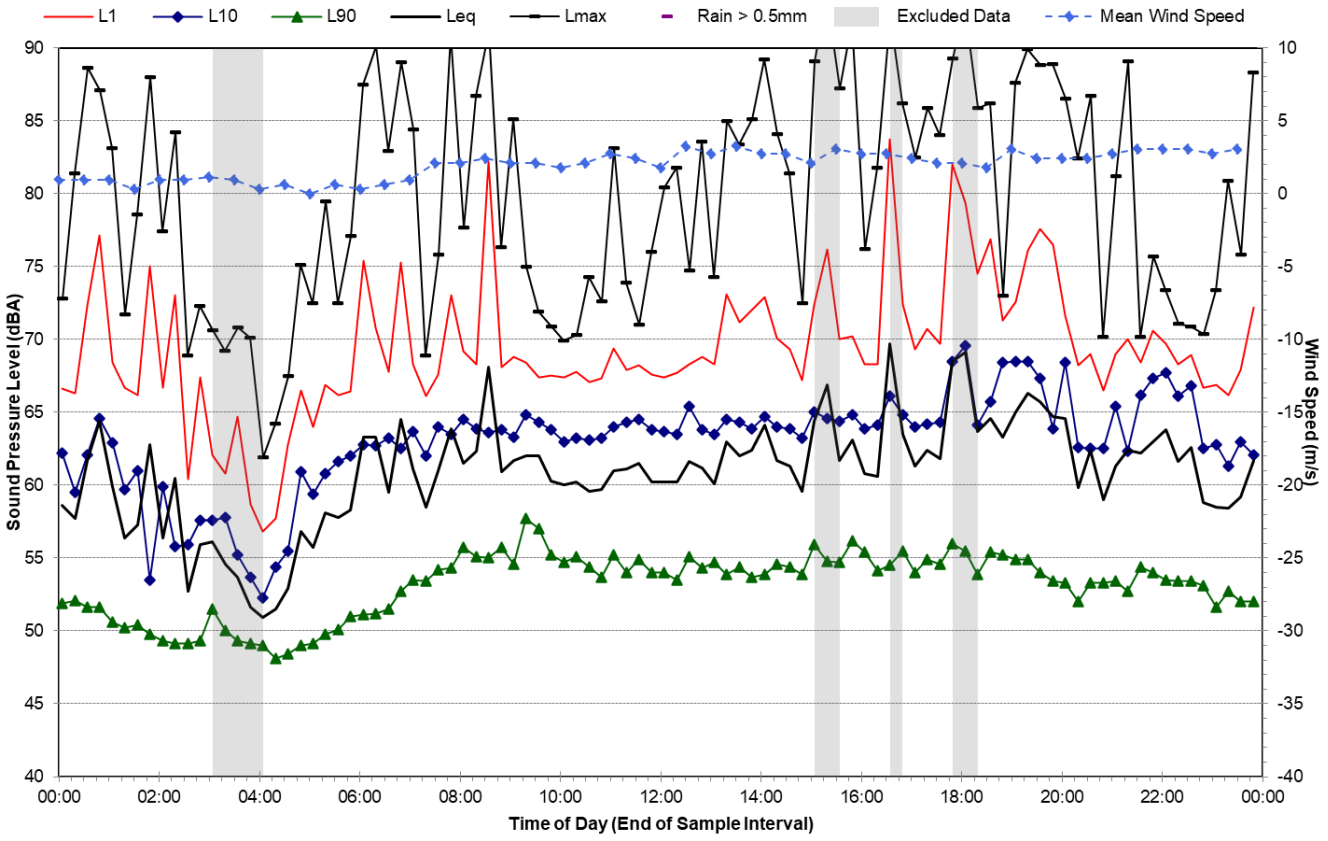
Statistical Ambient Noise Levels

38 Chalmers Street - Wednesday, 19 October 2022



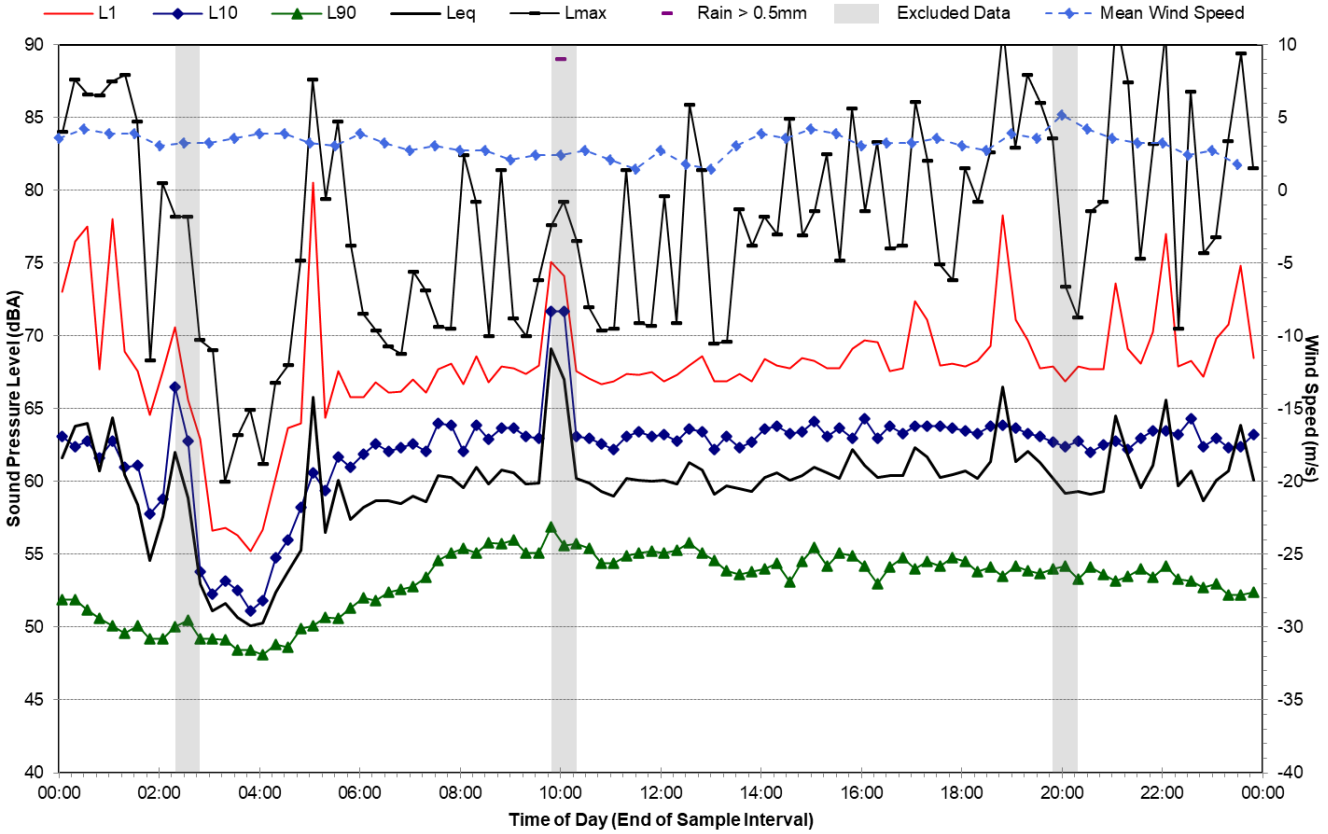
Statistical Ambient Noise Levels

38 Chalmers Street - Thursday, 20 October 2022



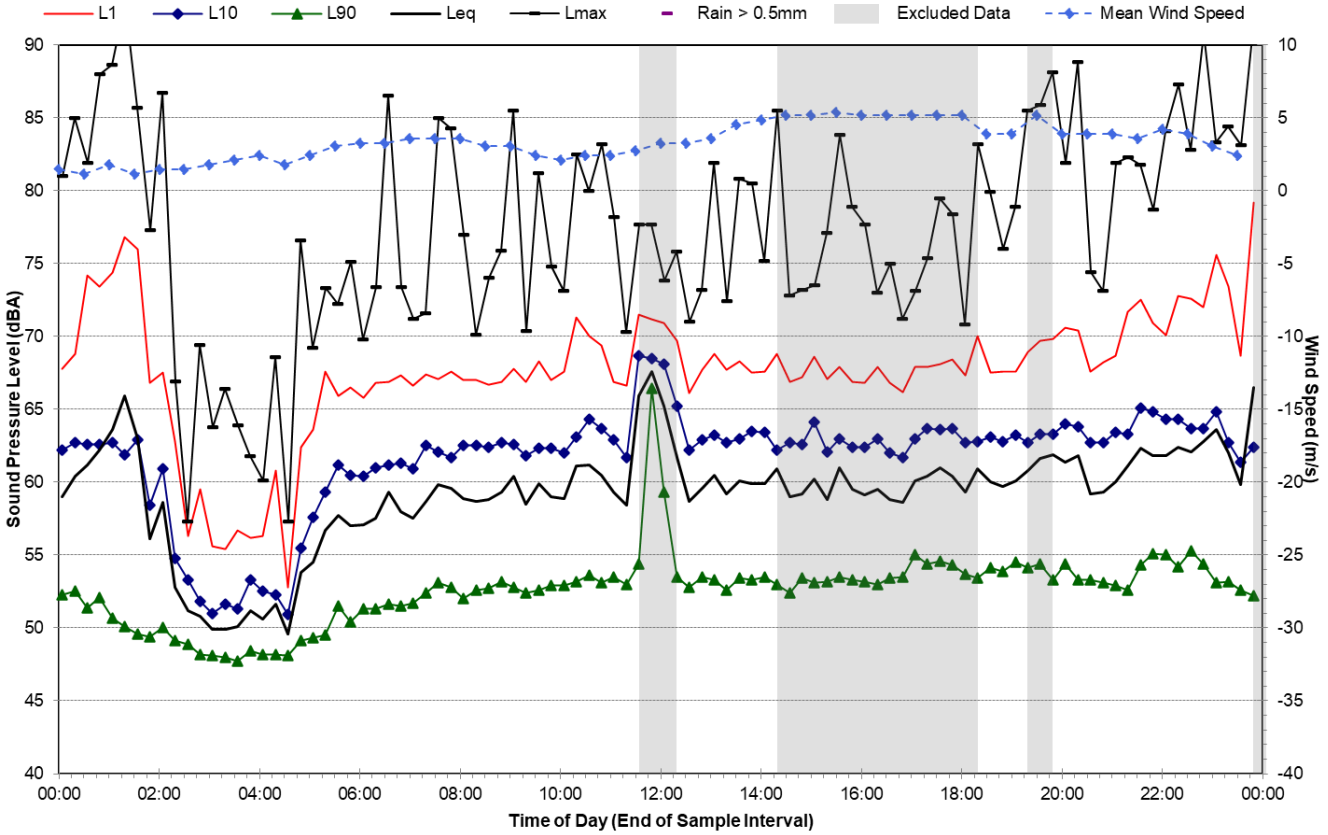
Statistical Ambient Noise Levels

38 Chalmers Street - Friday, 21 October 2022



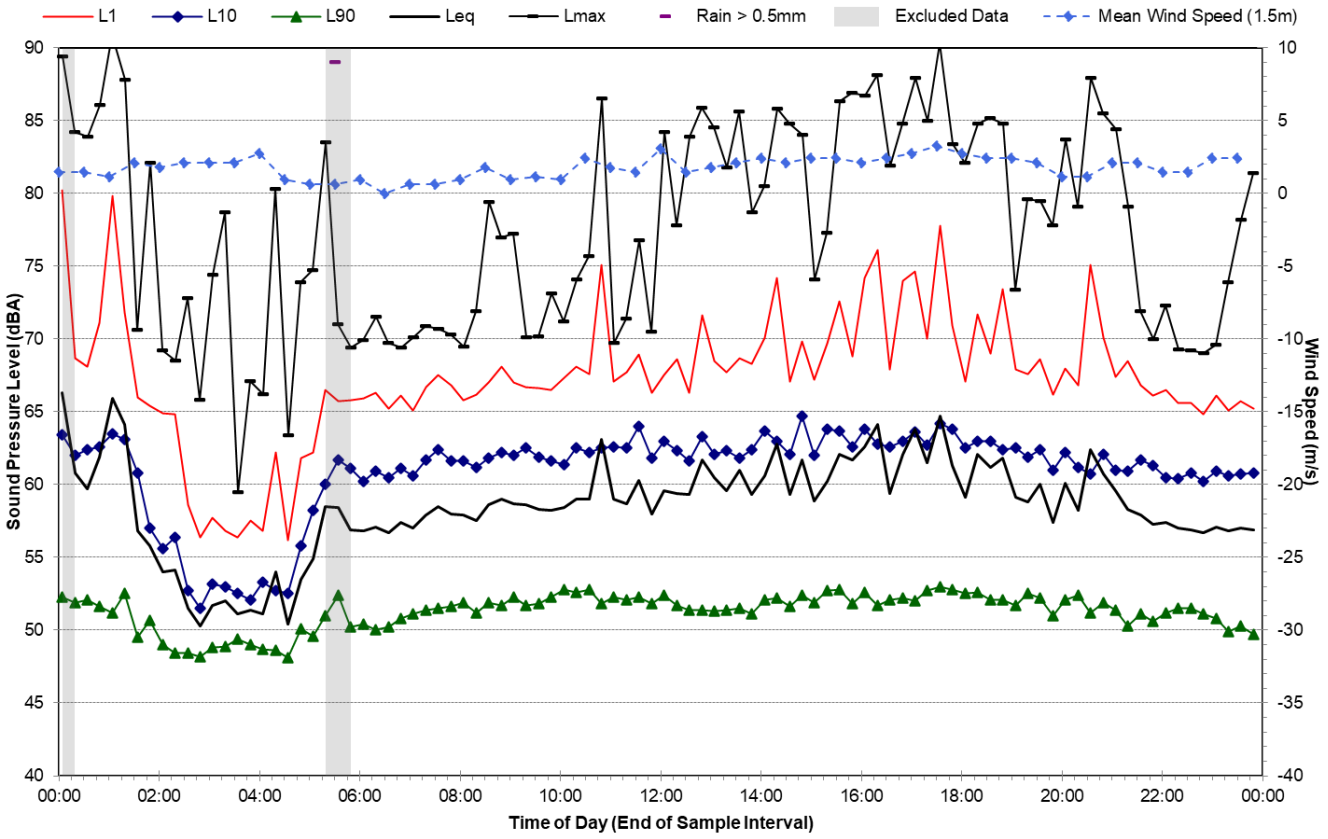
Statistical Ambient Noise Levels

38 Chalmers Street - Saturday, 22 October 2022



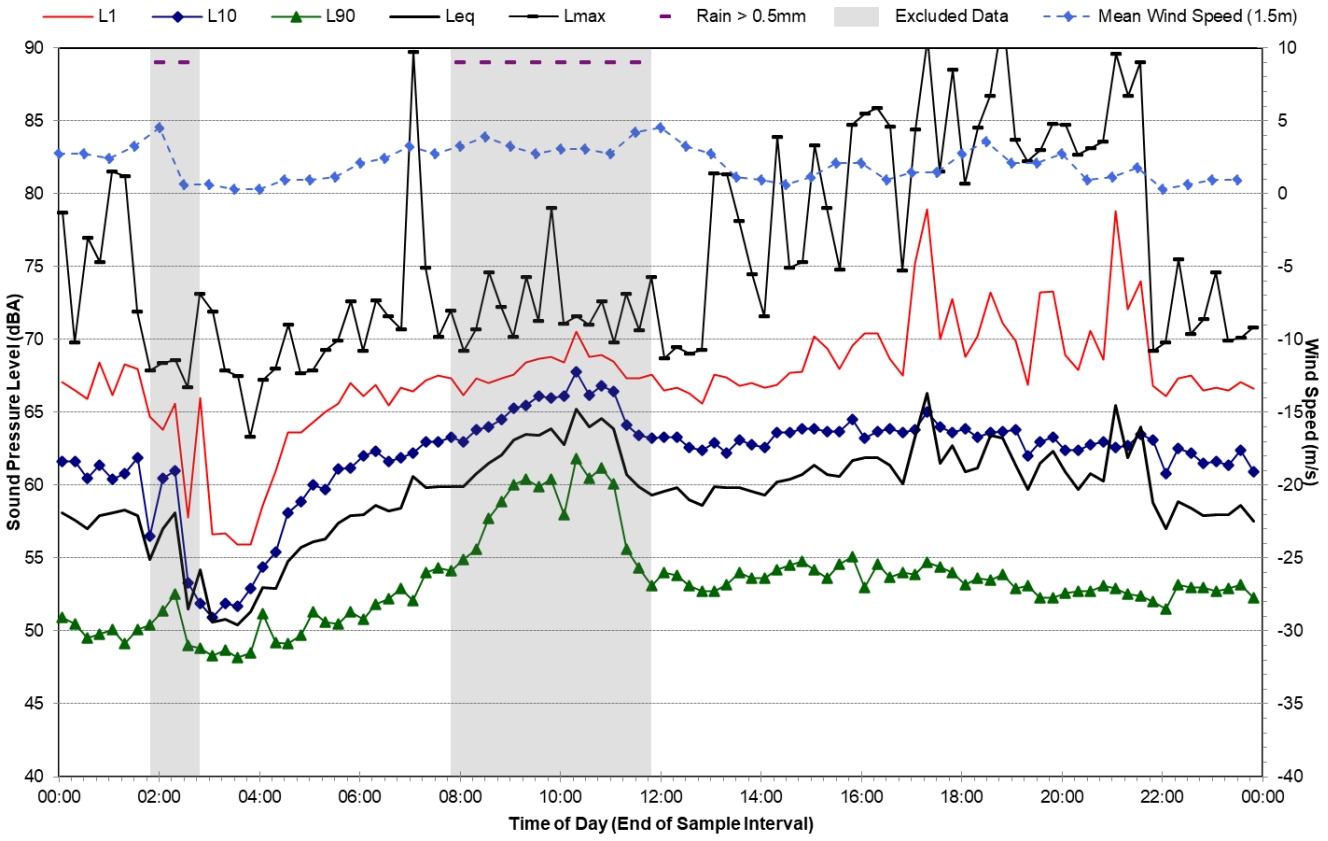
Statistical Ambient Noise Levels

38 Chalmers Street - Sunday, 23 October 2022



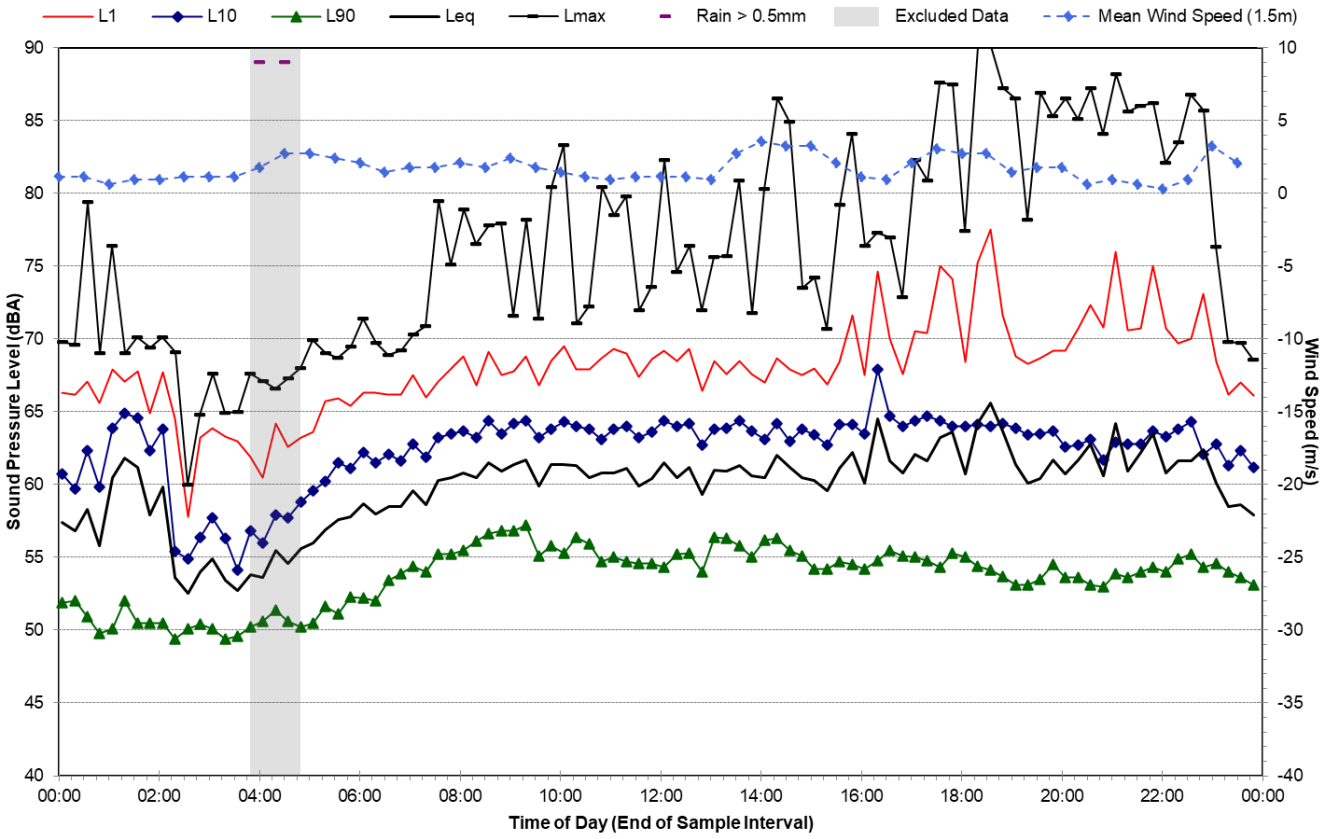
Statistical Ambient Noise Levels

38 Chalmers Street - Monday, 24 October 2022



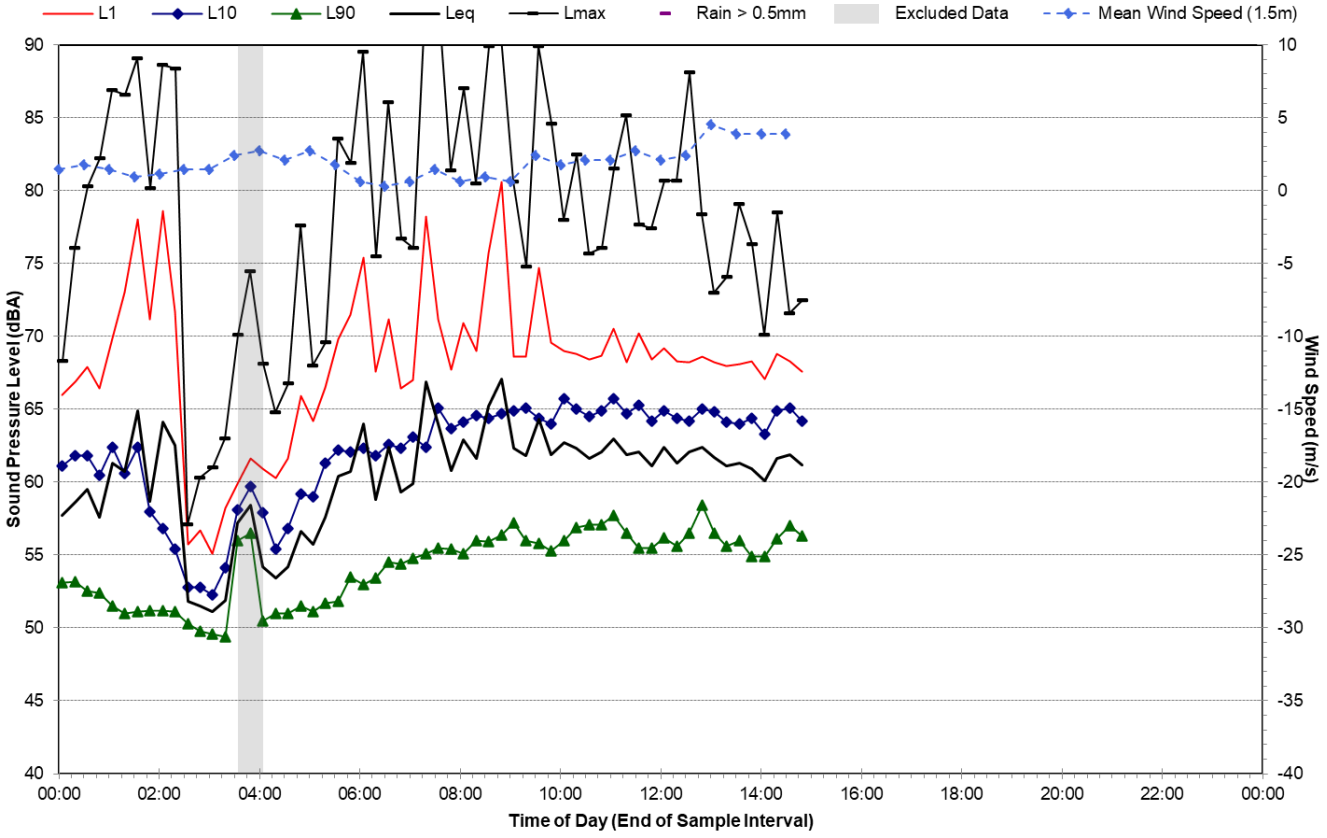
Statistical Ambient Noise Levels

38 Chalmers Street - Tuesday, 25 October 2022



Statistical Ambient Noise Levels

38 Chalmers Street - Wednesday, 26 October 2022



Noise Monitoring Location	L.04
Noise Monitoring Address	201 Commonwealth Street, Surry Hills

Logger Device Type: Svantek 957, Logger Serial No: 20665
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3004636

Ambient noise logger deployed at residential address 201 Commonwealth Street, Surry Hills. Logger located in terrace courtyard with direct view of Commonwealth Street.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise. Pedestrian activity and distant construction also influence the LAeq at this location.

Recorded Noise Levels (LAmax) 11/10/2022:

Light vehicle road traffic noise: 60-68 dBA
Heavy vehicle road traffic noise: 73
Pedestrian noise: 62 dBA
Construction noise: 60 dBA
Aircraft noise: 63 dBA

Map of Noise Monitoring Location

Photo of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	50	59	61	68
Evening	49	57	59	66
Night-time	44	55	53	63

Ambient Noise Logging Results – RNP Defined Time Periods

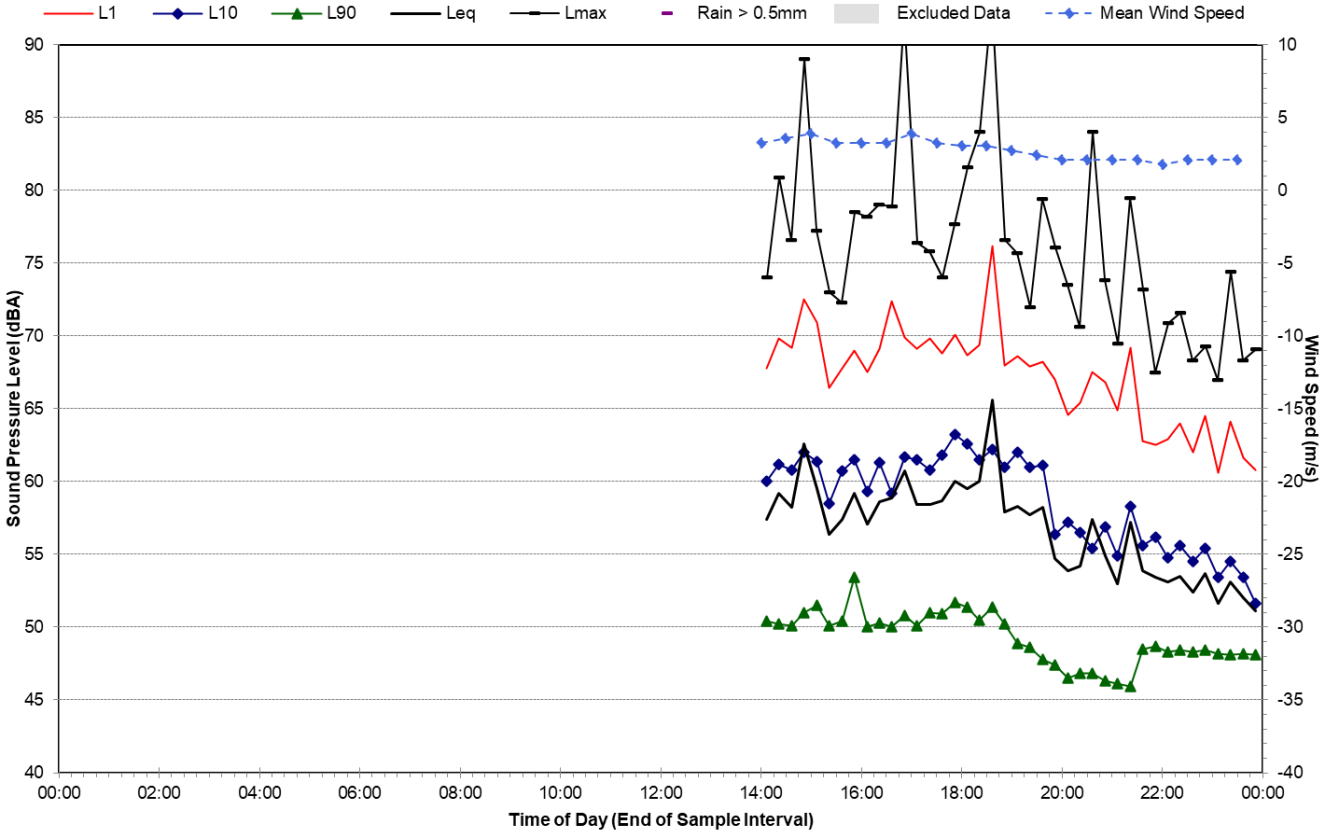
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	59	60
Night-time (10pm-7am)	55	57

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
11/10/2022	09:35	52	60	74

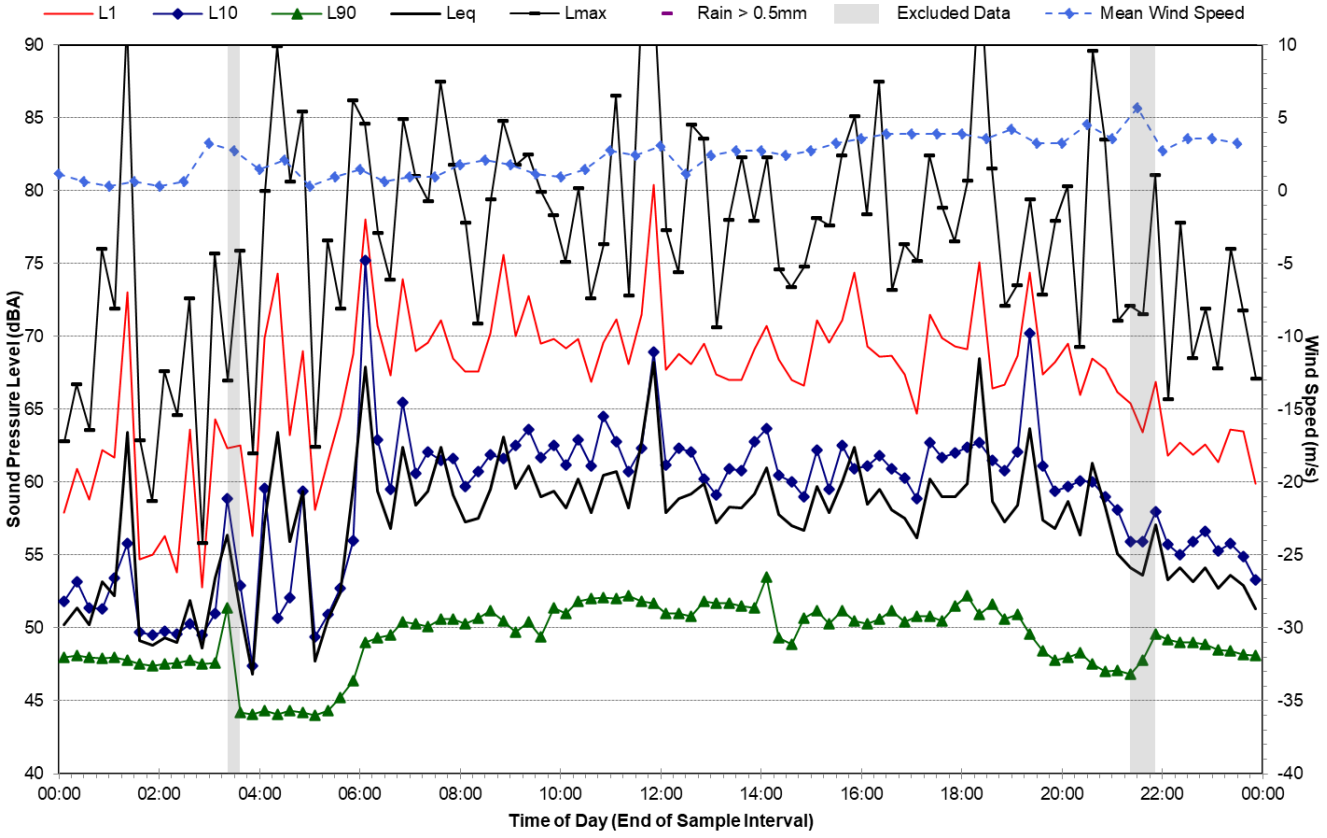
Statistical Ambient Noise Levels

201 Commonwealth Street - Tuesday, 11 October 2022



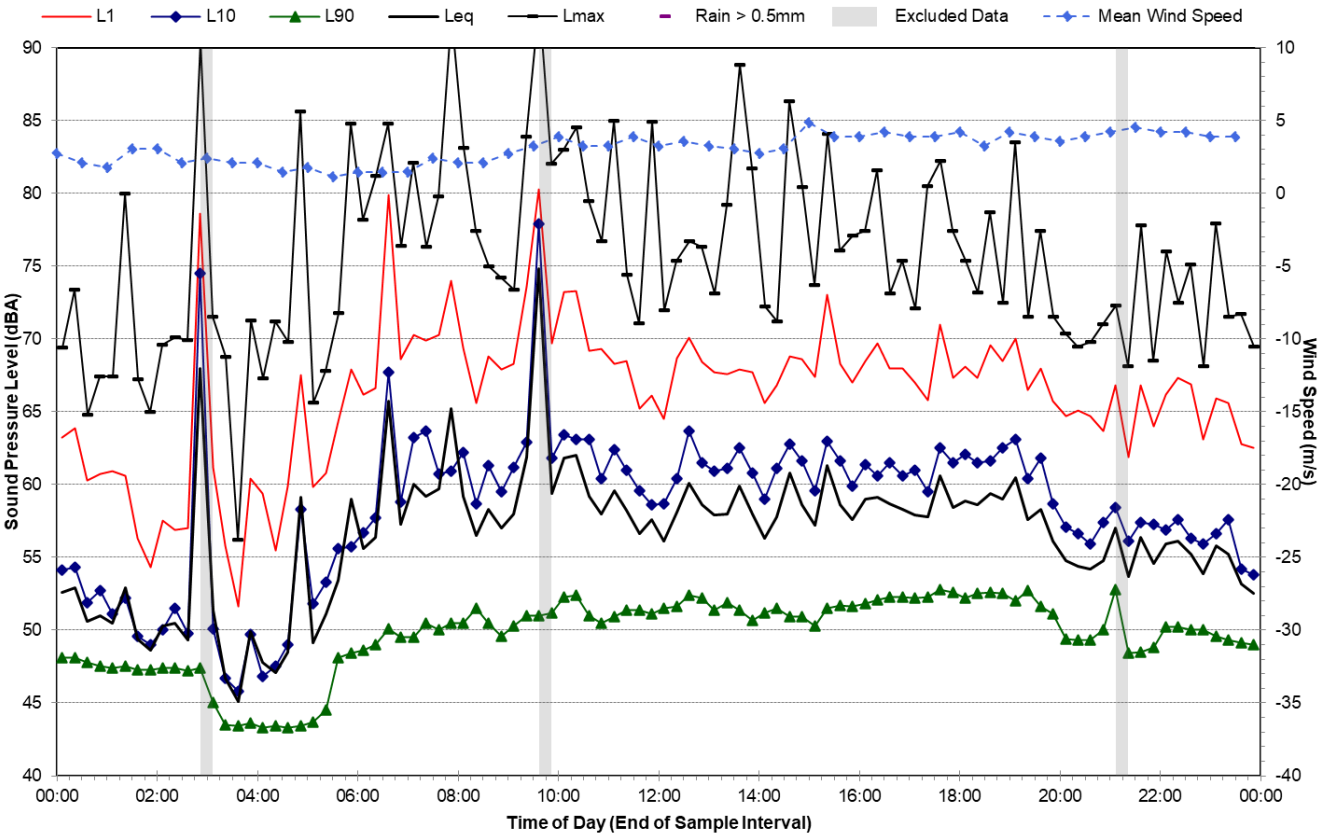
Statistical Ambient Noise Levels

201 Commonwealth Street - Wednesday, 12 October 2022



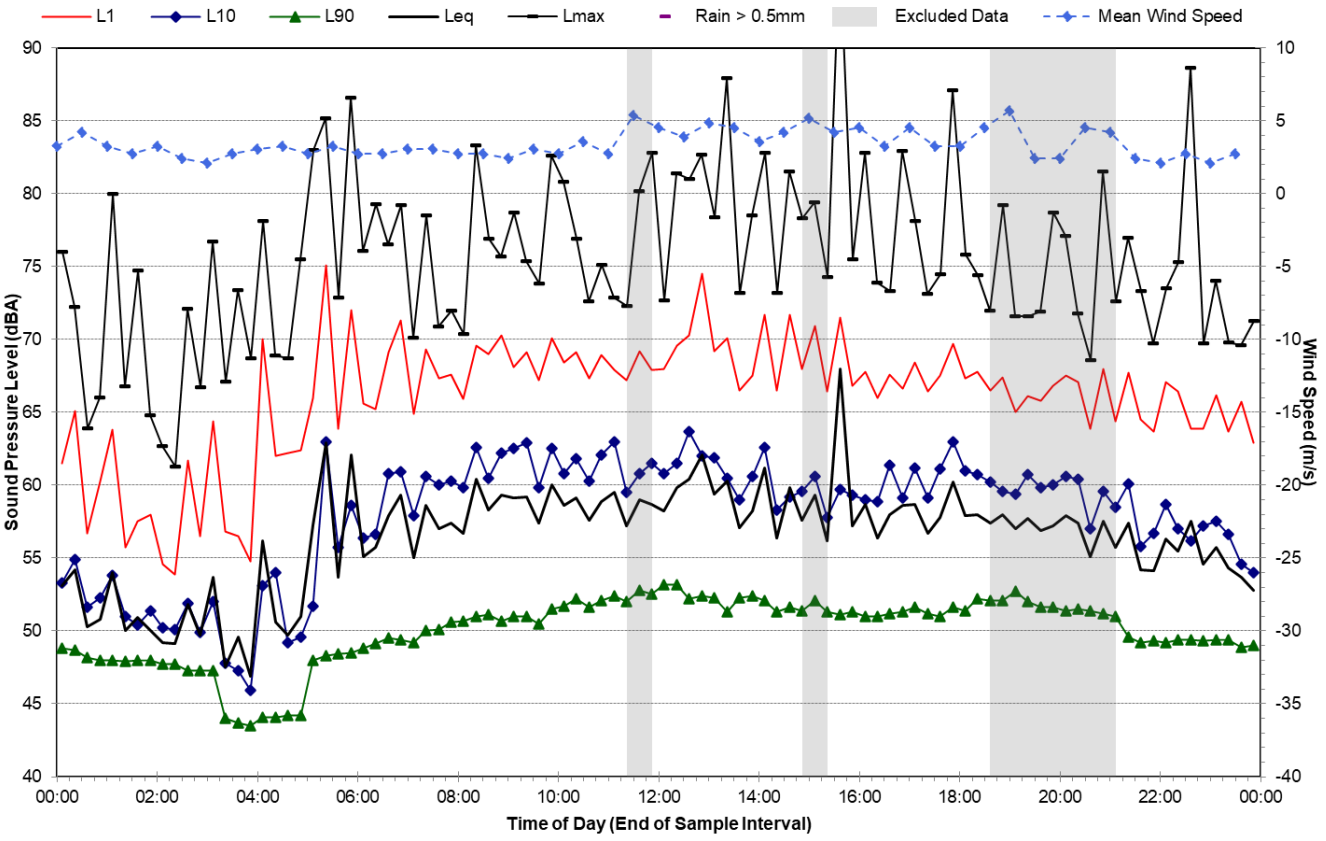
Statistical Ambient Noise Levels

201 Commonwealth Street - Thursday, 13 October 2022



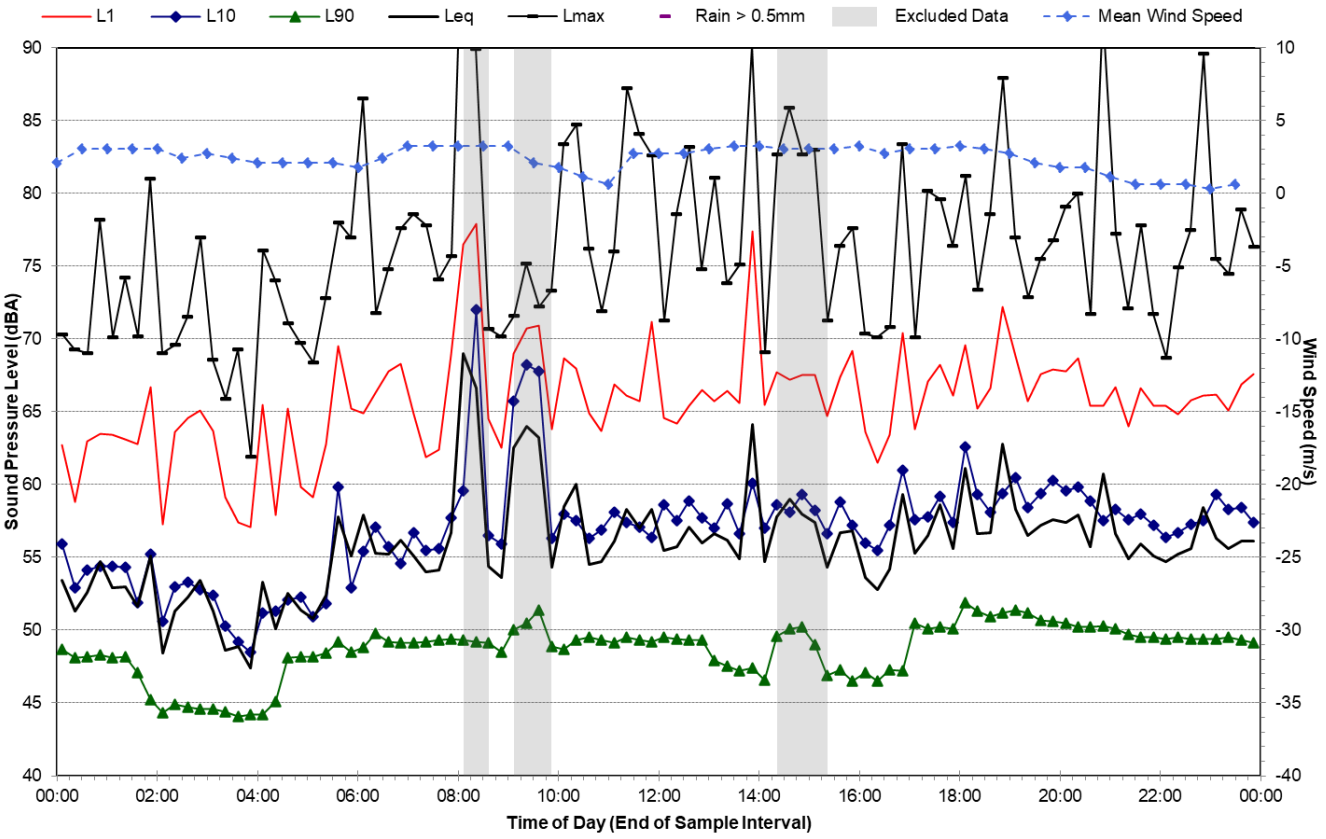
Statistical Ambient Noise Levels

201 Commonwealth Street - Friday, 14 October 2022



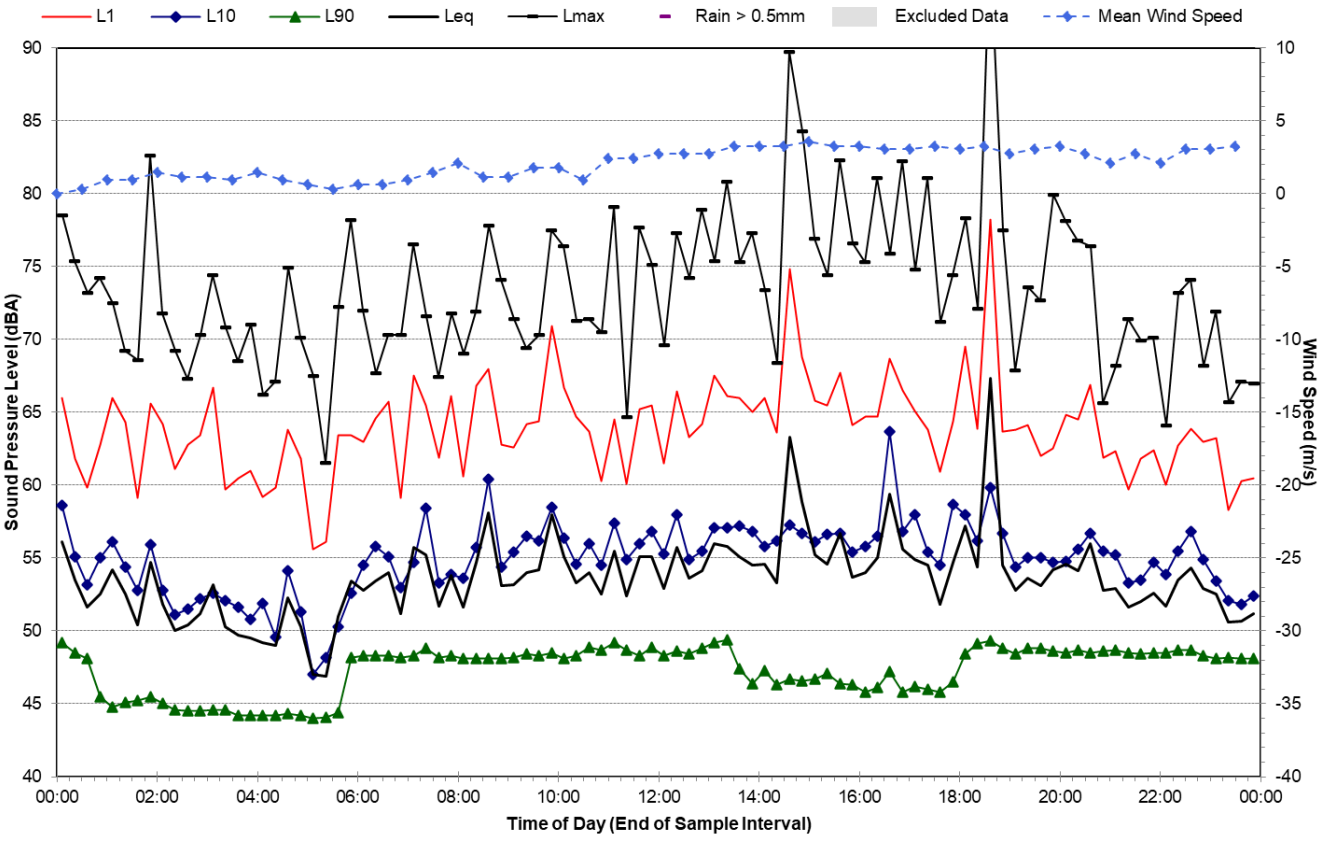
Statistical Ambient Noise Levels

201 Commonwealth Street - Saturday, 15 October 2022



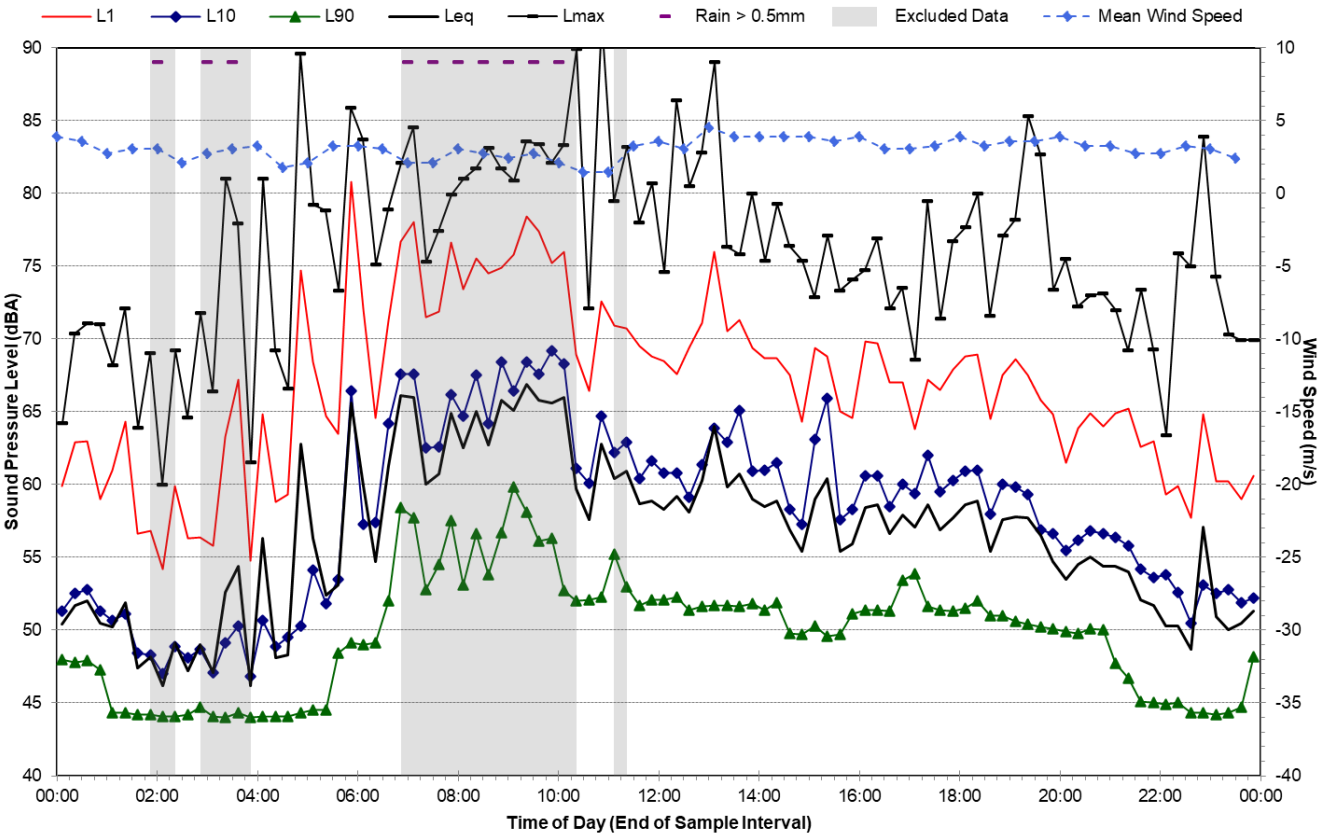
Statistical Ambient Noise Levels

201 Commonwealth Street - Sunday, 16 October 2022



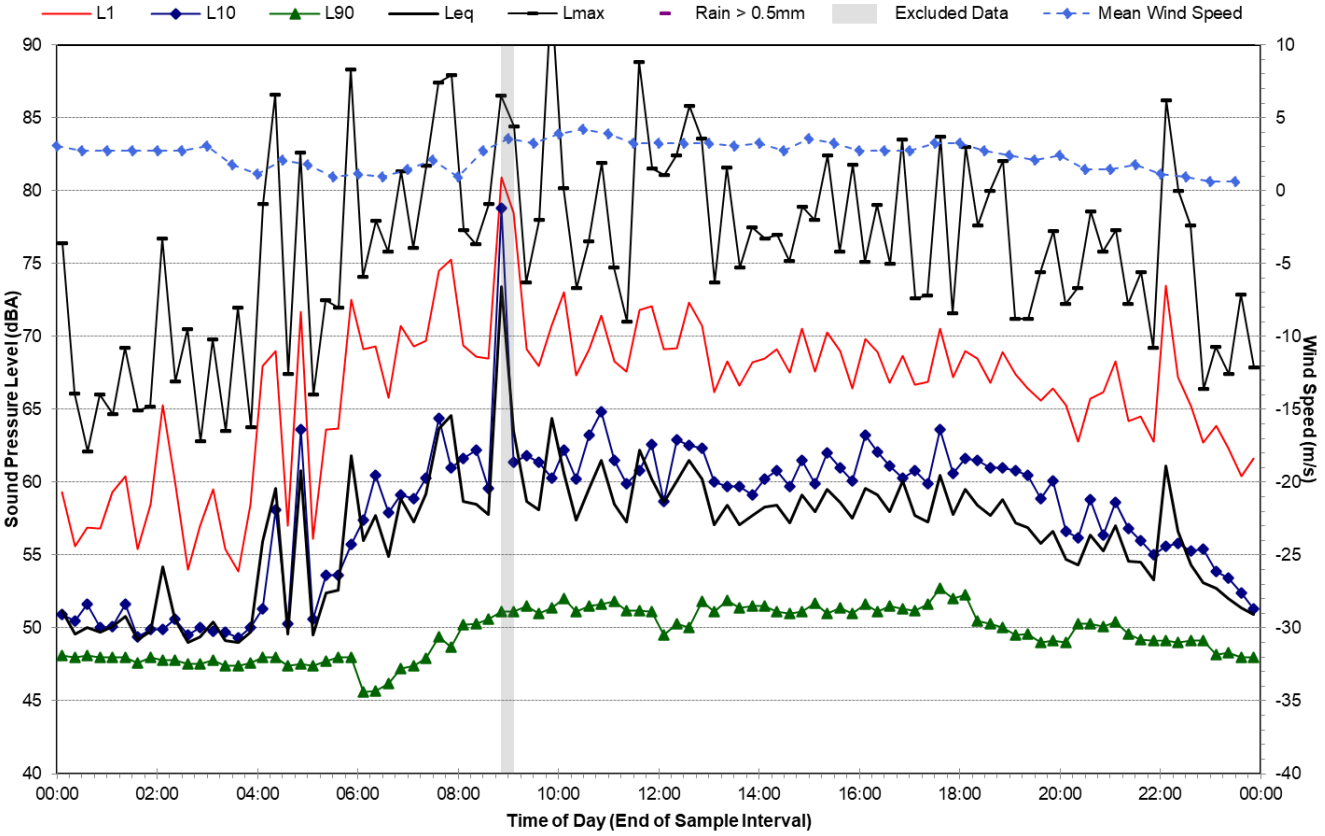
Statistical Ambient Noise Levels

201 Commonwealth Street - Monday, 17 October 2022



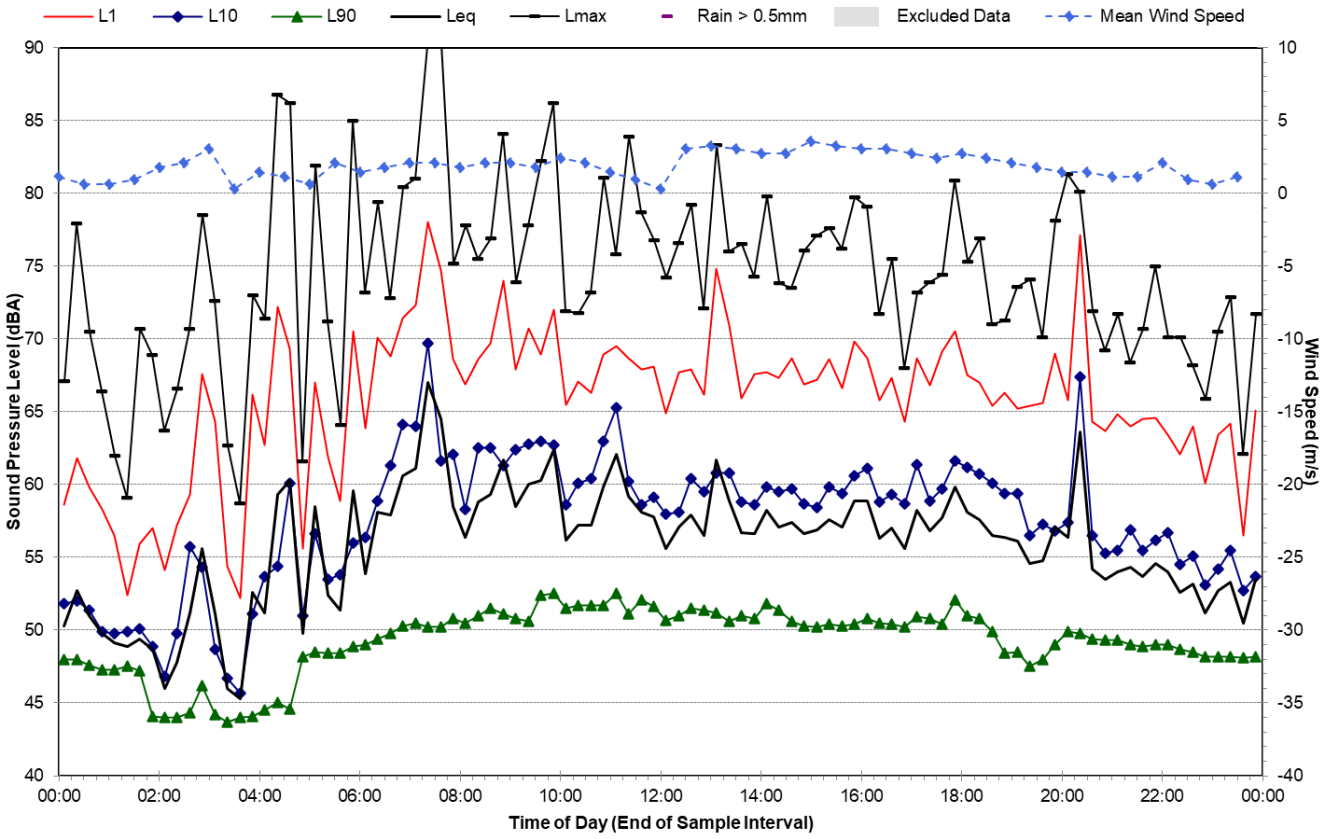
Statistical Ambient Noise Levels

201 Commonwealth Street - Tuesday, 18 October 2022



Statistical Ambient Noise Levels

201 Commonwealth Street - Wednesday, 19 October 2022



Statistical Ambient Noise Levels

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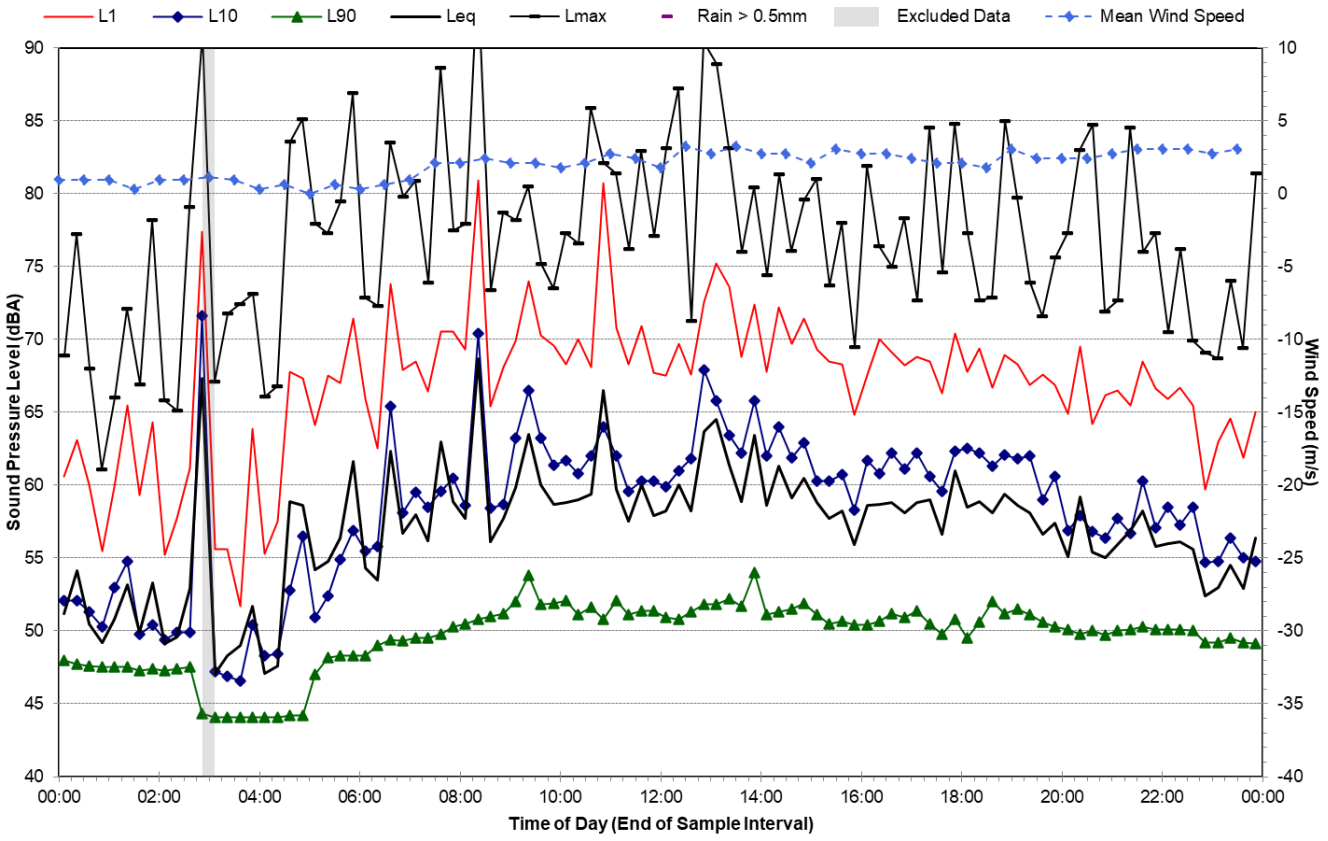
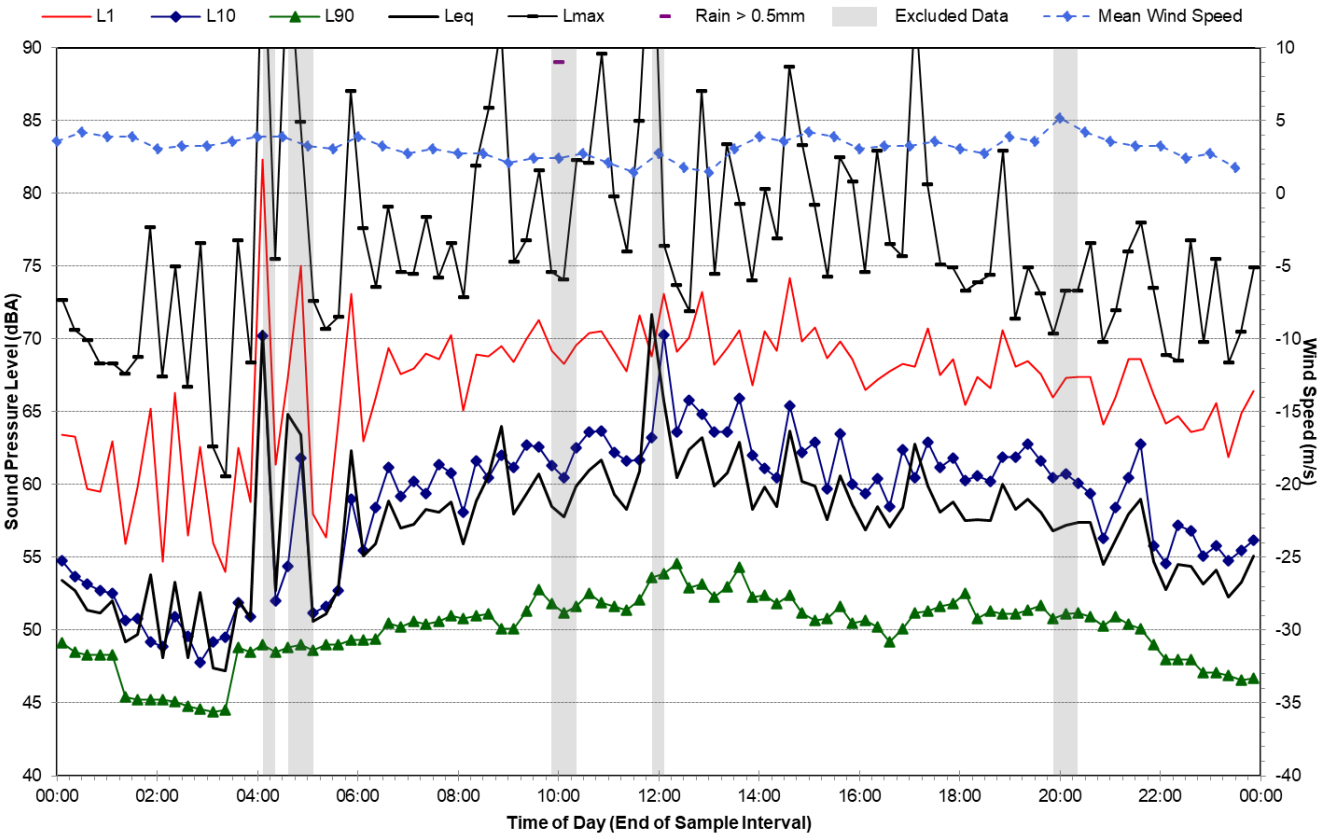


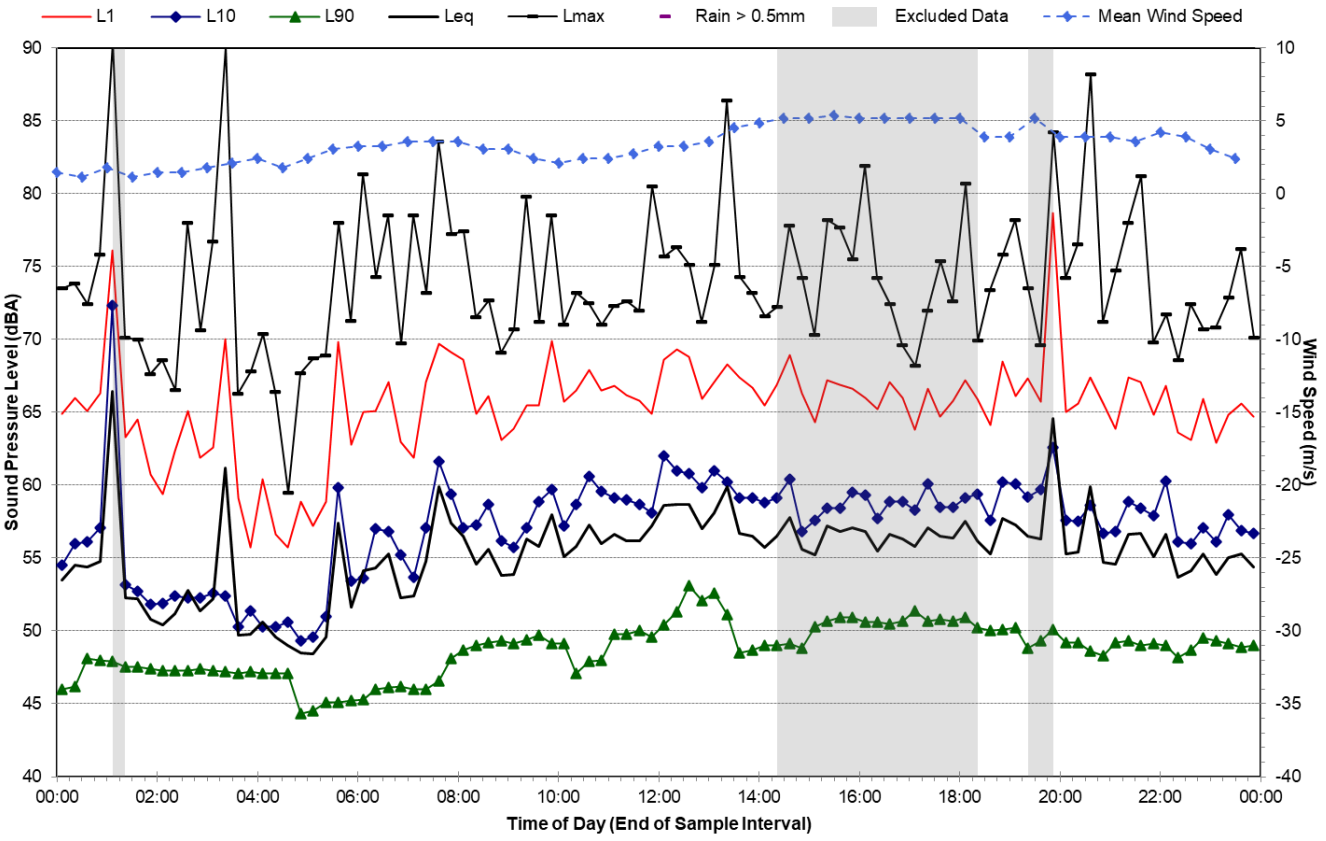
Statistical Ambient Noise Levels

201 Commonwealth Street - Friday, 21 October 2022



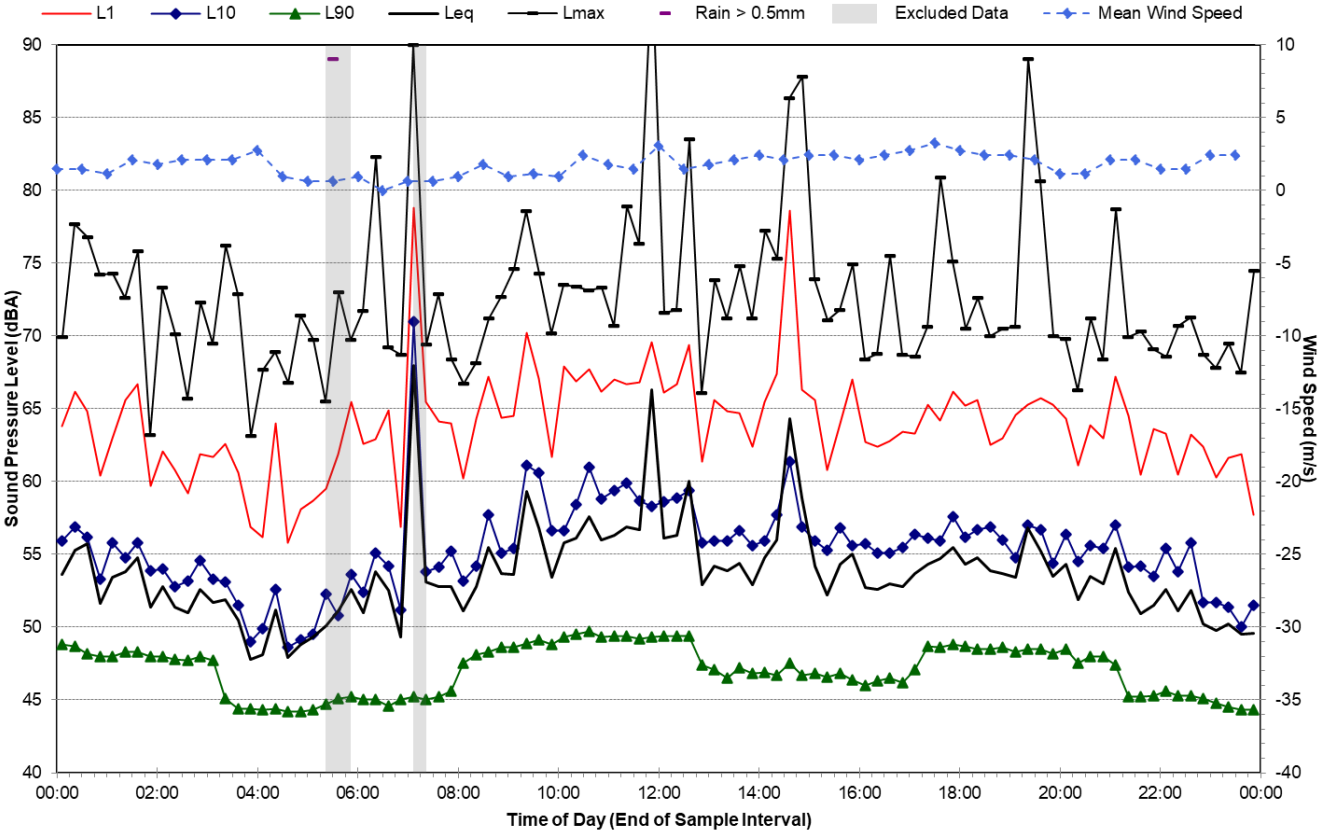
Statistical Ambient Noise Levels

201 Commonwealth Street - Saturday, 22 October 2022



Statistical Ambient Noise Levels

201 Commonwealth Street - Sunday, 23 October 2022



Statistical Ambient Noise Levels

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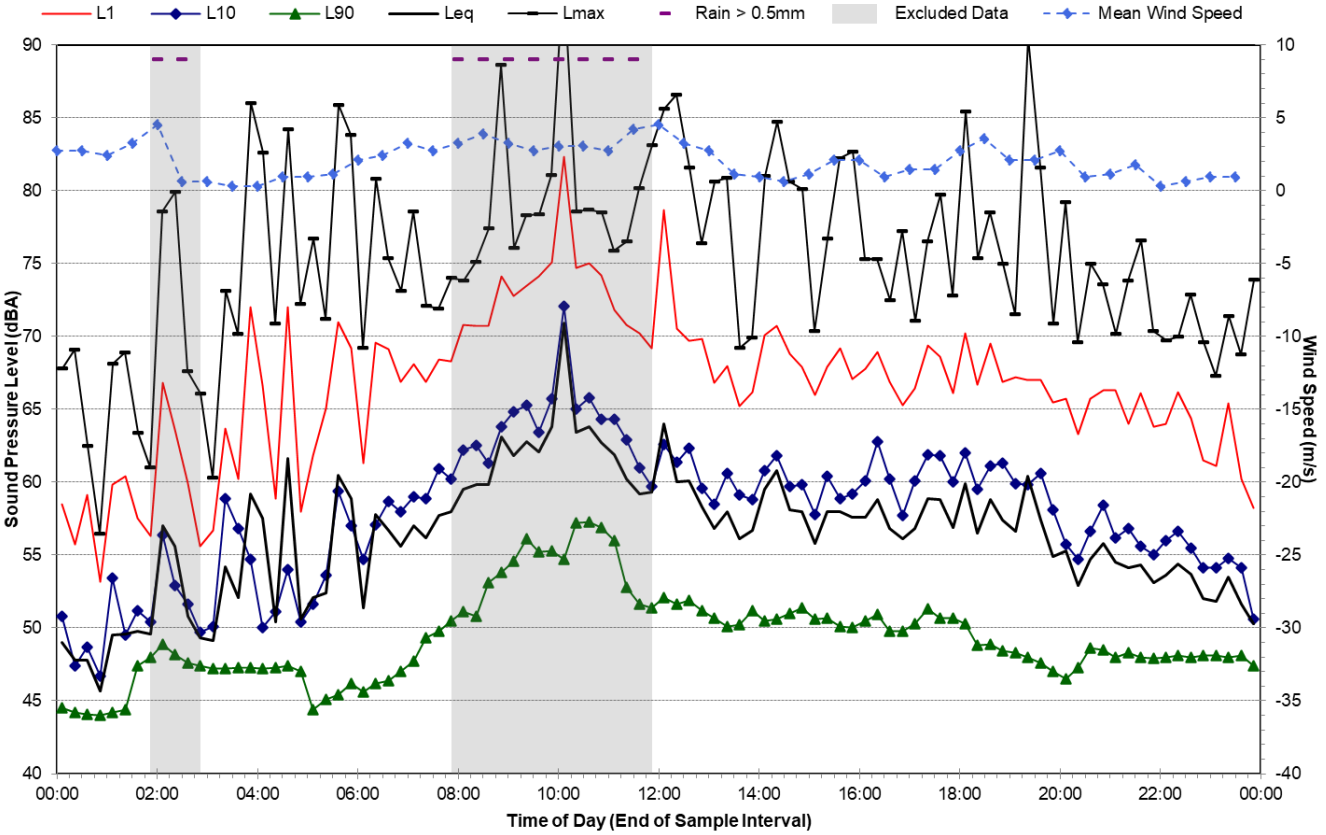
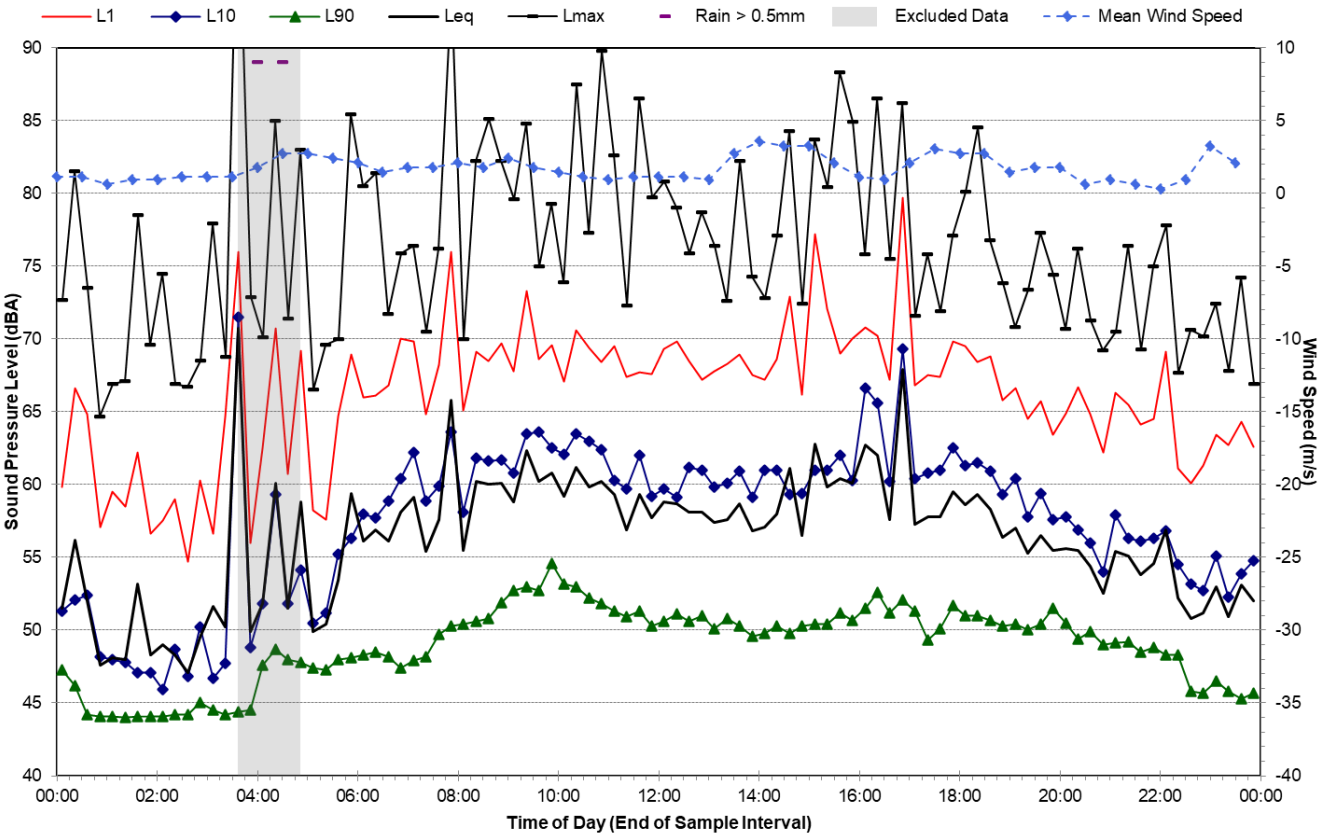


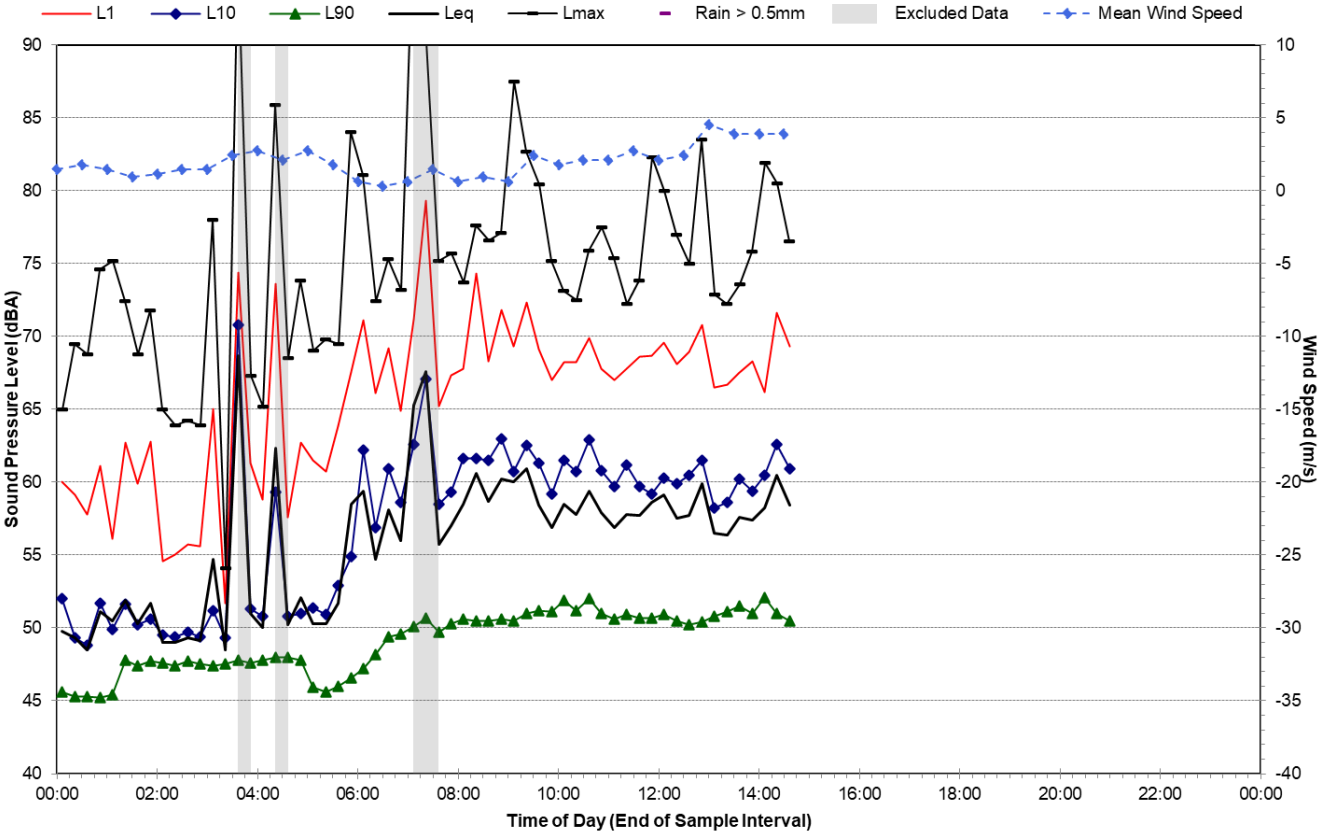
Statistical Ambient Noise Levels

201 Commonwealth Street - Tuesday, 25 October 2022



Statistical Ambient Noise Levels

201 Commonwealth Street - Wednesday, 26 October 2022



Appendix D:

Construction Scenarios and Equipment

Equipment Lists and Sound Power Levels

Equipment		Total Sound Power Level (dBA)	Circular Saw[1]	Compactor	Concrete Pump	Concrete Saw[1]	Concrete Truck	Concrete Vibrator	Crane - Franna	Crane - Mobile (100t)	Dust Extractor	Elevated Working Platform	Excavator (10t)	Excavator (10t) + Hydraulic Hammer[1]	Forklift	Front End Loader	Grinder1	Hand Tools	Jackhammer[1]	Pressure Washer / Sand Blast	Roller – Smooth Drum	Roller - Vibratory[1]	Truck - Medium Rigid	Truck - Road Truck / Truck & Dog	Welding Equipment
Sound Power Level[2] (dBA)			118	106	109	123	109	113	98	113	100	97	100	123	106	112	110	104	118	109	107	114	103	108	110
Estimated on-time in any 15-minute period			5	15	10	5	15	5	15	15	15	15	10	5	10	10	10	15	10	10	15	15	5	5	10
ID	**Construction scenario**																								
W.001	Deliveries and load out	107													X								X	X	
W.002	Demolition and hazmat removal	123				X					X		X	X				X	X						
W.003	Excavation	111											X			X									
W.004	Concrete work	115			X		X	X		X															
W.005	Installation of services	117	X							X		X					X	X							
W.006	Roof construction	115								X		X					X	X							
W.007	Grand Concourse work	120				X												X	X						
W.008	Facade refurbishment	114								X		X								X					
W.009	Paving and landscaping	115		X									X			X	X	X			X				
W.010	Western Forecourt strengthening	112							X			X					X	X							X

Note 1: Equipment classed as 'annoying' in the ICNG.

Note 2: Sound power level data is taken from the TfNSW *Construction Noise and Vibration Strategy*, RMS *Construction Noise and Vibration Guideline,* AS 2436-2010, and DEFRA Noise Database.

Appendix E:

CNVS Mitigation Measures

Table 1 CNVS Standard Mitigation and Management 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 stakeholder consultation measures	Airborne noise. Ground-borne noise and vibration	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted on a case-by-case basis: • Project Specific Website • Project Infoline • Construction Response Line • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings and • Community Based Forums (if required by approval conditions).
Register of noise and vibration sensitive receivers	Airborne noise Ground-borne noise and vibration	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (e.g. Residential, Commercial etc.) • Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.
Construction hours and scheduling	Airborne noise Ground-borne noise and vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating noise with special audible characteristics and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period	Airborne noise Ground-borne noise and vibration	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same NCA over any 7-day period, unless otherwise approved by the relevant authority.
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 noise generating activities with special audible characteristics • 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 shall be undertaken at all buildings within 25 m of vibration generating activities when these activities commence to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Plans	Airborne noise Ground-borne noise and vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to major project construction activities with the potential to cause property damage.
Source controls		
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.
Equipment selection	Airborne noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable, see APPENDIX C (of the CNVS). For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits
Maximum noise levels	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power Levels compliant with the allowable noise levels in APPENDIX C (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 allowable noise levels in APPENDIX C (of the CNVS).
Use and siting of plant	Airborne-noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
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, including delivery vehicles.
Minimise disturbance arising from delivery of goods to construction sites	Airborne-noise	Loading and unloading of materials/deliveries is to occur *as far as possible* from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Construction Related Traffic	Airborne-noise	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.

Silencers on Mobile Plant	Airborne-noise	Where possible reduce noise from mobile plant through additional fittings including: • Residential grade mufflers • Damped hammers such as "City" Model Rammer Hammers • Air Parking brake engagement is silenced.
Prefabrication of materials off-site	Airborne-noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Airborne-noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
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 practicable) and consideration of site topography when situating plant.

Table 2 CNVS Additional Mitigation and Management Measures

Additional Mitigation Measure	Description
Periodic Notification (PN)	For each I&S project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on stakeholders . The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the I&S Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11 (of the CNVS), for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the I&S Community Engagement Team will determine the community engagement strategy on a case-by-case basis.
Verification Monitoring (V)	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise). The purpose of monitoring is to confirm that:

	• construction noise and vibration from the project are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works. Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the CNVIS amended. Refer to Section 8.4 (of the CNVS) for more details.
Specific Notification (SN)	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. • Letters may be letterbox dropped or hand distributed • Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • Individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project. Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must
Respite Offer (RO)	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise prepurchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all I&S projects.
Alternative Accommodation (AA)	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.
Alternative construction methodology (AC)	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.
Respite Period (RP)	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of consecutive evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol (Section 6 of the CNVS). Note; this management measure does not apply to OOHW Period 1 – Days (See Table 1 of the CNVS).
Duration Reduction (DR)	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all I&S projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with I&S Community Engagement Representatives.

NSW GOVERNMENT