600-660 ELIZABETH STREET, REDFERN

Noise and Vibration Assessment

Prepared for:

NSW Land and Housing Corporation
Level 2, 31-39 Macquarie Street
Parramatta NSW 2150

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BASIS OF REPORT

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

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.17905-R01-v4.0	18 February 2020	Nicholas Vandenberg	Alex Campbell	Alex Campbell
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EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by NSW Land and Housing Corporation (LAHC) to prepare a noise and vibration impact assessment for the operational aspects of the build-to rent redevelopment at 600-660 Elizabeth Street, Redfern. The assessment has been carried out in accordance with NSW regulatory requirements and based on a Reference Scheme that includes:

- Approximately 327 dwellings, with a FSR of 2.75:1
- Buildings with a predominant height of 6-7 storeys with a single tower up to 14 storeys (RL76.6m); and
- New public spaces on Kettle and Phillip Streets activated by shops, cafes, community space and other services.

This study involves an assessment of the proposed Reference Scheme, including noise and vibration impact predictions and preliminary recommendations with respect to the proposed design.

To quantify the existing acoustic environment and to provide context to the predicted traffic noise emissions, continuous unattended noise monitoring equipment was deployed across the site.

These measured noise levels have been used to establish existing ambient noise levels throughout the project area and to develop a noise model to predict and assess noise levels from road traffic noise across the project site.

The assessment of the Reference Scheme indicates that noise control treatments will need to be incorporated into the design, particularly on the facades fronting Elizabeth Street and Phillip Street. Notwithstanding this, it is unlikely that road traffic noise intrusion would preclude residential development across the project site provided appropriate mitigation as outlined in this report are incorporated.

Typical sources of industrial noise that may be associated with the intended uses of the buildings within the project area may include noise from mechanical equipment including HVAC, corridor ventilation systems and fire pump and fire control equipment. At this stage, the technical specifications and layout of the proposed mechanical plant and other equipment have not been defined and potential impacts from these sources should be assessed during the DA and detailed design stage of the Project. It is envisaged that the industrial noise sources will be able to achieve compliance with the nominated criteria through use of typical mitigation methods.

CONTENTS

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

CONTENTS

APPENDICES

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by NSW Land and Housing Corporation (LAHC) to undertake a noise and vibration impact assessment of the existing and future environment of the project site located at 600-660 Elizabeth Street, Redfern.

The project site has been identified by LAHC as a significant opportunity to deliver on Communities Plus priorities and was nominated as a potential State Significant Precinct by the Minister for Planning in September 2017. In November 2019, the minister of Planning and Public Spaces decided to change the rezoning to a Council led Planning Proposal. The redevelopment of the project site will provide the NSW Government with the opportunity to increase social housing within an accessible location (10 minutes to Redfern Station and future Waterloo Metro Station) and to make significant contribution to housing supply in Sydney.

1.1 Overview

The project site is 1.1 hectares in size and located at 600-660 Elizabeth Street, Redfern. The site is part of the wider Redfern social housing estate. It is located to the east of Redfern Oval and comprises a city block, with a 146 metre frontage to Elizabeth and Walker Street and a 70 metre frontage to Kettle and Phillip Streets.

The site is within the 10 minute walking catchment of both the existing Redfern Station and the Waterloo Metro station. The site is largely vacant however the PCYC lease a single storey building and basketball court on the southern edge of the site.

1.2 Scope

The purpose of this report is to assess the noise and vibration impacts of the proposed rezoning and outline any recommended mitigation measures.

The purpose of this report is as follows:

- Review regulatory noise policies and guidelines relevant to the project.
- Characterise the existing noise environment via baseline measurements at key locations across the site.
- Identify key noise impact challenges, opportunities and key issues for the proposed use of the project site.
- Identify future sensitive noise receptors.
- Model the likely noise and vibration scenario based on 3D model of the Reference Scheme for the Site.
- Recommend appropriate noise and vibration mitigation measures.

A glossary of the acoustical terminology used throughout this report is contained within **Appendix A.**

1.3 Proposal

1.3.1 Introduction

600-600 Elizabeth Street, Redfern will be transformed into a market leading build-to-rent redevelopment featuring contemporary urban and architectural design and creating a high quality integrated community of social, affordable and private housing.

1.3.2 Communities Plus Build to Rent

Communities Plus is a key program under NSW Government's *Future Directions for Social Housing in NSW*, delivering integrated social, affordable and private housing by partnering with the private and not for profit sectors including registered Tier 1 or Tier 2 Community Housing Providers (CHPs).

The Redfern project aligns with Future Directions, by providing innovative options for private sector investment in social housing under a long term lease. The project presents an opportunity to renew and increase social housing in a well-located integrated community with good access to education, training, local employment, and close to community facilities such as shopping, health services and transport.

On 6 July 2018, the NSW Government announced the Site as the pilot for Communities Plus build-to-rent. The Project provides an opportunity for the private sector, in partnership with the not-for-profit sector, to fund, design, develop and manage the buildings as rental accommodation under a long-term lease.

Build-to-rent is a new residential housing delivery framework that is capable of providing access to broader housing choices. Established in overseas markets such as the UK and the USA, locally, build-to-rent has significant scope to provide increased rental housing supply and the opportunity for investment in residential housing in NSW.

1.3.3 Vision, Reference Scheme and Planning Framework

The Planning Proposal has been prepared to formulate and assess a suitable suite of planning controls to guide the redevelopment of the Site. A design, technical analysis and consultation process was undertaken to prepare a Reference Scheme which indicates how the future public domain, building form and connections could be delivered. The Reference Scheme (shown at **Figure 1** and **Figure 5**) balances the challenges and opportunities of the Site, particularly the desire to deliver high quality urban design while providing new and modern social housing in an integrated mixed tenure environment.

The Reference Scheme was prepared to indicate how the Site could, rather than will, be redeveloped and has been used as a basis to prepare draft amendments to the Sydney Local Environmental Plan 2012 (including zoning, height, floor space ratio and car parking controls) and the development of a new site specific Development Control Plan which will guide the detailed design of the Site.

The proposed planning framework has regard to:

- Accessibility and connectivity of the Site to public transport, employment, shops, education and other services.
- The site and local area's rich history and cultural significance.
- The surrounding urban form and context.

- The environmental and servicing considerations, including flooding, stormwater, traffic, utilities, noise, air quality and wind.

The proposed planning framework will guide future development applications for the Site which are anticipated to achieve the following:

- Approximately 327 dwellings, with a FSR of 2.75:1.
- Buildings with a predominant height of 6-7 storeys with a single tower up to 14 storeys (RL 76.6m).
- New public spaces on Kettle and Phillip Streets activated by shops, cafes, community space and other services.

It is expected the Site will be developed over a period of three years, once the site has been rezoned.

Figure 1 600-660 Elizabeth Street, Redfern Reference Scheme

A site locality map showing the project site and noise monitoring locations are shown in **Figure 2**.

Figure 2 Site Plan – Site Boundary and Noise Monitoring Locations

2 Existing Noise Environment

2.1 Existing Noise Sources

2.1.1 Road Traffic Noise

The existing noise environment across the project site is generally controlled by road traffic noise.

The main arterial road to the west of the site is Elizabeth Street, with Phillip Street adjoining the south of the site. During site inspections it was noted that these roads become congested during peak hours.

2.1.2 Aircraft Noise

The site is not located directly under the flight path and is not directly impacted by aircraft noise.

The Australian Noise Exposure Index (ANEI) is a parameter used to describe the noise impact by airports in Australia. The ANEI is an equal energy noise index, similar to the Leq from 7 pm to 7 am. The Australian Noise Exposure Forecast (ANEF) is the future predicted ANEI. Typically the ANEF 20 contour and higher defines an area where additional noise mitigation may be required for new residential buildings.

As the site is located outside the ANEF 20 contour, noise mitigation from aircraft noise would not be required for the project site.

The N70 noise contours illustrate the number of events above 70 dB(A) for an annual average day. These maps provide an indication of the likelihood of annoyance from aircraft noise. The N70 chart for the Sydney airport in 2016 indicates less than 10 noise events of greater than 70 dBA were experienced on an average day. This exposure is very small compared to other regions in Sydney and is not considered to be appreciably noise affected. Additionally, Sydney airport only operates between the hours of 0600 h to 2300 h and as such noise events greater than 70 dB (A) would generally occur during the less sensitive daytime period.

2.1.3 Sports Ground

While it is noted that there is a sports ground located across Elizabeth Street from the project site, it is not anticipated that this would have a significant impact on the noise environment. The results from the noise monitoring indicate that traffic noise remained the dominant noise source.

2.2 Ambient Noise Surveys and Monitoring Locations

In order to characterise the existing ambient noise environment, unattended noise monitoring was conducted at the site from 1 May to 8 May 2018. The measured noise levels have been used to establish existing road traffic noise impacts and to understand the existing ambient noise environment at the site.

Noise monitoring equipment was deployed in three locations across the site with consideration of existing noise sources that may influence the measurements, accessibility and security. The selected noise monitoring locations are shown in **Figure 1**.

2.3 Unattended Noise Monitoring

2.3.1 Methodology

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

The noise measurements were carried out using Svantek 957 noise loggers. The equipment was set up with microphones at 1.5 metres above the ground level. All microphones were fitted with wind shields.

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

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

Table 1 Ambient Noise Survey Locations – 1 May to 8 May 2018

Noise Monitoring Location ID	Location Description	Equipment Serial Number
L01	Adjacent Elizabeth Street, Redfern	20663
L02	Adjacent Walker Street, Redfern	23815
L03	Above PCYC	21887

2.3.2 Noise Monitoring Results

The results of the unattended ambient noise surveys are summarised in **Table 2** as the Rating Background Level (RBL) noise levels for the ICNG daytime, evening and night-time periods, and the L_{Aeq} (energy averaged) noise levels for the RNP daytime and night-time periods.

Daily graphs representing the measured noise levels are contained in **Appendix B**. The graphs represent each 24 hour period during the survey period and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels in 15 minute periods.

Table 2 Summary of Unattended Noise Logging Results

Location ID	Location Description	Noise Levels dBA					
		RBL[1]			$L_{Aeq(period)}$[2]		
		Daytime	Evening	Night-time	Daytime	Evening	Night-time
L01	Adjacent Elizabeth Street, Redfern	53	49	40	65	64	60
L02	Adjacent Walker Street, Redfern	48	47	41	59	55	52
L03	Above PCYC	53	49	40	62	61	56

Note 1: The RBL noise level is representative of the 'average minimum background sound level', or simply the background level.

Note 2: The L_{Aeq} is essentially the 'average sound level'. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

In order to assess road traffic noise impacts on the site, the data obtained from the noise logging has also been processed to establish maximum repeatable $L_{Aeq(1hour)}$ noise levels over the time periods as required by the City of Sydney Council Development Control Plan 2012. The results are presented in **Table 3**.

Table 3 Measured Road Traffic Noise Levels

Monitoring Location	Daytime (7am to 10pm)		Night-time (10pm to 7am)	
	$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	$L_{Aeq(9hour)}$	$L_{Aeq(1hour)}$
L01	65	67	60	63
L02	58	60	52	57
L03	62	63	57	60

The maximum repeatable $L_{Aeq(1hour)}$ descriptor represents the highest tenth percentile hourly A-weighted L_{eq} during the specific period. The "Daytime" represents the period between 7:00 am to 10:00 pm and "Night time" represents the period between 10:00 pm to 7:00 am.

2.4 Attended Airborne Noise

2.4.1 Methodology

Attended measurements of ambient noise were completed during the noise logging survey to determine the various noise sources that influence the existing noise environment. During each measurement the observer noted the various noise sources and the contributing noise level.

At each location the attended measurements were performed for 15 minutes using a calibrated Brüel and Kjær 2270 Precision Sound Level Meter (S/N:3008204). Wind speeds were less than 5 m/s at all times, and all measurements were performed at a height of 1.5 metres above ground level.

Calibration of the sound level meter was checked before and after each measurement and the variation in calibration at all locations was found to be within acceptable limits at all times.

2.4.2 Noise Measurement Results

Table 4 Summary of Attended Noise Monitoring Results

Measurement Location	Measured Noise Levels			Description of Ambient Noise Source - Typical L_{Amax} Levels
	L_{A90}	L_{Aeq}	L_{Amax}	
Location 1	58 dBA	65 dBA	77 dBA	Traffic 65 to 77 dBA Birds 75 dBA Plane 71 dBA
Location 2	53 dBA	61 dBA	80 dBA	Birdsong 69 to 80 dBA Traffic lulls of birds (58 dBA) Bus 65 to 68 dBA Plane 60 to 66 dBA
Location 3	55 dBA	64 dBA	82 dBA	Traffic – Elizabeth Street 55 to 69 dBA Traffic – Phillip Street 59 to 82 dBA Plane 75 to 79 dBA Birds 64 to 78 dBA

3 Existing Vibration Environment

3.1 Existing Vibration Environment

There are currently no major existing vibration sources in the project area.

3.2 Future Vibration Environment

The future vibration environment is not anticipated to significantly change from that of the existing situation.

4 Noise Criteria

4.1 Criteria for Development Adjacent to Existing Road and Rail Infrastructure

The NSW Government's State Environmental Planning Policy (Infrastructure) 2007 (the SEPP) was introduced to aid the delivery of infrastructure across the State by improving regulatory certainty and efficiency.

In accordance with the SEPP, Table 3.1 of the NSW Department of Planning and Infrastructure's guideline document entitled *Development near Rail Corridors and Busy Roads – Interim Guideline* (the DP&I Guideline) of December 2008, provides noise criteria for residential and non-residential buildings. These criteria are summarised in **Table 5**.

Table 5 DP&I Interim Guideline Noise Criteria

Residential Buildings		
Type of Occupancy	Noise Level (dBA)	Applicable Time Period
Sleeping areas (bedroom)	35	Night 10 pm to 7 am
Other habitable rooms (excl. garages, kitchens, bathrooms & hallways)	40	At any time
Non-Residential Buildings		
Type of Occupancy		Recommended Max Noise Level (dBA)
Educational Institutions including Child Care Centres		40
Places of Worship		40
Hospitals	Wards	35
	Other Noise Sensitive Areas	45

Note 1: Airborne noise is calculated as $L_{Aeq(15hour)}$ daytime and $L_{Aeq(9hour)}$ night-time

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

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

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

As the road traffic noise model predicts external noise levels, the internal noise goals have been adjusted by 10 dB for open windows and 20 dB for closed windows and standard glazing to provide external noise goals. The external noise goals applicable for the project are provided in **Table 6**.

Table 6 External Noise Goals Applicable to the Project

Type of Occupancy		External Noise Goals (dBA)[1,2]		Applicable Time Period
		Windows Open	Windows Closed	
Residential Buildings[3]				
Sleeping areas (bedrooms)		45	55	Night-time (10:00 pm to 7:00 am)
Other habitable rooms (excluding garages, kitchens, bathrooms and hallways)		50	60	At any time
Non-Residential Buildings				
Educational institutions including child care centres		50	60	Whenever in use
Places of worship		50	60	Whenever in use
Hospitals	- Wards	45	55	Whenever in use
	- Other noise sensitive areas	55	65	Whenever in use

Note 1: Airborne noise is calculated as $L_{Aeq(15hour)}$ for the daytime and $L_{Aeq(9hour)}$ for the night-time.

Note 2: External noise goals are applicable 1 m from the external facade of a habitable room.

Note 3: These noise goals apply to all forms of residential buildings as well as aged care and nursing home facilities.

4.2 City of Sydney Development Control Plan

The City of Sydney (CoS) Development Control Plan (DCP) provides noise criteria for the development of new residential houses and units. Provided below is a summary of the requirements pertinent to the consideration of external noise.

1. The repeatable maximum LAeq(1 hour) for residential buildings and serviced apartments must not exceed the following levels:
   a. for closed windows and doors:
      - 35 dB for bedrooms (10pm-7am); and
      - 45 dB for main living areas (24 hours).
   b. for open windows and doors:
      - 45 dB for bedrooms (10pm-7am); and
      - 55 dB for main living areas (24 hours)

2. Where natural ventilation of a room cannot be achieved, the repeatable maximum LAeq (1hour) level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:
    c. 38 dB for bedrooms (10pm-7am); and
    d. 48 dB for main living areas (24 hours)
3. These levels are to include the combined measured level of noise from both external sources and the ventilation system operating normally.

4.3 Industrial Noise Criteria

The *Noise Policy for Industry* (NPfI) was released in 2017 and sets out the NSW *Environment Protection Authority's* (EPA's) requirements for the assessment and management of noise from industry in NSW.

4.3.1 Trigger Levels

The NPfI describes 'trigger levels' which indicate the noise level at which feasible and reasonable noise management measures should be considered. Two forms of noise criteria are provided – 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 LAeq noise level of the source, measured over a period of 15 minutes, does not exceed the 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.

4.3.2 Project Specific Criteria

The noise emission trigger levels for mechanical plant at the facility are provided in **Table 7**. The project noise trigger level is the lowest value of the intrusiveness or amenity noise level for each period and these are shown below in bold.

Table 7 Project Specific Noise Trigger Levels

Receiver	Period	Recommended Amenity Noise Level LAeq (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels LAeq(15minute) (dBA)	
			RBL[1]	LAeq(period)	Intrusiveness	Amenity[2,3]
L01 - Residential	Daytime	60	53	65	**58**	63
	Evening	50	49	64	54	**49**[4]
	Night-time	45	40	60	45	**45**[4]
L02 - Residential	Daytime	60	48	59	**53**	63
	Evening	50	47	55	**52**	53
	Night-time	45	41	52	**46**	48
	Daytime	60	53	62	**58**	63

Receiver	Period	Recommended Amenity Noise Level LAeq (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels LAeq(15minute) (dBA)	
			RBL[1]	LAeq(period)	Intrusiveness	Amenity[2,3]
L03 - Residential	Evening	50	49	61	54	**46[4]**
	Night-time	45	40	56	45	**41[4]**

Note 1: RBL = Rating Background Level.

Note 2: The recommended amenity noise levels have been used as the project amenity noise levels as there are no other industries present or likely to be introduced.

Note 3: The project amenity noise level has been converted to a 15 minute level by adding 3 dB.

Note 4: The project amenity noise level has been derived in accordance with NPfI for areas of high traffic noise.

5 Vibration Criteria

Criteria for vibration from continuous events and activities such as those caused by vehicles operating on a roadway are provided by the NSW *"Assessing Vibration: A Technical Guideline"* (AVTG).

The AVTG is based on British Standard BS 6472-1992 *Evaluation of human exposure to vibration in buildings (1-80Hz)* which is similar to Australian Standard AS-2670.2-1990 but includes additional guidelines in relation to intermittent vibration[1]. **Table 8** sets out the preferred and maximum weighted RMS values for continuous vibration acceleration. There is a low probability of adverse comment at vibration values below the "preferred" value. Adverse comment or complaints may be expected if vibration values approach the "maximum" values.

Table 8 Preferred and Maximum Weighted RMS Values for Continuous Vibration Acceleration ((m/s^2)) 1-80Hz

Location	Assessment Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous Vibration					
Residences	Daytime (7:00AM-10:00PM)	0.01	0.0071	0.02	0.014
	Night-Time (10:00PM-7:00AM)	0.007	0.005	0.014	0.01

[1] Both referenced standards have been superseded or withdrawn. However, SLR's correspondence with the EPA indicates that BS 6472:1992 should continue to be used when assessing vibration in accordance with AVTG.

6 Noise Assessment

6.1 Road Traffic Noise

A noise model has been developed to determine the existing noise environment across the project site. The major roads surrounding the project site (Elizabeth Street and Phillip Street) have been modelled using SoundPLAN 8.0 and calibrated to the measured L_{Aeq} noise levels during the ambient noise survey at Location 1 and Location 3. The model allows us to predict the noise levels across the site from these sources and allows for a detailed analysis of the noise impacts.

6.1.1 Existing Road Traffic Noise Impacts across the Site

Noise levels have been predicted across the project site (without the existing buildings onsite) during the daytime and night-time periods. The results of the predictions are provided below in **Figure 2** and **Figure 3** as grid noise maps that represent the predicted noise level at 1.5 m above existing ground level. The daytime noise predictions represent the period from 7 am to 10 pm and the night-time period is 10 pm to 7 am.

Figure 3 Road Traffic Noise - Daytime Noise Level $L_{Aeq(15hour)}$

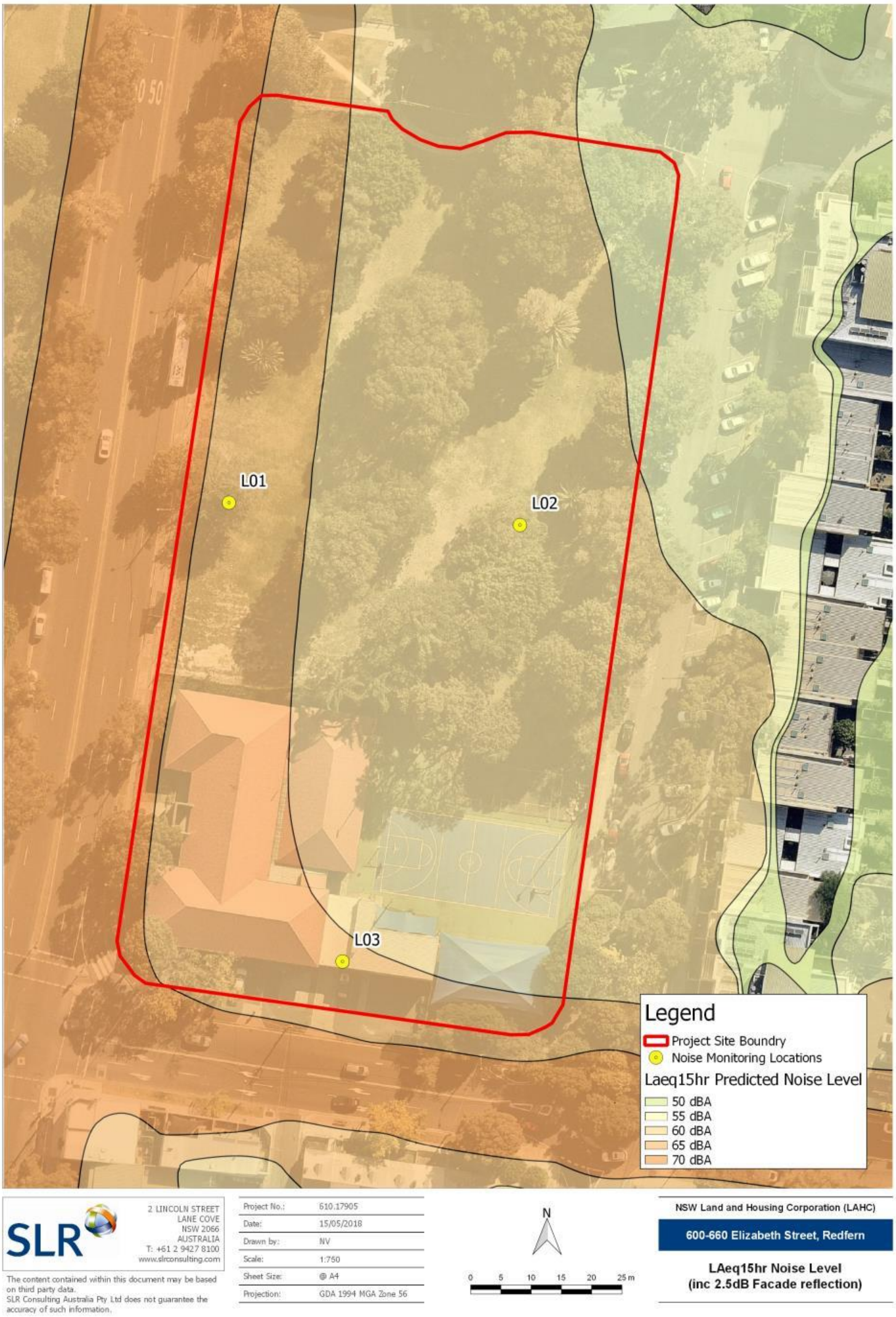
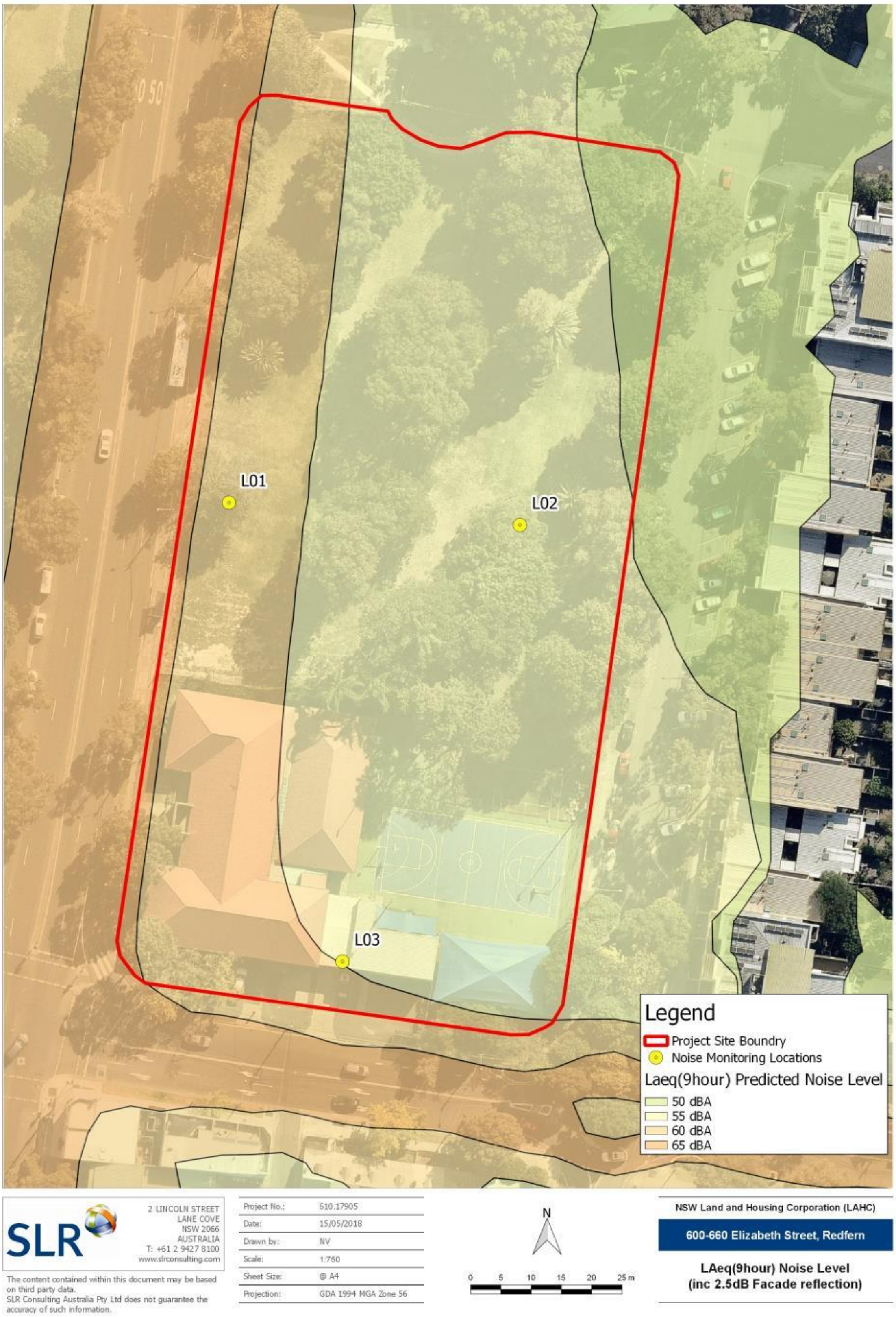


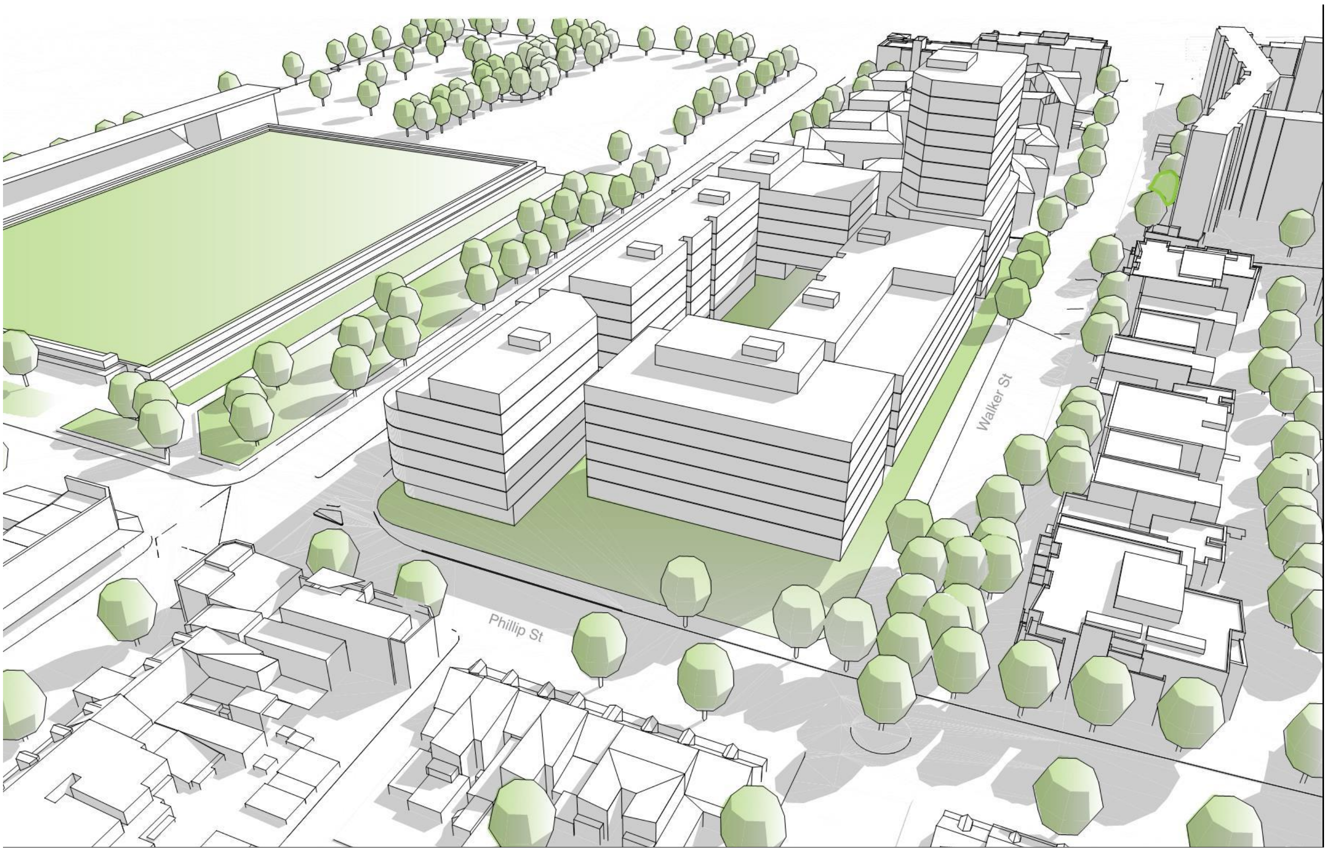
Figure 4 Road Traffic Noise - Night-time Noise Level $L_{Aeq(9hour)}$



6.2 Reference Scheme Review

A Reference Scheme (**Figure 5**) has been used to indicate how the future public domain, building form and connections could be delivered. It should be noted that the Reference Scheme was prepared to indicate how the Site could, rather than will, be redeveloped and has been used as a basis to prepare draft amendments to the Sydney Local Environmental Plan 2012 (including zoning, height, floor space ratio and car parking controls) and the development of a new site specific Development Control Plan which will guide the detailed design of the Site.

Figure 5 Reference Scheme Design



6.3 Predicted Noise Levels – Reference Scheme

The predicted noise level across the project site incorporating the Reference Scheme design is presented graphically in **Figure 6** and **Figure 7** for the 15 hour day time and 9 hour night time respectively.

Furthermore, as outlined in **Section 4.2**, the City of Sydney DCP 2012 requires a more stringent assessment against the repeatable maximum $L_{Aeq(1hour)}$ noise level. The predicted noise levels for each building façade and floor is provided in **Appendix C.** A plan showing facades where consideration of mitigation for some or all levels is shown in **Figure 8**.

Figure 6 Daytime $L_{Aeq\ (15\ hour)}$ Noise Levels

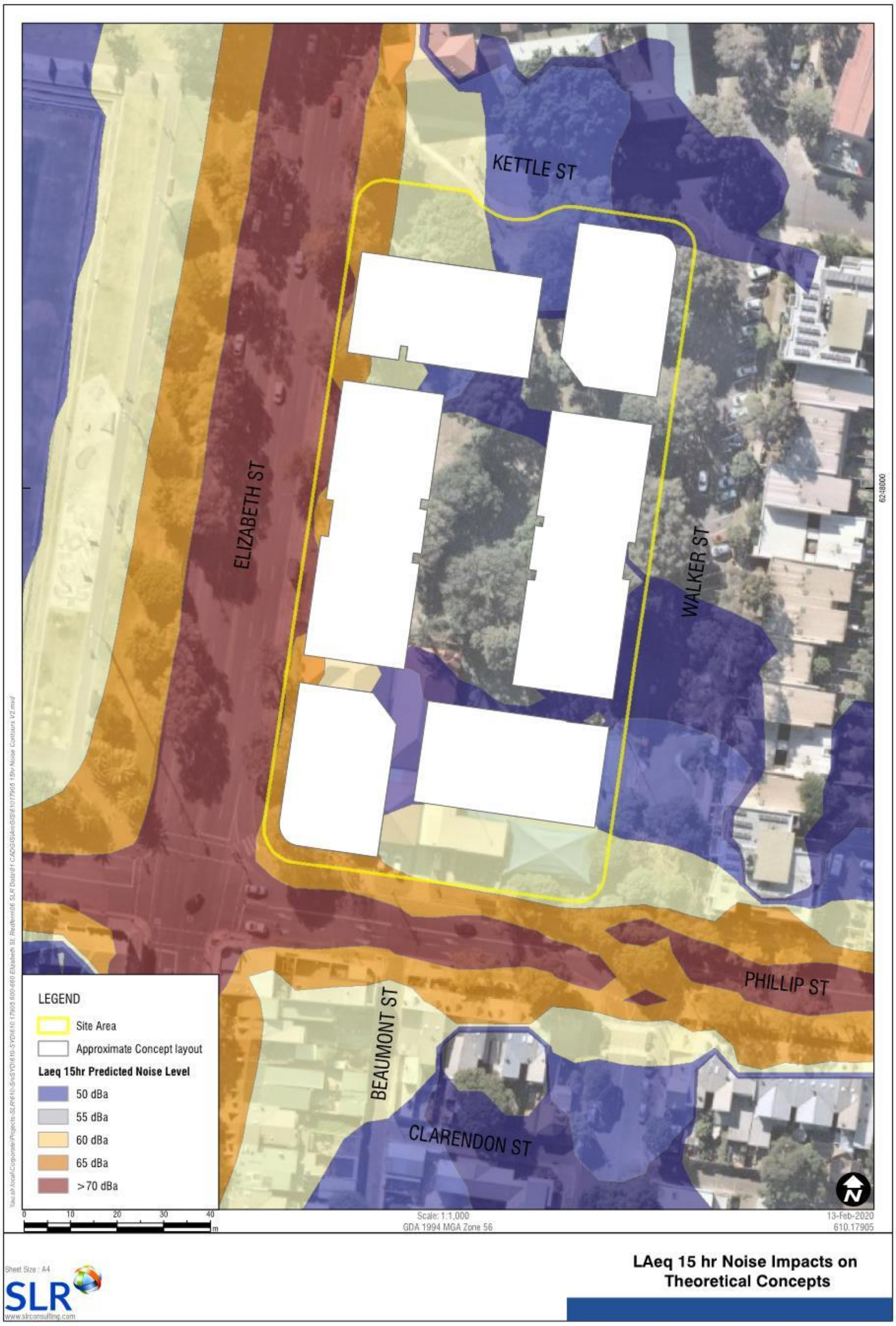


Figure 7 Night-time LAeq(9hour) Noise Levels

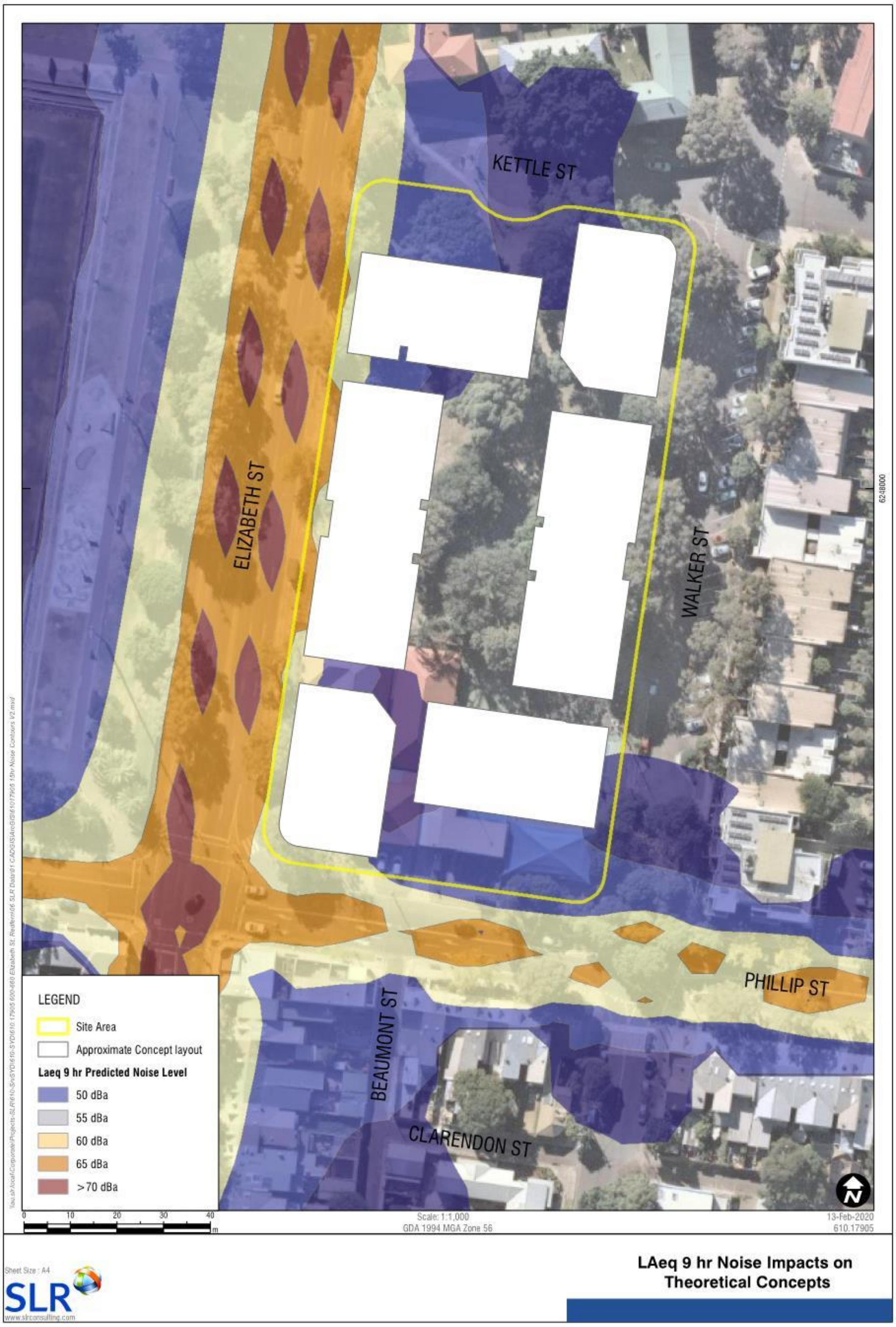
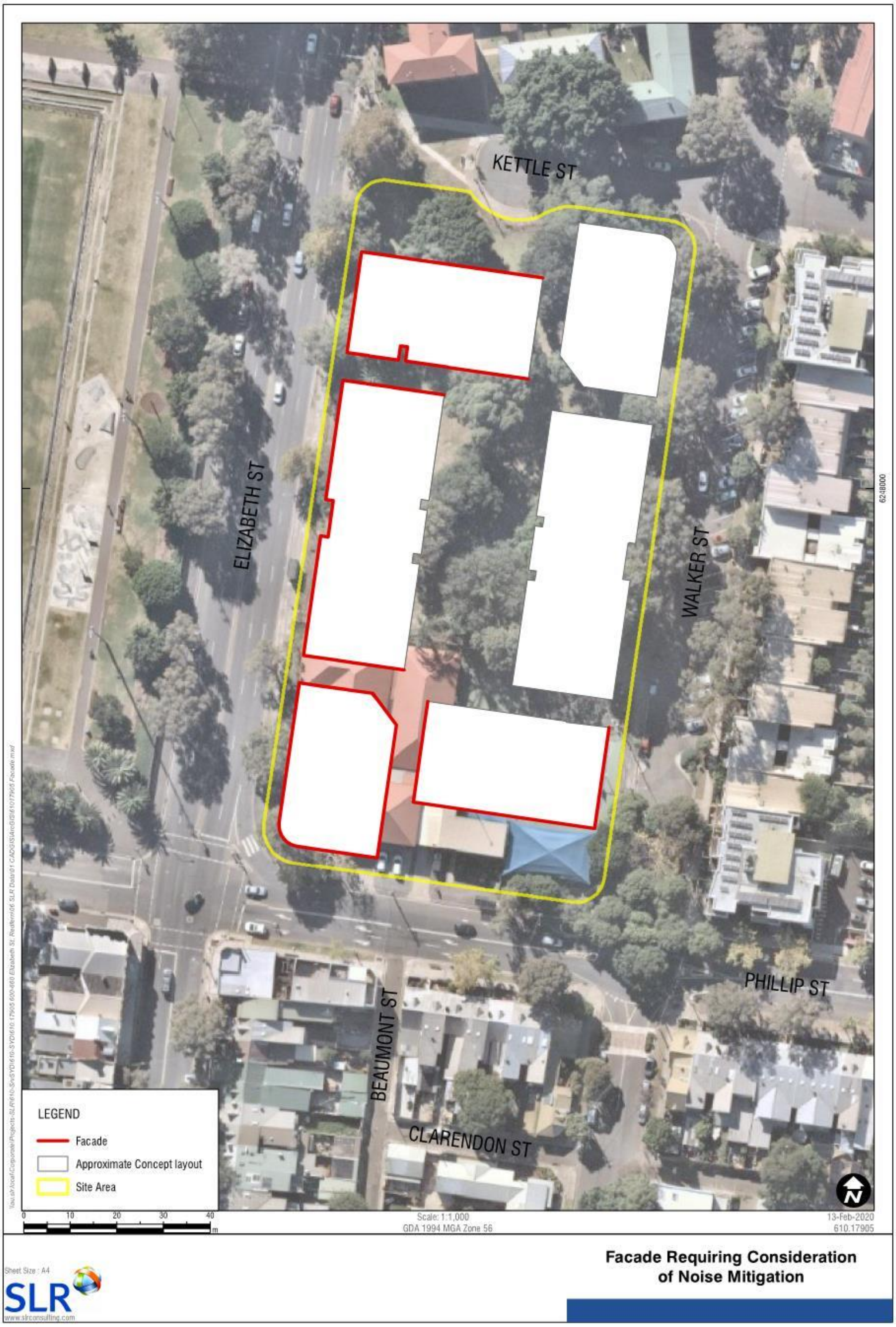


Figure 8 Facades Requiring Consideration of Noise Mitigation

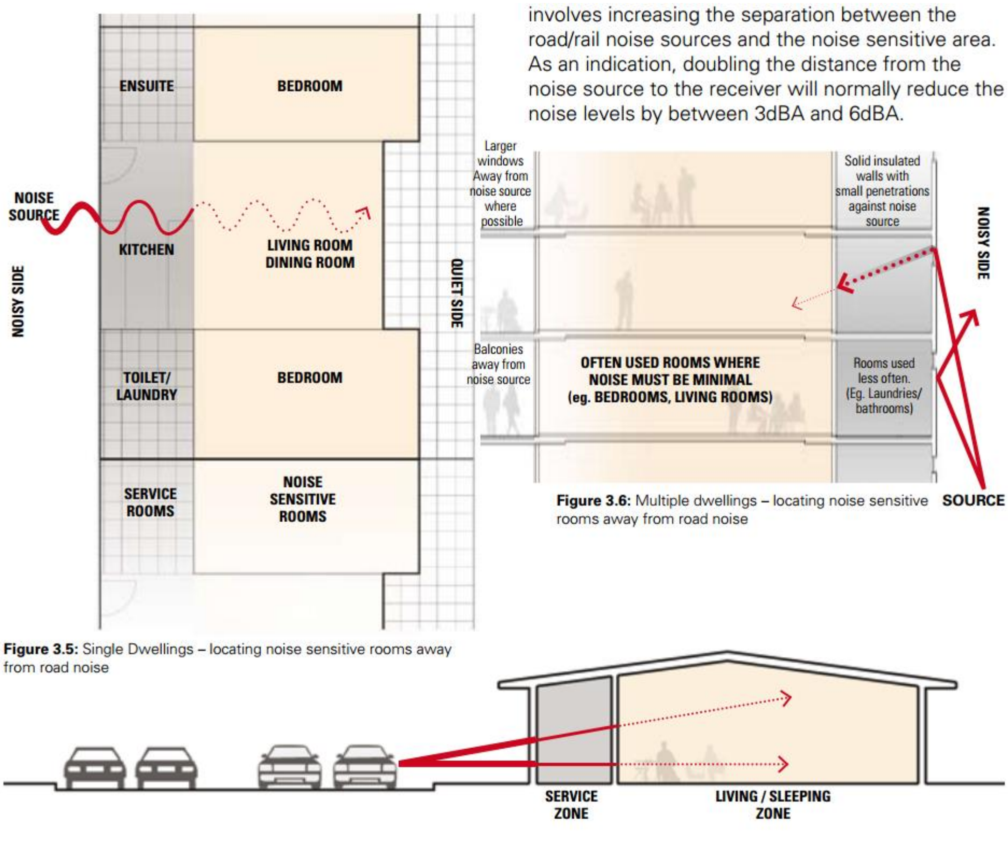


6.3.1 Internal Layout of Buildings

Adopting the criteria established by the City of Sydney DCP 2012, compliant noise levels could be achieved through various mitigation measures such as:

- Constructing the building as seen in **Figure 9** so that noise insensitive areas such as kitchens, storage areas and laundries are located closer to the noise source.
- Increasing noise attenuation through improving quality of glazing (The larger the glazing area, the greater the glazing needs to perform to reduce the internal level to below the criteria outlined above).
- Utilising a Masonry facade construction to reduce the noise intrusion into the dwelling.
- Minimising the number of windows on the most exposed façade.

Figure 9 Examples of Design Orientation and Room Layout



Note: Taken from DP&I Development near Rail Corridors and Busy Roads – Interim Guideline.

The exterior construction of buildings can also be designed to minimise noise intrusion into sensitive areas. Masonry facade construction can be used to reduce the noise intrusion into the dwelling, and the number of windows on the most exposed facades can be minimised and/or designed in a way to reduce the potential noise impact from the road (ie balcony doors on the sides, instead of looking out). The larger the glazing area, the greater the glazing needs to perform to reduce the internal level to below the criteria outlined above.

6.3.2 Ventilation Options

Where residual impacts remain after the optimisation of site layout and building design, the upgrading of facade elements of noise affected sensitive spaces can be used as a final mitigation approach to achieving appropriate internal noise levels.

As a guide, well designed and correctly installed standard 4 mm window glazing will typically attenuate external noise levels by approximately 20 dB with windows closed and approximately 10 dB with windows open (allowing for natural ventilation).

Based on the façade incident noise levels presented in **Appendix C**, the predicted Traffic Noise Reduction (TNR) required to achieve the specific internal noise levels are presented in **Appendix D**. These results have been colour coded based on the level of exceedance over the criteria with windows open.

Road Traffic Noise Level above Criteria					
0-10 dB	Can comply with windows open	10-20 dB	Consideration of screened openings (**Section 6.3.2.1**) or acoustically attenuated openings (**Section 6.3.2.2**)	20 dB+	Acoustically attenuated openings required (**Section 6.3.2.2**)

Note that this is considered informative at this stage and will be developed and made more concise as the design progresses.

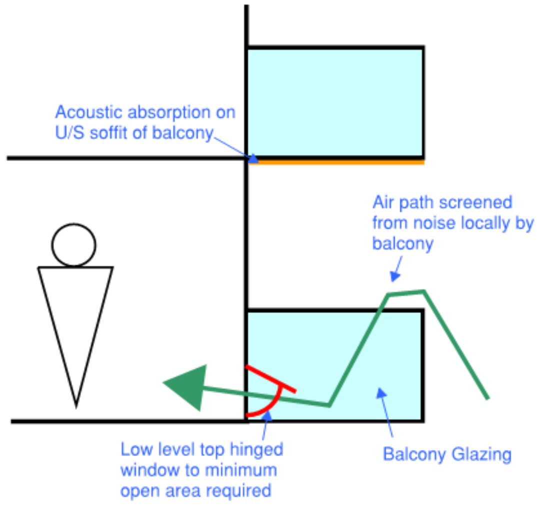
6.3.2.1 Screened Openings

It is considered that where a TNR of 10-15 dBA (or 20 dBA as a maximum) is required through an openable window, the design may employ one of the following options to achieve the required noise reduction through ventilation openings:

- Modelling of façade such that openings face wholly away from the noise source and do not have direct line of sight. This would be particularly applicable to facades which are on the “laneways” between the buildings, where modelling the façade may make it possible to have openings facing in to the precent courtyard, as opposed to either facing or being “side-on” to Elizabeth Street.
- Use of acoustically treated balcony’s in conjunction with optimised locations of opening windows. This would be particularly applicable to the upper levels of the building as it will be easier for a balcony balustrade to break line of sight from the opening to the road.

  Such an approach would include localised screening on the balcony with low-level windows and acoustic absorption that could be applied to the balcony surfaces. The conceptual design is as shown in **Figure 10**.

Figure 10 - Concept for acoustically screened balconies



The amount of attenuation offered by such a system will depend on the final detailed design of the balcony, as well as the location of the dwelling in relation to the noise source. A paper authored by the Queensland University of Technology "*Investigations on road noise level spatial variability within a specially designed acoustic balcony*" (Daniel A. NAISH, Andy C. C. TAN, F. Nur DEMIRBILEK, Inter.Noise 2014) showed that at certain positions at residential windows in appropriately designed balconies, noise levels can be up to 12 dBA lower than at the facade of the building without a balcony.

This result, combined with the typical 10 dBA 'outdoor-to-indoor' loss implies that up to 22 dBA overall reduction from facade predicted noise levels may be achievable in the absolute best case. It is considered that for apartments that require a TNR of between 10-15 dBA, the use of screened openings is appropriate. For apartments that require a TNR of between 15-20 dBA, screened openings may be sufficient, subject to detailed assessment, however alternatively attenuated openings (as per **Section 6.3.2.2**) may be employed.

6.3.2.2 Acoustically Attenuated Openings

Where 15-20 dBA TNR is required, the use of acoustically attenuated openings should be considered – and where a TNR of ≥ 20 dBA is required such a solution will almost certainly be required. The highest outdoor-to-indoor loss required for an acoustically treated opening as given in **Appendix D** is 23 dBA. Whilst this is a high performance requirement, it has been achieved in numerous projects previously, including a number of schools in the UK (https://www.machgroup.co.uk/category/nat-vent-attenuator/).

In addition, Flux Consultants (ESD) and Renzo Tonin and Associates (Acoustics) have design recommendations to achieve compliance with City of Sydney's "Draft Alternative natural ventilation of apartments in noisy environments Performance pathway guideline" on sites with external noise levels up to 78 dBA $L_{Aeq(15hour)}$ and 73 dBA $L_{Aeq(9hour)}$. SLR understands that this document was commissioned by the City of Sydney to develop the guideline referred to above.

The Flux Consulting document presents recommended attenuator designs based on theoretical calculations that achieve both airflow and acoustic requirements for apartments subject to high external noise levels. Permission has been sought from Flux Consultants to refer to this guideline and repeat an extract (see **Figure 11**).

Figure 11 Extract from Flux Consultants report showing example natural ventilator designs for up to 73 dBA night / 78 dBA day noise levels

Table 19

Corner Natural Ventilation- Both Noise Affected Facade -
Very-high noise level: 76-78 dB(A)(15hour) Day; 71-73 dB(A)(9hour) Night

Corner – Both Noise Affected Façade		Ventilation Device Configuration (low range noise level) Façade Noise Levels 76-78 dB(A)(15hour) Day; 71-73 dB(A)(9hour) Night										
		Reference Device Area (m2)	RDA ≥ 0.10		RDA ≥ 0.15		RDA ≥ 0.20		RDA ≥ 0.25		RDA ≥ 0.33	
					0.10< RDA		0.15< RDA		0.20< RDA		0.25< RDA.	
Device Type		Lining thickness (mm)	25	50	25	50	25	50	25	50	25	50
Horizontal	Plain Plenum	h (m)			0.35	0.40		0.40		0.40		0.40
		w (m)			1.42	1.47		1.92		2.37		2.82
		l (m)			3.77	2.47		2.87		3.27		3.27
		Ceiling height impact (m)			0.35	0.40		0.40		0.40		0.40
		Floor space req (m2)										
	Plenum With Septum's	h (m)			0.35	0.40	0.35	0.40	0.35	0.40	0.35	0.40
		w (m)			1.77	1.82	2.57	2.82	2.57	2.82	2.57	2.82
		l (m)			2.47	1.77	2.57	1.87	2.77	2.07	2.97	2.27
		Ceiling height impact (m)			0.35	0.40	0.35	0.40	0.35	0.40	0.35	1.40
		Floor space req (m2)										

It is noted (as per the full Flux report) these ventilator designs should be considered preliminary only and further site-specific design development will be required. However, the report demonstrates that compliance with the City of Sydney's Natural Ventilation and Noise requirements can be achieved on sites with noise levels exceeding those predicted for the proposed development.

Ventilator designs which may be considered as part of future design development may include:

- Horizontal lined plenum boxes used above-ceiling in the apartments and with grilles in the facade
- Vertical ventilator "cupboards" in the corner of habitable rooms on the facade
- Being integrated into external fixed furniture on the balconies.

However, the best integration method for these options is to be developed as part of any future detailed proposals for the site and included with future submissions.

As a result, it is expected that compliance with the established noise criteria whilst using natural, crossflow ventilation can be achieved, subject to the design development of the future development incorporating suitable acoustically attenuated natural facade ventilation openings.

6.3.3 Indicative constructions of building fabric

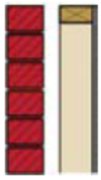
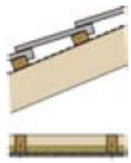
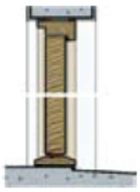
Based on the calculated Traffic Noise Reduction (TNR) as defined in '*AS 3671-1989: Acoustics – Road Traffic Noise Intrusion _ Building Siting and Construction*', facades are generally situated within the Category 2 and Category 3 construction type. From this, it is anticipated that the proposed treatments outlined in *'DP&I Development near Rail Corridors and Busy Roads – Interim Guideline'* under Category 2 and Category 3 treatments will need to be incorporated into the design particularly on the facades fronting Kettle Street, Elizabeth Street and Phillip Street.

Figure 12 Acoustic Performance of Building Elements

Category of Noise Control Treatment	R_w of Building Elements (minimum assumed)				
	Windows/Sliding Doors	Frontage Facade	Roof	Entry Door	Floor
Category 1	24	38	40	28	29
Category 2	27	45	43	30	29
Category 3	32	52	48	33	50
Category 4	35	55	52	33	50
Category 5	43	55	55	40	50

Figure 12 sets out standard (or deemed-to-satisfy) constructions associated with the Category 3 noise control treatments

Figure 13 Acoustic Construction of Building Elements

Category No.	Building Element	Standard Constructions	sample
3	**Windows/Sliding Doors**	Openable with minimum 6.38mm laminated glass and full perimeter acoustic seals	
	Frontage Facade	**Brick Veneer Construction:** 110mm brick, 90mm timber stud or 92mm metal stud, minimum 50mm clearance between masonry and stud frame, 10mm standard plasterboard internally.	
		Double Brick Cavity Construction: 2 leaves of 110mm brickwork separated by 50mm gap	
	Roof	Pitched concrete or terracotta tile or sheet metal roof with sarking, 1 layer of 13mm sound-rated plasterboard fixed to ceiling joists, R2 insulation batts in roof cavity.	
	Entry Door	45mm solid core timber door fitted with full perimeter acoustic seals	
	Floor	Concrete slab floor on ground	

It should however be noted that the glazing recommendations detailed above are only for small areas of glass, and may require a higher acoustic performance for glass with a large surface area and may be a significant cost. This can be partially mitigated by designing the apartment usages to have the balcony door opening to the side of the balcony instead of directly on to Elizabeth Street.

A detailed assessment should be undertaken at SSDA stage once final building form and internal layout is known.

6.4 Industrial Noise Sources

The noise emission of mechanical plant associated with the development should be controlled so that the operation of plant does not adversely impact nearby residential properties. At this stage of the project the location and selection of mechanical plant has not been defined. Therefore, appropriate assessment will need to be conducted once further information is available.

It is envisaged that the mechanical plant noise source will be controllable by common engineering methods that may consist of:

- Judicious location
- Barriers
- Silencers
- Acoustically lined ductwork

The selected mechanical equipment must be reviewed and assessed for conformance with established criteria as stipulated in **Section 3.2.2** at the detailed design stage of the project when specific plant selection and location is known.

7 Vibration Assessment

7.1 Occupancy Vibration Assessment

Road traffic typically generates very low vibration levels which are not likely to be perceptible and likely to be well below applicable criteria.

Where large discontinuities such as potholes, road plates or joins in the pavement occur, vibration levels can be perceived in close proximity to the road when heavy vehicles travel over them. Such vibration generating circumstances are a maintenance issue, rather than a design issue and have not been assessed.

8 Conclusion

SLR Consulting Australia Pty Ltd (SLR) has been engaged by NSW Land and Housing Corporation (LAHC) to undertake an assessment of the existing noise and vibration environment across the project site located at 600-660 Elizabeth Street, Redfern.

The existing noise environment is dominated by road traffic noise from Elizabeth Street and Phillip Street which was confirmed during the ambient noise monitoring undertaken at the project site.

The review of the Reference Scheme design scheme indicates that noise control treatments will need to be incorporated into the design, particularly on the facades fronting Elizabeth Street and Phillip Street. Notwithstanding this, it is not considered that road traffic noise intrusion would preclude residential development across the project site. Conceptual solutions are presented in this report, however a detailed assessment should be undertaken at SSDA stage once final building form and internal layout is known.

APPENDIX A

Acoustic Terminology

1. Sound Level or Noise Level

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

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

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

2. 'A' Weighted Sound Pressure Level

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

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

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

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

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

3. Sound Power Level

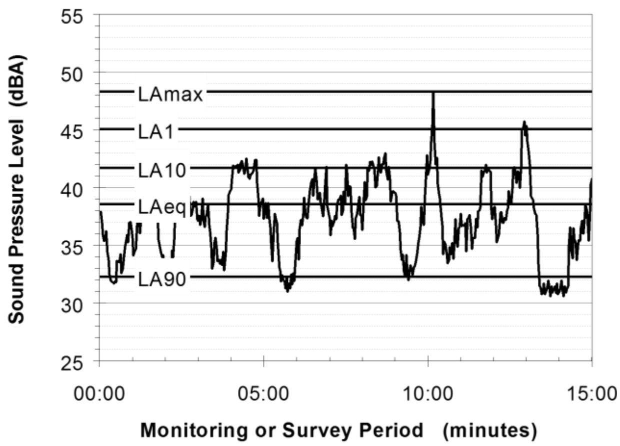
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

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

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

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

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

5. Frequency Analysis

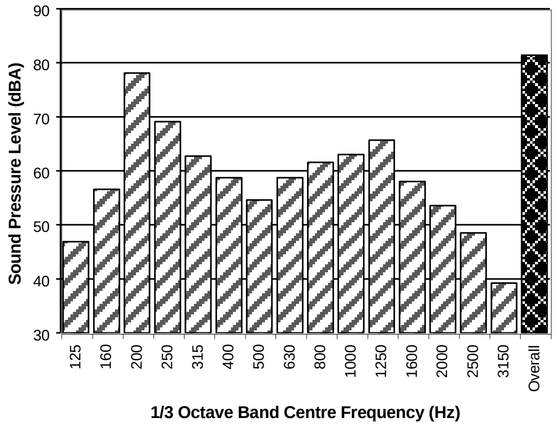
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

Frequency analysis can be in:

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

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



6. Annoying Noise (Special Audible Characteristics)

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

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

7. Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

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

8. Human Perception of Vibration

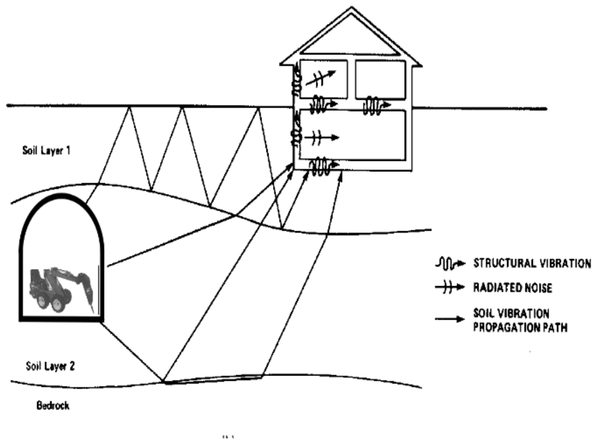
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience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

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

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

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

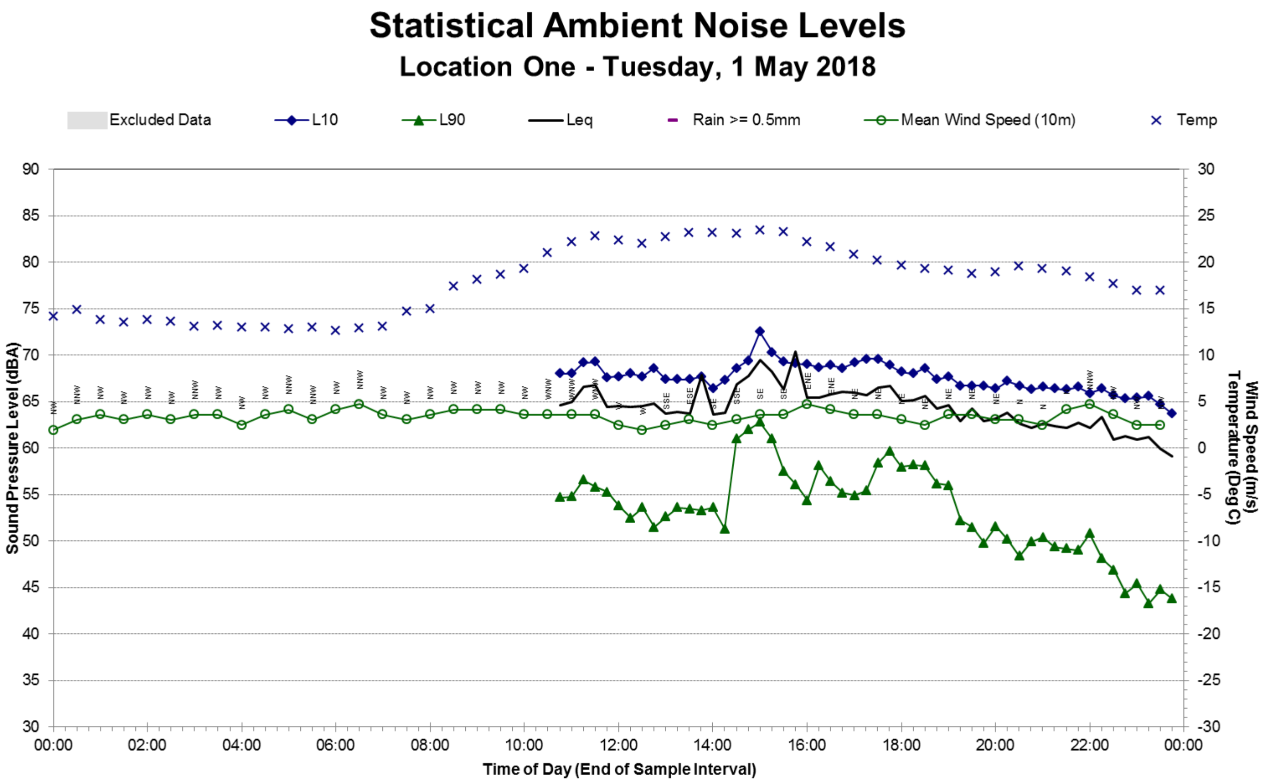
The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.

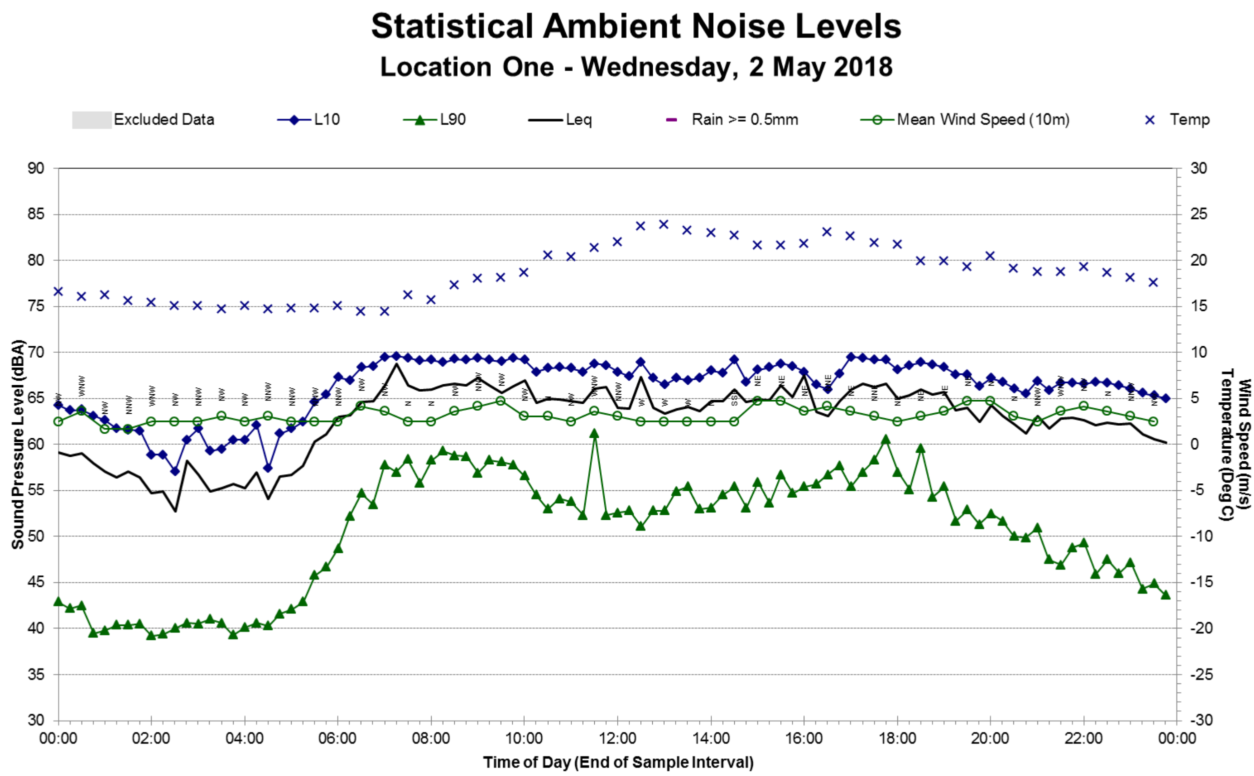


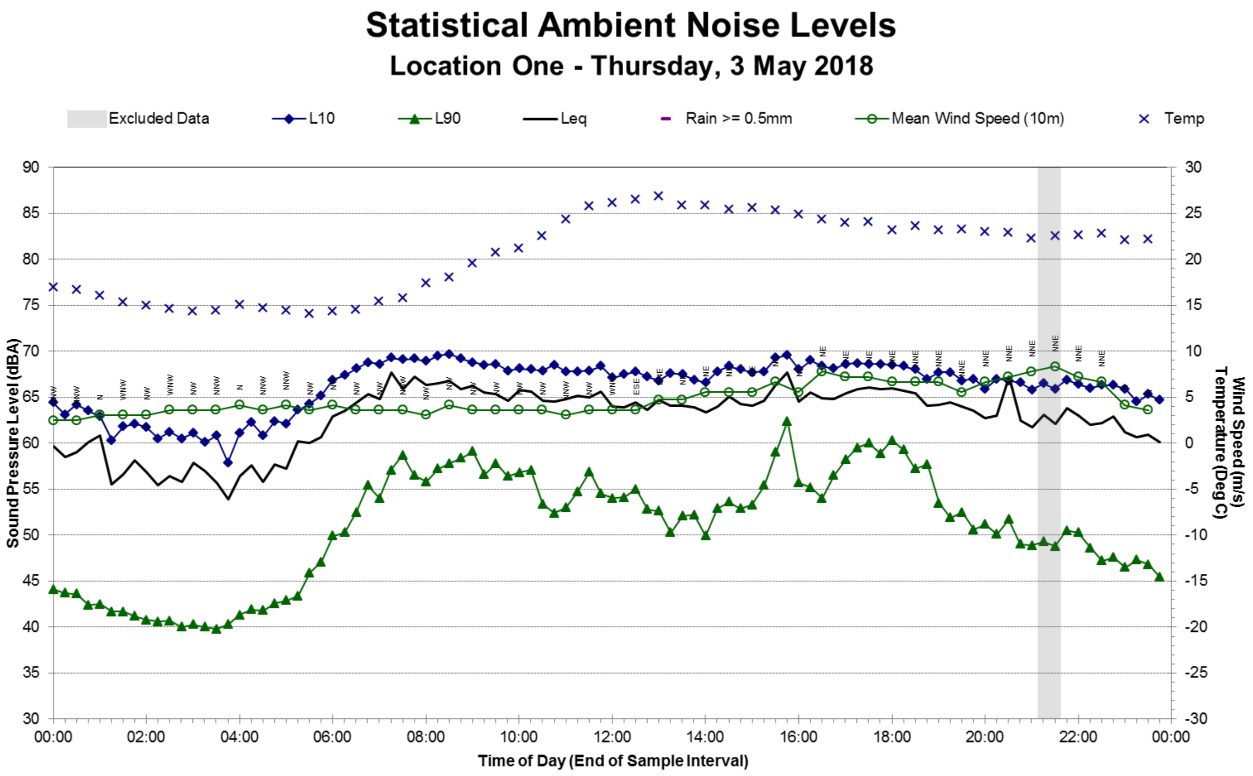
The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect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

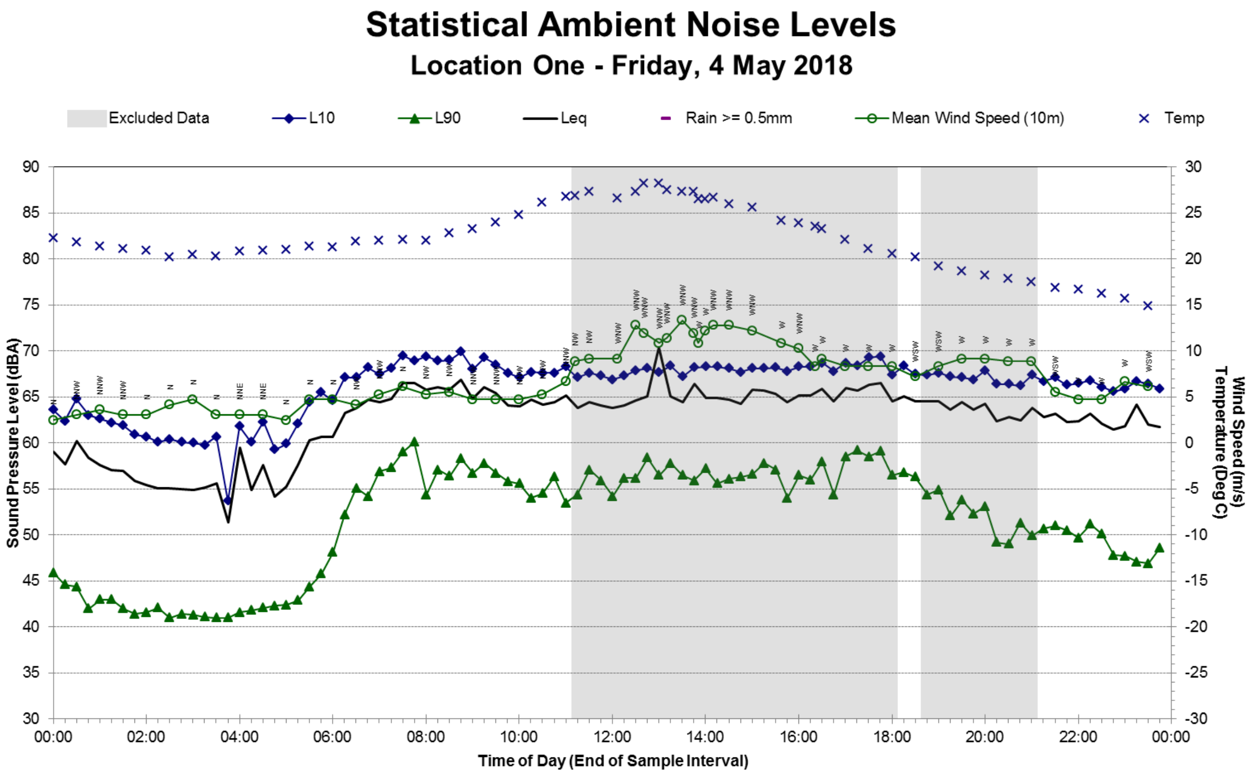
APPENDIX B

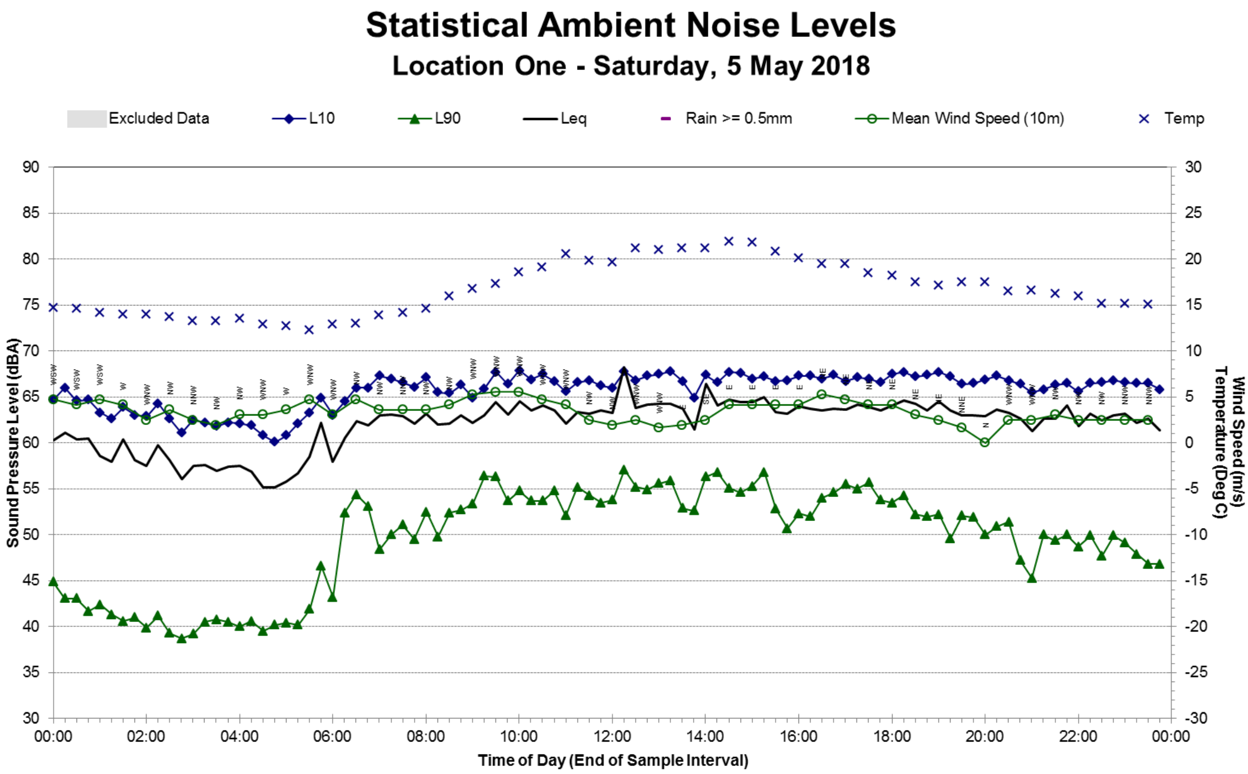
Noise Monitoring Graphs


Statistical Ambient Noise Levels
Location One - Tuesday, 1 May 2018
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
Location One - Wednesday, 2 May 2018
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
Location One - Thursday, 3 May 2018
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
Location One - Friday, 4 May 2018
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)



Statistical Ambient Noise Levels
Location One - Saturday, 5 May 2018
Excluded Data
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L90
Leq
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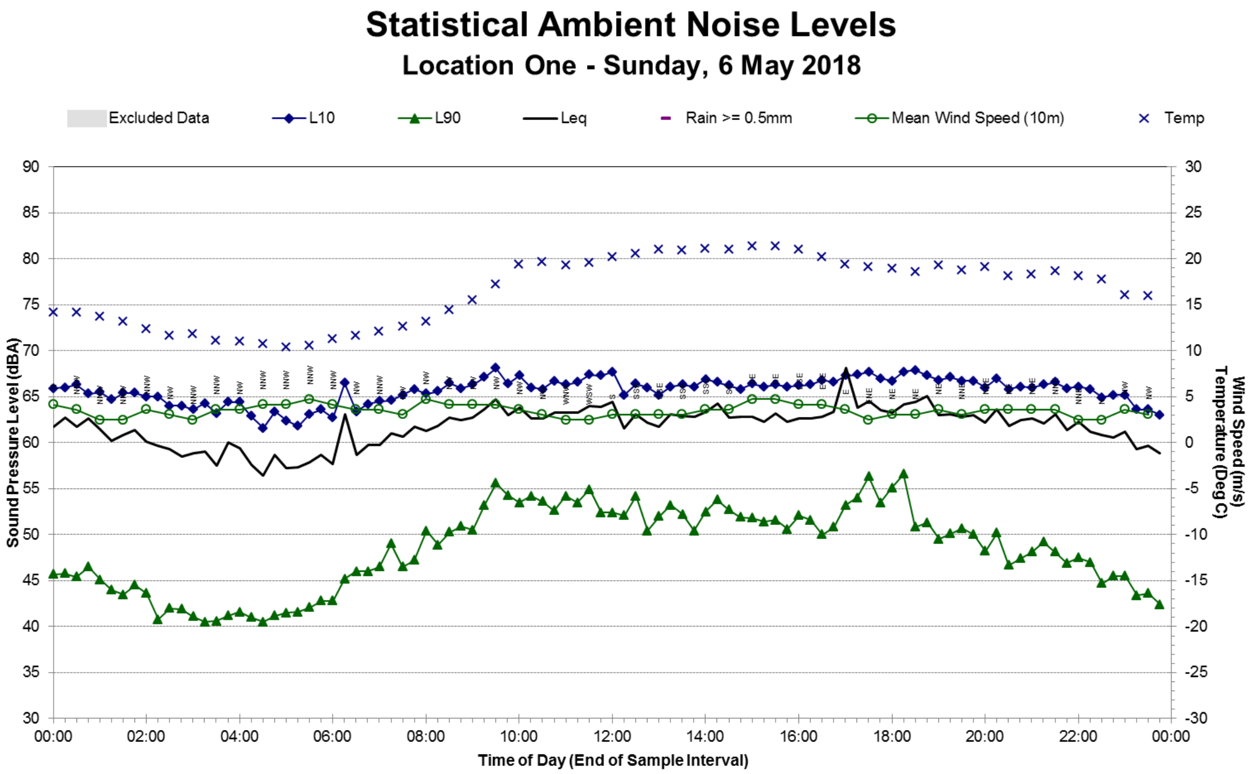
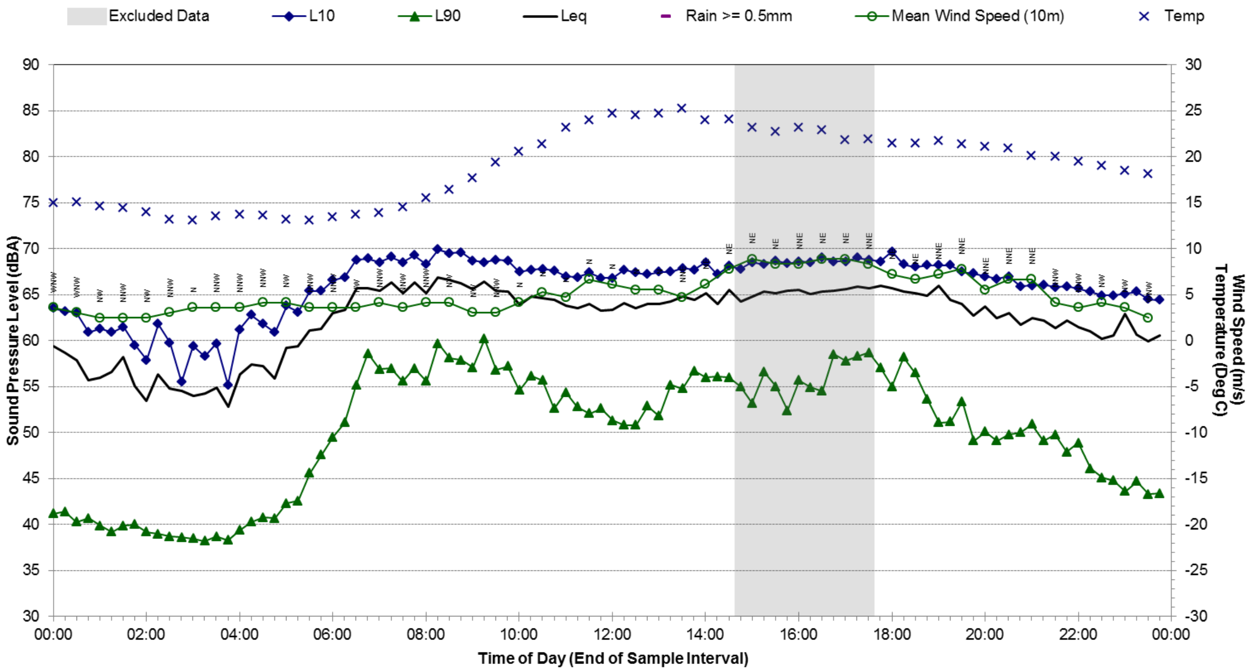
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

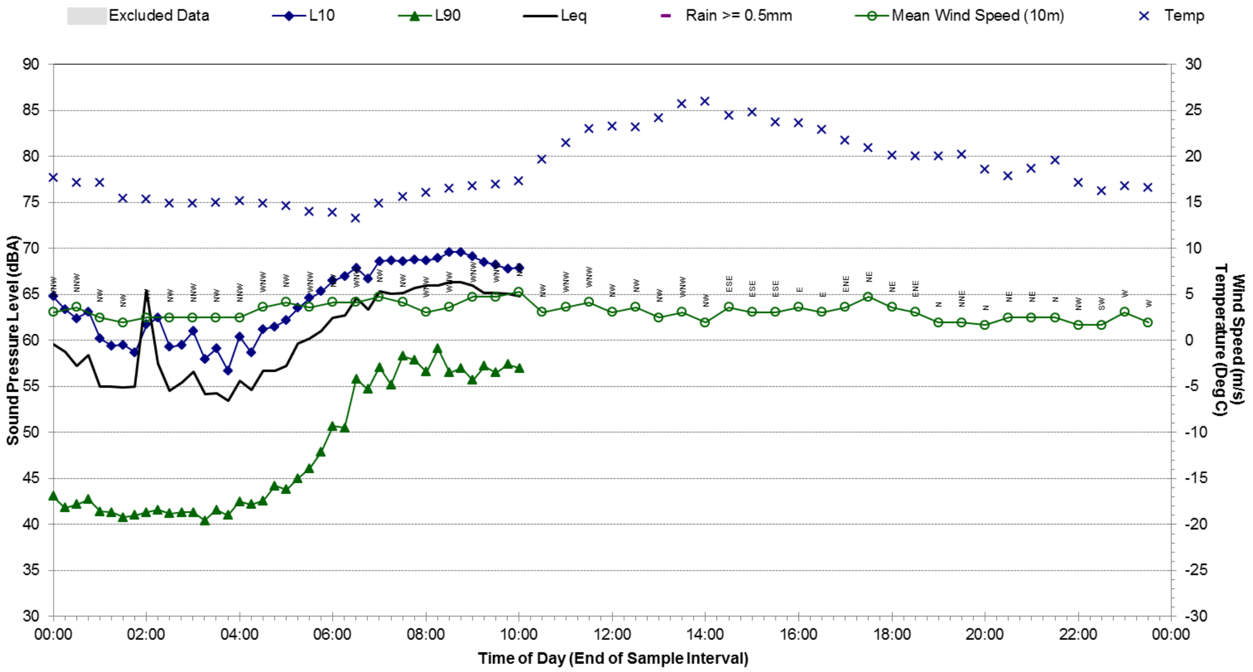


Statistical Ambient Noise Levels
Location One - Sunday, 6 May 2018
Excluded Data
L10
L90
Leq
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

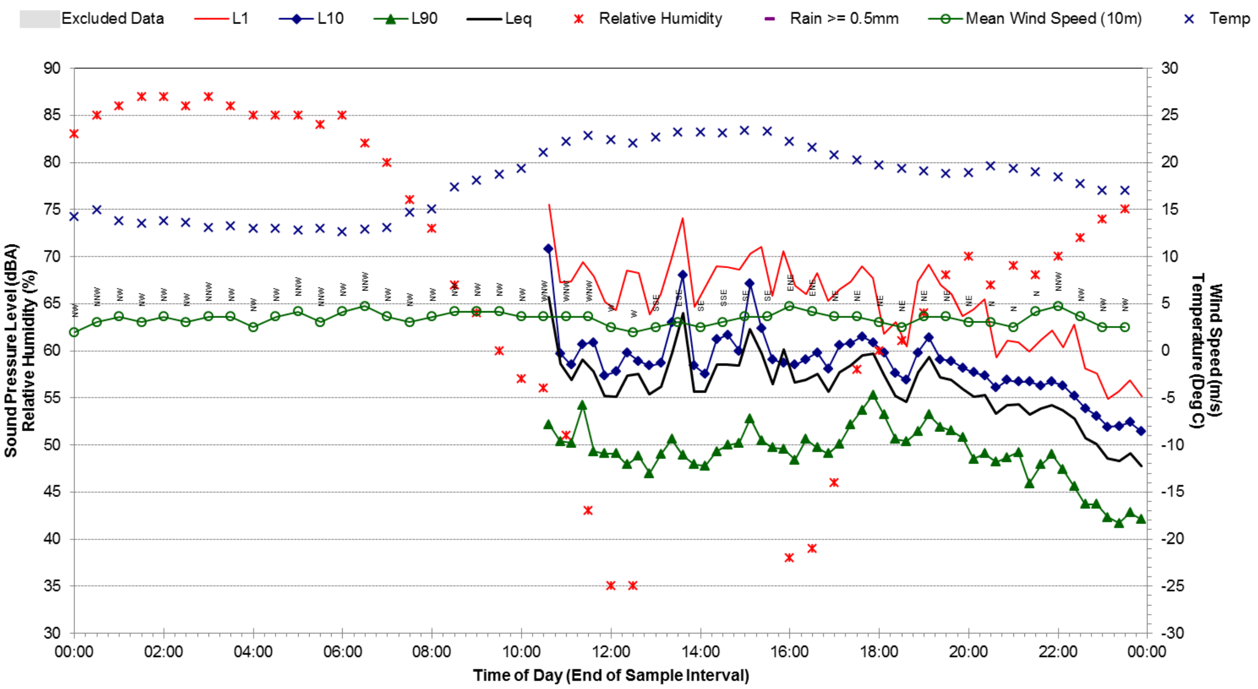
Statistical Ambient Noise Levels
Location One - Monday, 7 May 2018



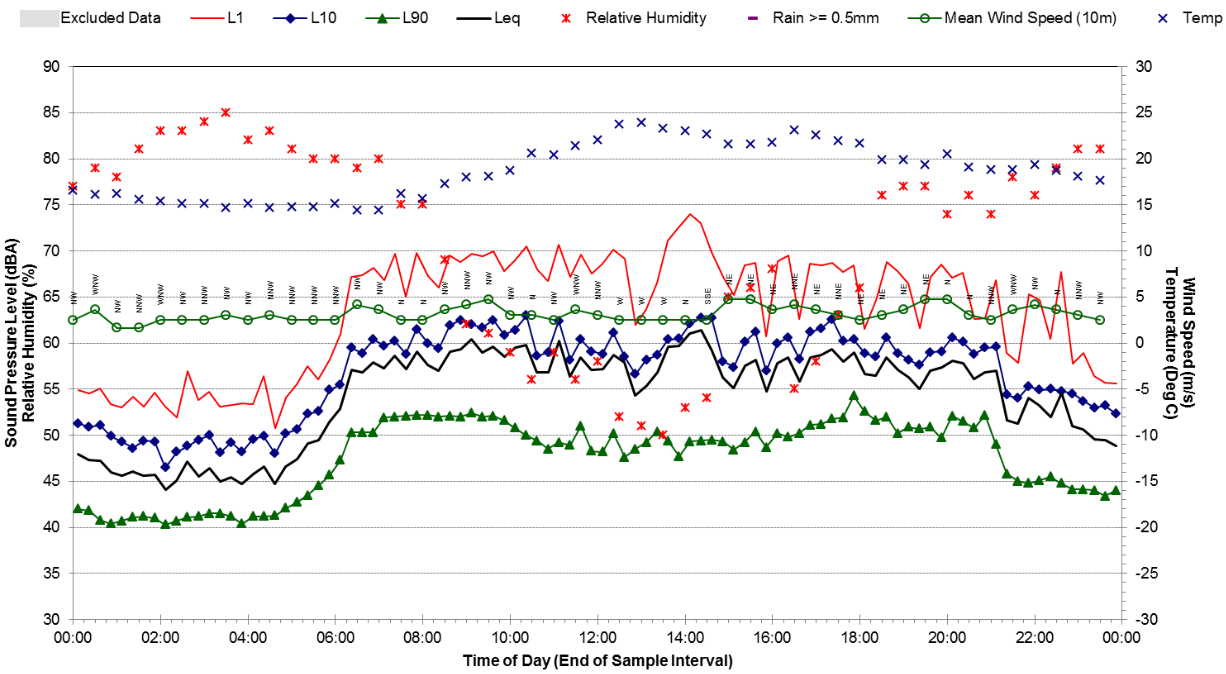
Statistical Ambient Noise Levels
Location One - Tuesday, 8 May 2018



Statistical Ambient Noise Levels
Location 2 - Tuesday, 1 May 2018

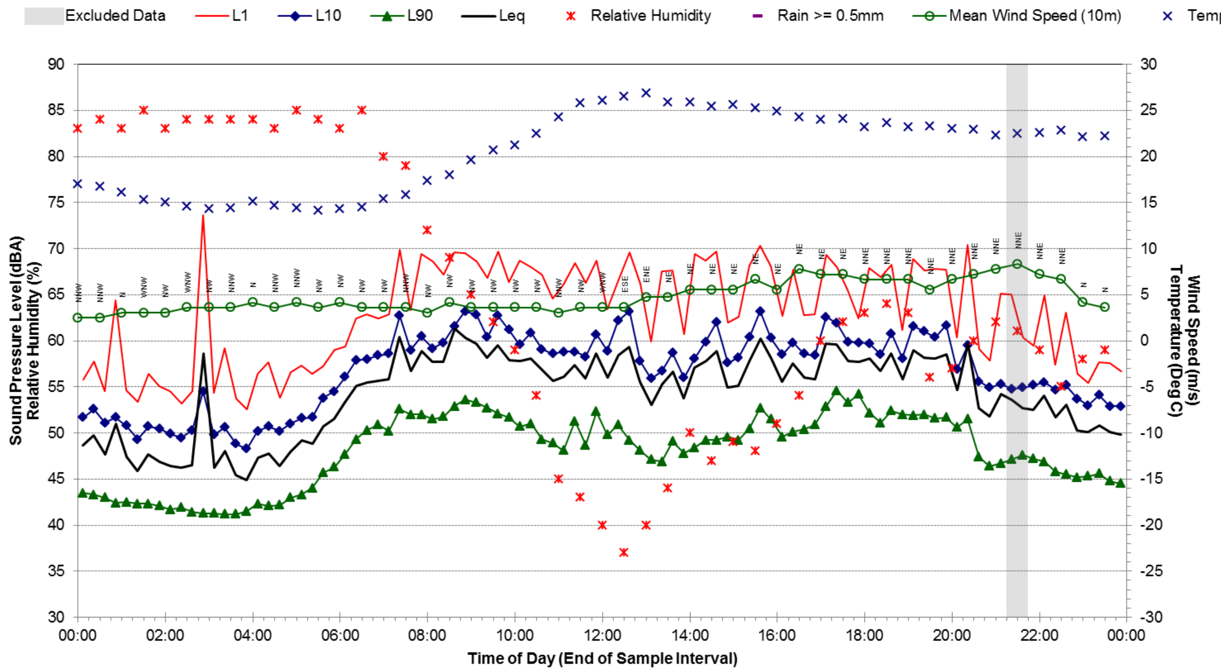


Statistical Ambient Noise Levels
Location 2 - Wednesday, 2 May 2018



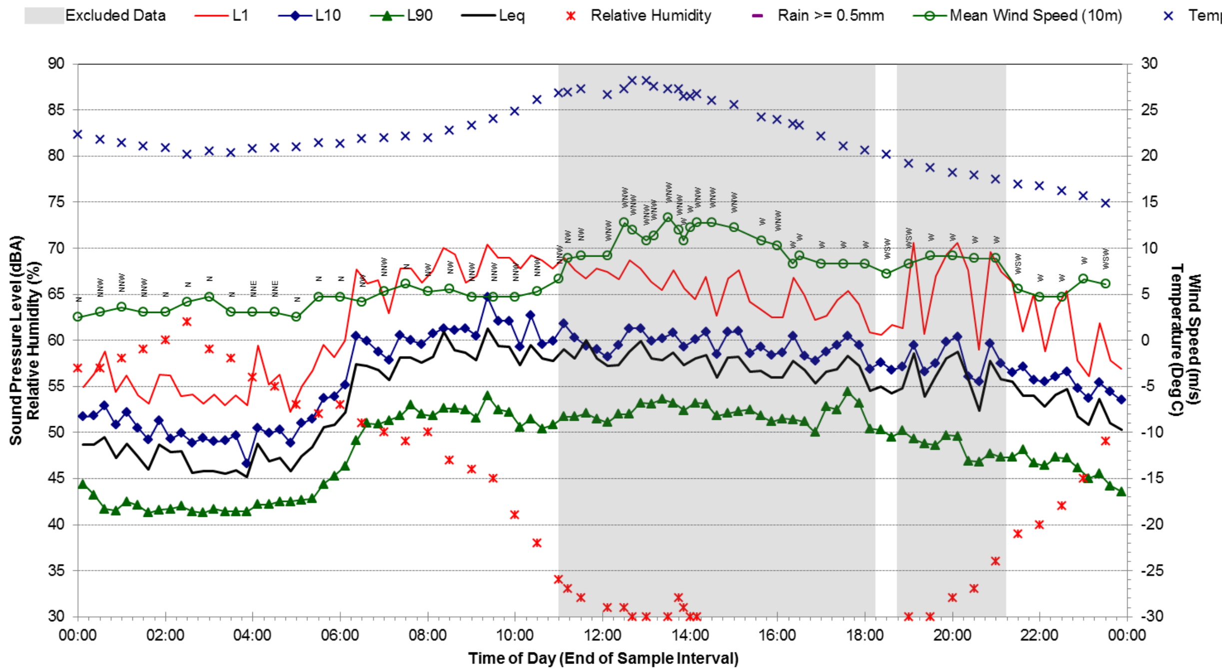
Statistical Ambient Noise Levels

Location 2 - Thursday, 3 May 2018



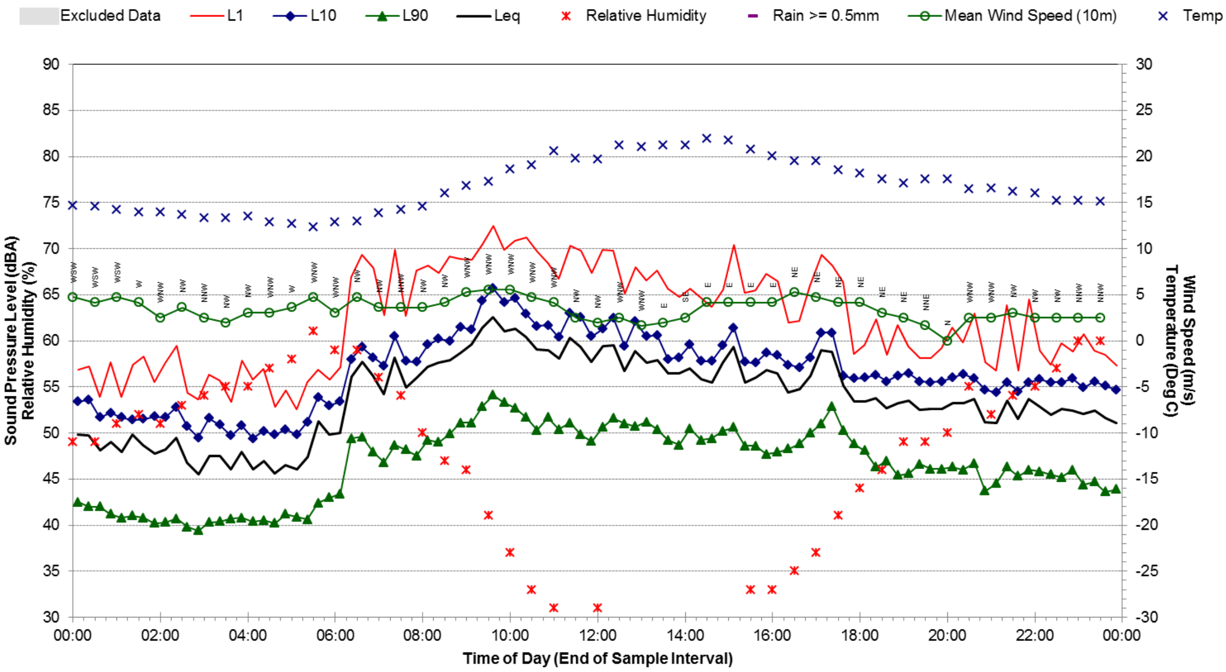
Statistical Ambient Noise Levels

Location 2 - Friday, 4 May 2018



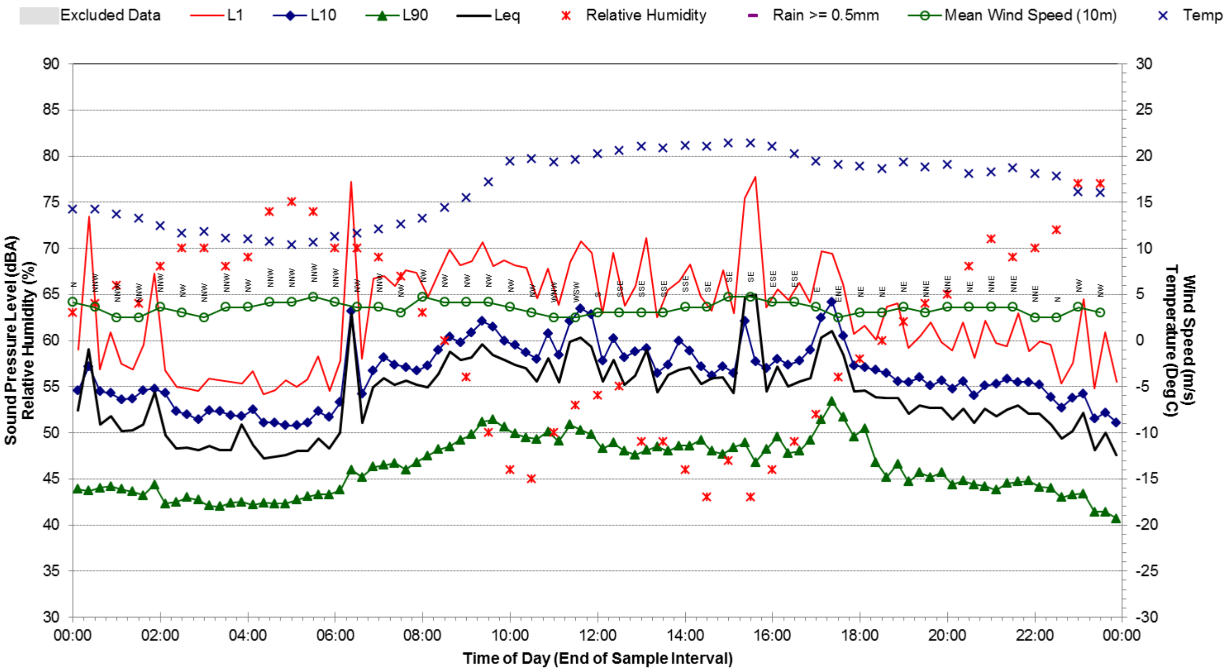
Statistical Ambient Noise Levels

Location 2 - Saturday, 5 May 2018



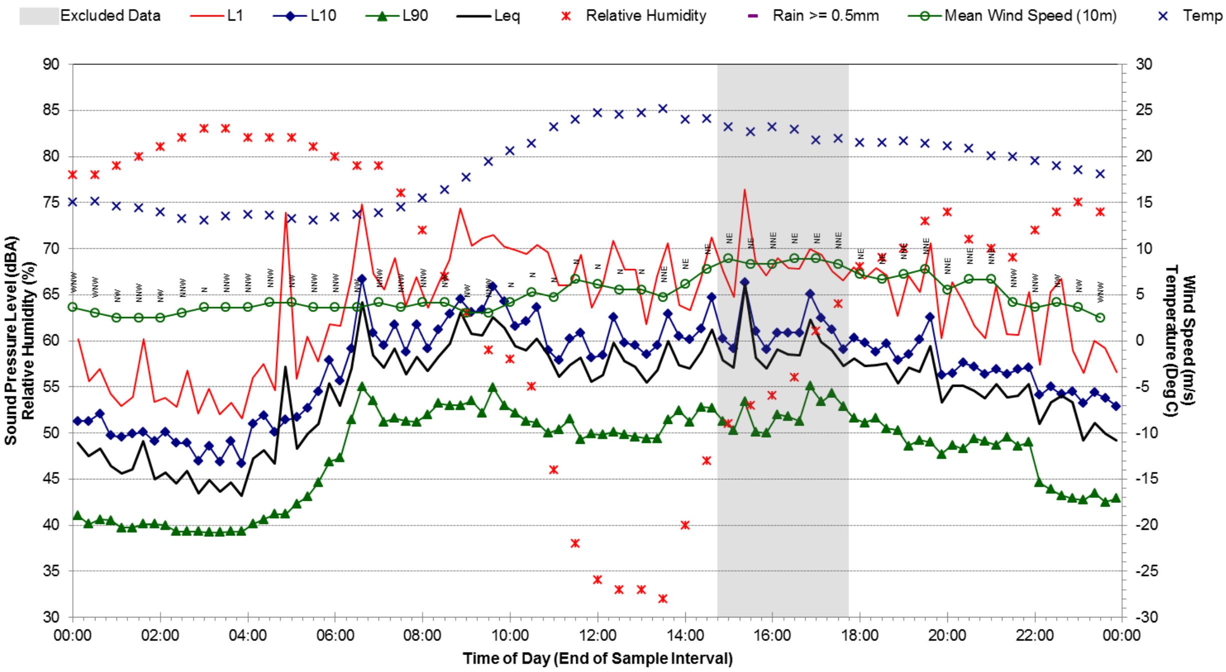
Statistical Ambient Noise Levels

Location 2 - Sunday, 6 May 2018



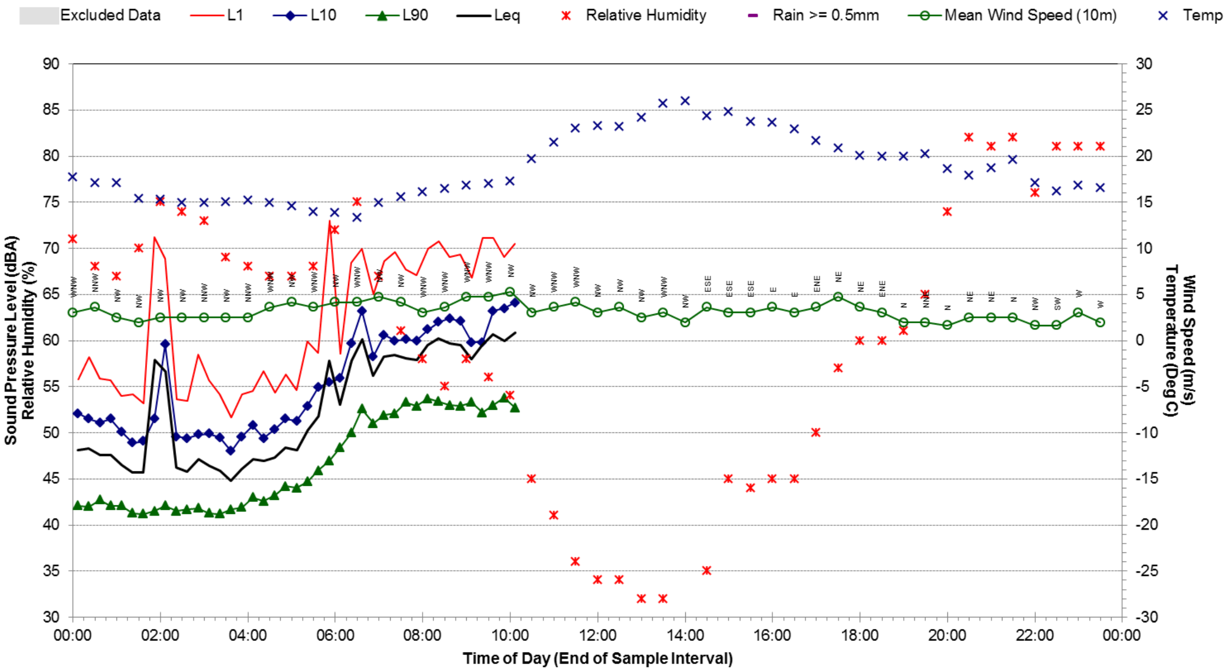
Statistical Ambient Noise Levels

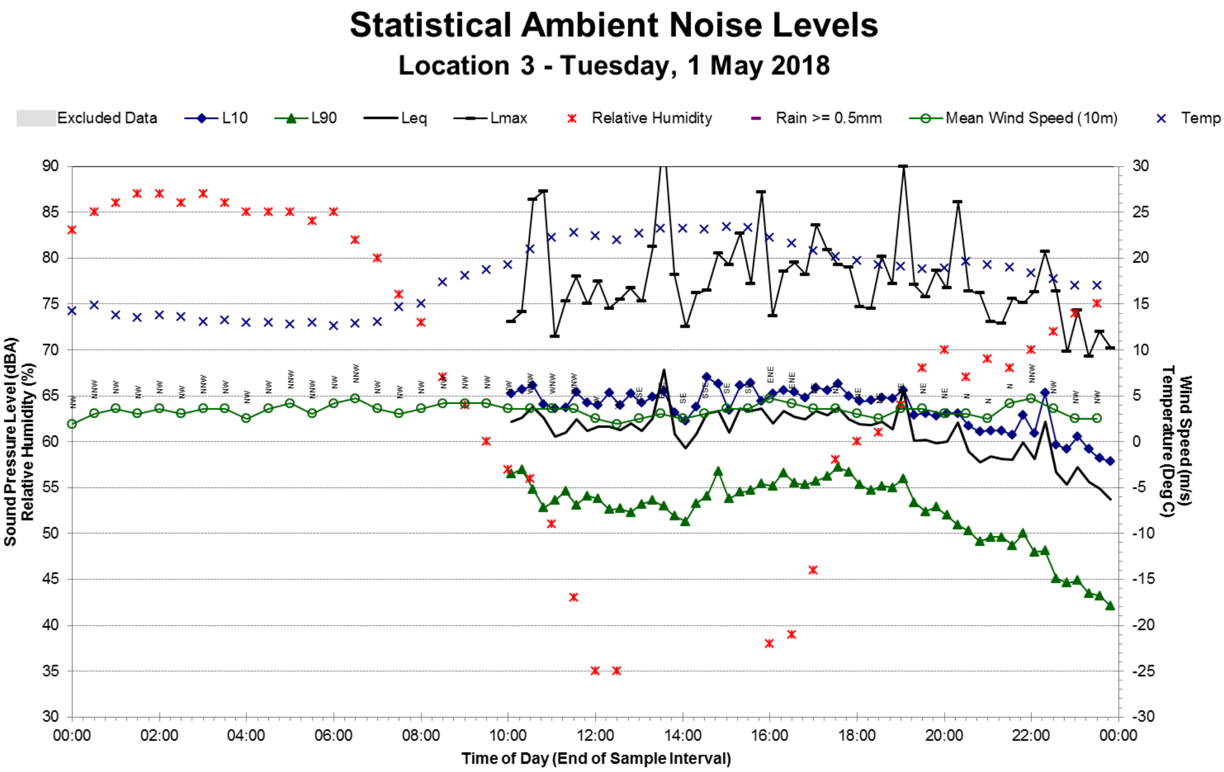
Location 2 - Monday, 7 May 2018

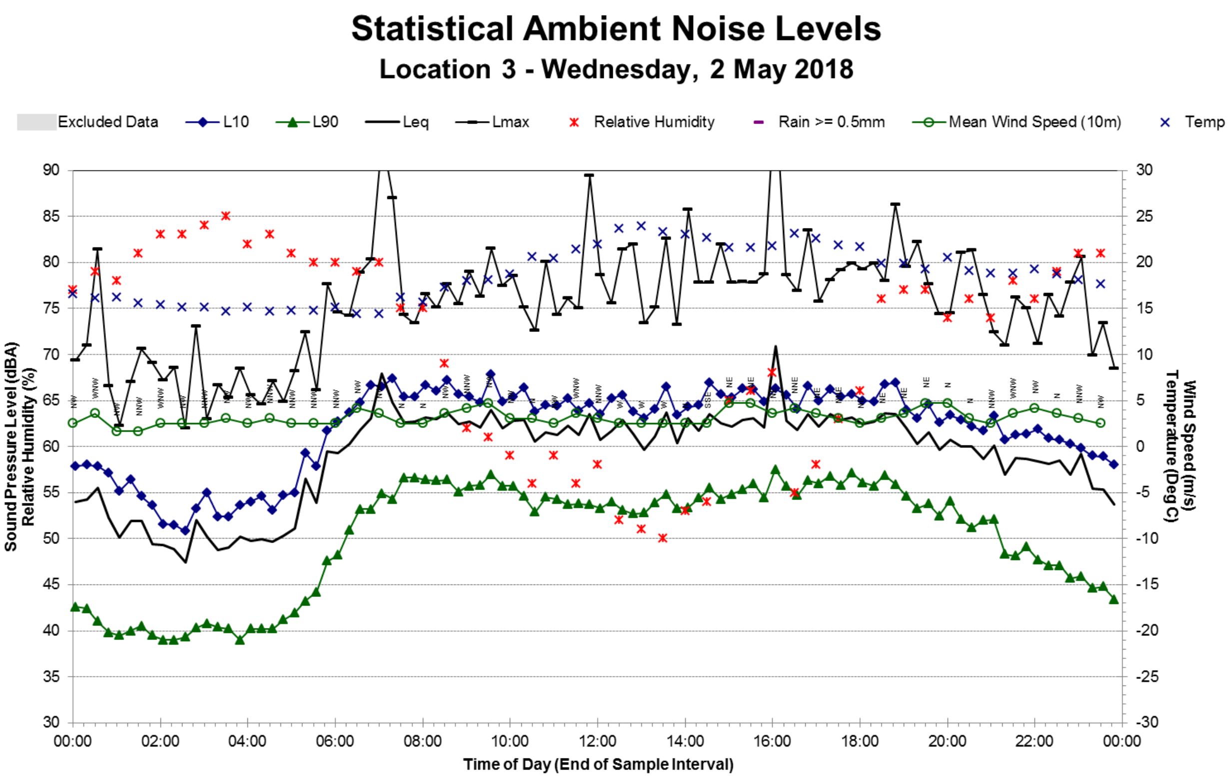


Statistical Ambient Noise Levels

Location 2 - Tuesday, 8 May 2018

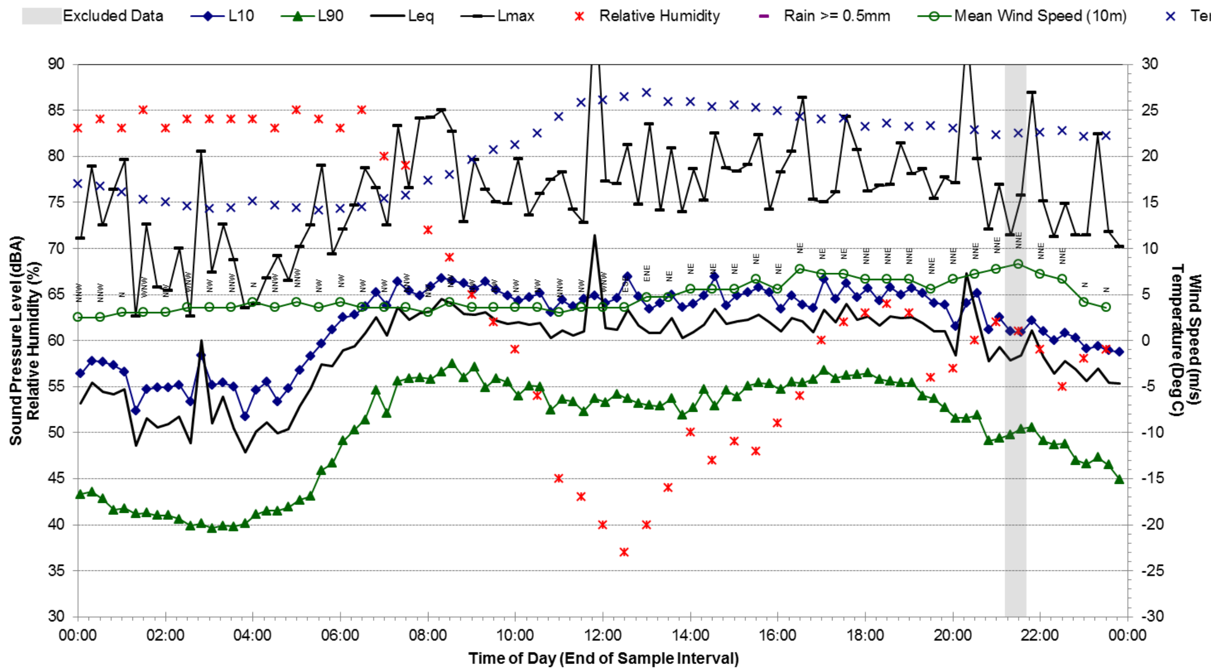



Statistical Ambient Noise Levels
Location 3 - Tuesday, 1 May 2018
Excluded Data
L10
L90
Leq
Lmax
Relative Humidity
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
Location 3 - Wednesday, 2 May 2018
Excluded Data
L10
L90
Leq
Lmax
Relative Humidity
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

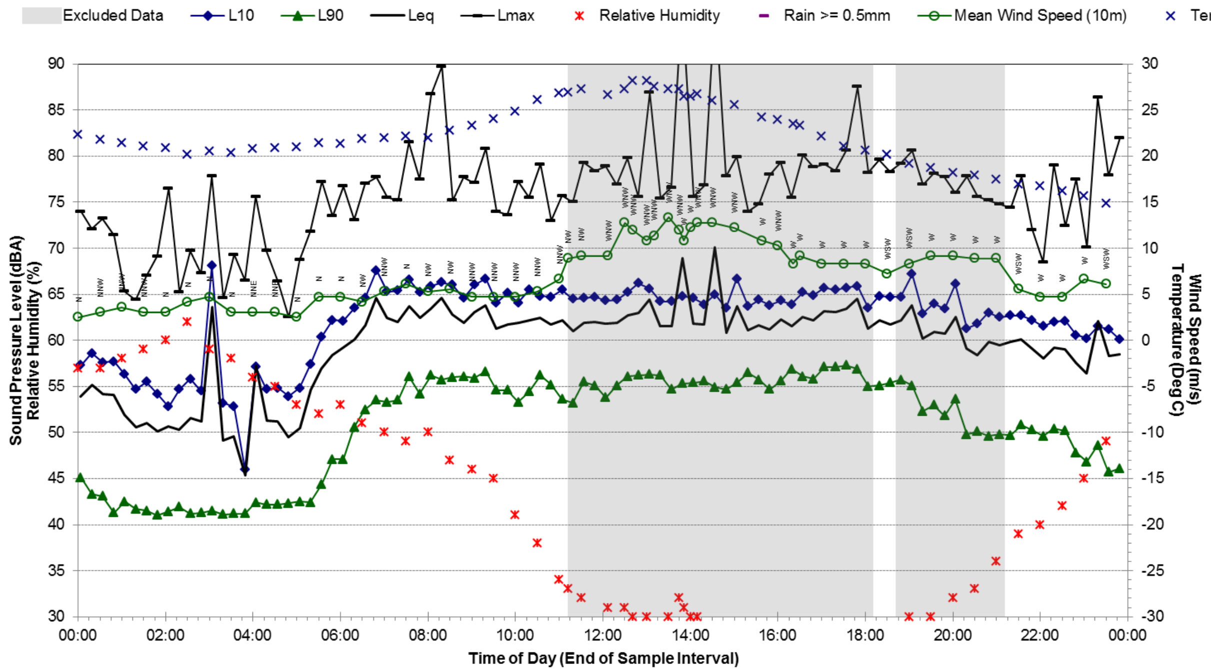
Statistical Ambient Noise Levels

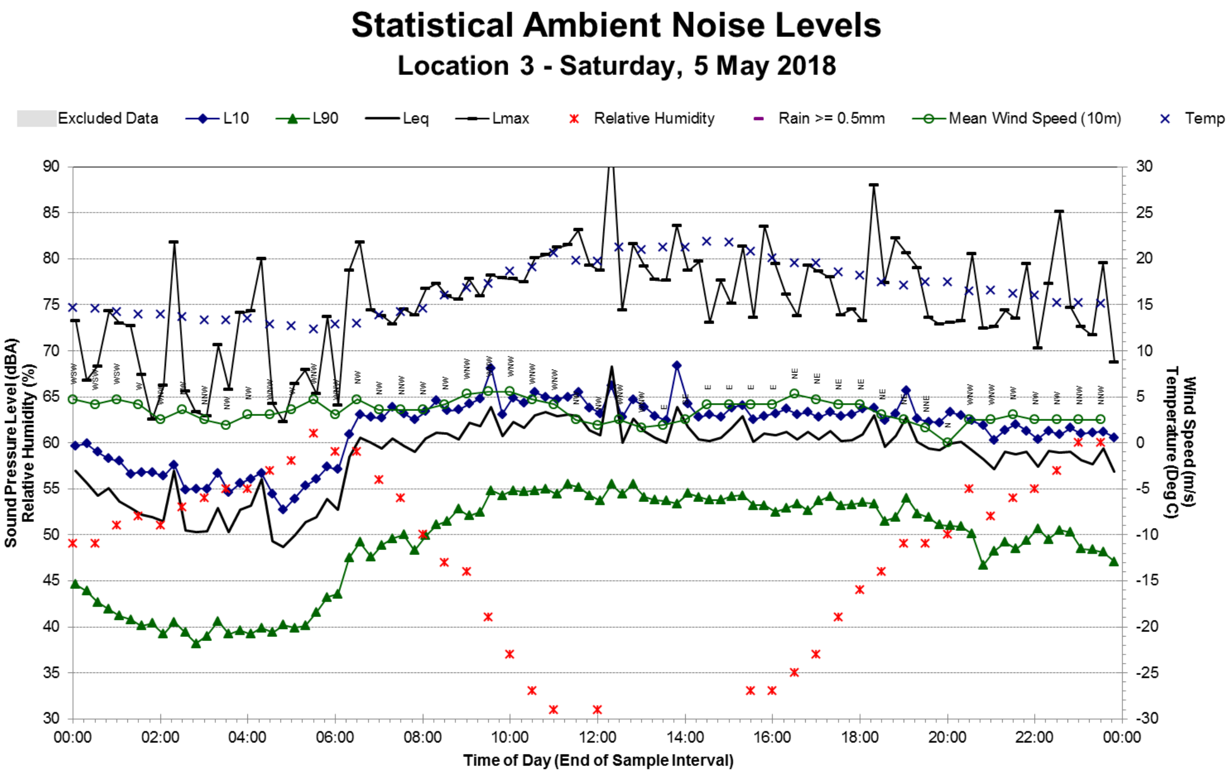
Location 3 - Thursday, 3 May 2018

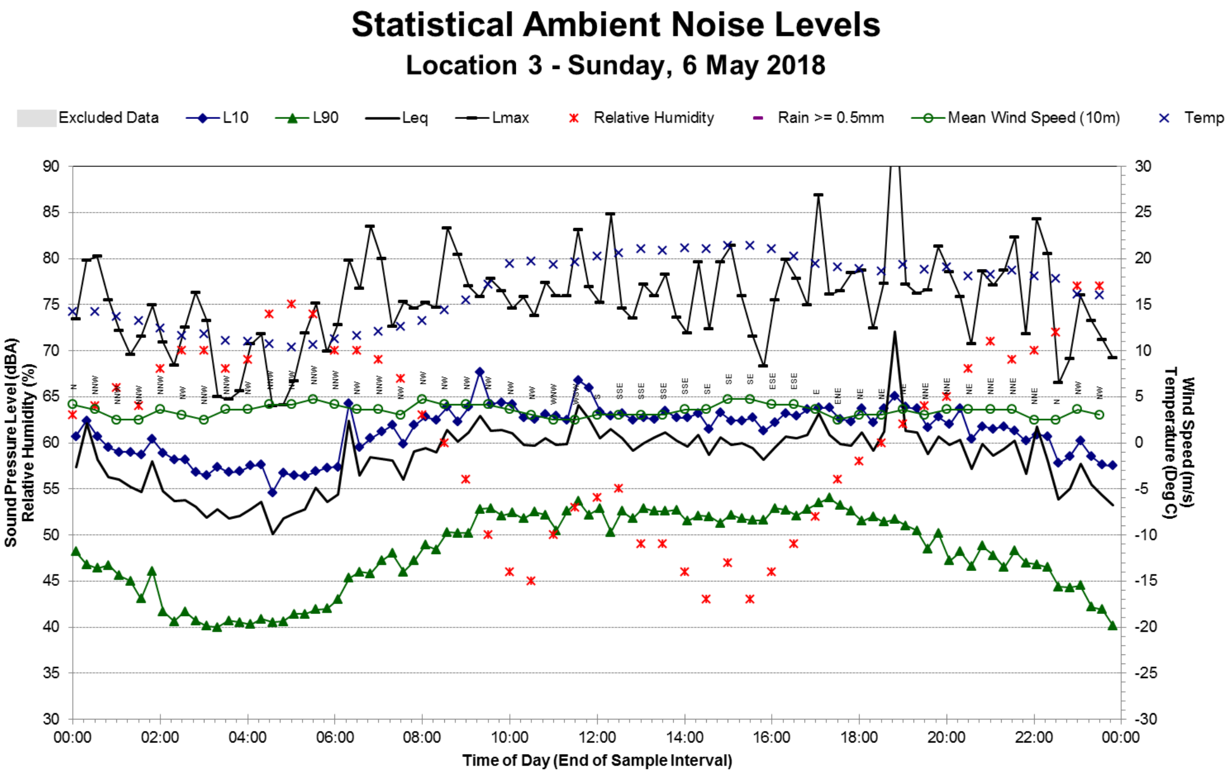


Statistical Ambient Noise Levels

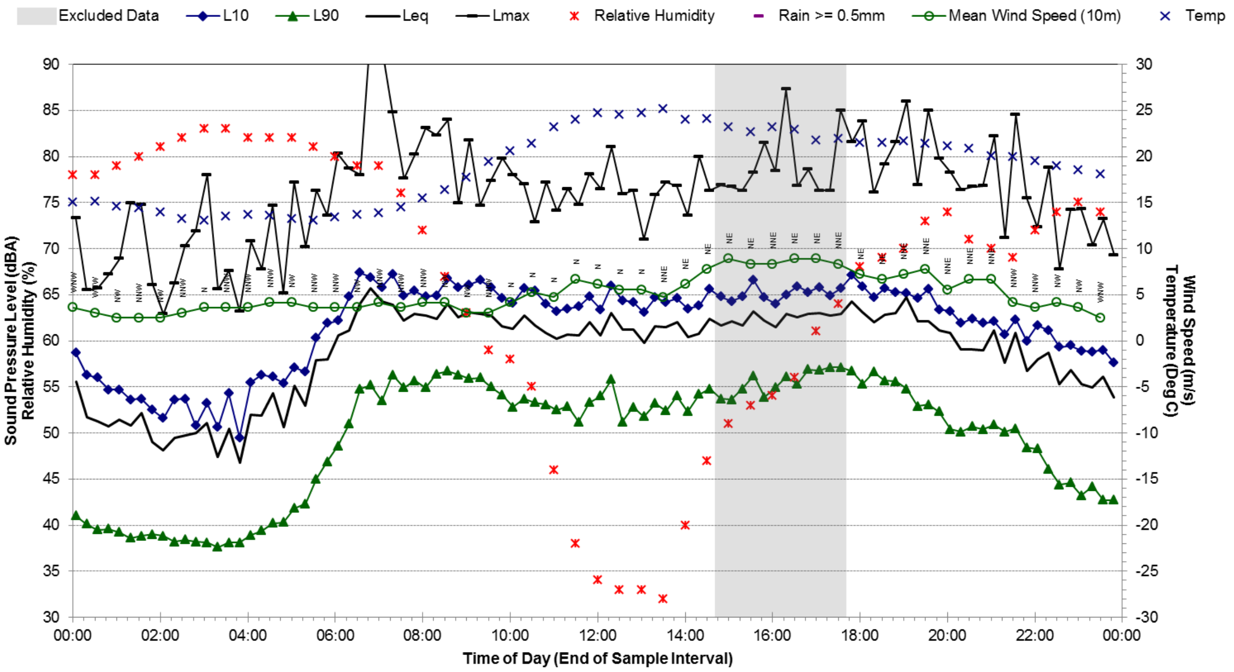
Location 3 - Friday, 4 May 2018



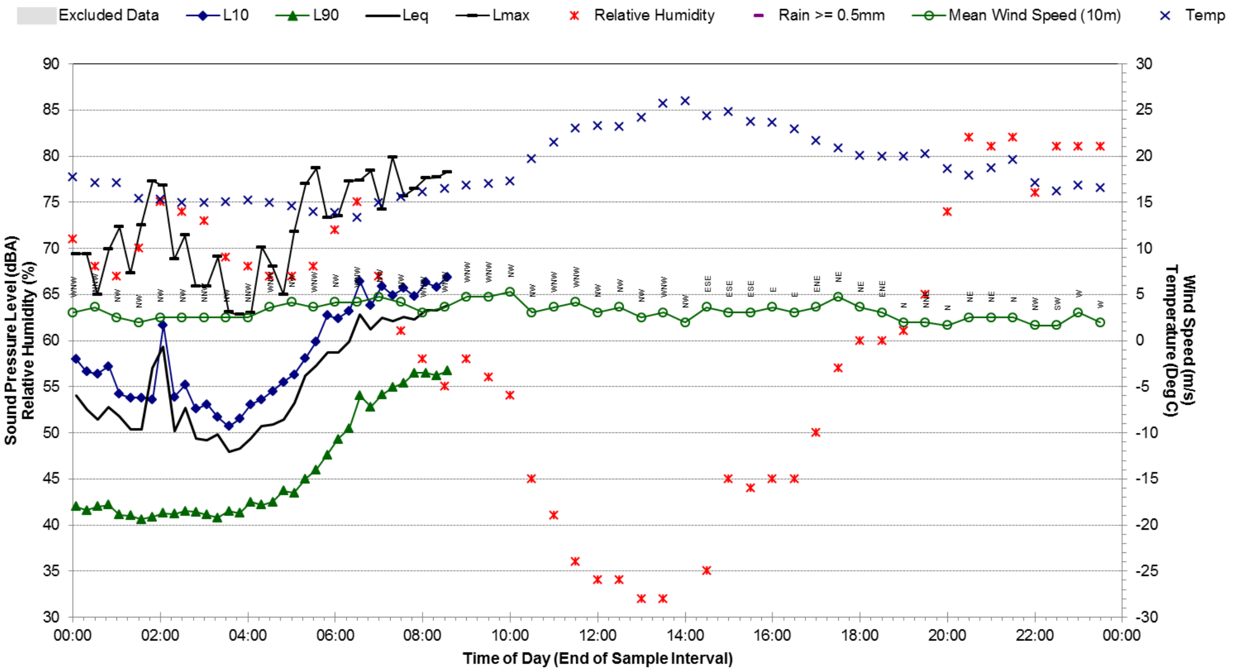

Statistical Ambient Noise Levels
Location 3 - Saturday, 5 May 2018
Excluded Data
L10
L90
Leq
Lmax
Relative Humidity
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
Location 3 - Sunday, 6 May 2018
Excluded Data
L10
L90
Leq
Lmax
Relative Humidity
Rain >= 0.5mm
Mean Wind Speed (10m)
Temp
Sound Pressure Level (dBA)
Relative Humidity (%)
Wind Speed (m/s)
Temperature (Deg C)
Time of Day (End of Sample Interval)

Statistical Ambient Noise Levels
Location 3 - Monday, 7 May 2018



Statistical Ambient Noise Levels
Location 3 - Tuesday, 8 May 2018



APPENDIX C

Predicted Facade Noise Levels

Floor	Facade	Daytime (7:00 am to 10:00 pm)[2]		Night-time (10:00 pm to 7:00 am) [2]	
		LAeq(15hour)	LAeq(1hour)[1]	LAeq(9hour)	LAeq(1hour) [1]
Building 1					
Ground	W	70 dBA	72 dBA	65 dBA	67 dBA
Level 1	W	70 dBA	72 dBA	65 dBA	67 dBA
Level 2	W	69 dBA	71 dBA	64 dBA	67 dBA
Level 3	W	69 dBA	70 dBA	63 dBA	66 dBA
Level 4	W	68 dBA	70 dBA	63 dBA	65 dBA
Level 5	W	58 dBA	60 dBA	52 dBA	55 dBA
Level 6	W	55 dBA	57 dBA	49 dBA	52 dBA
Ground	N	61 dBA	63 dBA	56 dBA	59 dBA
Level 1	N	65 dBA	67 dBA	60 dBA	62 dBA
Level 2	N	65 dBA	66 dBA	59 dBA	62 dBA
Level 3	N	64 dBA	66 dBA	59 dBA	62 dBA
Level 4	N	64 dBA	66 dBA	59 dBA	62 dBA
Level 5	N	63 dBA	65 dBA	58 dBA	61 dBA
Level 6	N	62 dBA	64 dBA	57 dBA	59 dBA
Ground	E	43 dBA	45 dBA	38 dBA	40 dBA
Level 1	E	52 dBA	54 dBA	47 dBA	49 dBA
Level 2	E	52 dBA	54 dBA	47 dBA	49 dBA
Level 3	E	52 dBA	54 dBA	47 dBA	49 dBA
Level 4	E	52 dBA	54 dBA	47 dBA	49 dBA
Level 5	E	51 dBA	53 dBA	46 dBA	48 dBA
Level 6	E	48 dBA	50 dBA	42 dBA	45 dBA
Ground	S	61 dBA	62 dBA	55 dBA	58 dBA
Level 1	S	65 dBA	67 dBA	60 dBA	63 dBA
Level 2	S	64 dBA	66 dBA	59 dBA	62 dBA
Level 3	S	64 dBA	66 dBA	59 dBA	61 dBA
Level 4	S	64 dBA	65 dBA	58 dBA	61 dBA
Level 5	S	62 dBA	64 dBA	57 dBA	60 dBA
Level 6	S	60 dBA	62 dBA	55 dBA	58 dBA
Building 2					
Ground	W	70 dBA	72 dBA	65 dBA	68 dBA
Level 1	W	70 dBA	72 dBA	65 dBA	67 dBA
Level 2	W	69 dBA	71 dBA	64 dBA	67 dBA
Level 3	W	69 dBA	70 dBA	63 dBA	66 dBA
Level 4	W	68 dBA	70 dBA	63 dBA	65 dBA
Level 5	W	60 dBA	61 dBA	54 dBA	56 dBA
Level 6	W	54 dBA	56 dBA	48 dBA	51 dBA

Floor	Facade	Daytime (7:00 am to 10:00 pm)[2]		Night-time (10:00 pm to 7:00 am) [2]	
		LAeq(15hour)	LAeq(1hour)[1]	LAeq(9hour)	LAeq(1hour) [1]
Ground	N	63 dBA	64 dBA	58 dBA	60 dBA
Level 1	N	64 dBA	66 dBA	59 dBA	62 dBA
Level 2	N	64 dBA	66 dBA	59 dBA	62 dBA
Level 3	N	63 dBA	65 dBA	58 dBA	61 dBA
Level 4	N	63 dBA	65 dBA	58 dBA	61 dBA
Level 5	N	62 dBA	64 dBA	57 dBA	60 dBA
Level 6	N	59 dBA	61 dBA	54 dBA	57 dBA
Ground	E	51 dBA	53 dBA	45 dBA	47 dBA
Level 1	E	51 dBA	52 dBA	44 dBA	47 dBA
Level 2	E	51 dBA	52 dBA	44 dBA	47 dBA
Level 3	E	50 dBA	52 dBA	44 dBA	46 dBA
Level 4	E	50 dBA	52 dBA	44 dBA	47 dBA
Level 5	E	50 dBA	51 dBA	43 dBA	46 dBA
Level 6	E	49 dBA	51 dBA	43 dBA	46 dBA
Ground	S	63 dBA	65 dBA	58 dBA	60 dBA
Level 1	S	65 dBA	66 dBA	59 dBA	62 dBA
Level 2	S	64 dBA	66 dBA	59 dBA	62 dBA
Level 3	S	64 dBA	65 dBA	59 dBA	61 dBA
Level 4	S	63 dBA	65 dBA	58 dBA	61 dBA
Level 5	S	62 dBA	64 dBA	57 dBA	60 dBA
Level 6	S	61 dBA	63 dBA	56 dBA	58 dBA
Building 3					
Ground	W	70 dBA	72 dBA	65 dBA	67 dBA
Level 1	W	70 dBA	72 dBA	65 dBA	67 dBA
Level 2	W	69 dBA	71 dBA	64 dBA	66 dBA
Level 3	W	69 dBA	70 dBA	63 dBA	66 dBA
Level 4	W	68 dBA	70 dBA	63 dBA	65 dBA
Level 5	W	59 dBA	60 dBA	53 dBA	55 dBA
Level 6	W	55 dBA	57 dBA	50 dBA	52 dBA
Ground	N	64 dBA	66 dBA	59 dBA	61 dBA
Level 1	N	65 dBA	67 dBA	60 dBA	63 dBA
Level 2	N	64 dBA	66 dBA	59 dBA	62 dBA
Level 3	N	64 dBA	66 dBA	59 dBA	61 dBA
Level 4	N	64 dBA	65 dBA	58 dBA	61 dBA
Level 5	N	62 dBA	64 dBA	57 dBA	60 dBA
Level 6	N	60 dBA	62 dBA	55 dBA	58 dBA
Ground	E	59 dBA	61 dBA	53 dBA	55 dBA

Floor	Facade	Daytime (7:00 am to 10:00 pm)[2]		Night-time (10:00 pm to 7:00 am)[2]	
		LAeq(15hour)	LAeq(1hour)[1]	LAeq(9hour)	LAeq(1hour)[1]
Level 1	E	61 dBA	63 dBA	55 dBA	58 dBA
Level 2	E	61 dBA	63 dBA	55 dBA	57 dBA
Level 3	E	61 dBA	63 dBA	55 dBA	57 dBA
Level 4	E	61 dBA	63 dBA	55 dBA	57 dBA
Level 5	E	60 dBA	62 dBA	54 dBA	56 dBA
Level 6	E	58 dBA	60 dBA	52 dBA	55 dBA
Ground	S	67 dBA	69 dBA	61 dBA	64 dBA
Level 1	S	70 dBA	71 dBA	64 dBA	66 dBA
Level 2	S	69 dBA	71 dBA	63 dBA	66 dBA
Level 3	S	69 dBA	70 dBA	63 dBA	65 dBA
Level 4	S	68 dBA	70 dBA	62 dBA	65 dBA
Level 5	S	67 dBA	69 dBA	61 dBA	64 dBA
Level 6	S	66 dBA	67 dBA	60 dBA	62 dBA
Building 4					
Ground	W	59 dBA	61 dBA	53 dBA	55 dBA
Level 1	W	60 dBA	62 dBA	54 dBA	56 dBA
Level 2	W	61 dBA	63 dBA	55 dBA	58 dBA
Level 3	W	61 dBA	63 dBA	55 dBA	58 dBA
Level 4	W	61 dBA	62 dBA	55 dBA	57 dBA
Level 5	W	60 dBA	62 dBA	54 dBA	57 dBA
Level 6	W	52 dBA	54 dBA	47 dBA	49 dBA
Ground	N	51 dBA	53 dBA	46 dBA	49 dBA
Level 1	N	52 dBA	54 dBA	47 dBA	49 dBA
Level 2	N	52 dBA	54 dBA	47 dBA	50 dBA
Level 3	N	52 dBA	54 dBA	47 dBA	50 dBA
Level 4	N	52 dBA	54 dBA	47 dBA	49 dBA
Level 5	N	52 dBA	54 dBA	47 dBA	49 dBA
Level 6	N	51 dBA	53 dBA	46 dBA	49 dBA
Ground	E	58 dBA	60 dBA	51 dBA	54 dBA
Level 1	E	58 dBA	60 dBA	52 dBA	54 dBA
Level 2	E	58 dBA	60 dBA	52 dBA	54 dBA
Level 3	E	58 dBA	60 dBA	52 dBA	54 dBA
Level 4	E	57 dBA	59 dBA	51 dBA	53 dBA
Level 5	E	57 dBA	58 dBA	50 dBA	53 dBA
Level 6	E	48 dBA	50 dBA	43 dBA	45 dBA
Ground	S	63 dBA	65 dBA	57 dBA	59 dBA
Level 1	S	63 dBA	65 dBA	57 dBA	60 dBA

Floor	Facade	Daytime (7:00 am to 10:00 pm)[2]		Night-time (10:00 pm to 7:00 am) [2]	
		LAeq(15hour)	LAeq(1hour)[1]	LAeq(9hour)	LAeq(1hour) [1]
Level 2	S	63 dBA	65 dBA	57 dBA	59 dBA
Level 3	S	63 dBA	65 dBA	57 dBA	59 dBA
Level 4	S	63 dBA	65 dBA	57 dBA	59 dBA
Level 5	S	62 dBA	64 dBA	56 dBA	59 dBA
Level 6	S	52 dBA	54 dBA	47 dBA	49 dBA
Building 5					
Ground	W	50 dBA	52 dBA	45 dBA	47 dBA
Level 1	W	51 dBA	52 dBA	45 dBA	48 dBA
Level 2	W	52 dBA	54 dBA	47 dBA	50 dBA
Level 3	W	53 dBA	55 dBA	48 dBA	50 dBA
Level 4	W	53 dBA	55 dBA	48 dBA	51 dBA
Level 5	W	53 dBA	55 dBA	48 dBA	51 dBA
Ground	N	49 dBA	51 dBA	44 dBA	46 dBA
Level 1	N	50 dBA	51 dBA	45 dBA	47 dBA
Level 2	N	51 dBA	53 dBA	46 dBA	49 dBA
Level 3	N	51 dBA	53 dBA	47 dBA	49 dBA
Level 4	N	51 dBA	53 dBA	46 dBA	49 dBA
Level 5	N	51 dBA	53 dBA	46 dBA	48 dBA
Ground	E	53 dBA	55 dBA	47 dBA	49 dBA
Level 1	E	53 dBA	55 dBA	47 dBA	49 dBA
Level 2	E	53 dBA	55 dBA	46 dBA	49 dBA
Level 3	E	52 dBA	54 dBA	46 dBA	48 dBA
Level 4	E	52 dBA	54 dBA	46 dBA	48 dBA
Level 5	E	49 dBA	50 dBA	42 dBA	45 dBA
Ground	S	51 dBA	53 dBA	46 dBA	48 dBA
Level 1	S	53 dBA	55 dBA	47 dBA	50 dBA
Level 2	S	53 dBA	55 dBA	47 dBA	50 dBA
Level 3	S	53 dBA	55 dBA	47 dBA	50 dBA
Level 4	S	52 dBA	54 dBA	47 dBA	49 dBA
Level 5	S	51 dBA	53 dBA	46 dBA	48 dBA
Building 6					
Level 1	W	57 dBA	59 dBA	52 dBA	54 dBA
Level 2	W	56 dBA	58 dBA	51 dBA	54 dBA
Level 3	W	56 dBA	58 dBA	51 dBA	54 dBA
Level 4	W	56 dBA	58 dBA	51 dBA	54 dBA
Level 5	W	56 dBA	58 dBA	51 dBA	53 dBA
Level 6	W	56 dBA	58 dBA	51 dBA	53 dBA

Floor	Facade	Daytime (7:00 am to 10:00 pm)[2]		Night-time (10:00 pm to 7:00 am) [2]	
		LAeq(15hour)	LAeq(1hour)[1]	LAeq(9hour)	LAeq(1hour) [1]
Level 7	W	55 dBA	57 dBA	50 dBA	53 dBA
Level 8	W	56 dBA	58 dBA	51 dBA	53 dBA
Level 9	W	56 dBA	58 dBA	51 dBA	54 dBA
Level 10	W	57 dBA	58 dBA	51 dBA	54 dBA
Level 11	W	57 dBA	59 dBA	52 dBA	54 dBA
Level 12	W	57 dBA	59 dBA	52 dBA	54 dBA
Level 13	W	57 dBA	59 dBA	52 dBA	54 dBA
Ground	N	56 dBA	57 dBA	51 dBA	53 dBA
Level 1	N	56 dBA	58 dBA	51 dBA	53 dBA
Level 2	N	56 dBA	58 dBA	51 dBA	53 dBA
Level 3	N	56 dBA	58 dBA	51 dBA	53 dBA
Level 4	N	56 dBA	58 dBA	51 dBA	53 dBA
Level 5	N	55 dBA	57 dBA	50 dBA	53 dBA
Level 6	N	55 dBA	57 dBA	50 dBA	52 dBA
Level 7	N	52 dBA	54 dBA	47 dBA	50 dBA
Level 8	N	55 dBA	56 dBA	49 dBA	52 dBA
Level 9	N	55 dBA	57 dBA	50 dBA	52 dBA
Level 10	N	55 dBA	57 dBA	50 dBA	52 dBA
Level 11	N	55 dBA	57 dBA	50 dBA	52 dBA
Level 12	N	55 dBA	57 dBA	50 dBA	52 dBA
Level 13	N	55 dBA	57 dBA	50 dBA	52 dBA
Ground	E	49 dBA	50 dBA	43 dBA	45 dBA
Level 1	E	49 dBA	51 dBA	43 dBA	46 dBA
Level 2	E	49 dBA	51 dBA	44 dBA	46 dBA
Level 3	E	49 dBA	51 dBA	43 dBA	46 dBA
Level 4	E	48 dBA	49 dBA	41 dBA	44 dBA
Level 5	E	47 dBA	49 dBA	41 dBA	44 dBA
Level 6	E	47 dBA	49 dBA	41 dBA	44 dBA
Level 7	E	46 dBA	48 dBA	40 dBA	42 dBA
Level 8	E	46 dBA	48 dBA	40 dBA	42 dBA
Level 9	E	46 dBA	48 dBA	40 dBA	42 dBA
Level 10	E	46 dBA	47 dBA	39 dBA	42 dBA
Level 11	E	46 dBA	47 dBA	39 dBA	42 dBA
Level 12	E	46 dBA	47 dBA	39 dBA	42 dBA
Level 13	E	46 dBA	47 dBA	39 dBA	42 dBA
Ground	S	47 dBA	49 dBA	42 dBA	44 dBA
Level 1	S	48 dBA	50 dBA	43 dBA	45 dBA

Floor	Facade	Daytime (7:00 am to 10:00 pm)[2]		Night-time (10:00 pm to 7:00 am) [2]	
		LAeq(15hour)	LAeq(1hour)[1]	LAeq(9hour)	LAeq(1hour) [1]
Level 2	S	48 dBA	50 dBA	43 dBA	46 dBA
Level 3	S	48 dBA	50 dBA	43 dBA	46 dBA
Level 4	S	48 dBA	50 dBA	43 dBA	45 dBA
Level 5	S	48 dBA	50 dBA	43 dBA	45 dBA
Level 6	S	49 dBA	51 dBA	43 dBA	46 dBA
Level 7	S	47 dBA	49 dBA	41 dBA	43 dBA
Level 8	S	49 dBA	51 dBA	43 dBA	46 dBA
Level 9	S	50 dBA	51 dBA	44 dBA	46 dBA
Level 10	S	50 dBA	52 dBA	44 dBA	47 dBA
Level 11	S	50 dBA	52 dBA	44 dBA	47 dBA
Level 12	S	51 dBA	53 dBA	45 dBA	47 dBA
Level 13	S	51 dBA	53 dBA	45 dBA	47 dBA

Note 1: Maximum repeatable LAeq(1hour) in accordance with City of Sydney DCP 2012 requirements.

Note 2: Includes façade correction calculated in SoundPlan.

APPENDIX D

Predicted Internal Noise Levels and Traffic Noise Reduction

Road Traffic Noise Level above Criteria					
0-10 dB	Can comply with windows open	10-20 dB	Consideration of screened openings (**Section 6.3.2.1**) or acoustically attenuated openings (**Section 6.3.2.2**)	20 dB+	Acoustically attenuated openings required (**Section 6.3.2.2**)

Floor	Direction	Traffic Noise Reduction (TNR)				
		Daytime			Night-time	
		$L_{Aeq(1hour)}$		$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	
		Windows Open	Window Closed	Window Closed	Windows Open	Windows Closed
Building 1						
Ground	W	17 dB	27 dB	30 dB	22 dB	32 dB
Level 1	W	17 dB	27 dB	30 dB	22 dB	32 dB
Level 2	W	16 dB	26 dB	29 dB	22 dB	32 dB
Level 3	W	15 dB	25 dB	29 dB	21 dB	31 dB
Level 4	W	15 dB	25 dB	28 dB	20 dB	30 dB
Level 5	W	5 dB	15 dB	18 dB	10 dB	20 dB
Level 6	W	2 dB	12 dB	15 dB	7 dB	17 dB
Ground	N	8 dB	18 dB	21 dB	14 dB	24 dB
Level 1	N	12 dB	22 dB	25 dB	17 dB	27 dB
Level 2	N	11 dB	21 dB	25 dB	17 dB	27 dB
Level 3	N	11 dB	21 dB	24 dB	17 dB	27 dB
Level 4	N	11 dB	21 dB	24 dB	17 dB	27 dB
Level 5	N	10 dB	20 dB	23 dB	16 dB	26 dB
Level 6	N	9 dB	19 dB	22 dB	14 dB	24 dB
Ground	E	0 dB	0 dB	3 dB	0 dB	5 dB
Level 1	E	0 dB	9 dB	12 dB	4 dB	14 dB
Level 2	E	0 dB	9 dB	12 dB	4 dB	14 dB
Level 3	E	0 dB	9 dB	12 dB	4 dB	14 dB
Level 4	E	0 dB	9 dB	12 dB	4 dB	14 dB
Level 5	E	0 dB	8 dB	11 dB	3 dB	13 dB
Level 6	E	0 dB	5 dB	8 dB	0 dB	10 dB
Ground	S	7 dB	17 dB	21 dB	13 dB	23 dB
Level 1	S	12 dB	22 dB	25 dB	18 dB	28 dB
Level 2	S	11 dB	21 dB	24 dB	17 dB	27 dB
Level 3	S	11 dB	21 dB	24 dB	16 dB	26 dB
Level 4	S	10 dB	20 dB	24 dB	16 dB	26 dB
Level 5	S	9 dB	19 dB	22 dB	15 dB	25 dB
Level 6	S	7 dB	17 dB	20 dB	13 dB	23 dB
Building 2						

Floor	Direction	Traffic Noise Reduction (TNR)				
		Daytime			Night-time	
		$L_{Aeq(1hour)}$		$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	
		Windows Open	Window Closed	Window Closed	Windows Open	Windows Closed
Ground	W	17 dB	27 dB	30 dB	23 dB	33 dB
Level 1	W	17 dB	27 dB	30 dB	22 dB	32 dB
Level 2	W	16 dB	26 dB	29 dB	22 dB	32 dB
Level 3	W	15 dB	25 dB	29 dB	21 dB	31 dB
Level 4	W	15 dB	25 dB	28 dB	20 dB	30 dB
Level 5	W	6 dB	16 dB	20 dB	11 dB	21 dB
Level 6	W	1 dB	11 dB	14 dB	6 dB	16 dB
Ground	N	9 dB	19 dB	23 dB	15 dB	25 dB
Level 1	N	11 dB	21 dB	24 dB	17 dB	27 dB
Level 2	N	11 dB	21 dB	24 dB	17 dB	27 dB
Level 3	N	10 dB	20 dB	23 dB	16 dB	26 dB
Level 4	N	10 dB	20 dB	23 dB	16 dB	26 dB
Level 5	N	9 dB	19 dB	22 dB	15 dB	25 dB
Level 6	N	6 dB	16 dB	19 dB	12 dB	22 dB
Ground	E	0 dB	8 dB	11 dB	2 dB	12 dB
Level 1	E	0 dB	7 dB	11 dB	2 dB	12 dB
Level 2	E	0 dB	7 dB	11 dB	2 dB	12 dB
Level 3	E	0 dB	7 dB	10 dB	1 dB	11 dB
Level 4	E	0 dB	7 dB	10 dB	2 dB	12 dB
Level 5	E	0 dB	6 dB	10 dB	1 dB	11 dB
Level 6	E	0 dB	6 dB	9 dB	1 dB	11 dB
Ground	S	10 dB	20 dB	23 dB	15 dB	25 dB
Level 1	S	11 dB	21 dB	25 dB	17 dB	27 dB
Level 2	S	11 dB	21 dB	24 dB	17 dB	27 dB
Level 3	S	10 dB	20 dB	24 dB	16 dB	26 dB
Level 4	S	10 dB	20 dB	23 dB	16 dB	26 dB
Level 5	S	9 dB	19 dB	22 dB	15 dB	25 dB
Level 6	S	8 dB	18 dB	21 dB	13 dB	23 dB
Building 3						
Ground	W	17 dB	27 dB	30 dB	22 dB	32 dB
Level 1	W	17 dB	27 dB	30 dB	22 dB	32 dB
Level 2	W	16 dB	26 dB	29 dB	21 dB	31 dB
Level 3	W	15 dB	25 dB	29 dB	21 dB	31 dB
Level 4	W	15 dB	25 dB	28 dB	20 dB	30 dB
Level 5	W	5 dB	15 dB	19 dB	10 dB	20 dB

Floor	Direction	Traffic Noise Reduction (TNR)				
		Daytime			Night-time	
		$L_{Aeq(1hour)}$		$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	
		Windows Open	Window Closed	Window Closed	Windows Open	Windows Closed
Level 6	W	2 dB	12 dB	15 dB	7 dB	17 dB
Ground	N	11 dB	21 dB	24 dB	16 dB	26 dB
Level 1	N	12 dB	22 dB	25 dB	18 dB	28 dB
Level 2	N	11 dB	21 dB	24 dB	17 dB	27 dB
Level 3	N	11 dB	21 dB	24 dB	16 dB	26 dB
Level 4	N	10 dB	20 dB	24 dB	16 dB	26 dB
Level 5	N	9 dB	19 dB	22 dB	15 dB	25 dB
Level 6	N	7 dB	17 dB	20 dB	13 dB	23 dB
Ground	E	6 dB	16 dB	19 dB	10 dB	20 dB
Level 1	E	8 dB	18 dB	21 dB	13 dB	23 dB
Level 2	E	8 dB	18 dB	21 dB	12 dB	22 dB
Level 3	E	8 dB	18 dB	21 dB	12 dB	22 dB
Level 4	E	8 dB	18 dB	21 dB	12 dB	22 dB
Level 5	E	7 dB	17 dB	20 dB	11 dB	21 dB
Level 6	E	5 dB	15 dB	18 dB	10 dB	20 dB
Ground	S	14 dB	24 dB	27 dB	19 dB	29 dB
Level 1	S	16 dB	26 dB	30 dB	21 dB	31 dB
Level 2	S	16 dB	26 dB	29 dB	21 dB	31 dB
Level 3	S	15 dB	25 dB	29 dB	20 dB	30 dB
Level 4	S	15 dB	25 dB	28 dB	20 dB	30 dB
Level 5	S	14 dB	24 dB	27 dB	19 dB	29 dB
Level 6	S	12 dB	22 dB	26 dB	17 dB	27 dB
Building 4						
Ground	W	6 dB	16 dB	19 dB	10 dB	20 dB
Level 1	W	7 dB	17 dB	20 dB	11 dB	21 dB
Level 2	W	8 dB	18 dB	21 dB	13 dB	23 dB
Level 3	W	8 dB	18 dB	21 dB	13 dB	23 dB
Level 4	W	7 dB	17 dB	21 dB	12 dB	22 dB
Level 5	W	7 dB	17 dB	20 dB	12 dB	22 dB
Level 6	W	0 dB	9 dB	12 dB	4 dB	14 dB
Ground	N	0 dB	8 dB	11 dB	4 dB	14 dB
Level 1	N	0 dB	9 dB	12 dB	4 dB	14 dB
Level 2	N	0 dB	9 dB	12 dB	5 dB	15 dB
Level 3	N	0 dB	9 dB	12 dB	5 dB	15 dB
Level 4	N	0 dB	9 dB	12 dB	4 dB	14 dB

Floor	Direction	Traffic Noise Reduction (TNR)				
		Daytime			Night-time	
		$L_{Aeq(1hour)}$		$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	
		Windows Open	Window Closed	Window Closed	Windows Open	Windows Closed
Level 5	N	0 dB	9 dB	12 dB	4 dB	14 dB
Level 6	N	0 dB	8 dB	11 dB	4 dB	14 dB
Ground	E	5 dB	15 dB	18 dB	9 dB	19 dB
Level 1	E	5 dB	15 dB	18 dB	9 dB	19 dB
Level 2	E	5 dB	15 dB	18 dB	9 dB	19 dB
Level 3	E	5 dB	15 dB	18 dB	9 dB	19 dB
Level 4	E	4 dB	14 dB	17 dB	8 dB	18 dB
Level 5	E	3 dB	13 dB	17 dB	8 dB	18 dB
Level 6	E	0 dB	5 dB	8 dB	0 dB	10 dB
Ground	S	10 dB	20 dB	23 dB	14 dB	24 dB
Level 1	S	10 dB	20 dB	23 dB	15 dB	25 dB
Level 2	S	10 dB	20 dB	23 dB	14 dB	24 dB
Level 3	S	10 dB	20 dB	23 dB	14 dB	24 dB
Level 4	S	10 dB	20 dB	23 dB	14 dB	24 dB
Level 5	S	9 dB	19 dB	22 dB	14 dB	24 dB
Level 6	S	0 dB	9 dB	12 dB	4 dB	14 dB
Building 5						
Ground	W	0 dB	7 dB	10 dB	2 dB	12 dB
Level 1	W	0 dB	7 dB	11 dB	3 dB	13 dB
Level 2	W	0 dB	9 dB	12 dB	5 dB	15 dB
Level 3	W	0 dB	10 dB	13 dB	5 dB	15 dB
Level 4	W	0 dB	10 dB	13 dB	6 dB	16 dB
Level 5	W	0 dB	10 dB	13 dB	6 dB	16 dB
Ground	N	0 dB	6 dB	9 dB	1 dB	11 dB
Level 1	N	0 dB	6 dB	10 dB	2 dB	12 dB
Level 2	N	0 dB	8 dB	11 dB	4 dB	14 dB
Level 3	N	0 dB	8 dB	11 dB	4 dB	14 dB
Level 4	N	0 dB	8 dB	11 dB	4 dB	14 dB
Level 5	N	0 dB	8 dB	11 dB	3 dB	13 dB
Ground	E	0 dB	10 dB	13 dB	4 dB	14 dB
Level 1	E	0 dB	10 dB	13 dB	4 dB	14 dB
Level 2	E	0 dB	10 dB	13 dB	4 dB	14 dB
Level 3	E	0 dB	9 dB	12 dB	3 dB	13 dB
Level 4	E	0 dB	9 dB	12 dB	3 dB	13 dB
Level 5	E	0 dB	5 dB	9 dB	0 dB	10 dB

Floor	Direction	Traffic Noise Reduction (TNR)				
		Daytime			Night-time	
		$L_{Aeq(1hour)}$		$L_{Aeq(15hour)}$	$L_{Aeq(1hour)}$	
		Windows Open	Window Closed	Window Closed	Windows Open	Windows Closed
Ground	S	0 dB	8 dB	11 dB	3 dB	13 dB
Level 1	S	0 dB	10 dB	13 dB	5 dB	15 dB
Level 2	S	0 dB	10 dB	13 dB	5 dB	15 dB
Level 3	S	0 dB	10 dB	13 dB	5 dB	15 dB
Level 4	S	0 dB	9 dB	12 dB	4 dB	14 dB
Level 5	S	0 dB	8 dB	11 dB	3 dB	13 dB
Building 6						
Level 1	W	4 dB	14 dB	17 dB	9 dB	19 dB
Level 2	W	3 dB	13 dB	16 dB	9 dB	19 dB
Level 3	W	3 dB	13 dB	16 dB	9 dB	19 dB
Level 4	W	3 dB	13 dB	16 dB	9 dB	19 dB
Level 5	W	3 dB	13 dB	16 dB	8 dB	18 dB
Level 6	W	3 dB	13 dB	16 dB	8 dB	18 dB
Level 7	W	2 dB	12 dB	15 dB	8 dB	18 dB
Level 8	W	3 dB	13 dB	16 dB	8 dB	18 dB
Level 9	W	3 dB	13 dB	16 dB	9 dB	19 dB
Level 10	W	3 dB	13 dB	17 dB	9 dB	19 dB
Level 11	W	4 dB	14 dB	17 dB	9 dB	19 dB
Level 12	W	4 dB	14 dB	17 dB	9 dB	19 dB
Level 13	W	4 dB	14 dB	17 dB	9 dB	19 dB
Ground	N	2 dB	12 dB	16 dB	8 dB	18 dB
Level 1	N	3 dB	13 dB	16 dB	8 dB	18 dB
Level 2	N	3 dB	13 dB	16 dB	8 dB	18 dB
Level 3	N	3 dB	13 dB	16 dB	8 dB	18 dB
Level 4	N	3 dB	13 dB	16 dB	8 dB	18 dB
Level 5	N	2 dB	12 dB	15 dB	8 dB	18 dB
Level 6	N	2 dB	12 dB	15 dB	7 dB	17 dB
Level 7	N	0 dB	9 dB	12 dB	5 dB	15 dB
Level 8	N	1 dB	11 dB	15 dB	7 dB	17 dB
Level 9	N	2 dB	12 dB	15 dB	7 dB	17 dB
Level 10	N	2 dB	12 dB	15 dB	7 dB	17 dB
Level 11	N	2 dB	12 dB	15 dB	7 dB	17 dB
Level 12	N	2 dB	12 dB	15 dB	7 dB	17 dB
Level 13	N	2 dB	12 dB	15 dB	7 dB	17 dB
Ground	E	0 dB	5 dB	9 dB	0 dB	10 dB

Floor	Direction	Traffic Noise Reduction (TNR)				
		Daytime			Night-time	
		LAeq(1hour)		LAeq(15hour)	LAeq(1hour)	
		Windows Open	Window Closed	Window Closed	Windows Open	Windows Closed
Level 1	E	0 dB	6 dB	9 dB	1 dB	11 dB
Level 2	E	0 dB	6 dB	9 dB	1 dB	11 dB
Level 3	E	0 dB	6 dB	9 dB	1 dB	11 dB
Level 4	E	0 dB	4 dB	8 dB	0 dB	9 dB
Level 5	E	0 dB	4 dB	7 dB	0 dB	9 dB
Level 6	E	0 dB	4 dB	7 dB	0 dB	9 dB
Level 7	E	0 dB	3 dB	6 dB	0 dB	7 dB
Level 8	E	0 dB	3 dB	6 dB	0 dB	7 dB
Level 9	E	0 dB	3 dB	6 dB	0 dB	7 dB
Level 10	E	0 dB	2 dB	6 dB	0 dB	7 dB
Level 11	E	0 dB	2 dB	6 dB	0 dB	7 dB
Level 12	E	0 dB	2 dB	6 dB	0 dB	7 dB
Level 13	E	0 dB	2 dB	6 dB	0 dB	7 dB
Ground	S	0 dB	4 dB	7 dB	0 dB	9 dB
Level 1	S	0 dB	5 dB	8 dB	0 dB	10 dB
Level 2	S	0 dB	5 dB	8 dB	1 dB	11 dB
Level 3	S	0 dB	5 dB	8 dB	1 dB	11 dB
Level 4	S	0 dB	5 dB	8 dB	0 dB	10 dB
Level 5	S	0 dB	5 dB	8 dB	0 dB	10 dB
Level 6	S	0 dB	6 dB	9 dB	1 dB	11 dB
Level 7	S	0 dB	4 dB	7 dB	0 dB	8 dB
Level 8	S	0 dB	6 dB	9 dB	1 dB	11 dB
Level 9	S	0 dB	6 dB	10 dB	1 dB	11 dB
Level 10	S	0 dB	7 dB	10 dB	2 dB	12 dB
Level 11	S	0 dB	7 dB	10 dB	2 dB	12 dB
Level 12	S	0 dB	8 dB	11 dB	2 dB	12 dB
Level 13	S	0 dB	8 dB	11 dB	2 dB	12 dB

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