WATERLOO SOUTH

Noise and Vibration Assessment

Prepared for:

NSW Land and Housing Corporation
219-241 Cleveland Street
Strawberry Hills NSW 2016

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

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.17084-R10-v2.0	24 March 2020	Nicholas Vandenberg	Alex Campbell	Alex Campbell
610.17084-R10-v1.0	20 March 2020	Nicholas Vandenberg	Alex Campbell	Alex Campbell
610.17084-R10-v0.1	9 March 2020	Nicholas Vandenberg	Alex Campbell	Alex Campbell

EXECUTIVE SUMMARY

SLR has undertaken a noise and vibration impact assessment associated with the proposed redevelopment of Waterloo South which forms the first stage of redevelopment for the Waterloo Estate. The assessment has been carried out in accordance with NSW regulatory requirements and in consultation with City of Sydney and other relevant stakeholders.

The scope of the assessment involved deriving and establishing project specific noise goals through consultation with various NSW and Australian guidelines; undertaking a noise and vibration impact assessment for the future development with respect to the appropriate criteria; and, where required, providing recommendations for noise control measures.

On 19th May, 2017, the Minister issued Study Requirements for the Waterloo Estate. Of relevance to this study are the following requirements relating to noise, vibration and pollution as presented below

Reference	Item Requirement	Refer Section:
18. Noise, Vibration and Pollution		
18.1	*Provide a noise and vibration impact assessment for the proposal. The assessment will address the relevant policies and guidelines in relation to noise including State Environmental Planning Policy (Infrastructure) 2007 and the Development Near Rail Corridors and Busy Roads – Interim Guideline.*	**Sections 1 - 6**
18.2	*Consider and assess potential pollution impacts from the proposed rezoning including, but not limited to, water, air, noise and light pollution.*	**Section 5**
18.4	*These assessments should also consider other current local air and noise issues in the Waterloo area, including potential cumulative impacts from the Waterloo Estate.*	**Section 6**
18.5	*Identify and map current and proposed future sensitive receptors (e.g. residential uses, schools, child care centres).*	**Section 4.2 Figure 6**
18.6	*Identify current and likely future noise, vibration and pollution affecting the precinct, including sources and nature and impact. Site monitoring will be required to determine current road noise levels on Botany Road. 3D mapping to clearly communicate these impacts, including demonstrating for example how noise reduces with distance from source, is desirable.*	**Sections 4 and 6**
18.7	*Model the likely future noise, vibration and pollution scenario based on 3D block envelope diagrams prepared by the urban designer. This is to include road and rail noise.*	**Section 6**
18.8	*Recommend appropriate noise and vibration mitigation measures. The consultant is expected to work with the urban designer, and suggested measures are provided for the protection of future residents of buildings through the careful siting and layout of buildings maintaining natural ventilation through open windows.*	**Section 6**
18.9	*Outline the recommended measures relating to noise, vibration and pollution to minimise the nuisance and harm to people or property within the precinct.*	**Sections 6.1.2, 6.2.3, 6.4.2, 6.4.3**

EXECUTIVE SUMMARY

Baseline investigations identified the existing noise and vibration environment across the Waterloo Estate and has been utilised for the Waterloo South.

This study involves a more detailed assessment regarding the proposed Waterloo South Site (the Project) design, including noise and vibration impact predictions and preliminary recommendations with respect to the proposed design.

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, carpark ventilation fans, corridor ventilation systems and carpark entry gates, substation, fire pump and fire control equipment. It is envisaged that the industrial noise sources will be able to achieve compliance with the nominated criteria through use of typical mitigation methods.

Due to the location of the site with the surrounding road network, road traffic noise impacts on the proposed site have been predicted to assess if natural ventilation could be feasibly achieved while complying with the requirements of the Infrastructure SEPP and CoS SDCP 2012 acoustic amenity requirements for residential properties. A SoundPLAN computer noise model was developed to predict road traffic noise levels at the proposed future Estate building facades. It is apparent that a simple natural ventilation solution may not be possible on the frontages of buildings facing McEvoy Street to the south of the site. SLR has worked closely with the design team to develop options that limit the exposure of residential apartments, and allow ventilation through alternate facades. Through certain design features, it is expected that the noise ingress requirements can be achieved. Detailed assessments will need to be conducted on final building configurations to ensure ventilation needs can be met while also meeting noise requirements.

The cumulative increases in traffic from the Estate are small in comparison to the high existing traffic volumes. As such, potential cumulative increases in road traffic noise due to the project are expected to be negligible.

At this stage the specific construction methodology and selection of construction plant and equipment is unknown. However based on similar project types, SLR has developed expected scenarios for the construction of the Estate, and predicted noise impacts from construction based upon these. It should be noted that this is considered a high level screening exercise of potential construction impacts. Once further details surrounding the proposed construction methodology and equipment is known, it is recommended that the managing contractor produces a comprehensive assessment and Construction Noise and Vibration Management Plan (CNVMP). If required, the Construction Contractor would need to, where feasible and reasonable, implement best practice noise mitigation measures outlined in this report.

In summary, it is expected that the development would meet all established Noise and Vibration Criteria if the recommendations are outlined within this assessment undertaken. Future detailed development applications would need to demonstrate compliance with the outlined criteria.

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1 Introduction

The Greater Sydney Region Plan and Eastern City District Plan seek to align growth with infrastructure, including transport, social and green infrastructure. With the catalyst of Waterloo Metro Station, there is an opportunity to deliver urban renewal to Waterloo Estate that will create great spaces and places for people to live, work and visit.

The proposed rezoning of Waterloo Estate is to be staged over the next 20 years to enable a coordinated renewal approach that minimises disruption for existing tenants and allows for the up-front delivery of key public domain elements such as public open space. Aligned to this staged approach, Waterloo Estate comprises three separate, but adjoining and inter-related stages:

- Waterloo South;
- Waterloo Central; and
- Waterloo North.

Waterloo South has been identified as the first stage for renewal. The lower number and density social housing dwellings spread over a relatively large area, makes Waterloo South ideal as a first sub-precinct, as new housing can be provided with the least disruption for existing tenants and early delivery of key public domain elements, such as public open space.

A planning proposal for Waterloo South is being led by NSW Land and Housing Corporation (LAHC). This will set out the strategic justification for the proposal and provide an assessment of the relevant strategic plans, state environmental planning policies, ministerial directions and the environmental, social and economic impacts of the proposed amendment. The outcome of this planning proposal will be a revised planning framework that will enable future development applications for the redevelopment of Waterloo South. The proposed planning framework that is subject of this planning proposal, includes:

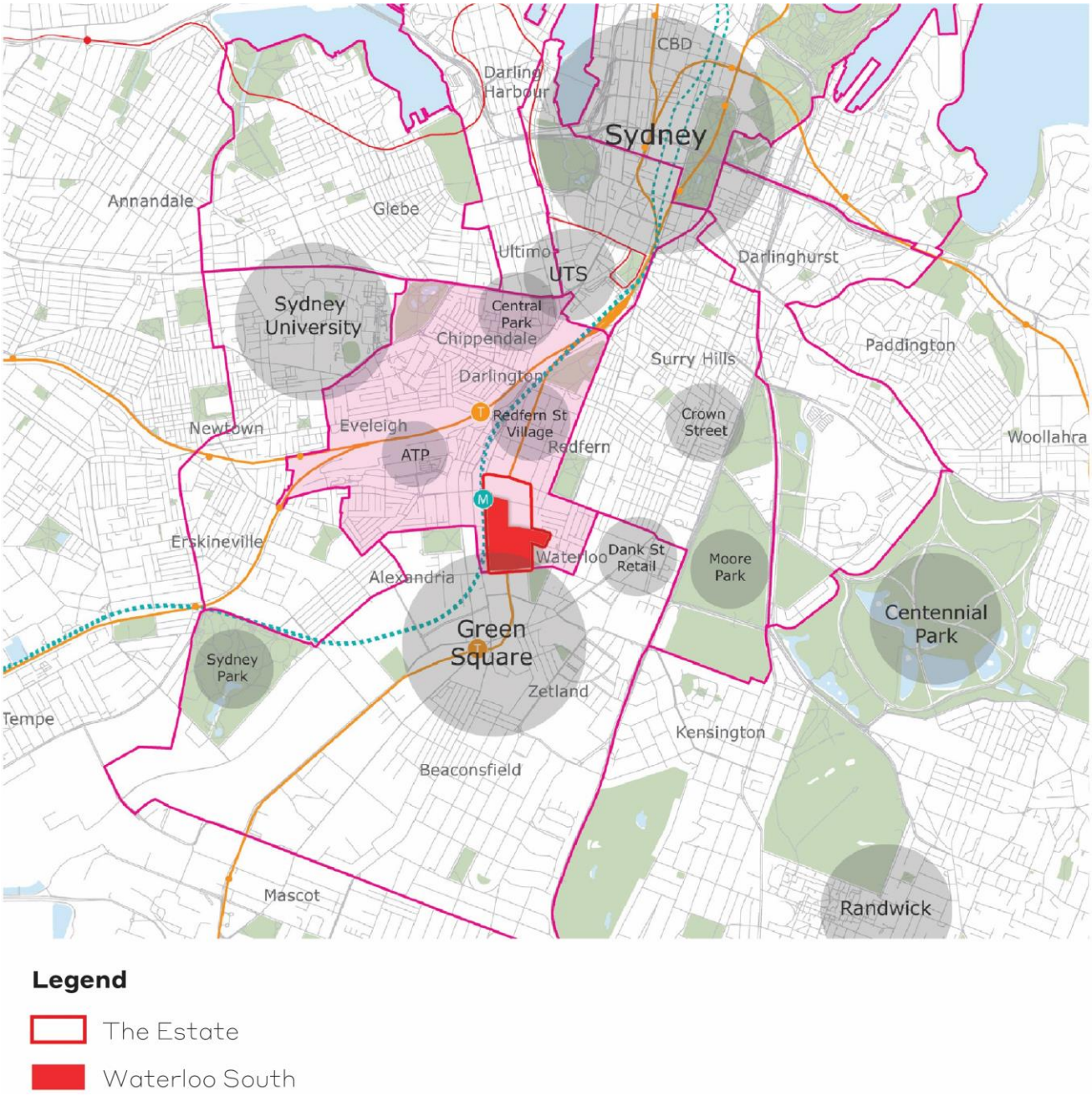
- **Amendments to the Sydney Local Environmental Plan 2012** – This will include amendments to the zoning and development standards (i.e. maximum building heights and floor space ratio) applied to Waterloo South. Precinct-specific local provisions may also be included.
- **A Development Control Plan (DCP)** – This will be a new part inserted into 'Section 5: Specific Areas' of the Sydney DCP 2012 and include detailed controls to inform future development of Waterloo South.
- **An infrastructure framework** – in depth needs analysis of the infrastructure required to service the needs of the future community including open space, community facilities and servicing infrastructure.

1.1 Waterloo Estate

Waterloo Estate is located approximately 3.3km south-south-west of the Sydney CBD in the suburb of Waterloo (refer to **Figure 1**). It is located entirely within the City of Sydney local government area (LGA). Waterloo Estate is situated approximately 0.6km from Redfern train station and 0.5km from Australia Technology Park. The precinct adjoins the new Waterloo Metro Station, scheduled to open in 2024. The Waterloo Metro Quarter adjoins Waterloo Estate and includes the station and over station development, and was rezoned in 2019. Waterloo Estate comprises land bounded by Cope, Phillip, Pitt and McEvoy Street, including an additional area bounded by Wellington, Gibson, Kellick and Pitt Streets. It has an approximate gross site area of 18.98 hectares (14.4 hectares excluding roads). Waterloo Estate currently comprises 2,012 social housing dwellings owned by LAHC, 125 private dwellings, a small group of shops and community uses on the corner of Wellington and George Streets, and commercial properties on the south-east corner of Cope and Wellington Streets.

A map of Waterloo Estate and relevant boundaries is illustrated in **Figure 2**.

Figure 1 Location plan of Waterloo Estate and Waterloo South



Source: Turner Studio

1.1.1 Waterloo South

Waterloo South includes land bounded by Cope, Raglan, George, Wellington, Gibson, Kellick, Pitt and McEvoy Streets, and has an approximate gross site area of 12.32 hectares (approximately 65% of the total Estate).

Waterloo South currently comprises 749 social housing dwellings owned by LAHC, 125 private dwellings, and commercial properties on the south-east corner of Cope and Wellington Streets. Existing social housing within Waterloo South is predominantly walk up flat buildings constructed in the 1950s and '60s, and mid-rise residential flat buildings (Drysdale, Dobell & 76 Wellington Street) constructed in the 1980s. Listed Heritage Items within Waterloo South include the Duke of Wellington Hotel, Electricity Substation 174 on the corner of George and McEvoy Streets, the terrace houses at 229-231 Cope Street and the Former Waterloo Pre-School at 225-227 Cope Street. The State Heritage listed 'Potts Hill to Waterloo Pressure Tunnel and Shafts' passes underneath the precinct.

A map of Waterloo South and relevant boundaries is illustrated in **Figure 2**.

Figure 2 Waterloo Precinct

Source: Ethos Urban

1.2 Renewal Vision

The transition of Waterloo Estate will occur over a 20-year timeframe, replacing and providing fit for purpose social (affordable rental) housing as well as private housing to create a new integrated and inclusive mixed-tenure community.

This aligns with Future Directions for Social Housing in NSW – the NSW Government's vision for social housing. It also aligns with LAHC's Communities Plus program, which is tasked with achieving key objectives:

1.. Provide more social housing

2. Provide a better social housing experience

3. Provide more opportunities and support for social housing tenants

The following is LAHC's Redevelopment Vision for Waterloo Estate, which was derived from extensive consultation and technical studies:

Source: Let's Talk Waterloo: Waterloo Redevelopment (Elton Consulting, 2019)

Culture and Heritage

- Recognise and celebrate the significance of Waterloo's Aboriginal history and heritage across the built and natural environments.
- Make Waterloo an affordable place for more Aboriginal people to live and work.
- Foster connection to culture by supporting authentic storytelling and recognition of artistic, cultural and sporting achievements.

Communal and Open Space

- Create high quality, accessible and safe open spaces that connect people to nature and cater to different needs, purposes and age groups.
- Create open spaces that bring people together and contribute to community cohesion and wellbeing.

Movement and Connectivity

- Make public transport, walking and cycling the preferred choice with accessible, reliable and safe connections and amenities.
- Make Waterloo a desired destination with the new Waterloo Station at the heart of the Precinct's transport network – serving as the gateway to a welcoming, safe and active community.

Character of Waterloo

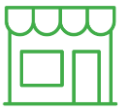
- Strengthen the diversity, inclusiveness and community spirit of Waterloo.
- Reflect the current character of Waterloo in the new built environment by mixing old and new.

Local Employment Opportunities

- Encourage a broad mix of businesses and social enterprise in the area that provides choice for residents and creates local job opportunities.

Community Services, Including Support for Those Who Are Vulnerable

- Ensure that social and human services support an increased population and meet the diverse needs of the community, including the most vulnerable residents.
- Provide flexible communal spaces to support cultural events, festivals and activities that strengthen community spirit.



Accessible Services

- Deliver improved and affordable services that support the everyday needs of the community, such as health and wellbeing, grocery and retail options.

Design Excellence

- Ensure architectural design excellence so that buildings and surrounds reflect community diversity, are environmentally sustainable & people friendly – contributing to lively, attractive and safe neighbourhoods.
- Recognise and celebrate Waterloo's history and culture in the built environment through artistic and creative expression.
- Create an integrated, inclusive community where existing residents and newcomers feel welcome, through a thoughtfully designed mix of private, social (affordable rental) housing.

1.3 Purpose of this Report

This report relates to the Waterloo South planning proposal. While it provides comprehensive baseline investigations for Waterloo Estate, it only assesses the proposed planning framework amendments and Indicative Concept Proposal for Waterloo South.

The key matters addressed as part of this study, include:

- Noise and Vibration impacts both on the development and from the development on the surrounding area (as per the Study Requirements)

2 The Proposal

The planning proposal will establish new land use planning controls for Waterloo South, including zoning and development standards to be included in Sydney LEP 2012, a new section in Part 5 of DCP 2012, and an infrastructure framework. Turner Studio and Turf has prepared an Urban Design and Public Domain Study which establishes an Indicative Concept Proposal presenting an indicative renewal outcome for Waterloo South. The Urban Design and Public Domain Study provides a comprehensive urban design vision and strategy to guide future development of Waterloo South and has informed the proposed planning framework. The Indicative Concept Proposal has also been used as the basis for testing, understanding and communicating the potential development outcomes of the proposed planning framework.

The Indicative Concept Proposal comprises:

- Approximately 2.57 hectares (ha) of public open space representing 17.8% of the total Estate (Gross Estate area - existing roads) proposed to be dedicated to the City of Sydney Council, comprising:
    - Village Green – a 2.25 ha park located next to the Waterloo Metro Station; and
    - Waterloo Common and adjacent – 0.32 ha located in the heart of the Waterloo South precinct.
    - The 2.57 ha all fall within the Waterloo South Planning Proposal representing 32.3% of public open space (Gross Waterloo South area - proposed roads)
- Retention of 52% of existing high and moderate value trees (including existing fig trees) and the planting of three trees to replace each high and moderate value tree removed.
- Coverage of 30% of Waterloo South by tree canopy.
- Approximately 257,000 square metres (sqm) of GFA on the LAHC land, comprising:
    - Approximately 239,100 sqm GFA of residential accommodation, providing for approximately 3,048 dwellings comprising a mix of market and social (affordable rental) housing dwellings;
    - Approximately 11,200 sqm of GFA for commercial premises, including, but not limited to, supermarkets, shops, food & drink premises and health facilities; and
    - Approximately 6,700 sqm of community facilities and early education and child care facilities.

The key features of the Indicative Concept Proposal are:

- It is a design and open space led approach.
- Creation of two large parks of high amenity by ensuring good sunlight access.
- Creation of a pedestrian priority precinct with new open spaces and a network of roads, lanes and pedestrian links.
- Conversion of George Street into a landscaped pedestrian and cycle friendly boulevard and creation of a walkable loop designed to cater to the needs of all ages.
- A new local retail hub located centrally within Waterloo South to serve the needs of the local community.
- A target of 80% of dwellings to have local retail services and open space within 200m of their building entry.
- Achievement of a 6 Star Green Star Communities rating, with minimum 5-star Green Star – Design & As-Built (Design Review certified).
- A range of Water Sensitive Urban Design (WSUD) features.

- The proposed land allocation for the Waterloo South precinct (the Precinct) is described in **Table 1** below.

Table 1 Breakdown of Allocation of Land within the Waterloo South

Land allocation	Existing	Proposed
Roads	3.12 ha / 25.3%	4.38 ha / 35.5%
Developed area (Private sites)	0.86 ha / 6.98%	0.86 ha / 7%
Developed area (LAHC property)	8.28 ha / 67.2%	4.26 ha / 34.6%
Public open space (proposed to be dedicated to the City of Sydney)	Nil / 0%	2.57 ha / 20.9% (32.3% excluding roads)
Other publicly accessible open space (Including former roads and private/LAHC land)	0.06 ha / 0.5%	0.25ha / 2%
TOTAL	**12.32 ha**	**12.32 ha**

The Indicative Concept Proposal for the Waterloo South is illustrated in **Figure 3** below.

Figure 3 Indicative Concept Proposal

Source: Turner Studio

3 Study Requirements

On 19th May, 2017, the Minister issued Study Requirements for the Waterloo Estate. Of relevance to this study are the following requirements relating to noise, vibration and pollution as presented in **Table 2**.

Table 2 Waterloo SSP - Study Requirements

Reference	Item Requirement	Refer Section:
18. Noise, Vibration and Pollution		
18.1	*Provide a noise and vibration impact assessment for the proposal. The assessment will address the relevant policies and guidelines in relation to noise including State Environmental Planning Policy (Infrastructure) 2007 and the Development Near Rail Corridors and Busy Roads – Interim Guideline.*	**Sections 1 - 6**
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18.9	*Outline the recommended measures relating to noise, vibration and pollution to minimise the nuisance and harm to people or property within the precinct.*	**Sections 6.1.2, 6.2.3, 6.4.2, 6.4.3**

4 Baseline Investigations

4.1 Project Overview

Baseline investigations identified the existing noise, vibration, air quality, and lighting environment throughout the Waterloo State Significant Precinct.

This study involves a more detailed assessment regarding the proposed Estate (the Project) design, including noise and vibration impact predictions and preliminary recommendations with respect to the proposed design.

A glossary of acoustic terminology used throughout this report is included as **Appendix A**.

4.2 Existing Noise Environment

4.2.1 Existing Noise Sources

4.2.1.1 Road Traffic Noise

The existing noise environment throughout the project area is generally controlled by road traffic noise. The major arterial road near the project is Botany Road, on the west side of the project. McEvoy Street to the south of the site serves as a collector road between Botany Road, Elizabeth Street and Bourke Street which results in a higher noise generation than other collector roads due to higher traffic flows.

This road becomes quite congested during peak hours. Vehicle speeds are limited to 60 km/h which generally remains free-flowing outside peak hours. The surface appears to be a worn dense-graded asphalt (DGA) pavement and is likely to perform consistent with the standard DGA pavement correction.

Collector roads include Phillip Street, Pitt Street and Cope Street. These roads are all limited to 50 km/h. Lower traffic volumes on the arterials result in generally lower noise levels.

Traffic calming measures including roundabouts and speed humps reduce speeds below the posted speed limits which reduce tyre noise. Conversely, engine noise is increased as a result of these measures as the vehicles accelerate away from these measures.

4.2.1.2 Railway Noise

At street level, existing rail noise is generally not audible in the project area due to shielding provided by the surrounding buildings. While the rail noise may be audible at times, due to the significant road network in closer proximity to the Estate it is unlikely to be a controlling noise source.

4.2.1.3 Aircraft Noise

The precinct 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 L_{eq} from 7 pm to 7 am.

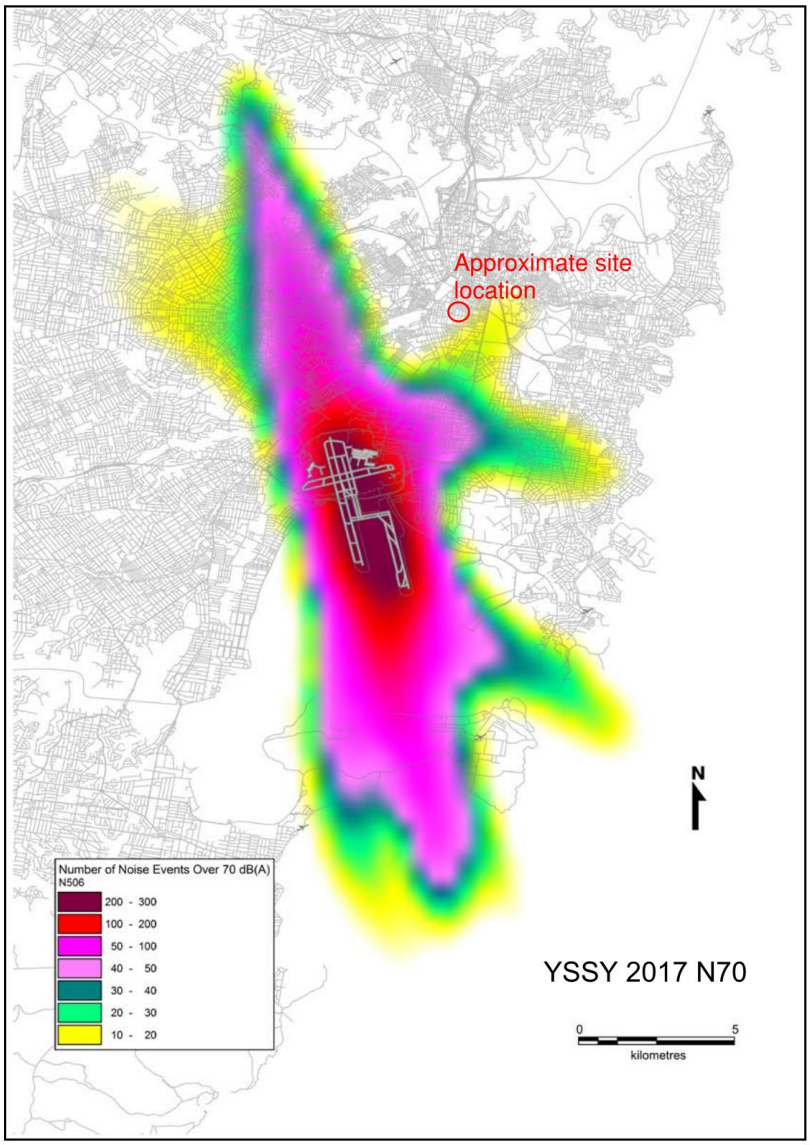
The Australian Noise Exposure Forecast (ANEF) is the future predicted ANEI. Typically, the ANEF 20 contour and higher defines an area where additional noise mitigation may be required for new residential buildings.

No receivers within the Estate site exceeded the ANEI 20 contour based on the AirService Australia 2017 Sydney Airport Annual Report *(Sydney Airport N506 Australian Noise Exposure Index 1 January to 31 December 2017*, August 2018. See **Figure 4.**

Figure 4 2017 ANEI 20 Contour and site location

The N70 noise contours illustrate the number of events above 70 dBA for an annual average day. These maps provide an indication of the likelihood of annoyance from aircraft noise. No receivers within the Estate site exceeded the N70 contour based on the AirService Australia 2017 Sydney Airport Annual Report *(Sydney Airport N506 Australian Noise Exposure Index 1 January to 31 December 2017*, August 2018. See **Figure 5.**

Figure 5 2017 N70 Contour and site location



Noise mitigation from aircraft noise would not be required throughout the project area.

4.2.1.4 Industrial Noise Sources

While there is some light industry such as warehousing and car mechanics adjacent to the project area, there have been no noise generating industrial sources identified that would have a significant impact on the noise environment.

4.2.2 Noise Catchment Areas

Due to the urban density and colocation of different land uses surrounding the Project site in addition to the differences in the surrounding existing noise environments, Noise Catchment Areas (NCAs) have been established, containing different receiver types that may potentially be affected by noise impacts from the proposed Project.

Within each NCA, appropriate noise goals have been defined for each receiver type based on the following:

- The receiver's surroundings and sensitivity to noise.
- The receiver's location relative to the proposed Project site.
- The results of the existing ambient noise surveys (presented in **Section 4.2.4.2**)
- Relevant NSW noise assessment policies and guidelines.

The defined NCAs containing different receiver types are presented in **Figure 6**.

4.2.3 Ambient Noise Surveys and Monitoring Locations

To quantify and characterise the existing ambient noise environment across the project area, a baseline noise monitoring survey was undertaken from 8 to 15 June 2016.

The measured noise levels have been used to establish existing ambient noise levels throughout the project area and to develop a detailed understanding of the existing noise environment.

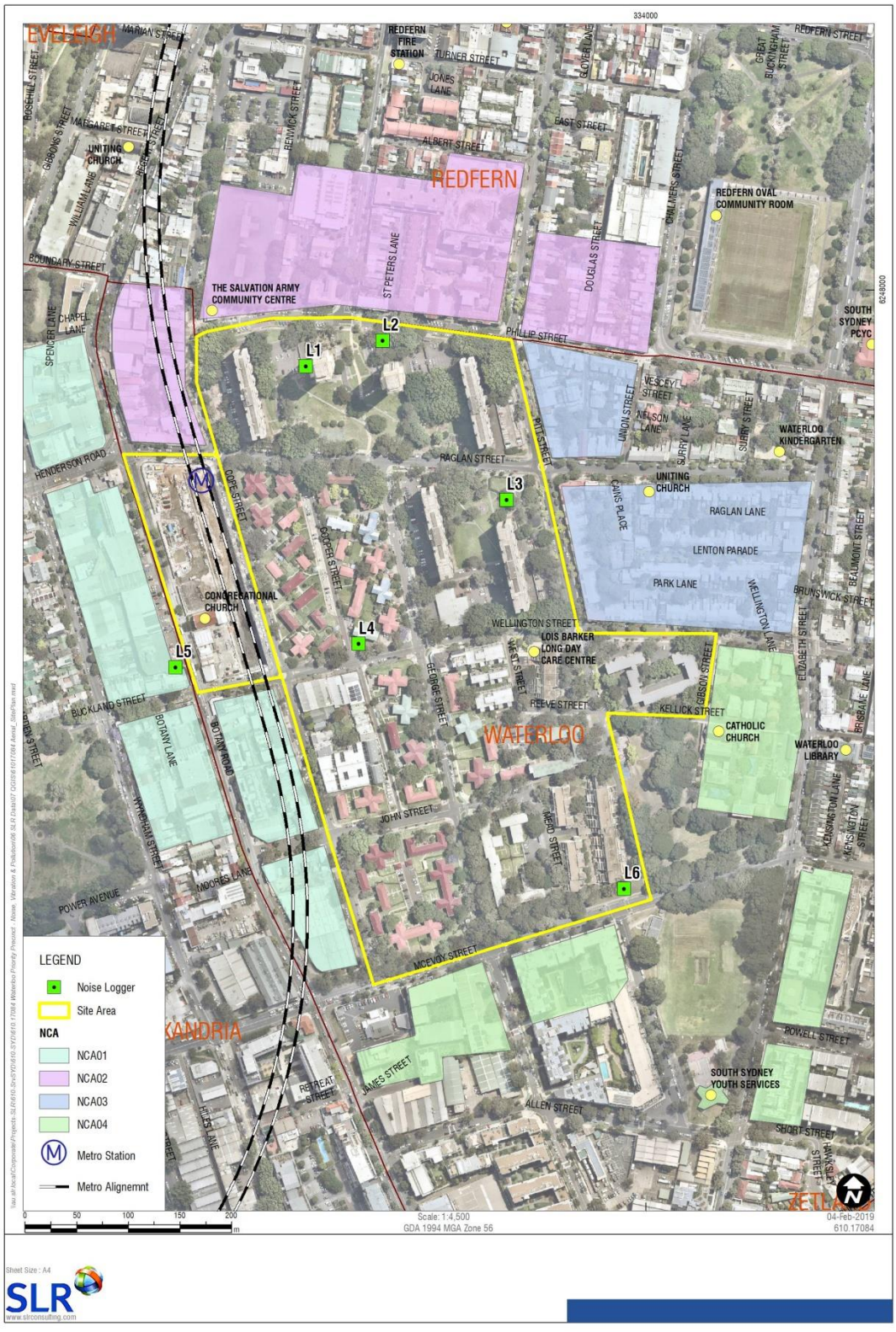
Noise monitoring equipment was deployed with consideration of other noise sources that may influence the measurements, accessibility and security, and with the consent of relevant land owners.

The noise monitoring locations, Noise Catchment Areas and Proposal location are presented in **Table 3** and **Figure 6**.

Table 3 Ambient Noise Survey Locations

Noise Monitoring Location ID	Noise Monitoring Location Address	Equipment Serial Number
L1	1 Phillip Street, Waterloo	20663
L2	3 Phillip Street, Waterloo	3004636
L3	200 Pitt Street, Waterloo	3003632
L4	113 Wellington Street, Waterloo	3005908
L5	130 Botany Road, Waterloo	3005904
L6	34 McEvoy Street, Waterloo	3003389

Figure 6 Waterloo State Significant Precinct, Noise Catchment Areas and Noise Logging Locations



4.2.4 Unattended Noise Monitoring

4.2.4.1 Methodology

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

The noise measurements were carried out with a combination of Svantek 957 and Bruel and Kjaer 2250L 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 at all times.

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

4.2.4.2 Noise Monitoring Results

The results of the unattended ambient surveys are summarised in **Table 4** as the Rating Background Level (RBL) noise levels for the *Noise Policy for Industry* (NPfI) daytime, evening and night-time periods, and the L_{Aeq} (energy averaged) noise levels for the *NSW Road Noise Policy* RNP daytime and night-time periods. The 24 hour daily noise levels at each monitoring location are presented graphically in **Appendix B**.

Table 4 Summary of Unattended Noise Logging Results

Noise Monitoring Location	Measured Noise Level (dB)							
	NPfI Time Periods[1]						RNP Time Periods[2]	
	Daytime - RBL	Evening - RBL	Night-time - RBL	Daytime - L_{Aeq}	Evening - L_{Aeq}	Night-time - L_{Aeq}	Daytime - $L_{Aeq(15hour)}$	Night-time - $L_{Aeq(9hour)}$
L1	50	46	40	57	53	50	56	51
L2	48	42	38	57	52	50	56	50
L3	47	43	37	61	58	59	60	59
L4[3]	50	46	41	65	57	54	64	54
L5	60	57	46	72	70	69	72	69
L6[4]	Failed	-	-	-	-	-	-	-

Note 1: *Noise Policy for Industry (NPfI)* assessment periods – Daytime: 7:00 am to 6:00 pm Monday to Saturday, 8:00 am to 6:00 pm Sundays and Public Holidays; Evening: 6:00 pm to 10:00 pm; Night: 10:00 pm to 7:00 am Monday to Saturday, 10:00 pm to 8:00 am Sundays and Public Holidays.

Note 2: Road Noise Policy (RNP) Assessment Time Periods – Day: 7.00 am to 10.00 pm; Night: 10.00 pm to 7.00 am (weekly data).

Note 3: Attended noise measurements at this location identified a bird feeder located on the wall of the residential building. This was not identified at the time the noise logger was deployed as it was raining. At the time of the attended measurements the bird feeder attracted a large number of Rosellas which were generating noise levels over 100 dBA. This significant noise source is the reason that the RNP noise levels for L4 are higher than other comparable noise environment areas of the Waterloo project area.

Note 4: The noise logger at location L6 was damaged during the logging survey and no data was recorded. This was supplementary data so a replacement logger was not deemed necessary to deploy.

The noise levels display a typical diurnal trend with lower noise levels during the night-time than the daytime and evening periods. This is characteristic of urban and suburban areas where the ambient noise environment is primarily influenced by road traffic.

4.2.5 Attended Airborne Noise

4.2.5.1 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.

4.2.5.2 Attended Noise Measurement Results

The noise environment at each of the attended monitoring locations is summarised in **Table 5**.

Table 5 Summary of Attended Noise Monitoring Results

Measurement Location	Measured Noise Levels (dB)			Description of Ambient Noise Source - Typical LAmax Levels
	L_{A90}	L_{Aeq}	L_{Amax}	
1 Phillip Street L1	48.2	58.2	74.5	Constant nature sounds with regular pedestrian movements. Intermittent traffic from Raglan Street and Phillip Street. Aircraft pass-bys are dominant sound source when present.
Phillip Street L2	51.7	60.7	84.8	Constant nature sounds with regular pedestrian movements. Intermittent traffic from Phillip Street. Dominant sound source is landscaping works in the area and aircraft pass-bys when present.
200 Pitt Street L3	55.1	61.9	80.6	Intermittent traffic noise from Raglan Street, particularly from vehicles travelling uphill. Landscaping works are dominant sound source during measurement
113 Wellington Street L4	51.1	63.3	92.4	Constant parrot activity during measurement. Intermittent traffic noise from Wellington Road with some aircraft passby noise. Limited pedestrian activity.
130 Botany Road[1] L5	64.9	72.5	87.7	Traffic noise from Botany Road is dominant sound source, with limited aircraft passby.
34 McEvoy L6	58.2	66.4	80.0	Dominant sound source McEvoy Street traffic, with occasional pedestrian activity. Limited aircraft passbys during measurement.

Note 1: Monitoring location near to building facade. Measured noise levels considered to represent facade affected noise levels which are up to 2.5 dBA higher than the equivalent free-field condition.

4.3 Existing Vibration Environment

4.3.1 Existing Vibration Environment

There are currently no major existing vibration sources in the project area. Road traffic typically generates very low vibration levels which are 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.

Those vibration generating circumstances are a maintenance issue, rather than a design issue and are not assessed.

5 Relevant Criteria

5.1 Construction Noise Criteria

5.1.1 Construction Noise Guidelines

The noise guidelines and management levels for construction works are based on the publications managed by the NSW Environment Protection Authority[1] (EPA). The EPA construction guidelines applicable to this project include:

- *Interim Construction Noise Guideline* (DECC 2009).

5.1.2 Recommended Standard Construction Hours

The EPA's *Interim Construction Noise Guideline* (ICNG) recommends restricting construction works to the times outlined in **Table 6**.

Table 6 ICNG - Recommended Standard Hours of Construction

Day	Recommended Construction Hours
Monday to Friday	7.00 am to 6.00 pm
Saturdays	8.00 am to 1.00 pm
Sundays or Public Holidays	No construction

5.1.3 Construction Noise Management Levels

5.1.3.1 Residential Receivers

The ICNG recommends that the $L_{Aeq(15minute)}$ noise levels from a construction project, measured within the curtilage of an occupied noise-sensitive residence (ie at the boundary or within 30 m of the residence, whichever is the lesser) should not exceed the levels indicated in **Table 7**.

Table 7 Recommended ICNG Noise Management Levels for Residences Affected by Construction Works

Period of Noise Exposure	$L_{Aeq(15minute)}$ Construction Noise Management Level
Recommended Standard Hours	Noise affected[1] RBL[2] + 10 dBA
	Highly Noise Affected[3] 75 dBA
Outside Recommended Standard Hours	Noise affected[1] RBL[2] + 5 dBA

Note 1: The noise affected level represents the point above which there may be some community reaction to noise.

Note 2: The Rated Background Level (RBL) noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The highly noise affected level represents the point above which there may be strong community reaction to noise.

1 Noise and Vibration guidelines managed by EPA are available at the following web address http://www.environment.nsw.gov.au/noise/noise_legislation.htm.

Where the predicted or measured $L_{Aeq(15\text{-}minute)}$ is greater than the noise affected level during recommended standard hours, the proponent should apply all feasible and reasonable work practices to meet the Noise Management Levels (NML's). 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.

Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the Highly Noise Affected, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours during which highly noisy intensive 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.

Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level outside recommended standard hours, consultation with the community is required and negotiations should be considered.

The Project specific residential receiver NMLs for each defined NCA (discussed in **Section 4.2.2** and shown in **Figure 6**) were derived from the relevant unattended noise monitoring results. The airborne construction NMLs for residences surrounding the proposed Project site are shown in **Table 8**.

Table 8 Construction Noise Management Levels – Residential

Residential receivers within Noise Catchment Area (NCA)[1]	Rating Background Level (dBA)			Recommended Standard Hours		Outside Recommended Standard Hours[3]		
				Noise Affected (RBL + 10 dB)	Highly Noise Affected (75 dB)	Noise affected (RBL + 5 dB)		
	Day[2]	Evening[2]	Night[2]			Day (dBA)	Evening (dBA)	Night (dBA)
NCA01 – L5	60	57	46	70	75	65	62	51
NCA02 – L2	48	42	38	58	75	53	47	43
NCA03 – L3	47	43	37	57	75	52	48	42
NCA04 – L3[4]	47	43	37	57	75	52	48	42

Note 1: Subdivision of noise catchment areas (containing residential receivers) surrounding the Project site discussed in **Section** .

Note 2: Rating Background Levels (RBL) shown with respect to the *Noise Policy for Industry (NPfI)* assessment periods – Daytime: 7:00 am to 6:00 pm Monday to Saturday, 8:00 am to 6:00 pm Sundays and Public Holidays; Evening: 6:00 pm to 10:00 pm; Night: 10:00 pm to 8:00 am Monday to Saturday, 10:00 pm to 8:00 am Sundays and Public Holidays.

Note 3: EPA's recommended standard construction hours are 7.00 am to 6.00 pm Mon-Fri; 8.00 am to 1.00 pm Sat.

Note 4: The logger (L3) located at 200 Pitt St was used for representative worst case noise levels for NCA04 due to the failure of logger 6 due to vandalism during the noise survey.

5.1.3.2 Other Sensitive Land Uses

To minimise disturbance to the characteristic activities of these other sensitive land uses, the ICNG recommends construction Noise Management Levels through a combination of internal design levels and the assessment of external noise levels. In accordance with the ICNG, the recommended airborne construction NMLs for other sensitive land uses within the defined NCAs surrounding the Project site are presented in **Table 9**.

Table 9 Construction Noise Management Levels – Other Sensitive Land Uses

Noise Catchment Area	Other Sensitive Land Use within Noise Catchment Area (NCA)	$L_{Aeq(15minute)}$ Construction Noise Management Level[1]
NCA01	Places of worship	Internal noise level[2] 45 dBA
NCA02	Community Facility	Internal noise level[2] 45 dBA
	Educational Facility	Internal noise level[2] 40 dBA
NCA03	Places of worship	Internal noise level[2] 45 dBA
NCA04	Active recreation area	External noise level[3] 65 dBA
	Places of worship	Internal noise level[2] 45 dBA
	Community Facility	Internal noise level[2] 45 dBA

Note 1: Applies when properties are being used.

Note 2: Internal noise levels are to be assessed at the centre of the occupied room.

Note 3: External noise levels are to be assessed at the most affected point at the property boundary or 30 m from the residence (whichever is the lesser).

5.1.3.3 Commercial and Industrial Premises

Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the ICNG outlines the process of defining management levels by separating them into the following three categories:

- Industrial premises: external L_{Aeq} 75 dBA
- Offices, retail outlets: external L_{Aeq} 70 dBA
- Other businesses that may be very sensitive to noise (eg theatres and child care centres): determine suitable noise levels on a project-by-project basis; consultation with the 'upper-limit' internal noise levels in AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels* (Standards Australia 2016) is recommended.

In accordance with the ICNG, the recommended airborne construction NMLs for commercial and industrial premises within the defined NCAs surrounding the Project are presented in **Table 10**.

Table 10 Construction Noise Management Levels – Commercial and Industrial Premises

Noise Catchment Area	Land Use	$L_{Aeq(15minute)}$ Construction Noise Management Level[1]
NCA01	Commercial	External noise level 70 dBA
	Other – Radio studio	Internal noise level 25 dBA[2]
NCA02	Commercial	External noise level 70 dBA
NCA04	Commercial	External noise level 70 dBA

Note 1: As outlined in the ICNG, construction NMLs are to be assessed externally at the most-affected occupied point of the premises.

Note 2: Internal noise level derived from AS 2107 *Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels* as recommended in the ICNG.

5.2 Construction Vibration Criteria

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

5.2.1 Human Comfort Vibration

The DECCW's *Assessing Vibration: A Technical Guideline* dated February 2006 (DECCW, 2006) recommends the use of British Standard BS 6472-1992 for the purpose of assessing vibration in relation to human comfort.

BS 6472-1992 *Guide to evaluation of human exposure to vibration in building* nominates guideline values for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

BS 6472-1992 provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV), rather than a continuous vibration level. The vibration dose value is dependent upon the level and duration of the short term vibration event, as well as the number of events occurring during the daytime or night-time period.

The vibration dose values recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in **Table 11**.

Table 11: Vibration Dose Value Ranges which Might Result in Various Probabilities of Adverse Comment within Residential Buildings

Place and Time	Low Probability of Adverse Comment ($m/s^{1.75}$)	Adverse Comment Possible ($m/s^{1.75}$)	Adverse Comment Probable ($m/s^{1.75}$)
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Note: For offices and workshops, multiplying factors of 2 and 4 respectively would be applied to the above vibration dose value ranges for a 16 hr day.

5.2.2 Structural Damage Vibration

Most commonly specified 'safe' structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage goals, Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* as they "are applicable to Australian conditions".

The Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the Standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

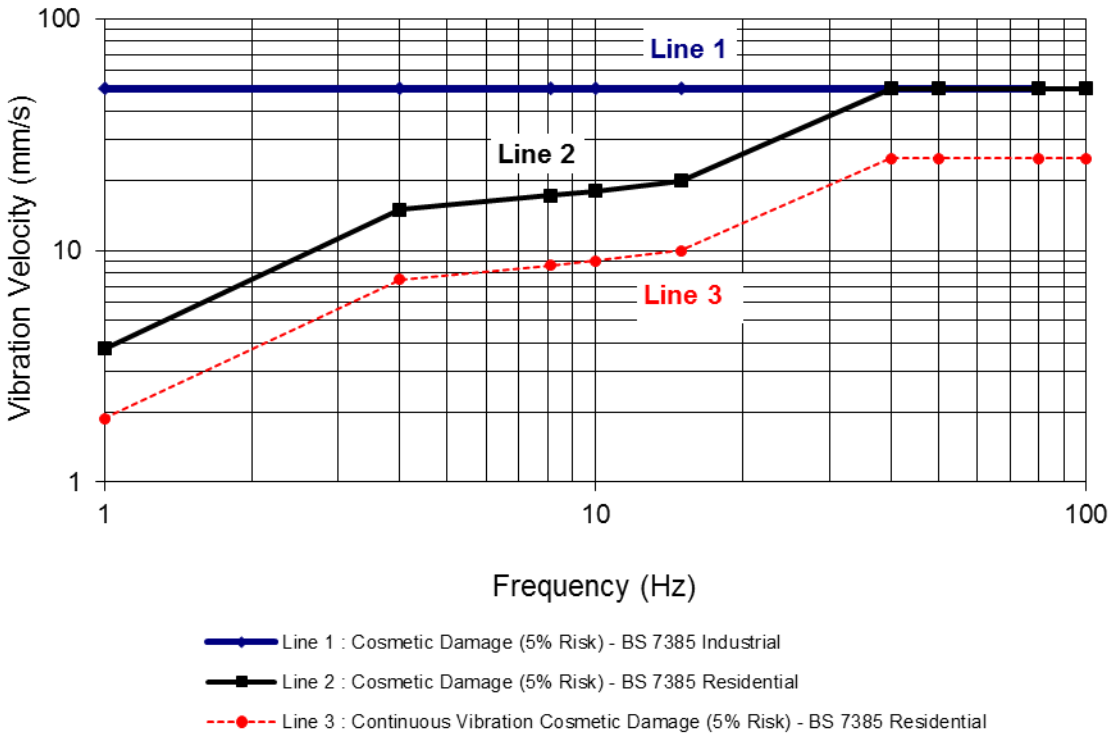
5.2.3 Cosmetic Damage Vibration

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 12** and graphically in **Figure 7**.

Table 12 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Figure 7 Graph of Transient Vibration Guide Values for Cosmetic Damage



The Standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 12**, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the Standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 12** would not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS 2187 specifies that vibration measured would be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) would be compared with the guidance curves presented in **Figure 7**.

It is noteworthy that in addition to the guide values nominated in **Table 12** the Standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

5.2.4 General Vibration Screening Criterion

The Standard states that the guide values in **Table 12** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

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 in **Table 12** may need to be reduced by up to 50%.

Note: rockbreaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may therefore be appropriate to reduce the transient values by 50%.

Therefore for most construction activities involving intermittent vibration sources such as rockbreakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, a conservative vibration damage screening level per receiver type is given below:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above (peak component particle velocity), a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

5.2.5 Heritage

Heritage buildings and structures would be assessed as per the above screening criteria as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage criteria of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered.

5.3 Operational Noise Criteria

This section outlines criteria for assessing the potential impacts of noise generated by the proposed development on the surrounding noise sensitive receivers.

5.3.1 Operational Noise – Industrial Noise Emissions

The *Noise Policy for Industry* (NPfI) (EPA, 2017) outlines the procedure for assessing noise emissions from industrial noise sources, such as mechanical plant and equipment. The process involves determining project noise trigger levels at existing noise-sensitive receivers surrounding a proposed development, predicting whether emissions from the development are likely to exceed the established levels and result in potential noise impacts, and reducing the predicted levels through feasible and reasonable mitigation strategies.

The Project Noise Trigger Level is the lower (ie the more stringent) value of the project intrusiveness noise level and project amenity noise level. The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative impacts from industry and maintain amenity for particular land uses.

Typically, the intrusiveness level would inform the project noise trigger level in areas with little industry (and/or ambient noise levels), whereas the amenity level would inform the project noise trigger level in areas with higher existing background noise levels.

5.3.1.1 Intrusiveness Noise Level

The intrusiveness noise level is based on the measured existing background noise levels. In accordance with the NPfI, the equivalent continuous noise level (L_{Aeq}) of the source should not exceed the measured Rating Background Level (RBL) at a residence by more than 5 dBA over any 15 minute period within any assessment period. Intrusive noise levels are only applied to residential receivers (residences). For other receiver types, only the amenity levels apply.

5.3.1.2 Amenity Noise Level

The recommended amenity noise level represents the total industrial noise at a receiver location, whereas the project amenity level represents the objective for noise from a single industrial development. The project area is considered to be urban.

5.3.1.3 Project Noise Trigger Levels

The results of the unattended noise monitoring (refer to **Section 4.2.4)** have been used to establish the Project Noise Trigger Levels which would be used to assess the potential industrial impacts associated with the Project at the surrounding receivers.

The project noise trigger levels are the more stringent of the intrusiveness and amenity noise levels and are marked in bold and shaded as shown below in **Table 13**.

Table 13 Indicative Project Noise Trigger Levels for Surrounding Receivers

NCA	Receiver Type	Period	Representative Noise Logger	Recommended Amenity Noise Level (dBA)	Measured Noise Level (dBA)		Indicative Project Noise Trigger Levels LAeq(15minute) (dBA)	
					RBL	LAeq(period)	Intrusiveness	Amenity [1,2]
NCA01	Residential	Day	L5	60	60	72	65	**60**[3]
		Evening		50	57	70	62	**58**[3]
		Night		45	46	69	**51**	57[3]
	Commercial	When in use		65	n/a	72	n/a	**63**
	Place of worship – external[4]	Day		50	n/a	72	n/a	**60**[3]
		Evening		50	n/a	70	n/a	**58**[3]
		Night		50	n/a	69	n/a	**57**[3]
NCA02	Residential	Day	L2	60	48	57	**53**	63
		Evening		50	42	52	**47**	53
		Night		45	38	50	**43**	48
NCA03	Residential	Day	L3	60	47	61	**52**	63
		Evening		50	43	58	**48**	53
		Night		45	37	59	**42**	48
	Commercial	When in use		65	n/a	61	n/a	**59**
	Place of worship – external	Day		50	n/a	61	n/a	**63**[3]
		Evening		50	n/a	58	n/a	**53**[3]
		Night		50	n/a	59	n/a	**48**
NCA04	Residential	Day	L3[5]	60	47	61	**52**	63[3]
		Evening		50	43	58	**48**	53[3]
		Night		45	37	59	**42**	48
	Commercial	When in use		65	n/a	61	n/a	**59**
	Place of worship – external	Day		50	n/a	61	n/a	**63**[3]
		Evening		50	n/a	58	n/a	**53**[3]
		Night		50	n/a	59	n/a	**48**

Note 1: The project amenity noise levels have been converted to 15 minute levels by adding 3 dB.

Note 2: The recommended amenity noise levels have been reduced by 5 dB to give the project amenity noise levels due to future sources of industrial noise potentially being built in the area.

Note 3: The NPfI notes that where the existing traffic noise level is 10 dB or more above the recommended amenity noise level, then the High Traffic project amenity noise level is the existing traffic L_{Aeq} minus 15 dB.

Note 4: Internal noise levels have been converted to external noise levels using a typical 10 dB external to internal transmission loss factor.

Note 5: The logger (L3) located at 200 Pitt St was used for representative worst case noise levels for NCA04 due to the failure of logger 6 due to vandalism during the noise survey.

At this early stage of the project, the criteria presented in **Table 13** should be regarded as indicative and would be confirmed during the next stages of the project. The final project trigger levels would be determined or confirmed in specific future SSDA assessments as the surrounding noise environment or receivers may have changed since this SSP assessment.

5.4 Internal Noise Level Criteria – Residential

This section establishes appropriate internal noise criteria for the residential areas of the proposed development in order to protect the amenity of future occupants from external noise intrusion.

5.4.1 State Environment Planning Policy

The *State Environment Planning Policy* (Infrastructure) 2007 (Infrastructure SEPP) provides guidelines to ensure that the development of new residential buildings protects the occupants adequately from noise associated with existing road and railway infrastructure. The key objectives of the provisions are to:

- Protect the safety and integrity of key transport infrastructure from adjacent development
- Ensure that adjacent development achieves an appropriate acoustic amenity by meeting the internal noise criteria specified in the Infrastructure SEPP.

The key clauses of the Infrastructure SEPP are:

5.4.1.1 Rail Corridors

Clause 86 *Any development (other than development to which clause 88 of the Infrastructure SEPP applies) that involves the penetration of the ground to a depth of at least 2 m below ground level (existing) on land that is:*

a. *Within or above a rail corridor; or*

b. *Within 25 m (measure horizontally) of a rail corridor); or*

c. *Within 25 m (measure horizontally) of the ground directly above an underground rail corridor*

Note: the consent authority must not grant consent without consulting with the rail authority and obtaining concurrence consistent with clauses 86(2)-(5)

Clause 87 *Development for any of the following purposes that is on land that is in or immediately adjacent to a rail corridor and the consent authority considers development is likely to be adversely affected by rail noise or vibration:*

- *Building for residential use*
- *A place of worship*
- *A hospital*
- *An educational establishment or childcare centre*

5.4.1.2 Road Corridors

Development for any of the following purposes that is on land in or adjacent to a road corridor for a freeway, a tollway, or a transit way or any other road with an annual average daily traffic volume of more than 40,000 vehicles (based on the traffic volume data available on the website of the RTA) and that the consent authority considers is likely to be adversely affected by road noise or vibration:

- *Building for residential use*
- *A place of worship*
- *A hospital*
- *An educational establishment or childcare centre*

Clause 103 *Any development which involves penetration of the ground to a depth of at least 3m below ground level (existing) on land that is the road corridor of roads or road projects as specified in schedule 2 of the SEPP.*

For Clauses 87 (Rail) and 102 (Road)

- *If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures would be taken to ensure that the following L_{Aeq} noise levels are not exceeded:*
  - *In any bedroom in the building: 35 dB(A) at any time (10pm – 7am)*
  - *Anywhere else in the building (other than a garage, kitchen, bathroom, or hallway): 40dB(A) at any time*

5.4.2 City of Sydney Development Control Plan 2012

The *City of Sydney Development Control Plan* (SDCP 2012) 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.

- *The repeatable maximum $L_{Aeq(1\ hour)}$ for residential buildings and serviced apartments must not exceed the following levels:*

  a. for closed windows and doors:
  (i) 35 dB for bedrooms (10pm-7am); and
  (ii) 45 dB for main living areas (24 hours).

  b. for open windows and doors:
  (i) 45 dB for bedrooms (10pm-7am); and
  (ii) 55 dB for main living areas (24 hours)

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

5.4.3 Apartment Design Guideline and City of Sydney Consultation

As part of the development of the proposal for the site, NSW Land and Housing Corporation and SLR has undertaken consultation with City of Sydney and Department of Planning and Environment (DP&E). Based on this consultation, it is understood that the project should be designed to meet the requirements of DP&E's *Apartment Design Guide* (ADG) Objective 4B-1 for natural ventilation.

As a result, residential areas should comply with the "windows open" (item 1 b) noise criteria of the CoS DCP as repeated in **Section 5.4.2**.

5.4.4 Vibration Criteria

Although vibration requirements aren't specified in the Infrastructure SEPP, impacts from vibration associated with transport infrastructure are commonly translated into ground-borne noise. Vibration transmission into the buildings would need to be controlled to ensure that ground-borne noise levels comply with the internal airborne noise criteria for residential buildings discussed in **Section 5.2**.

5.5 Internal Noise Criteria – Non-residential uses

All internal non-residential areas shall be designed to mitigate external noise intrusion to recommended internal noise criteria based upon their use contained within AS 2107:2016 "*Acoustics - Recommended design sound levels and reverberation times for building interiors*".

6 Assessment

6.1 Operational Noise Impacts

6.1.1 Operational Noise – Industrial Noise Impacts

A review of the most recent architectural drawings provided by NSW Land and Housing Corporation indicates that typical sources of industrial noise that may be associated with the commercial premises component of the Project area may include:

- Noise from mechanical equipment including Heating Ventilation Air Conditioning (HVAC), carpark ventilation fans, corridor ventilation systems and carpark entry gates, substation, 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 (in accordance with the indicative project noise trigger levels outlined in **Section 5.3.1**) during the detailed design stage of the Project.

Operational noise emissions from mechanical plant associated with the Project should be controlled to reduce noise impacts upon neighbouring residential receivers and occupants within the proposed development.

Detailed assessment and verification of mechanical noise emissions should be carried out during the detailed design stage of the project ensuring that the nominated criteria for mechanical plant emissions are met.

6.1.2 In-Principle Acoustic Treatment Recommendations

It is envisaged that the industrial noise sources will be able to achieve compliance with the nominated criteria through common engineering methods that may consist of:

- Selection of low-noise mechanical plant and other noise generating equipment.
- Judicious location of mechanical plant and equipment with respect to nearby noise-sensitive receivers.
- Barriers/enclosures (eg plant rooms).
- Silencers and acoustically lined ductwork.

The required noise mitigation measures would be reviewed during detailed design when more information regarding sources of industrial noise is available.

6.2 Noise Ingress

Due to the location of the Project site with the surrounding road network, road traffic noise impacts on the proposed site have been predicted to assess if natural ventilation could be feasibly be achieved while complying with the requirements of the Infrastructure SEPP and CoS SDCP 2012 acoustic amenity requirements for residential properties outlined in **Section 5.4**.

6.2.1 Noise Model

A SoundPLAN computer noise model was developed to predict road traffic noise levels at the proposed future Estate building facades.

SoundPLAN is a software package which allows noise predictions to be made in a 3D environment and includes a digitised ground map (containing ground contours and significant structures, where appropriate), the location and acoustic power levels of significant noise sources, and the location of noise-sensitive receivers.

6.2.2 Methodology

The computer model generates noise emission levels accounting for factors such as road traffic volume flows, attenuation due to distance, ground and air absorption and shielding attenuation, as well as meteorological conditions.

Heights of buildings, screens and other structures were estimated based on architectural drawings provided by NSW Land and Housing Corporation, site inspections and aerial photography. Forecasted traffic volumes for the year 2036 have been provided by the project traffic engineers (Jacobs).

Daytime (15 hour) and night-time (9 hour) two-way traffic volumes were assigned to the road traffic sources and are presented in **Appendix E**.

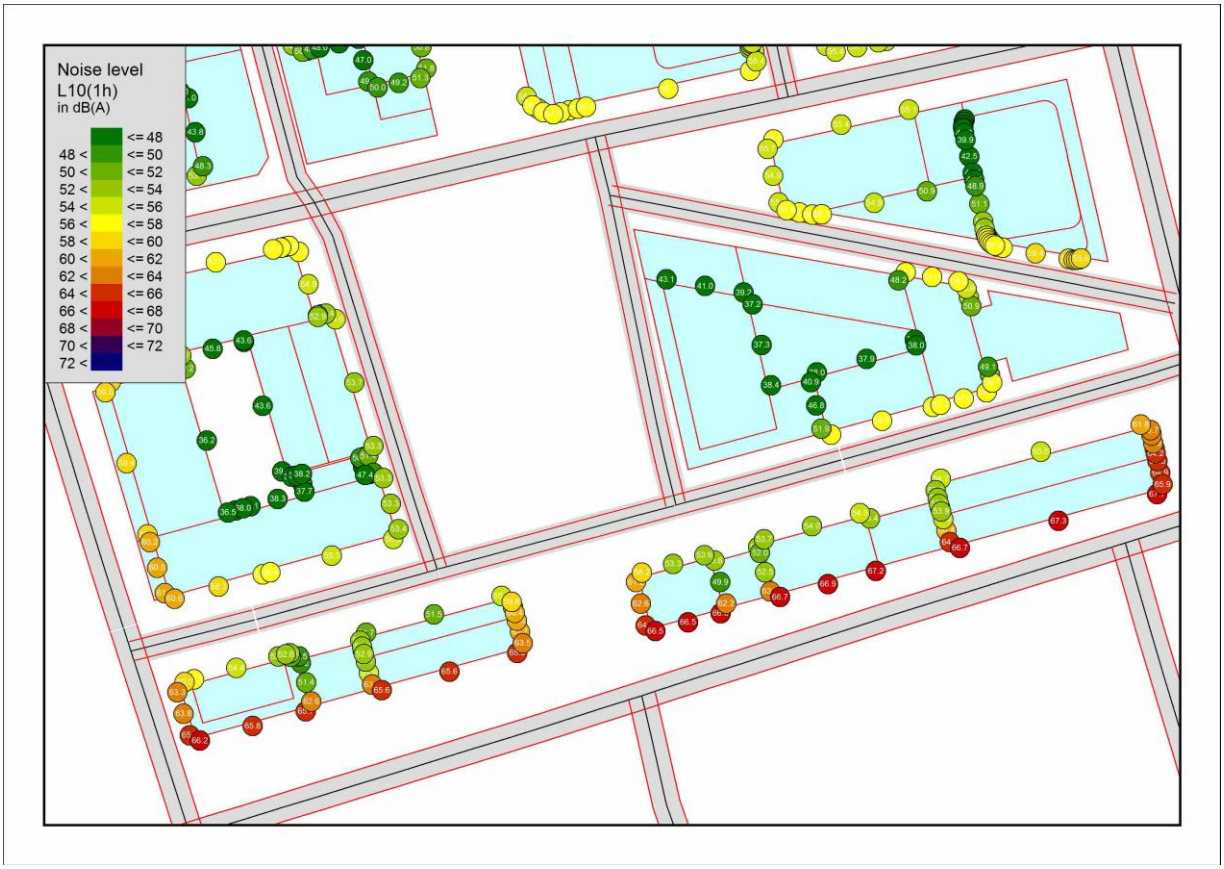
For the assessment, a Grid Noise Map has been produced at heights of 2 m, 17 m and 40 m to visualise the traffic noise impacts at various heights for the buildings within the Estate boundaries for the existing and the proposed. These Grid Noise Maps from the existing traffic are shown in **Appendix C** and the Grid Noise Maps from the future traffic are shown in **Appendix D**.

6.2.3 Results and Mitigation

Through reviewing the results of the Grid Noise Maps of the existing traffic shown in **Appendix C**, and applying a typical conservative 10 dB outdoor-to-indoor loss for an open window, it is apparent that the area where a simple natural ventilation solution may not be possible in the Estate is on the frontages of buildings facing McEvoy street to the south of the site.

As a result, this area of the site has been explored in greater detail. **Figure 8** shows the predicted night-time noise levels on these building frontages (at 17m height) in the range of 65-67 dBA $L_{eq,9hr}$. Noise levels for a maximum repeatable average 1hr night-time period ($L_{eq,1hr}$) as required to assess against the SDCP 2012 will be typically 3 dBA higher than the overall night-time average noise levels modelled. This is based upon a modelling exercise undertaken using the Average Annual Daily Traffic flows in the project vicinity.

Figure 8 - Predicted night-time ($L_{eq,9hr}$) noise levels on McEvoy Street frontages

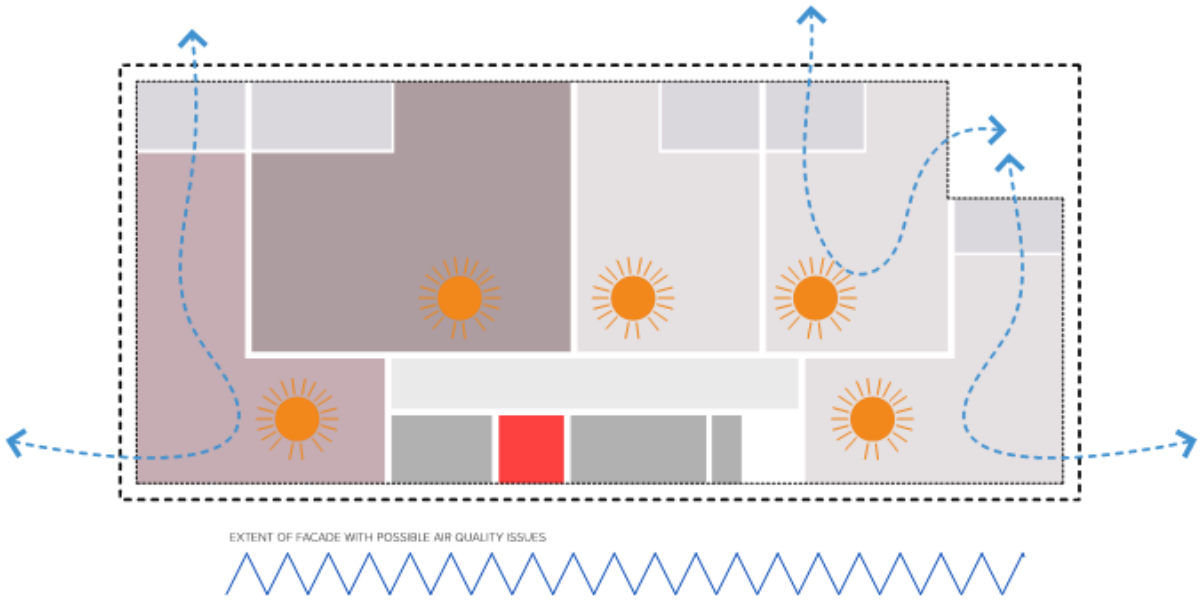


SLR has worked closely with the design team in order to develop tower massing options which:

- Limits the exposure of residential apartments to the most highly impacted frontage, through placing the core and fewer dwellings on this façade
- Allows dwellings on this façade to have air enter from alternative frontages (such as the 'side' facades)
- Allowance for fresh air ventilation paths which can mitigate noise through either shielding (e.g., wintergardens) and/or acoustically attenuated openings.

Figure 9 illustrates how internal floor plates could potentially be planned to mitigate McEvoy street noise impacts.

Figure 9 – Example floorplate showing building layout limiting exposure to McEvoy frontage



Where particularly high external-to-internal noise reductions (circa 20 dBA and over) are required the use of acoustically attenuated openings should be investigated by future detailed design proponents.

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 10**).

Figure 10 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	h (m)			0.35	0.40		0.40		0.40		0.40
	w (m)			1.42	1.47		1.92		2.37		2.82
Plain Plenum 	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)										
	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
Plenum With Septum's 	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.

Through a combination of the above, it is expected that the noise ingress requirements can be achieved. Throughout the SSDA assessments for future developments across the site, particularly those fronting McEvoy Street, detailed assessments on final building configurations shall be undertaken to ensure that – as well as meeting noise requirements – ventilation needs can be met. This may require assessment in line with the City of Sydney's draft "*Alternative natural ventilation of apartments in noisy environments: Performance pathway guideline*" (Sept 2018) or future equivalent where necessary.

6.3 Cumulative Impacts

6.3.1 Additional Road Traffic Noise

The NSW *Road Noise Policy* (RNP) requires consideration of noise mitigation where new land use developments increase road traffic noise by more than 2 dB. For a 2 dB increase in noise to be apparent a corresponding increase in traffic volumes of approximately 60% is required (assuming road speeds and other factors remain unchanged).

Peak two-way traffic volume data on Botany Road has been provided by Jacobs for the existing situation together with volumes associated with the Estate. These are shown below in **Table 14**.

Table 14 Traffic Volumes on Botany Road

Existing Traffic Flows	Estate Predicted Increases
23,175 vehicles (15-hour)	<1000 vehicles (15-hour)
6,428 (9-hour)	<500 vehicles (9-hour)

The above shows that the cumulative increases in traffic from the Estate are small in comparison to the high existing traffic volumes during the daytime and night-time. As such, potential cumulative increases in road traffic noise due to the Project are expected to be significantly less than 2 dB.

6.3.2 Industrial Noise

As noise sources and locations within and surrounding the precinct area are unknown at this early stage in the project, a cumulative impact assessment of potential operational noise from future industrial sources within the precinct cannot be completed.

The potential cumulative impacts from all sources of industrial noise from the Metro Quarter, Sydney Metro and the Estate will be undertaken in the future stages of the project when more information regarding the various noise sources and locations are known.

It is anticipated that compliance with the final project trigger levels from cumulative industrial noise impacts will be achievable with standard noise mitigation measures.

6.4 Construction Noise and Vibration Impacts

At this stage the specific construction methodology and selection of construction plant and equipment is unknown. However based on experience, SLR has developed expected scenarios for the construction of the Estate.

It should be noted that this is considered a high level screening exercise of potential construction impacts. Once further details surrounding the proposed construction methodology and equipment is known, it is recommended that the managing contractor produces a comprehensive assessment and Construction Noise and Vibration Management Plan (CNVMP).

The CNVMP should incorporate mitigation and management strategies developed through consultation with the surrounding community and regulatory authority that is also in accordance with the framework for compliance established in this report (outlined in **Section 5.1**).

6.4.1 Construction Noise

A 3D noise model (SoundPLAN v7.4) was created to predict the potential noise impacts during construction staging (or scenarios) for the duration of the project. The surrounding buildings were digitised using aerial information and CAD data.

These impacts represent the most-affected worst-case scenario at residential properties due to being based on a close proximity and high construction noise levels. It would also be expected that noise levels would be lower during the works.

6.4.1.1 Construction Staging and Equipment

Table 15 below tabulates expected construction scenarios and equipment in use. These scenarios have been generated from SLR experience in construction noise assessments, however is not considered to be final.

Table 15 Construction staging and equipment

Works Number	Scenario Name	Activity Name	Equipment	Items (in 15 min)	On-Time (15 min)	Individual SWL[1] L_{Aeq}	Works SWL[1] L_{Aeq}
W.0001	Demolition	Demolition of existing buildings	Dozer	1	15	114	119
			Excavator - Breaker1	1	5	121	
			Truck	1	5	107	
			Generator	1	15	102	
			Excavator - Pulverizer	1	15	108	
W.0002	Earthworks	Excavation, underground basement or carpark earth removal	Piling - Impact1	1	7.5	116	114
			Generator (small)	1	15	93	
			Excavator (14 tonne)	1	7.5	97	
			Roller - Smooth Drum	1	15	107	
			Truck	1	5	107	
			Mobile Crane - Franna	1	7.5	98	
W.0003	Concrete works	Foundation, concrete works	Concrete Mixer Truck	1	7.5	103	109
			Concrete Pump	1	7.5	106	
			Roller - Smooth Drum	1	15	107	
W.0004	Infrastructure	high-rise construction	Mobile Crane (400 tonne)	2	15	106	111
			Truck	1	5	107	
			Generator (small)	1	15	93	
			hand tools	1	15	94	
			Tower Crane	2	15	100	
W.0005	Trades	Completion trades, landscaping	hand tools	1	15	94	100
			Generator (small)	1	15	93	
			Excavator (14 tonne)	1	7.5	97	
			Compressor	1	15	95	

Note 1: SWL = Sound Power Level

6.4.1.2 Predicted noise impacts

Table 16 below represents the worst-case noise impacts at residential receivers at a distance of approximately 30 m from the works (assuming the edge of the proposal boundary). These have been assessed against the criteria established in **Section 5.1.3**

Table 16 Worst-case Noise Impacts, dBA

Works ID	Predicted noise impacts – Worst-case residential noise levels, dBA				
	SWL (L_{Aeq})	NCA01	NCA02	NCA03	NCA04
W.0001	119	81	81	81	85
W.0002	114	76	76	76	80
W.0003	109	71	71	71	75
W.0004	111	73	73	73	77
W.0005	100	62	62	62	66

The above table outlines the following:

- Noise levels exceeding *Highly Noise Affected* (>75 dBA) criteria may be experienced at residential properties around the boundary of the proposal – as highlighted in red.
- Generally high noise levels would be expected at other sensitive premises such as Places of Worship and Educational Facilities, internal noise levels may be greater than the recommended internal noise levels

6.4.2 Construction Noise Mitigation and Management

If required, the Construction Contractor would need to, where feasible and reasonable, implement best practice noise mitigation measures including measures such as:

- Judicious selection of mechanical plant and equipment (eg quieter machinery and power tools).
- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers.
- Orienting equipment away from noise-sensitive areas.
- Carrying out loading and unloading away from noise-sensitive areas.
- Localised shielding of noisy equipment.
- Minimising consecutive works in the same locality.
- Considering periods of respite.

6.4.3 Construction Vibration Impacts

As details surrounding the proposed construction methodology, equipment and phasing are unknown, a detailed construction vibration assessment is not possible at this stage. However, it is recommended to mitigate any potential impacts using the recommended safe working distances for vibration intensive plant as indicated in **Table 17**, reproduced from the Transport for New South Wales's document *Construction Noise and Vibration Strategy* (2018).

Table 17 Recommended Safe Working Distances for Vibration Intensive Plant

Equipment Item	Rating/ Description	Safe Working Distance	
		Cosmetic Damage[1]	Human Response
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (Typically > 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	300 kg – 5 to 12t excavator	2 m	7 m
Medium Hydraulic Hammer	900 kg – 12 to 18t excavator	7 m	23 m
Large Hydraulic Hammer	1,600 kg – 18 to 34t excavator	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Piling Rig - Boring	≤ 800 mm	2 m (nominal)	4 m
Piling Rig – Hammer	12 t down force	15 m	50 m
Jackhammer	Hand held	1 m (nominal)	2 m

Note 1: More stringent conditions may apply to heritage or other sensitive structures.

7 Implementation Plan and Strategy

The proposed development is to be undertaken in accordance with the noise and vibration requirements contained within the following documents and guidelines:

Controlling operational noise impacts of the development on surrounding land uses:

- The Noise Policy for Industry (NPfI) (EPA, 2017)

Operational noise emissions from mechanical plant associated with the Project should be controlled to reduce noise impacts upon neighbouring residential receivers and occupants within the proposed development.

The final project trigger levels would be determined or confirmed in specific future SSDA assessments Detailed assessment and verification of mechanical noise emissions should be carried out during the SSDA for each stage of the project ensuring that the nominated criteria for mechanical plant emissions are met.

Controlling noise impacts for the amenity of future residents of the development:

- The *State Environment Planning Policy* (Infrastructure) 2007 (Infrastructure SEPP)
- The *City of Sydney Development Control Plan* (SDCP 2012)
- AS 2107:2016 "*Acoustics - Recommended design sound levels and reverberation times for building interiors*". For non-residential spaces.

Throughout the SSDA assessments for future developments across the site, particularly those fronting McEvoy Street, detailed assessments on final building configurations shall be undertaken to ensure that – as well as meeting noise requirements – ventilation needs can be met. This may require assessment in line with the City of Sydney's draft "*Alternative natural ventilation of apartments in noisy environments: Performance pathway guideline*" (Sept 2018) or future equivalent where necessary.

Controlling construction noise and vibration impacts of the development on surrounding land uses:

- *Interim Construction Noise Guideline* (DECC 2009).
- *Assessing Vibration: A Technical Guideline* dated February 2006 (DECCW, 2006)
- BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*

Once details surrounding the proposed construction methodology and equipment is known, a comprehensive assessment and Construction Noise and Vibration Management Plan (CNVMP) shall be undertaken as part of the future detailed proposal approval process.

The CNVMP should incorporate mitigation and management strategies developed through consultation with the surrounding community and regulatory authority that is also in accordance with the relevant guidelines above.

8 Conclusion

SLR has undertaken a noise and vibration impact assessment associated with the proposed redevelopment of Waterloo South which forms part of the Waterloo Estate. The assessment has been carried out in accordance with NSW regulatory requirements and in consultation with City of Sydney and other relevant stakeholders.

The scope of the assessment involved deriving and establishing project specific noise goals through consultation with various NSW and Australian guidelines; undertaking a noise and vibration impact assessment for the future development with respect to the appropriate criteria; and, where required, providing recommendations for noise control measures.

It is expected that the development would meet all established Noise and Vibration Criteria if the recommendations are undertaken. Future detailed development applications would need to demonstrate compliance with these criteria.

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

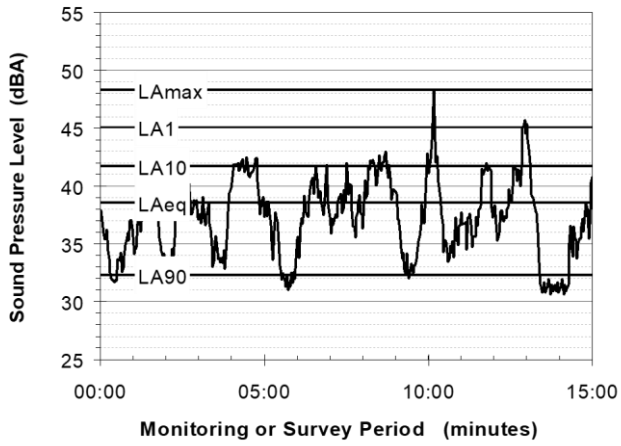
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

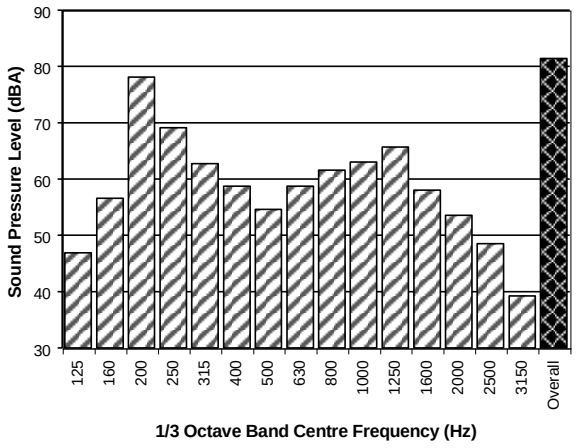
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

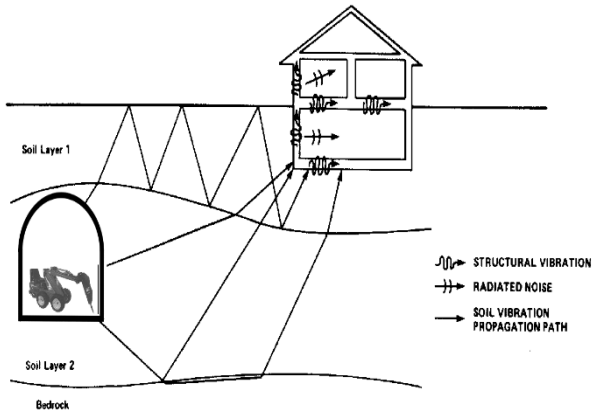
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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.



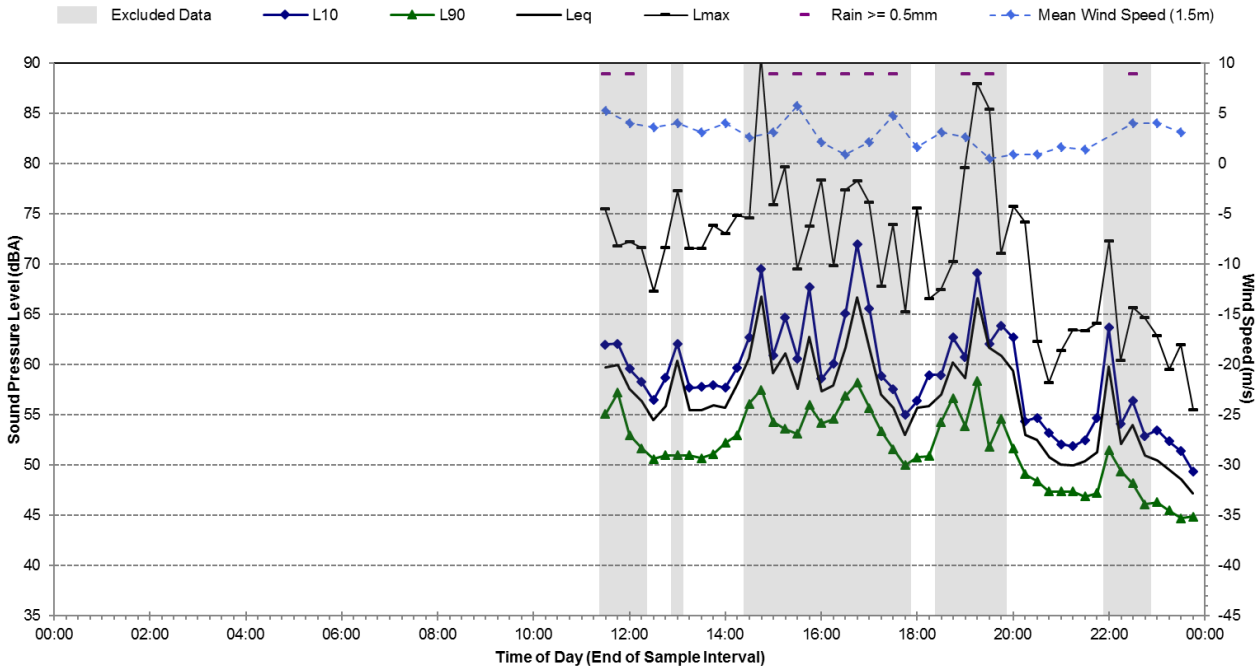
The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect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

APPENDIX B

Ambient Noise Monitoring Results

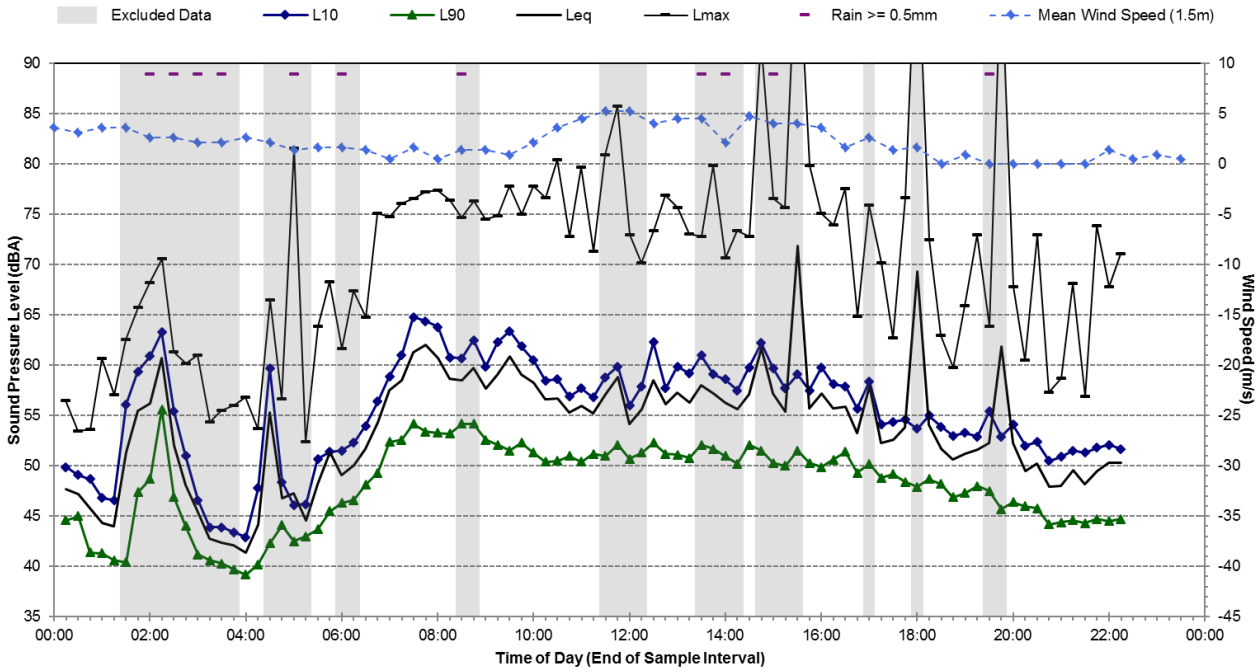
Statistical Ambient Noise Levels

L1 - 1 Phillip Street, Waterloo - Wednesday, 7 June 2017



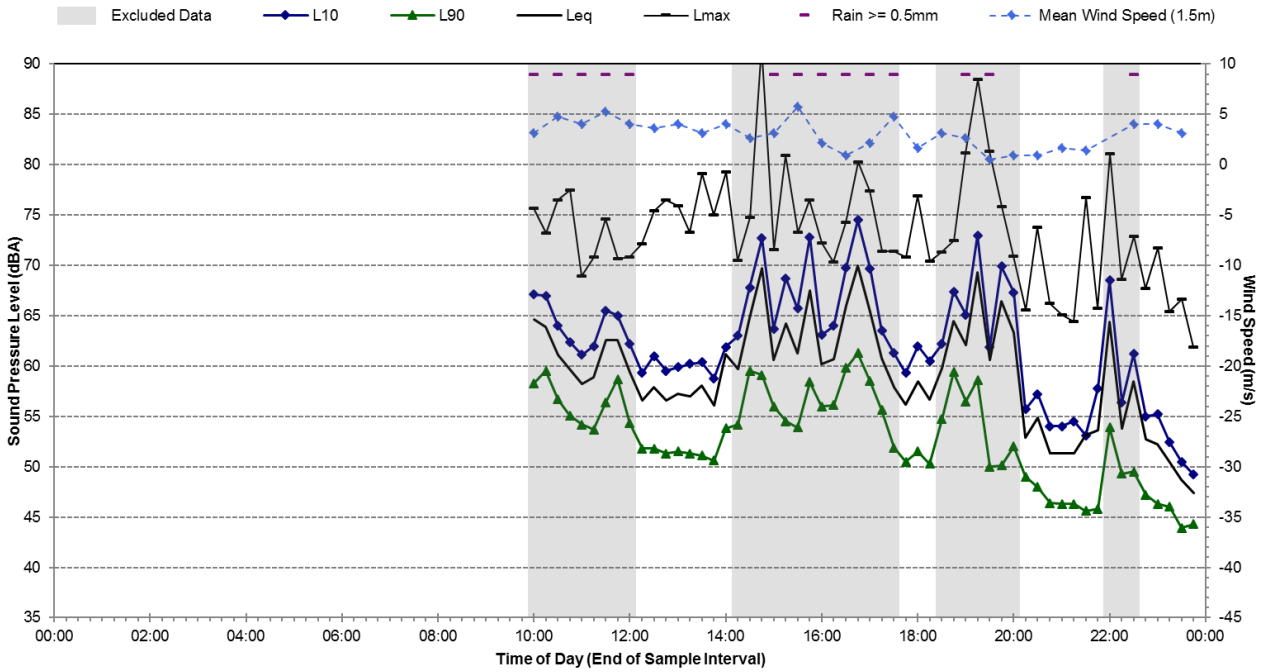
Statistical Ambient Noise Levels

L1 - 1 Phillip Street, Waterloo - Thursday, 8 June 2017



Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Wednesday, 7 June 2017



Statistical Ambient Noise Levels

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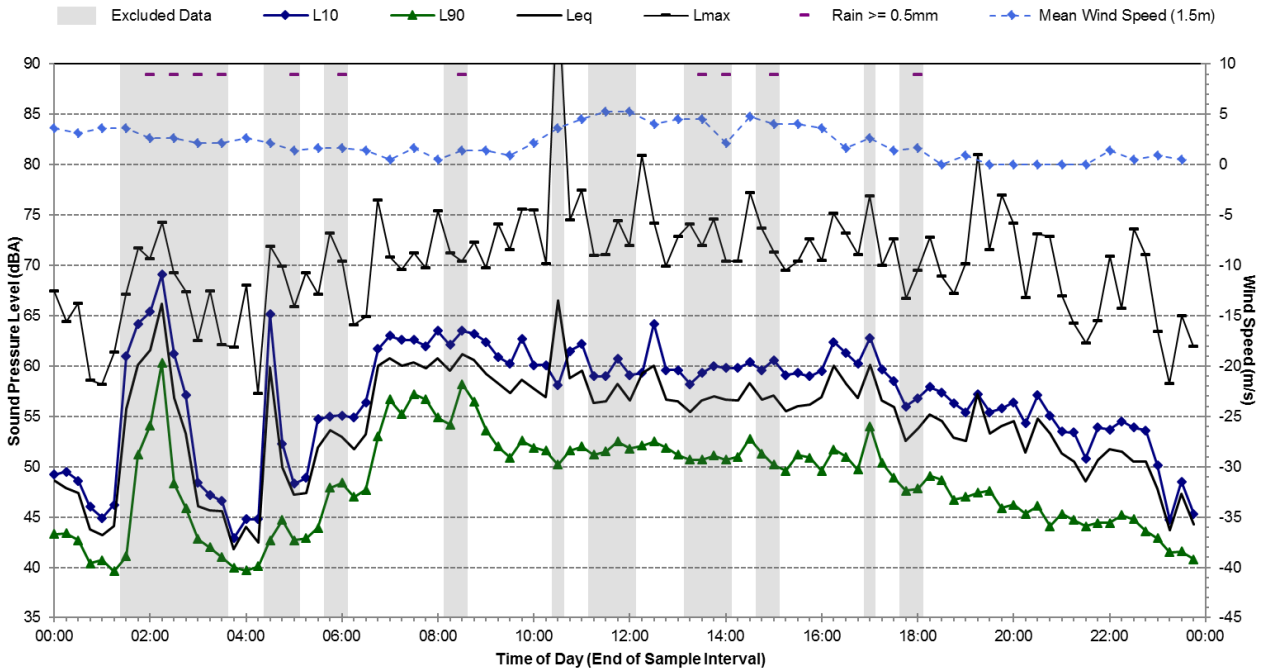
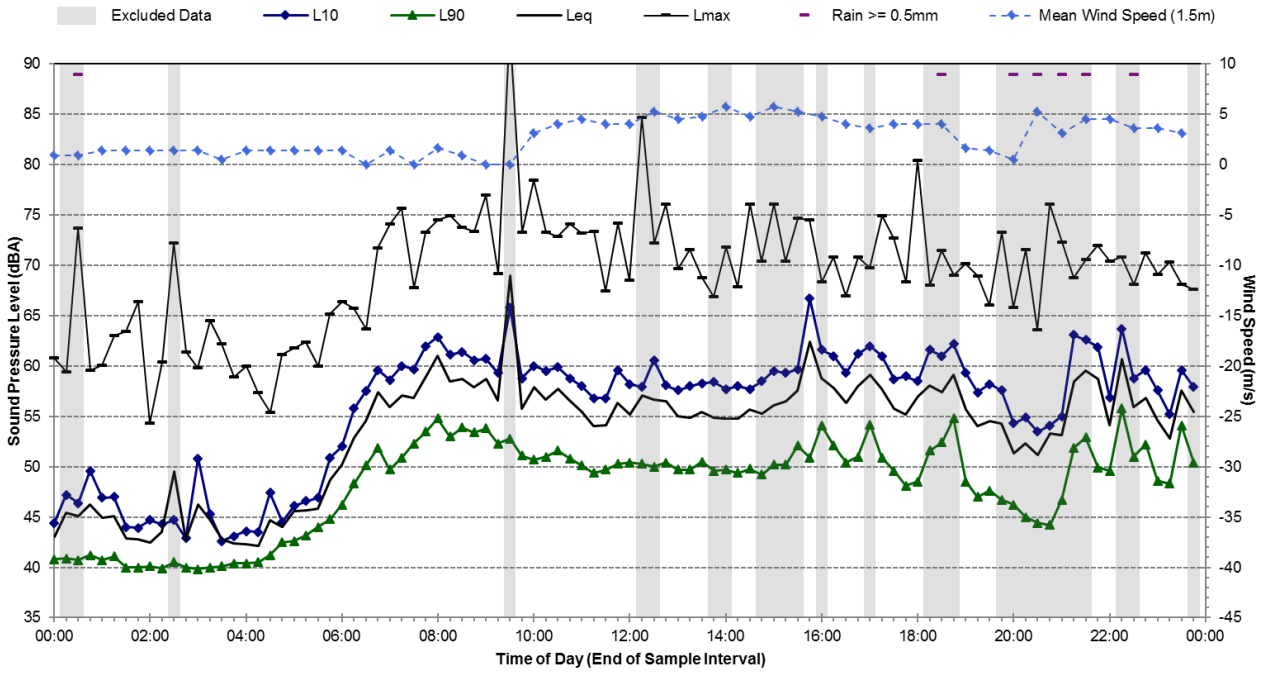


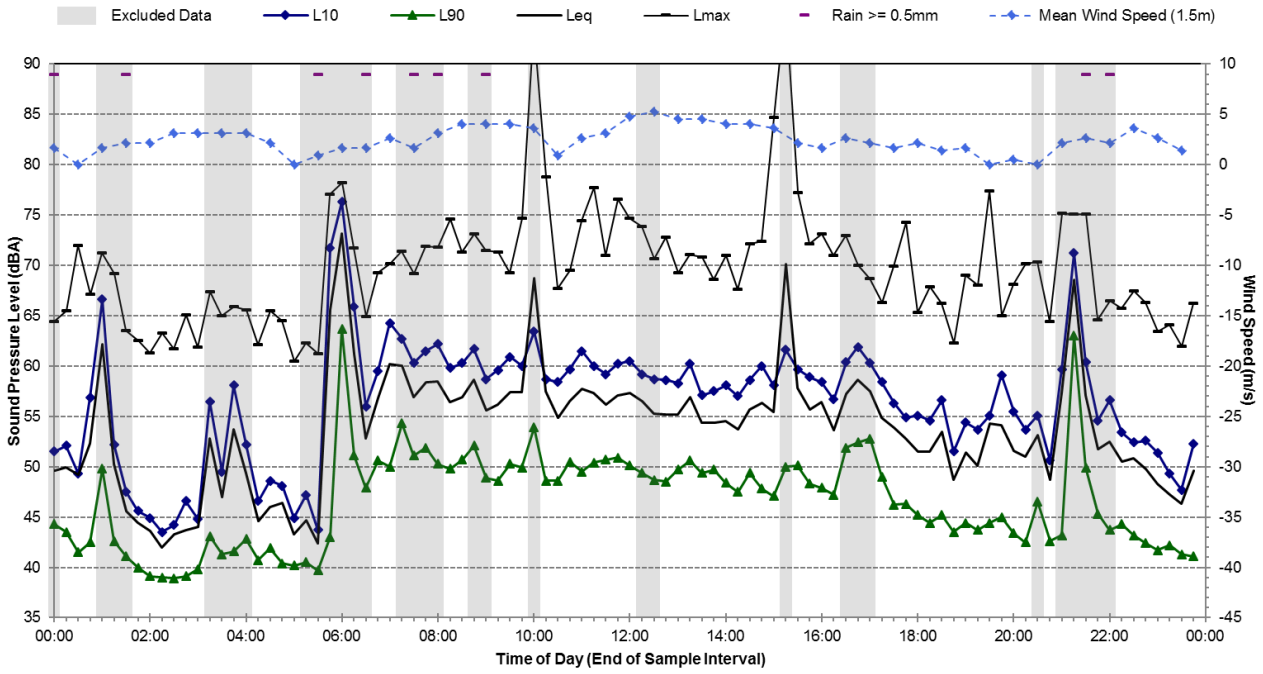
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Friday, 9 June 2017



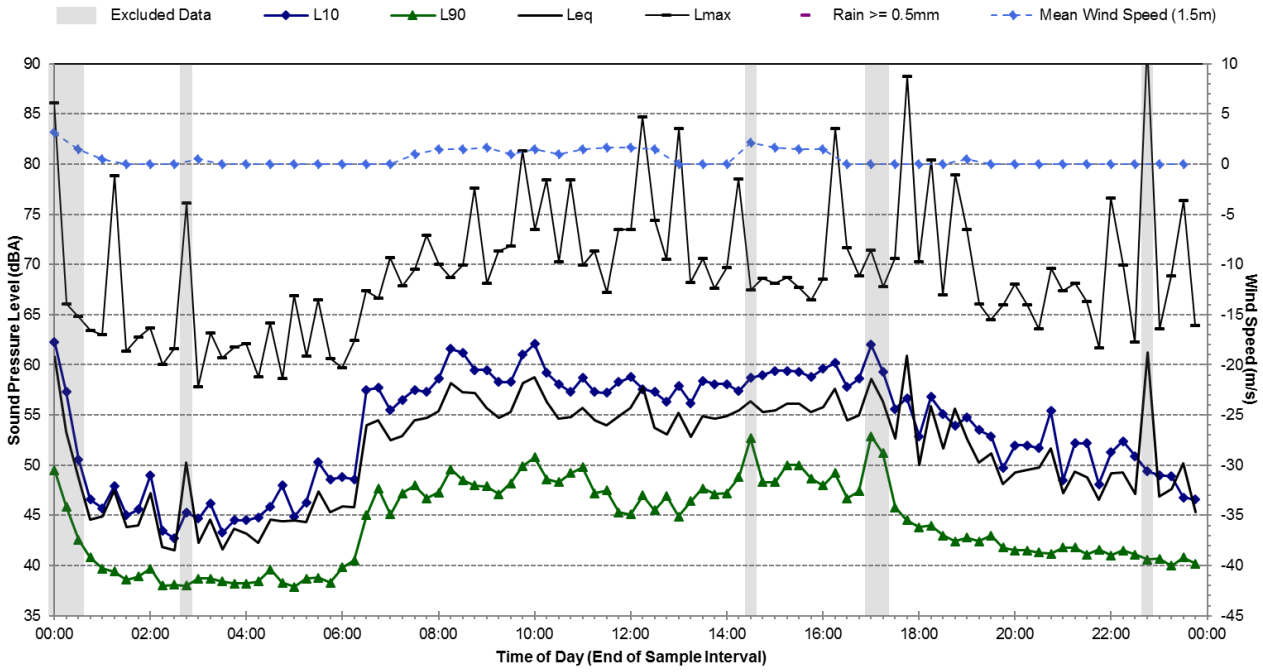
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Saturday, 10 June 2017



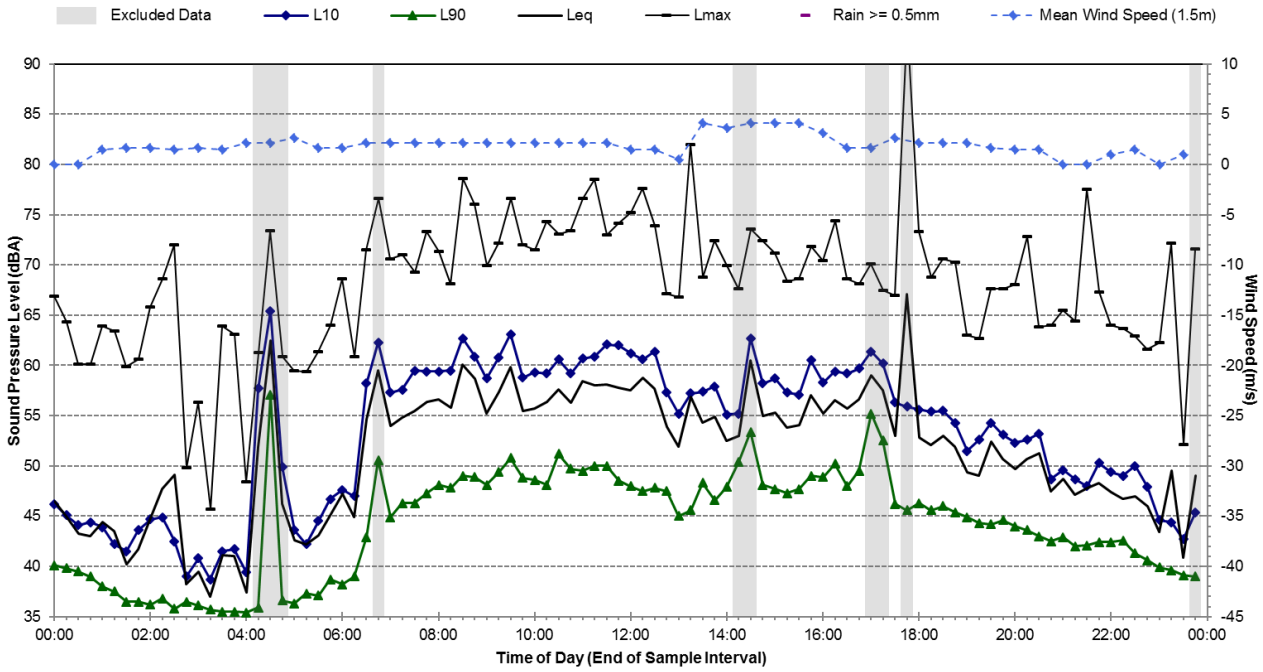
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Sunday, 11 June 2017



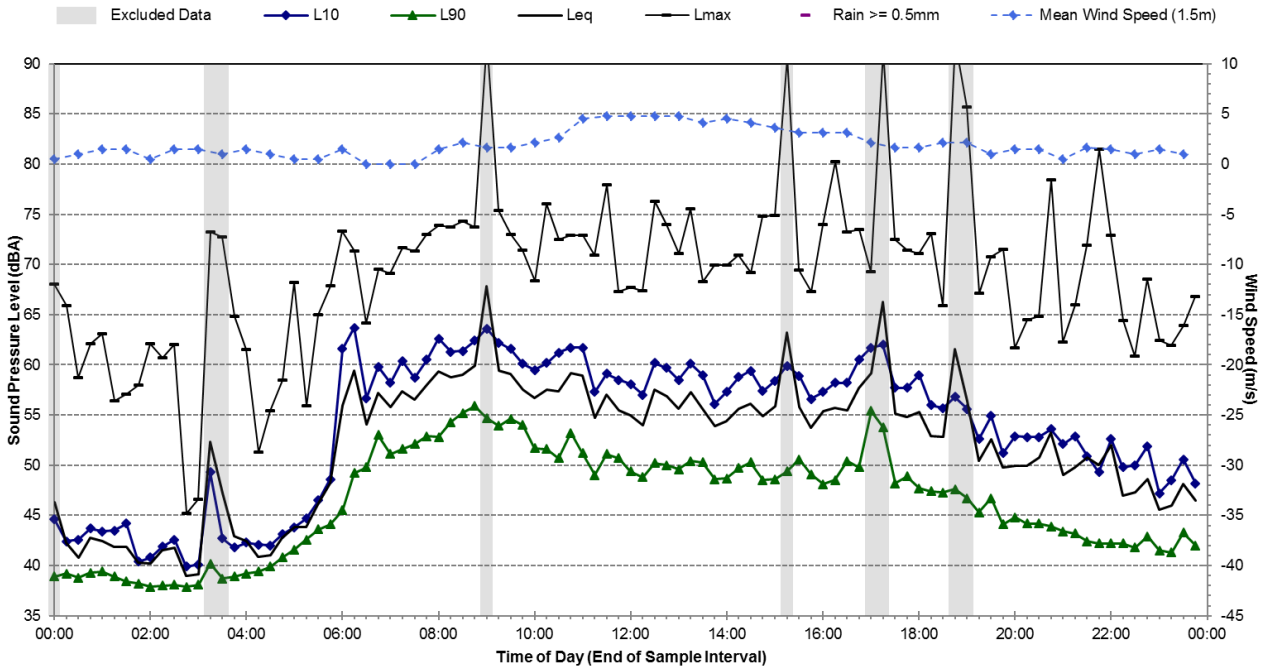
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Monday, 12 June 2017



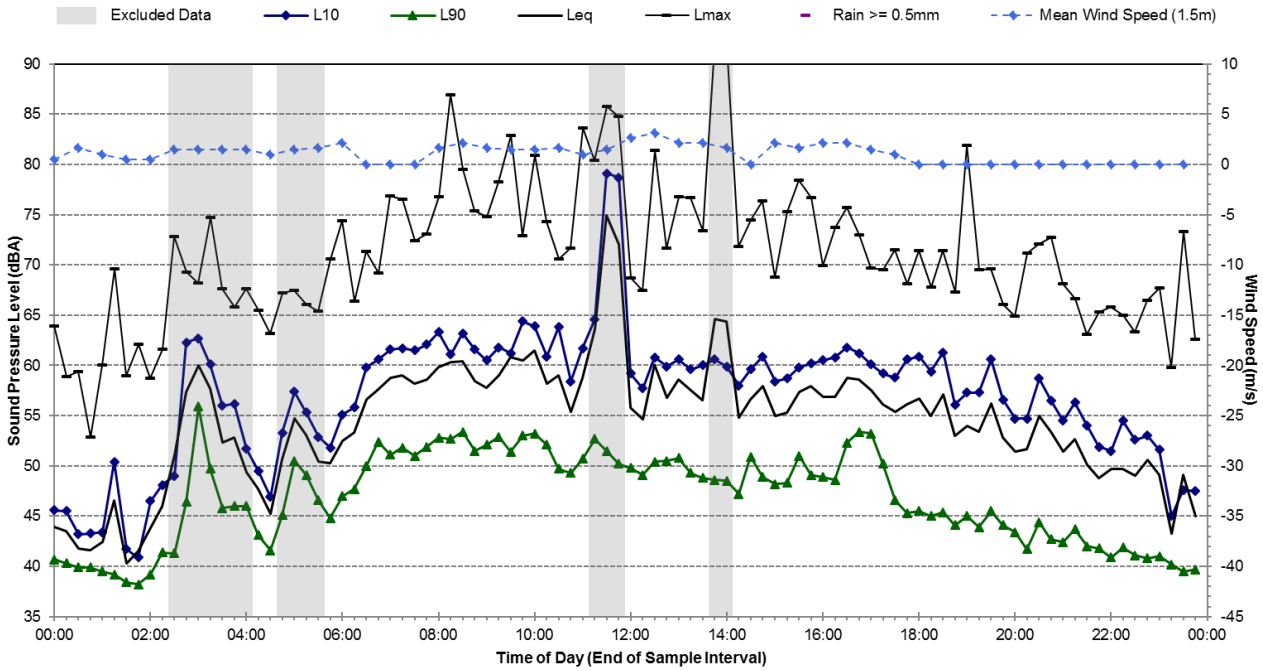
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Tuesday, 13 June 2017



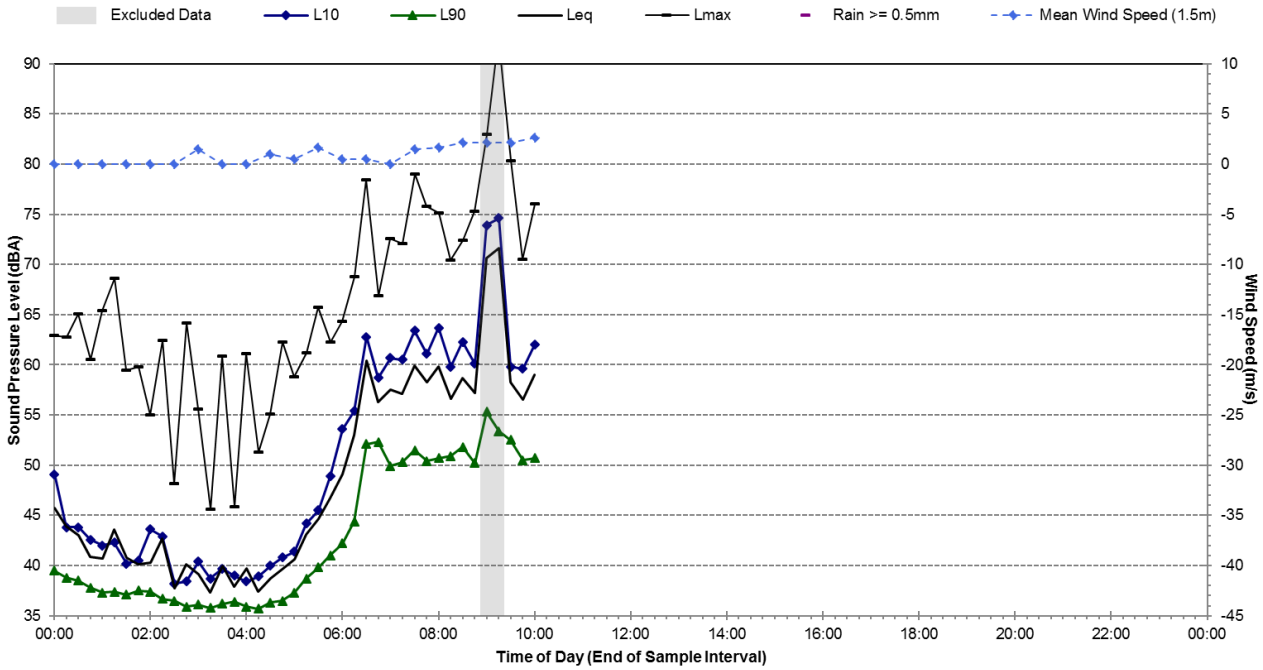
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Wednesday, 14 June 2017



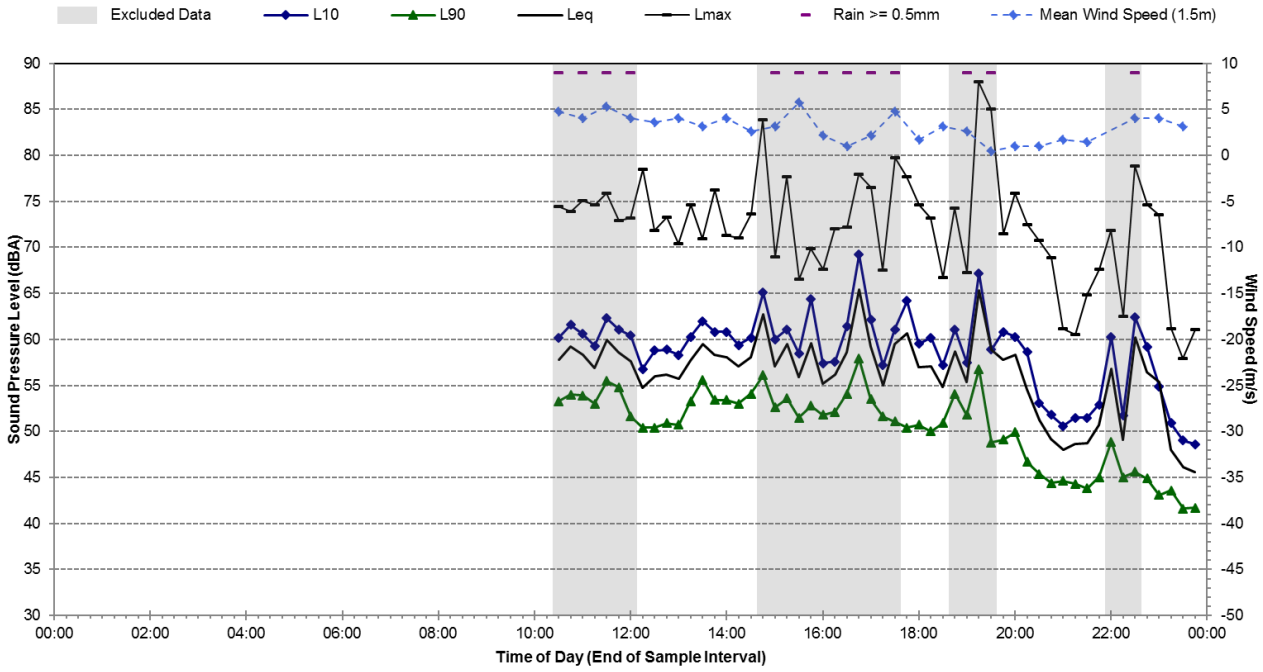
Statistical Ambient Noise Levels

L2 - 3 Phillip Street, Waterloo - Thursday, 15 June 2017



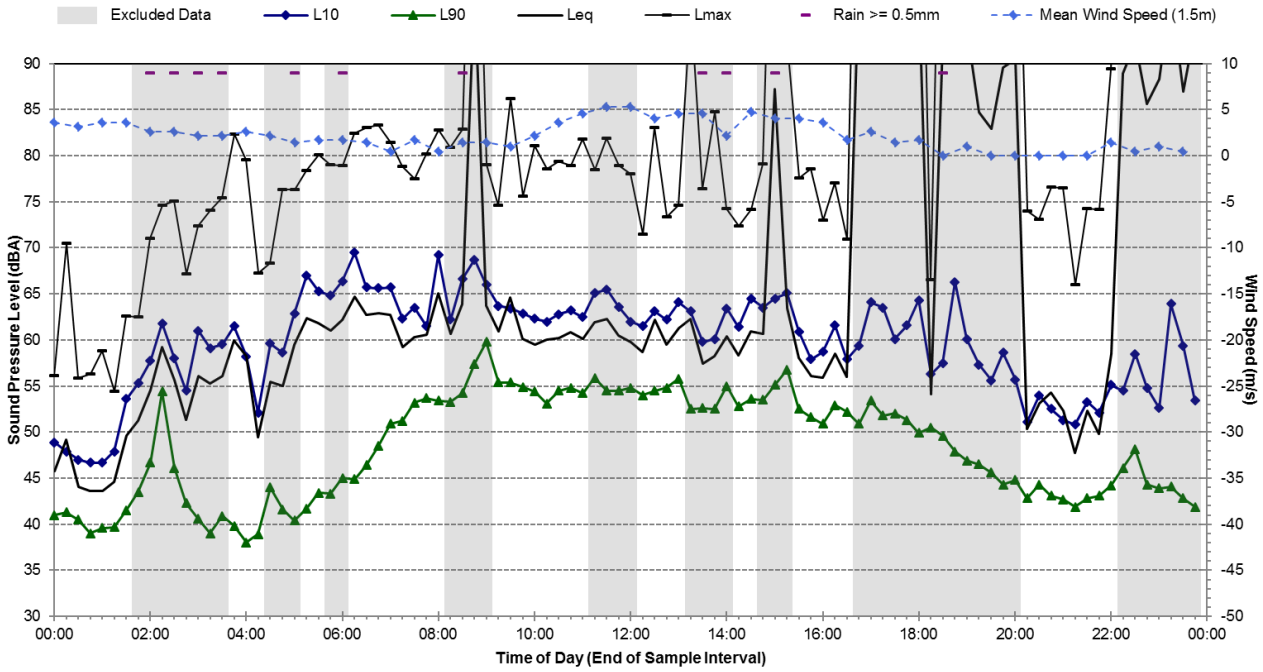
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Wednesday, 7 June 2017



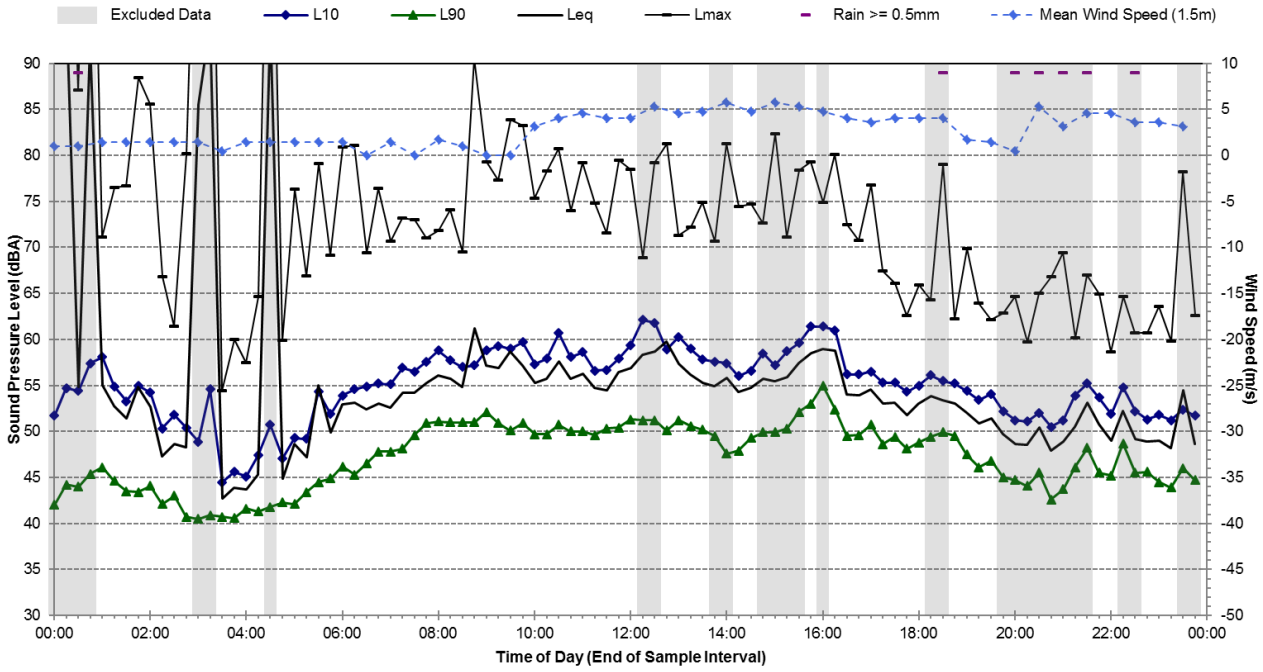
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Thursday, 8 June 2017



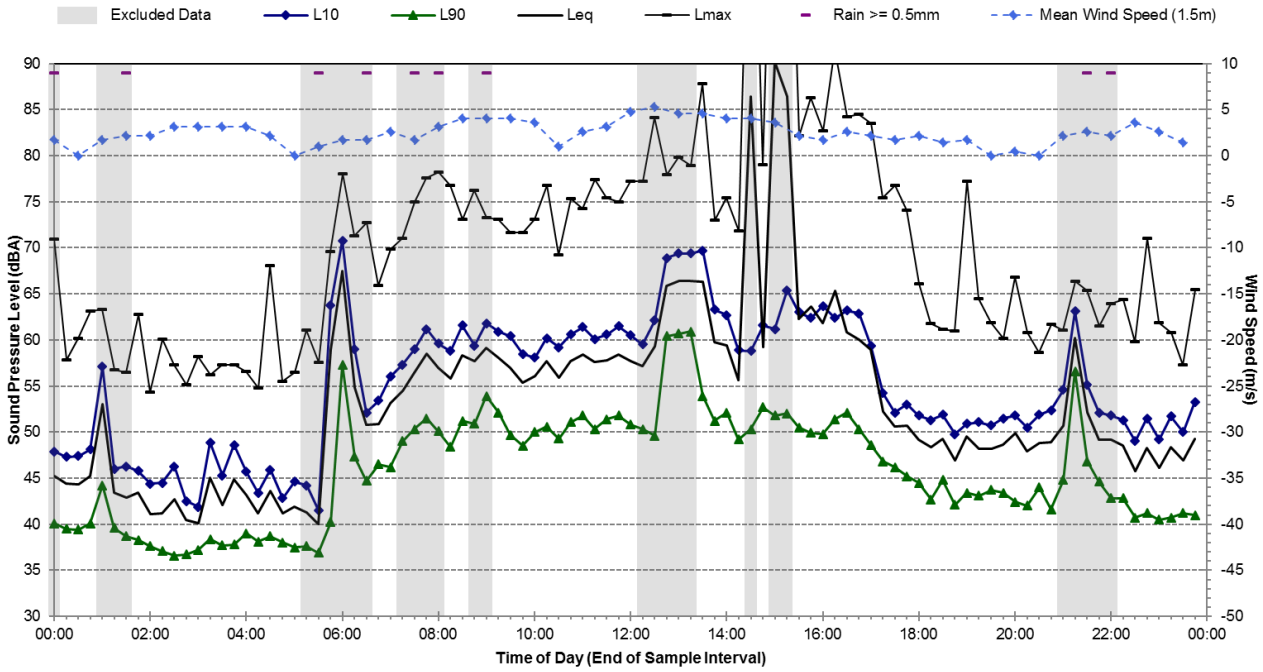
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Friday, 9 June 2017



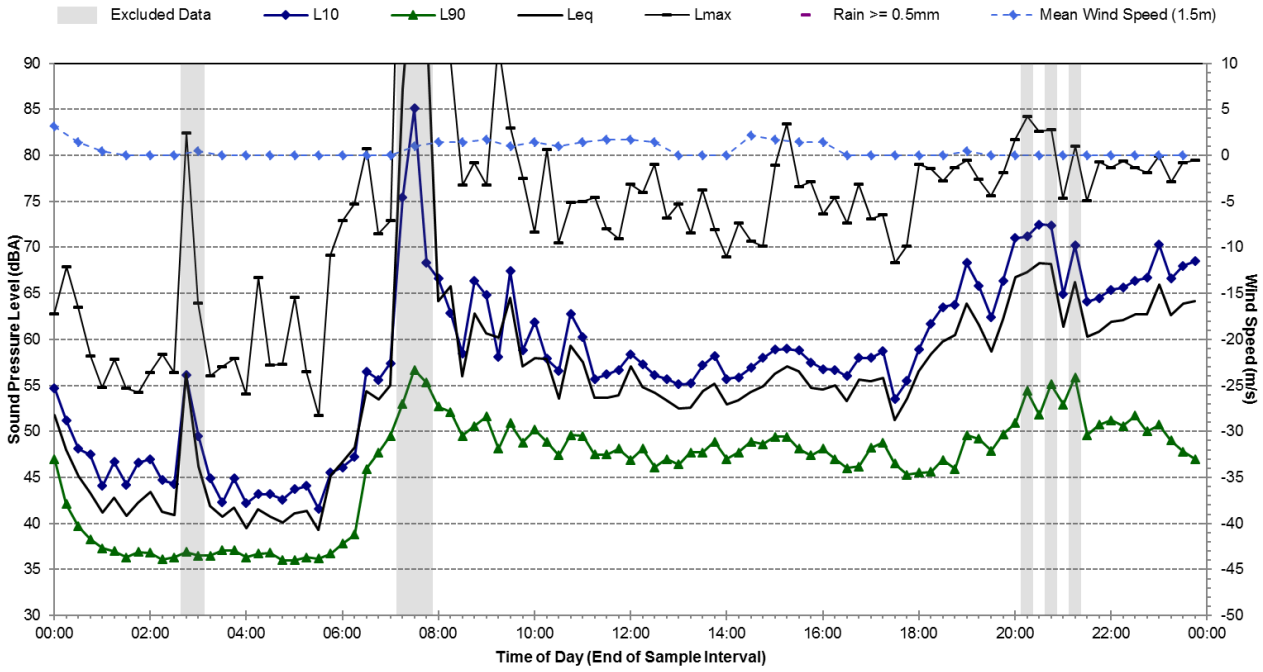
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Saturday, 10 June 2017



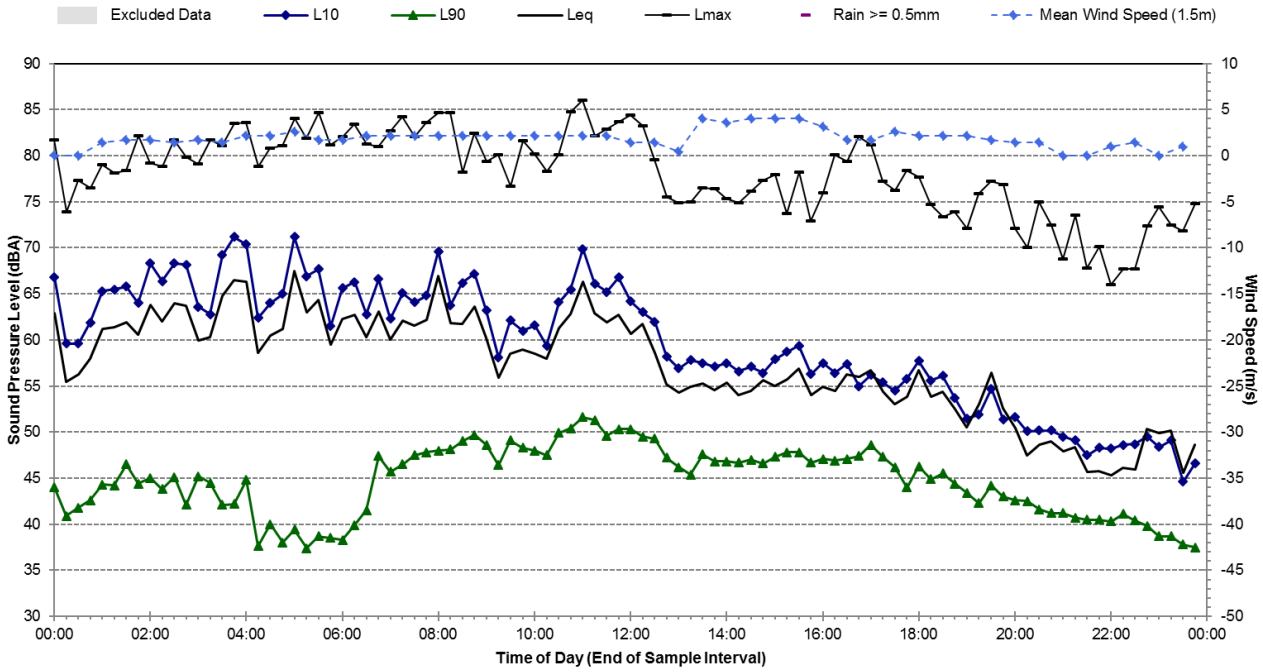
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Sunday, 11 June 2017



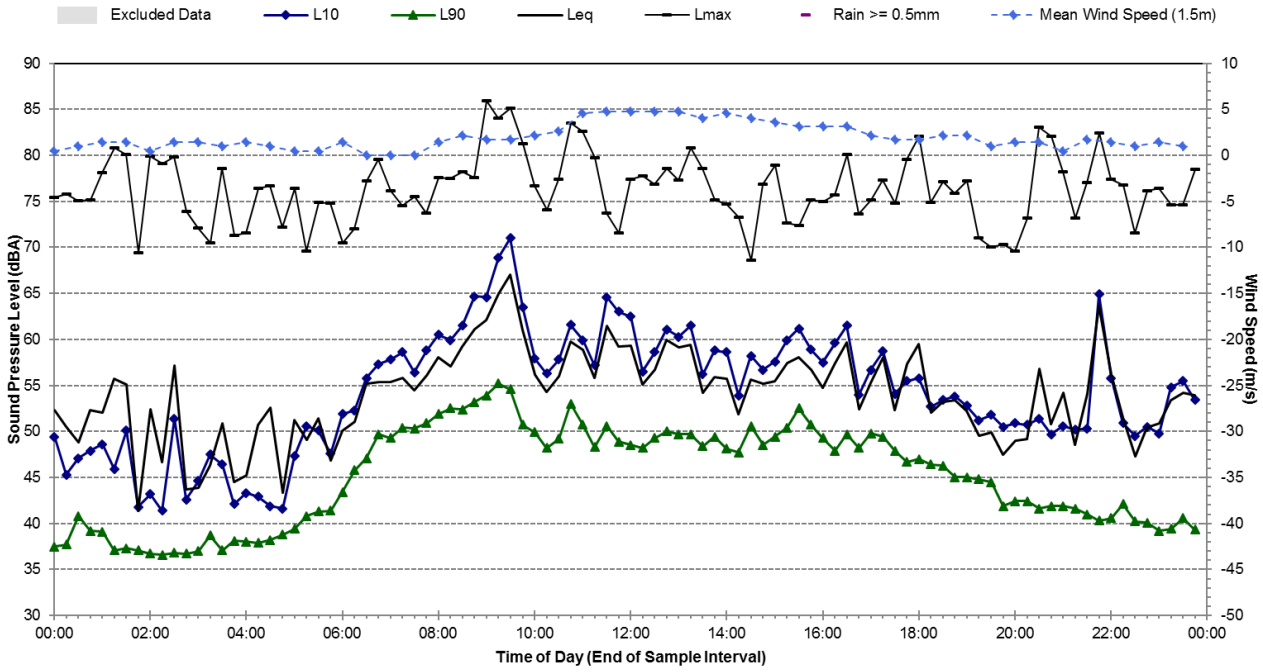
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Monday, 12 June 2017



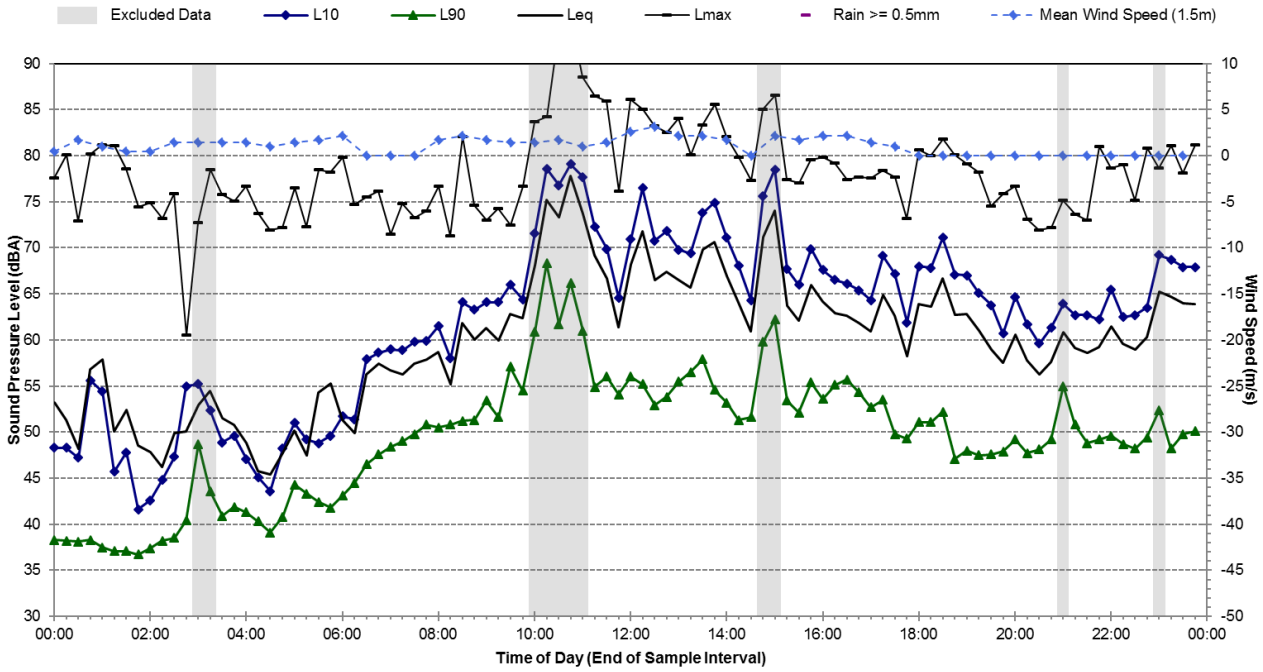
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Tuesday, 13 June 2017



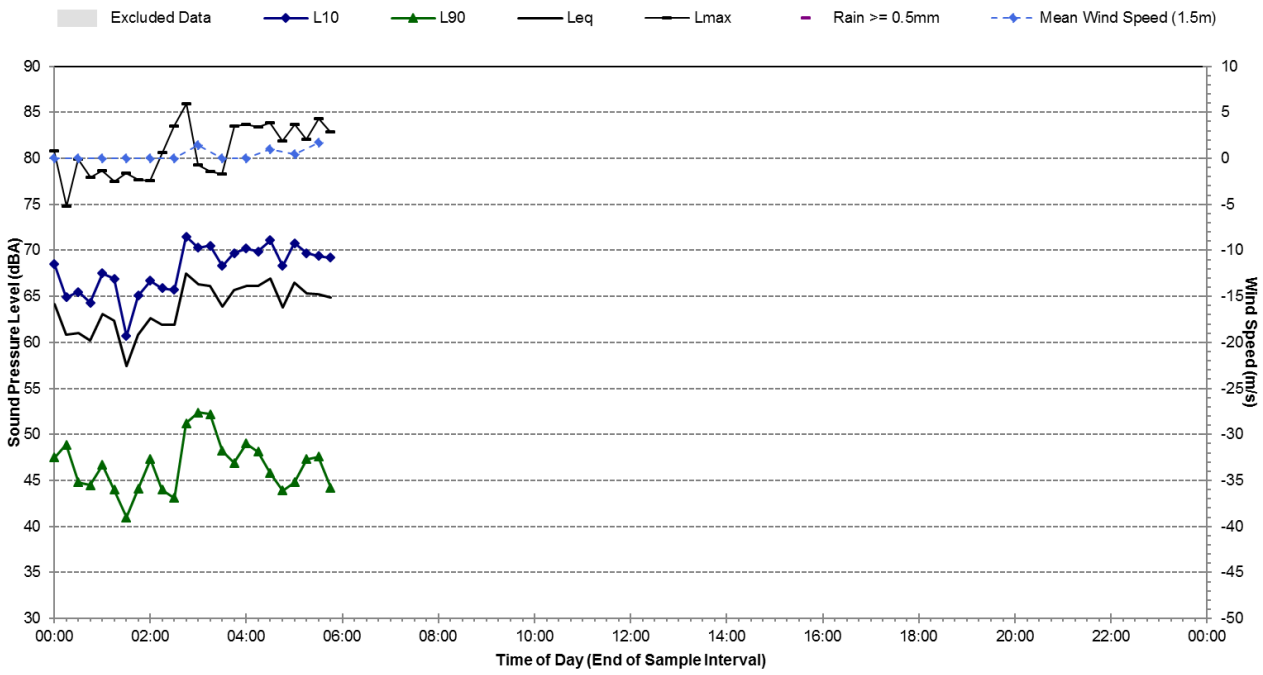
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Wednesday, 14 June 2017



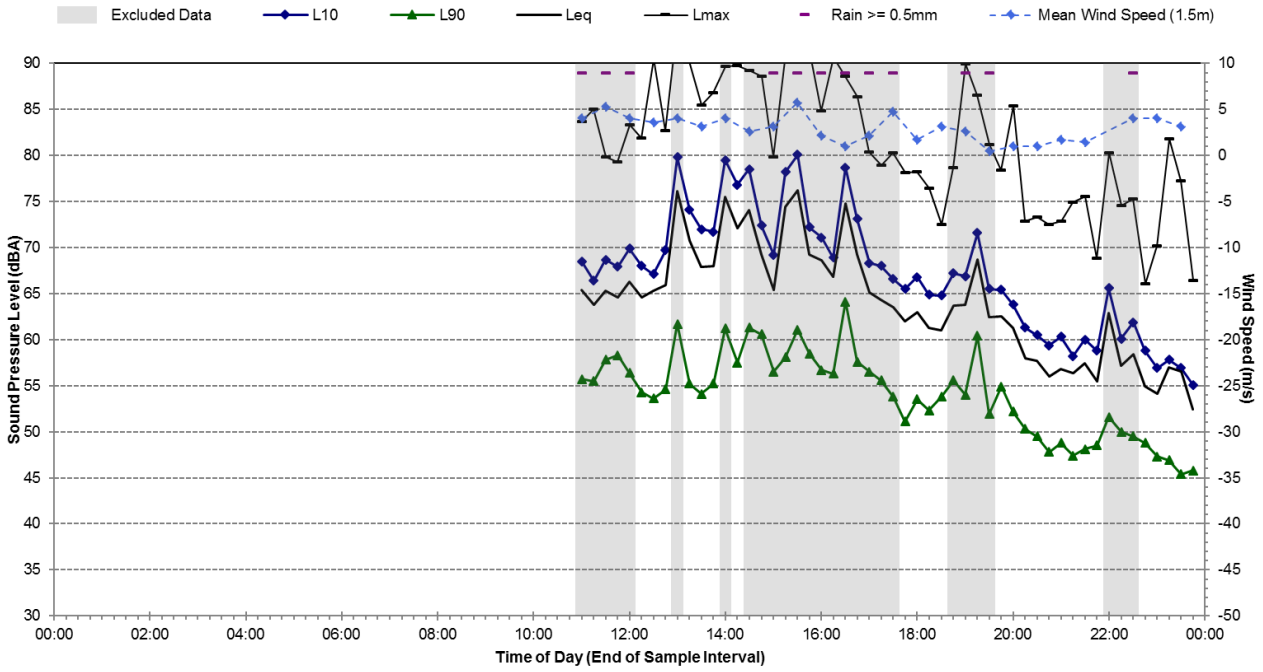
Statistical Ambient Noise Levels

L3 - 200 Pitt Street, Waterloo - Thursday, 15 June 2017



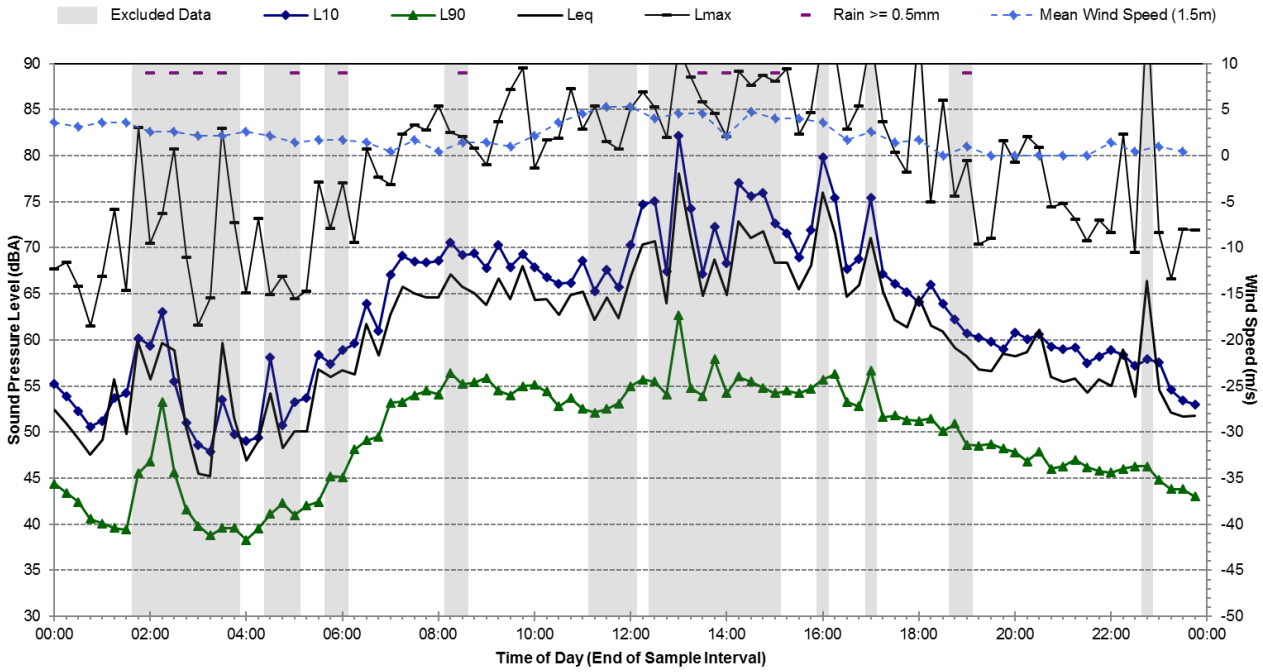
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Wednesday, 7 June 2017



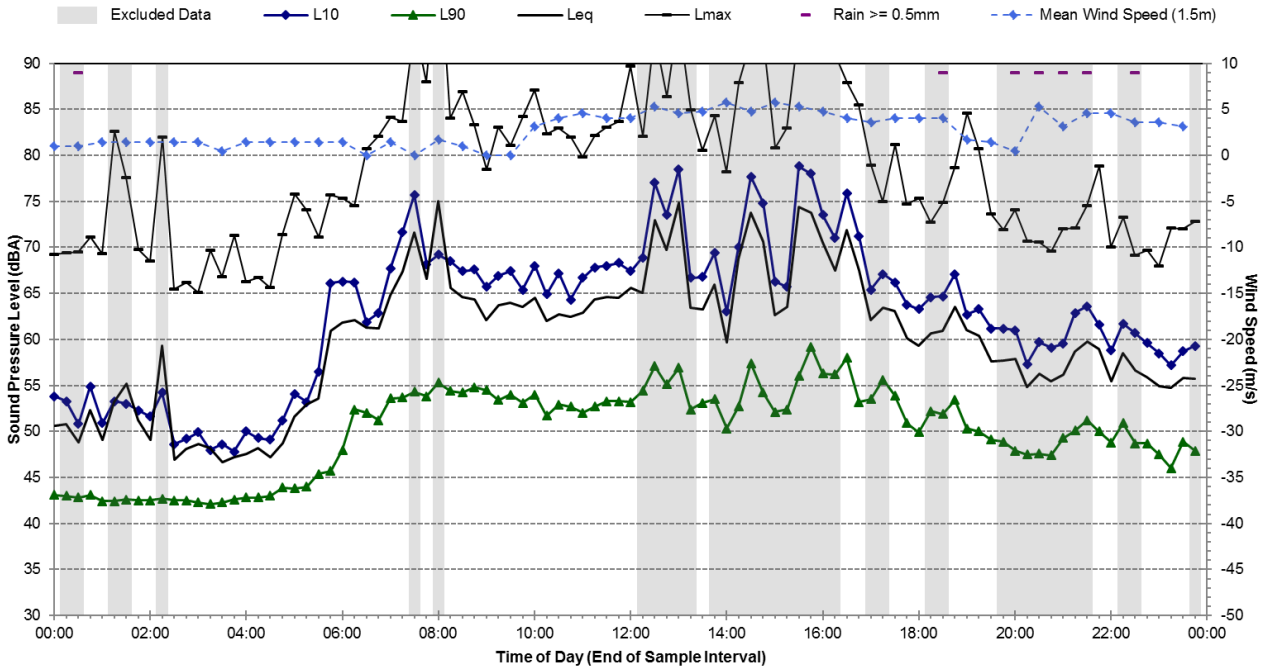
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Thursday, 8 June 2017



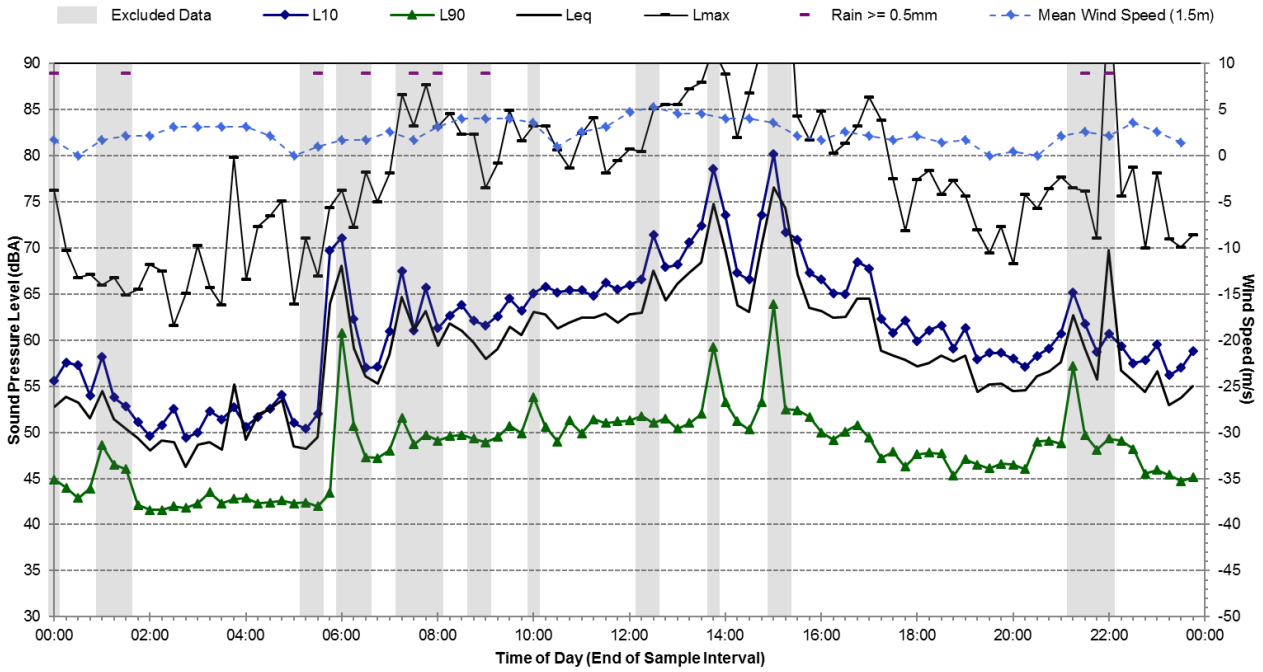
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Friday, 9 June 2017



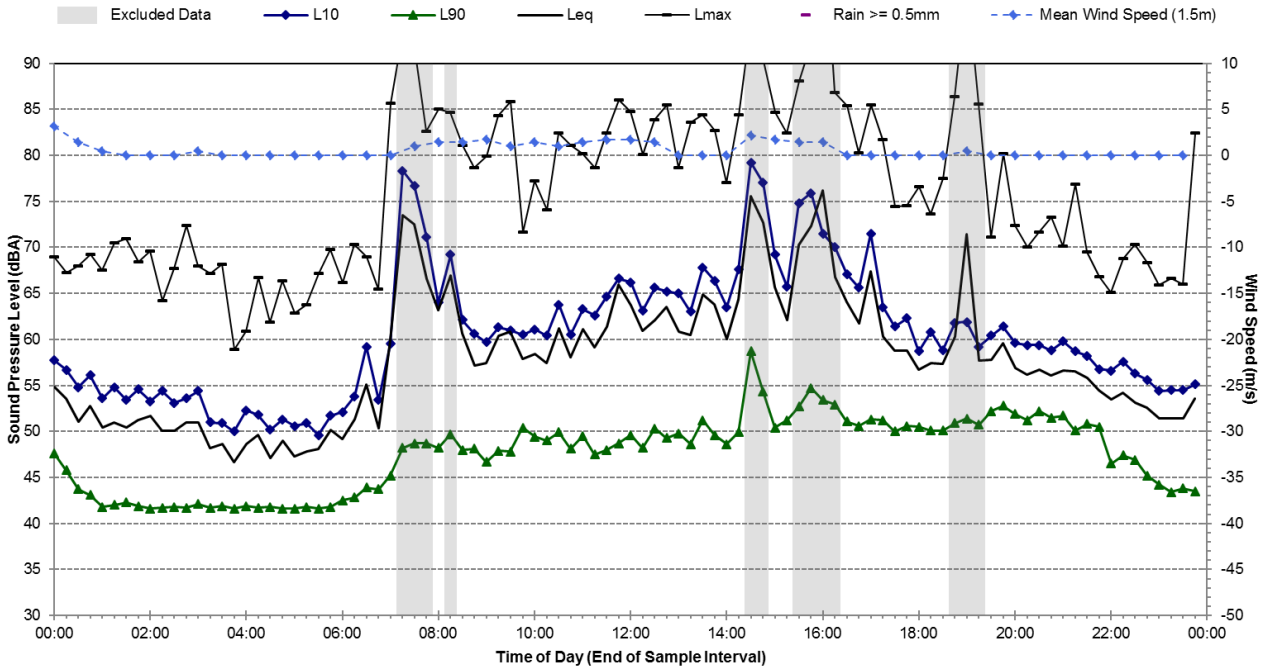
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Saturday, 10 June 2017



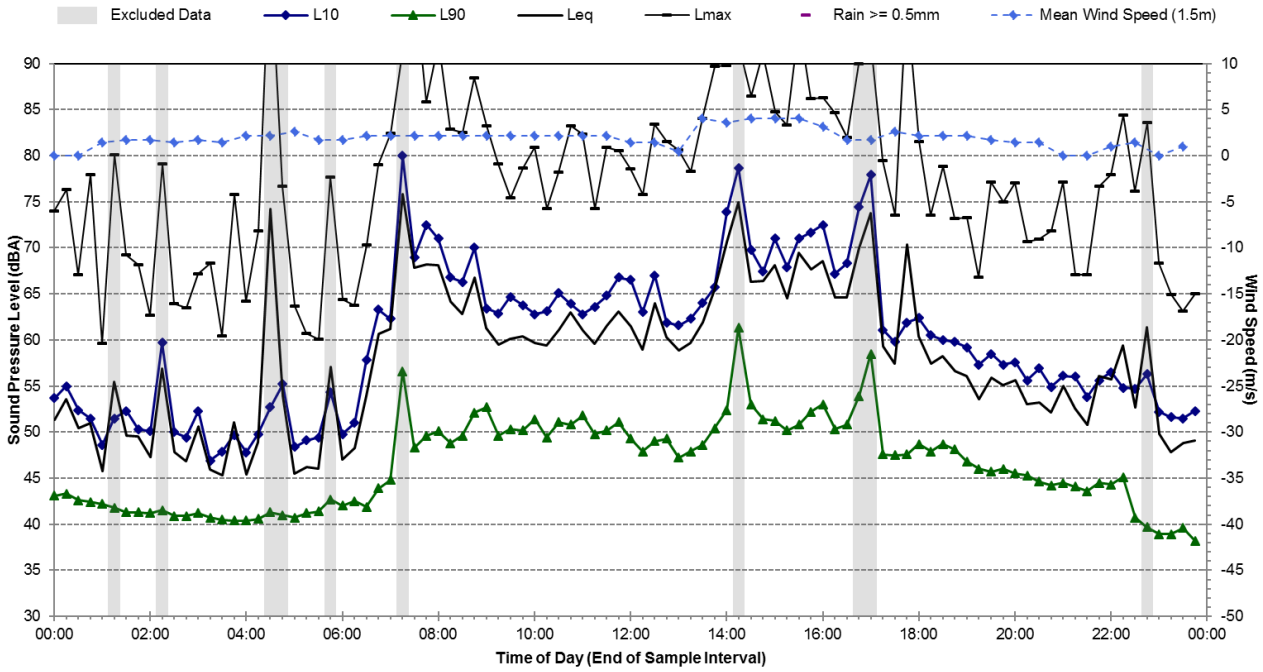
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Sunday, 11 June 2017



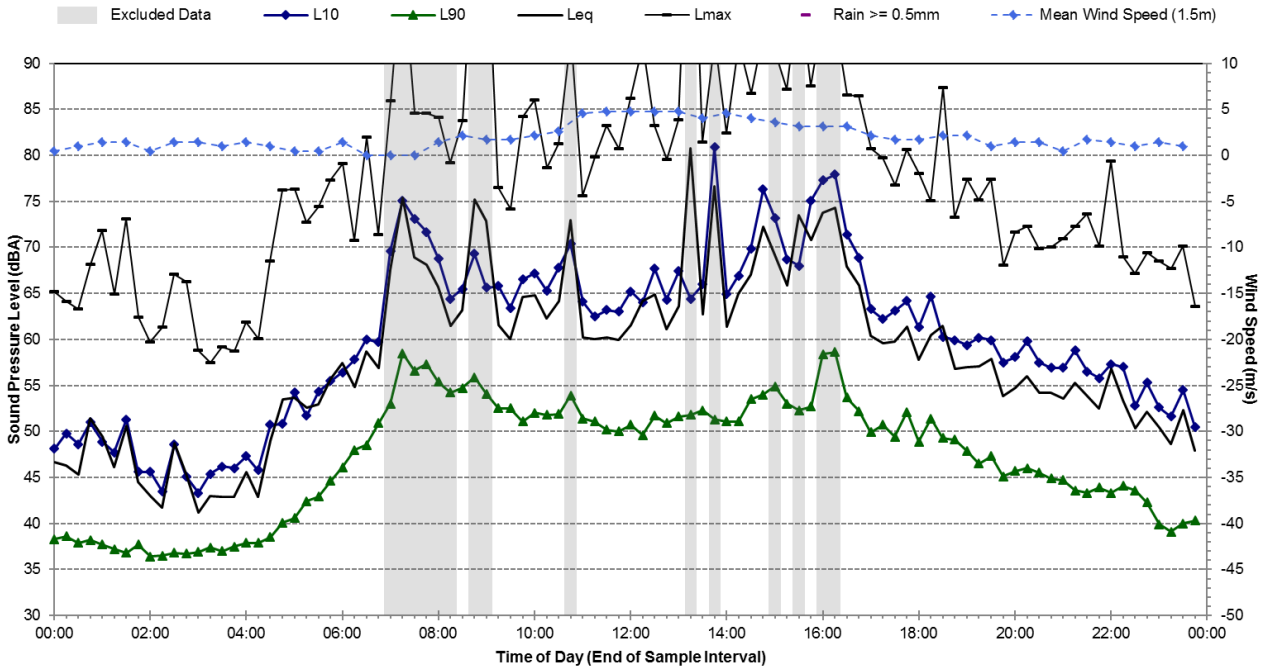
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Monday, 12 June 2017



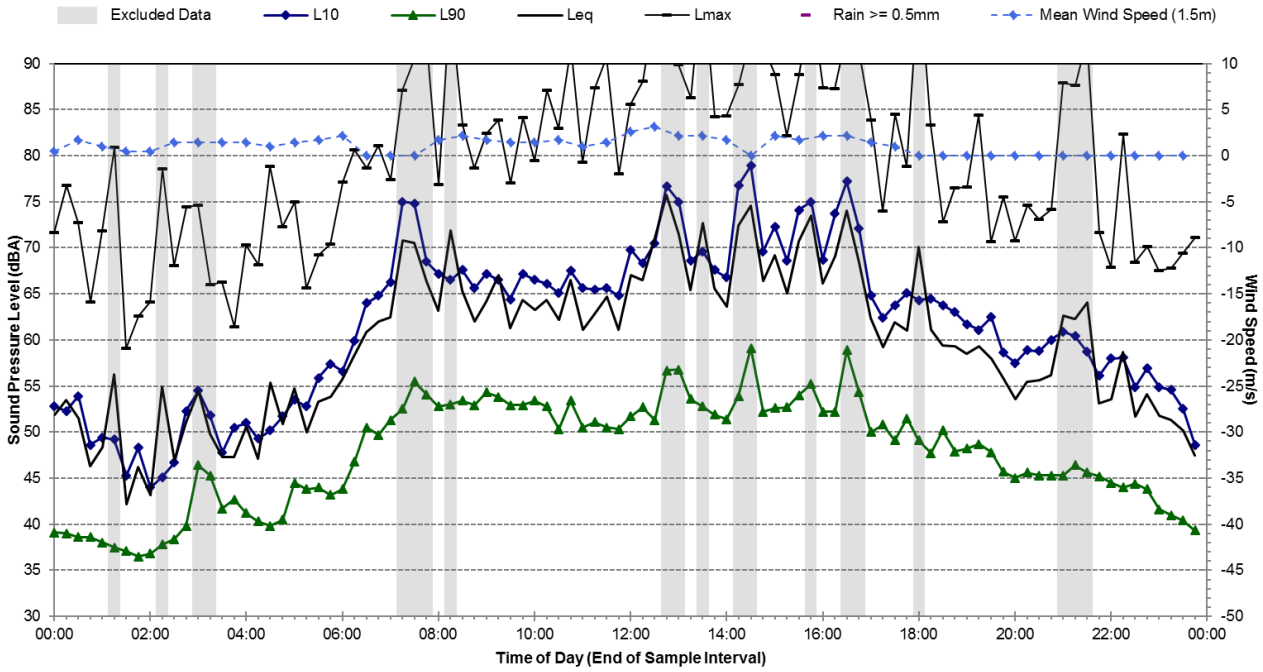
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Tuesday, 13 June 2017



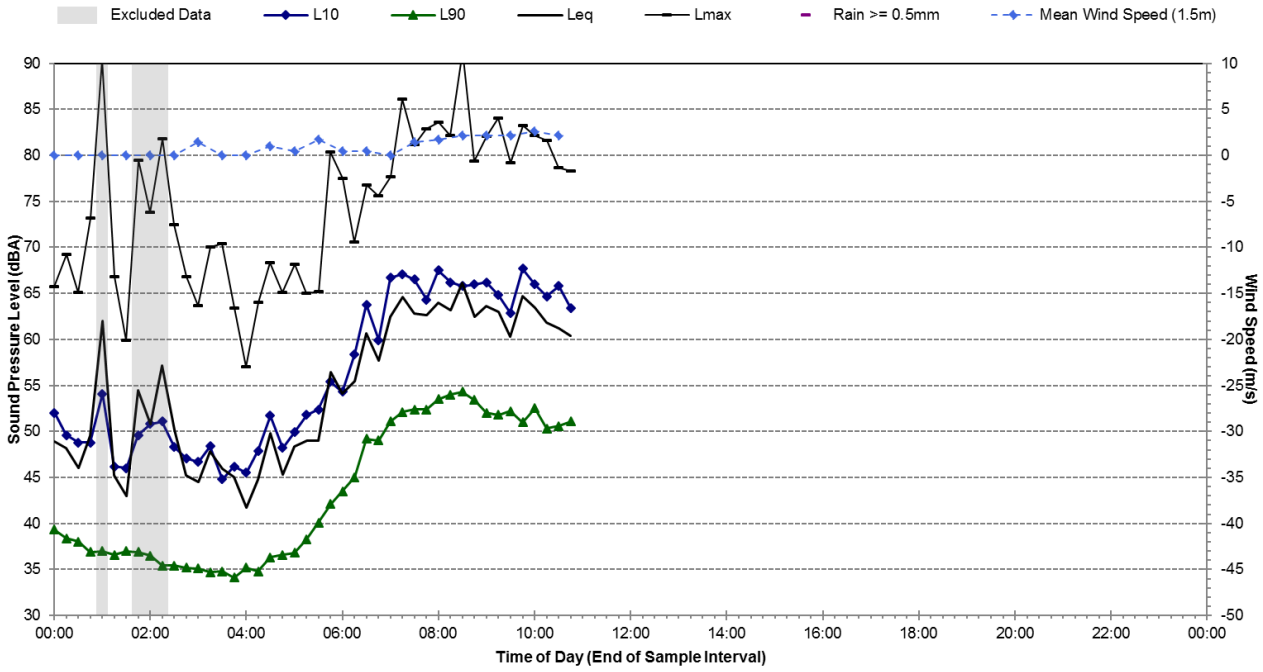
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Wednesday, 14 June 2017



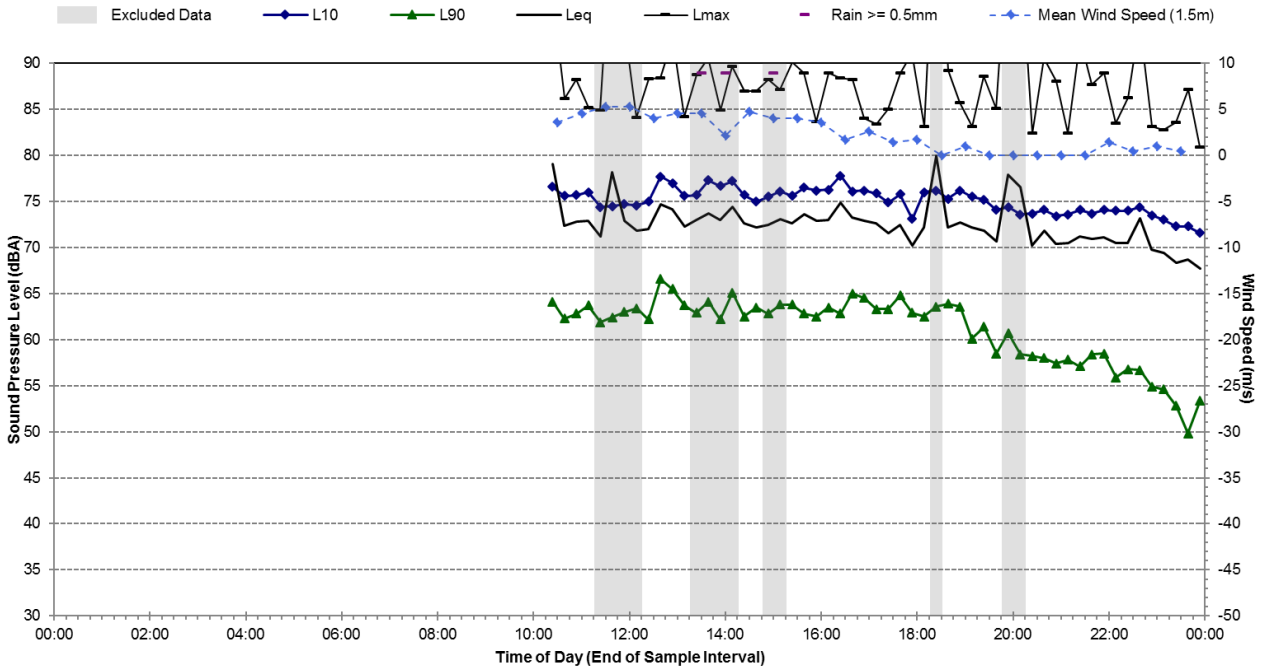
Statistical Ambient Noise Levels

L4 - 113 Wellington Street, Waterloo - Thursday, 15 June 2017



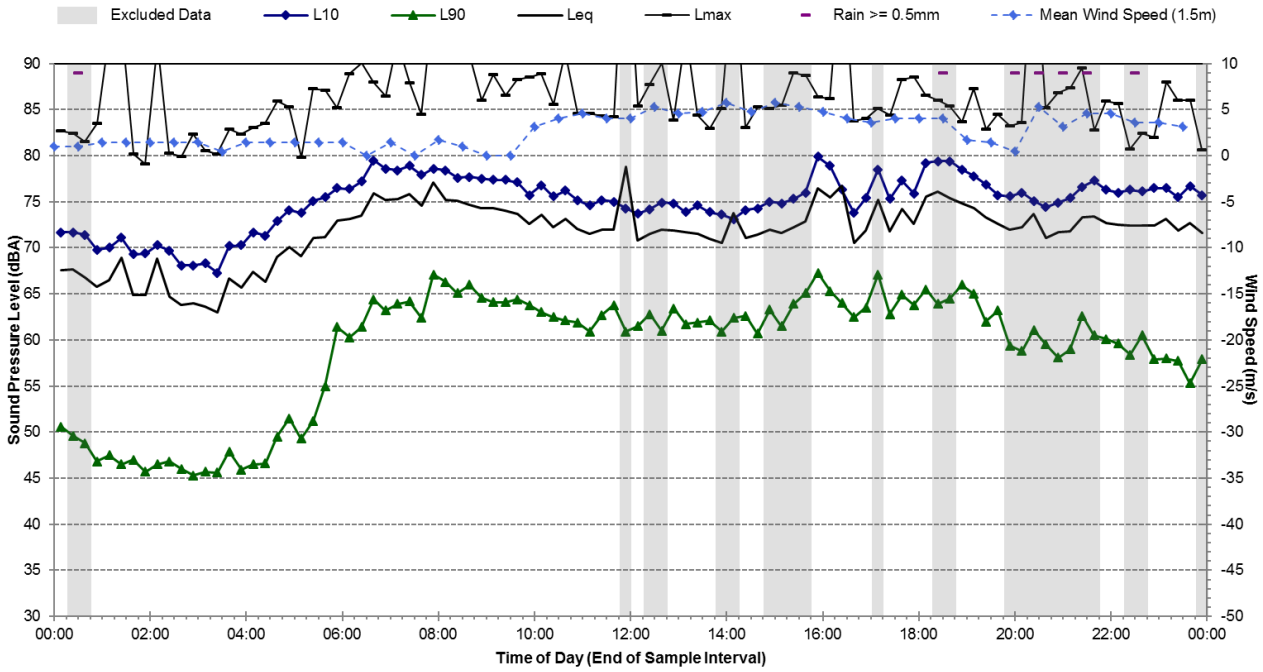
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Thursday, 8 June 2017



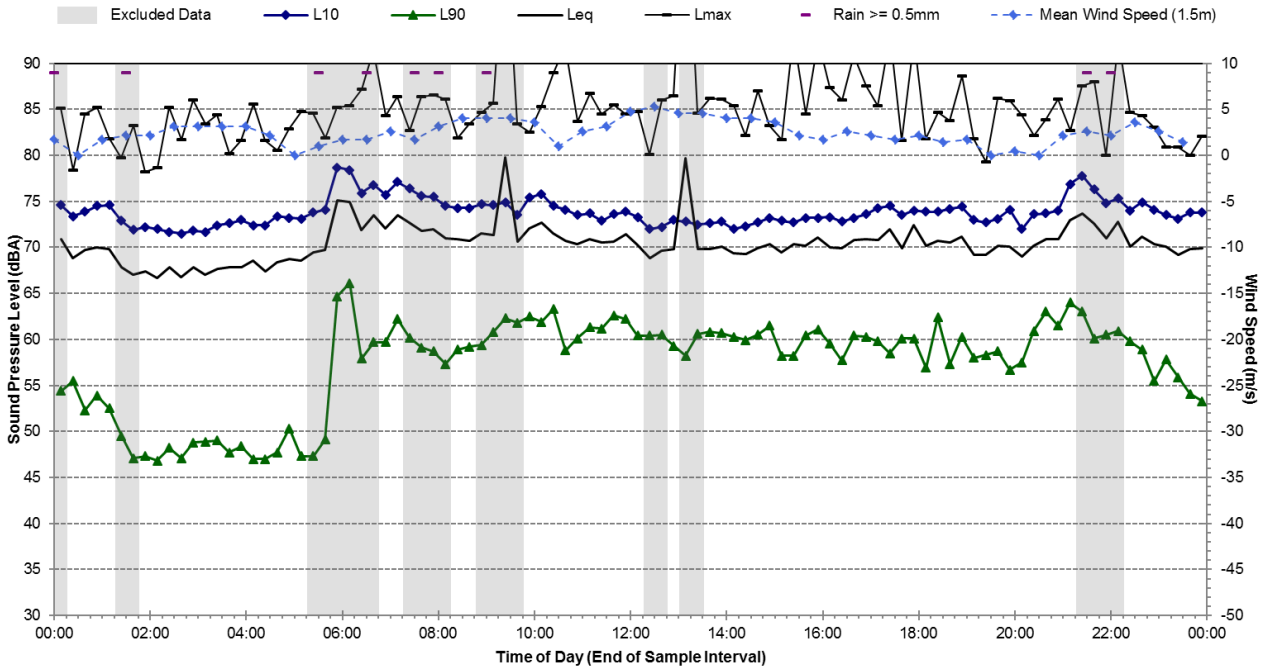
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Friday, 9 June 2017



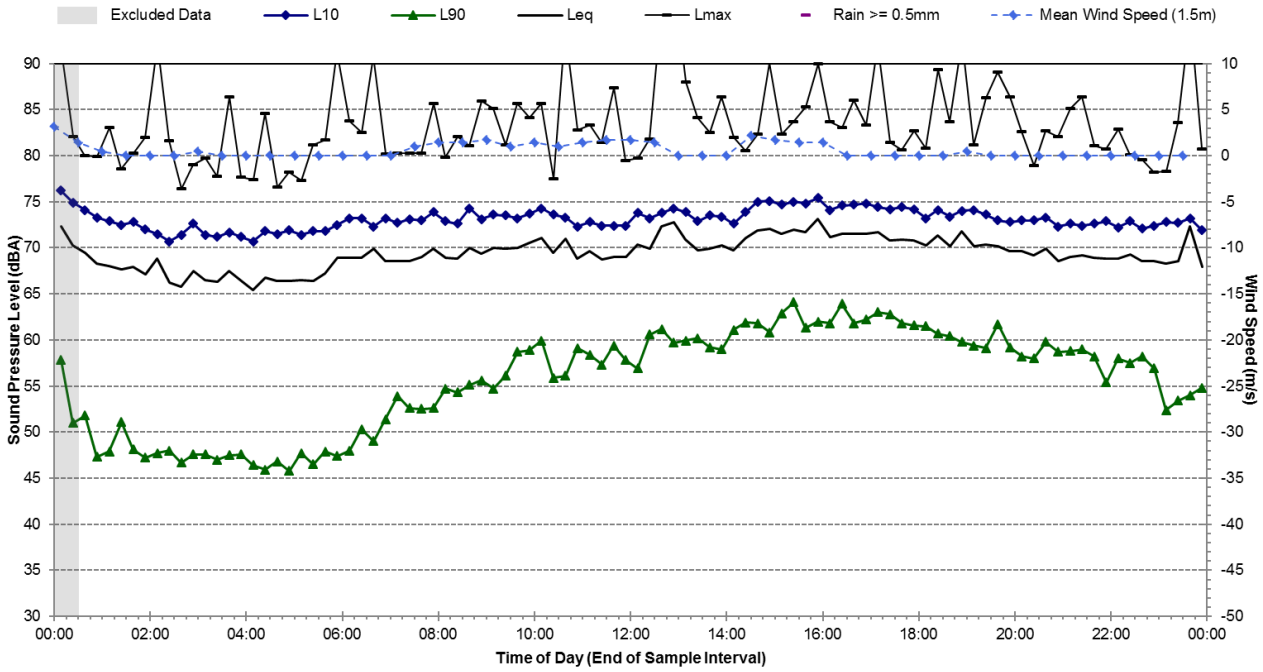
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Saturday, 10 June 2017



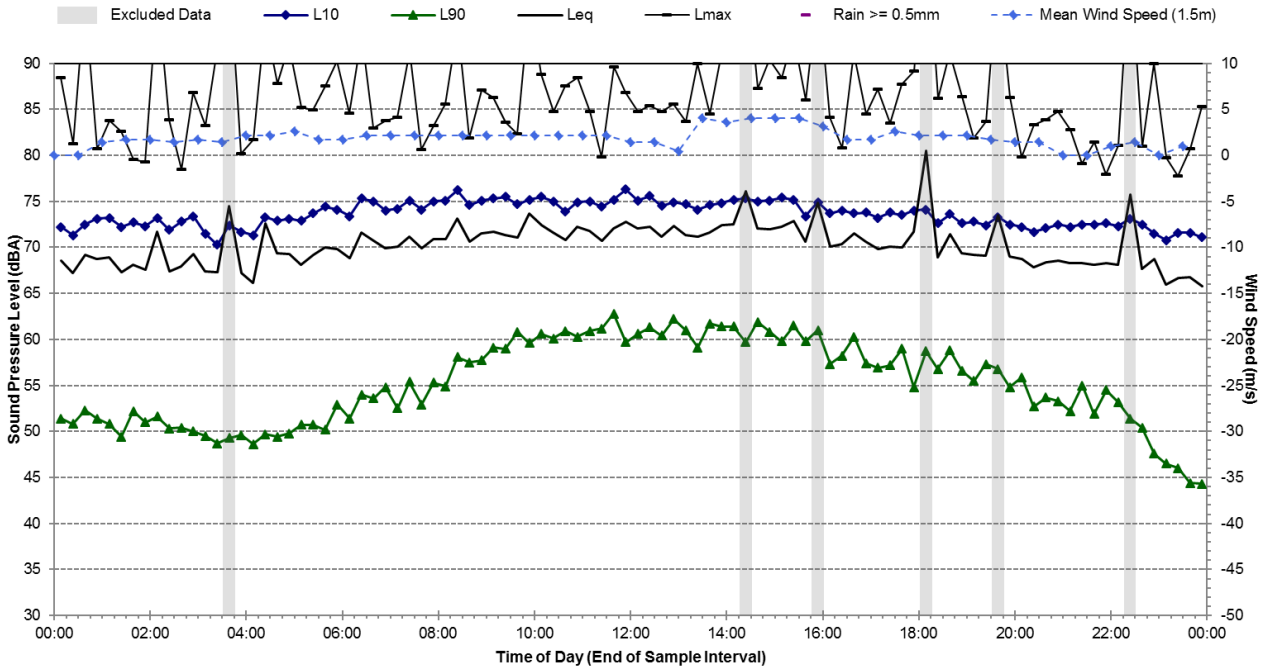
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Sunday, 11 June 2017



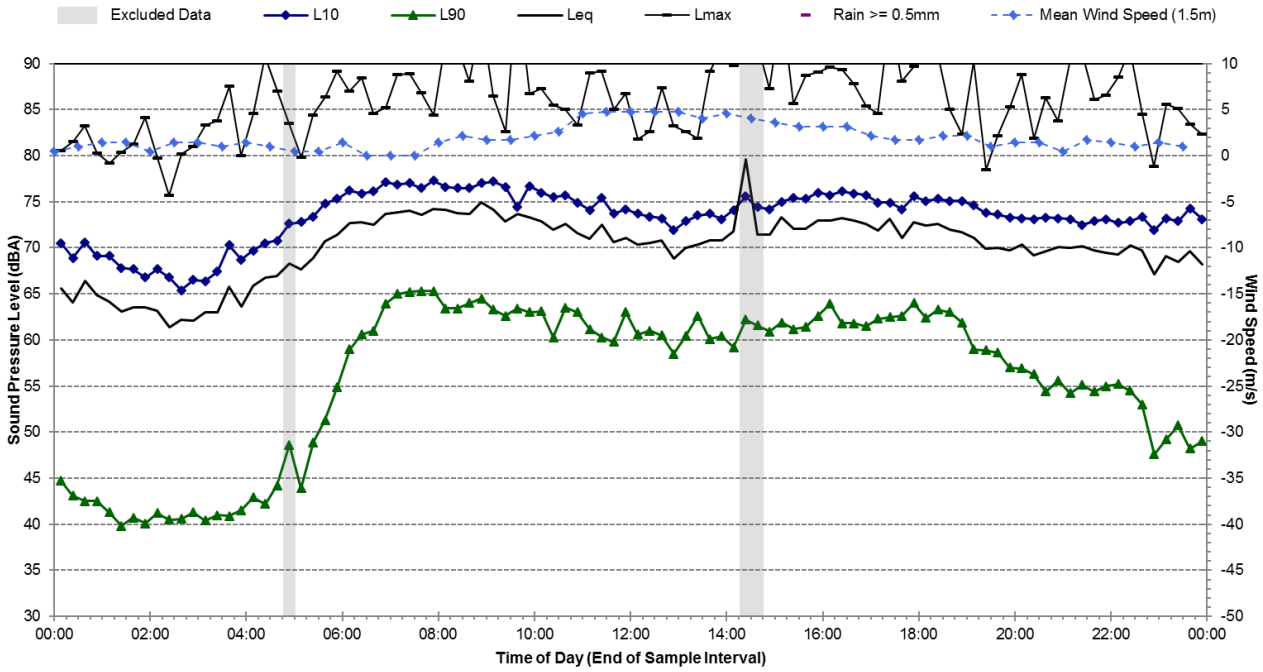
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Monday, 12 June 2017



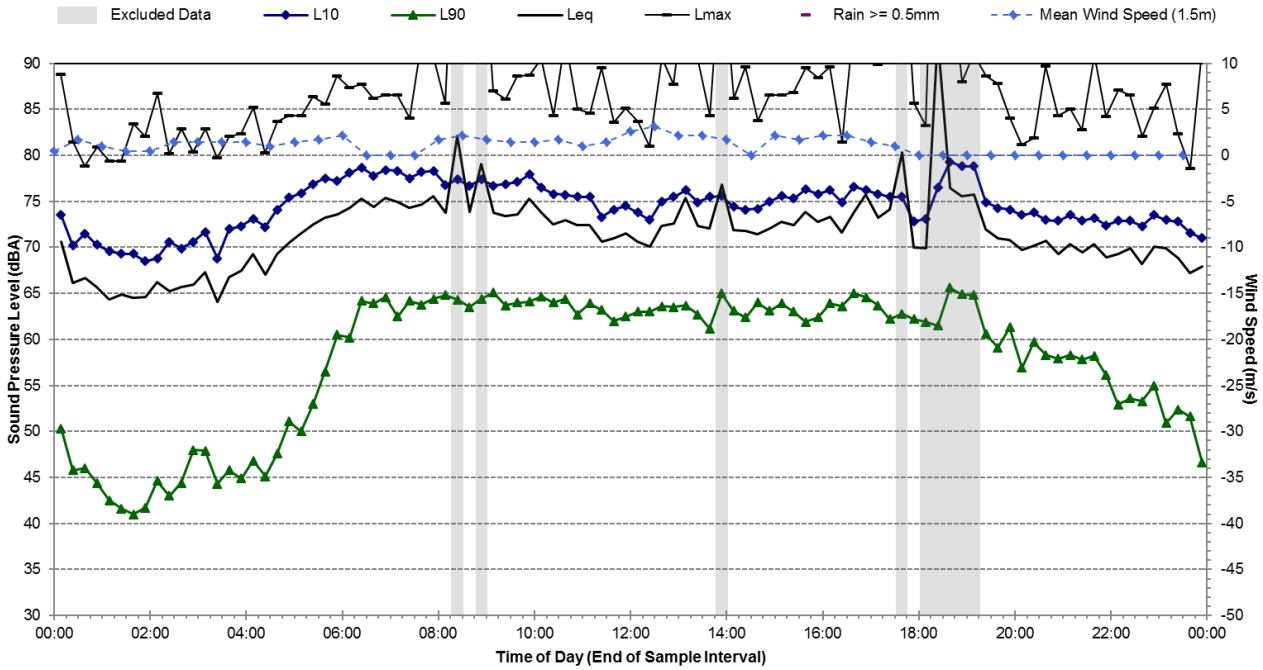
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Tuesday, 13 June 2017



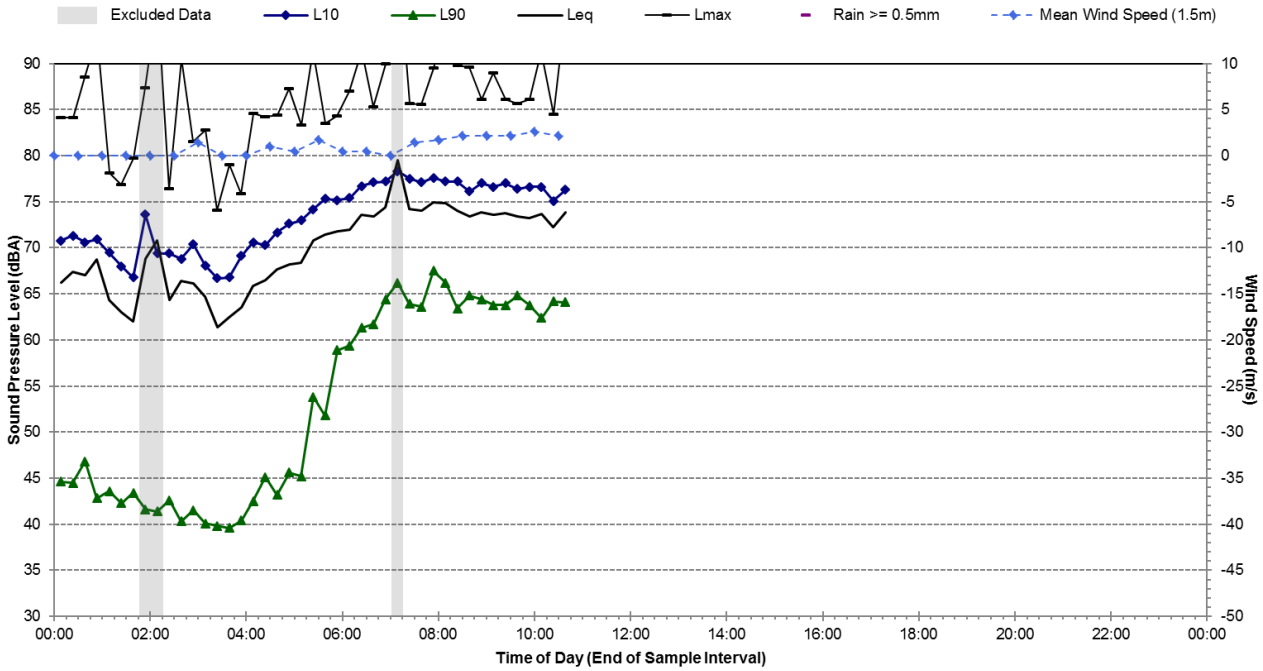
Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Wednesday, 14 June 2017



Statistical Ambient Noise Levels

L5 - 128 Botany Road, Waterloo - Thursday, 15 June 2017



APPENDIX C

Sitewide Existing Grid Noise Maps

Figure 11 Grid Noise Maps – 2 m elevation

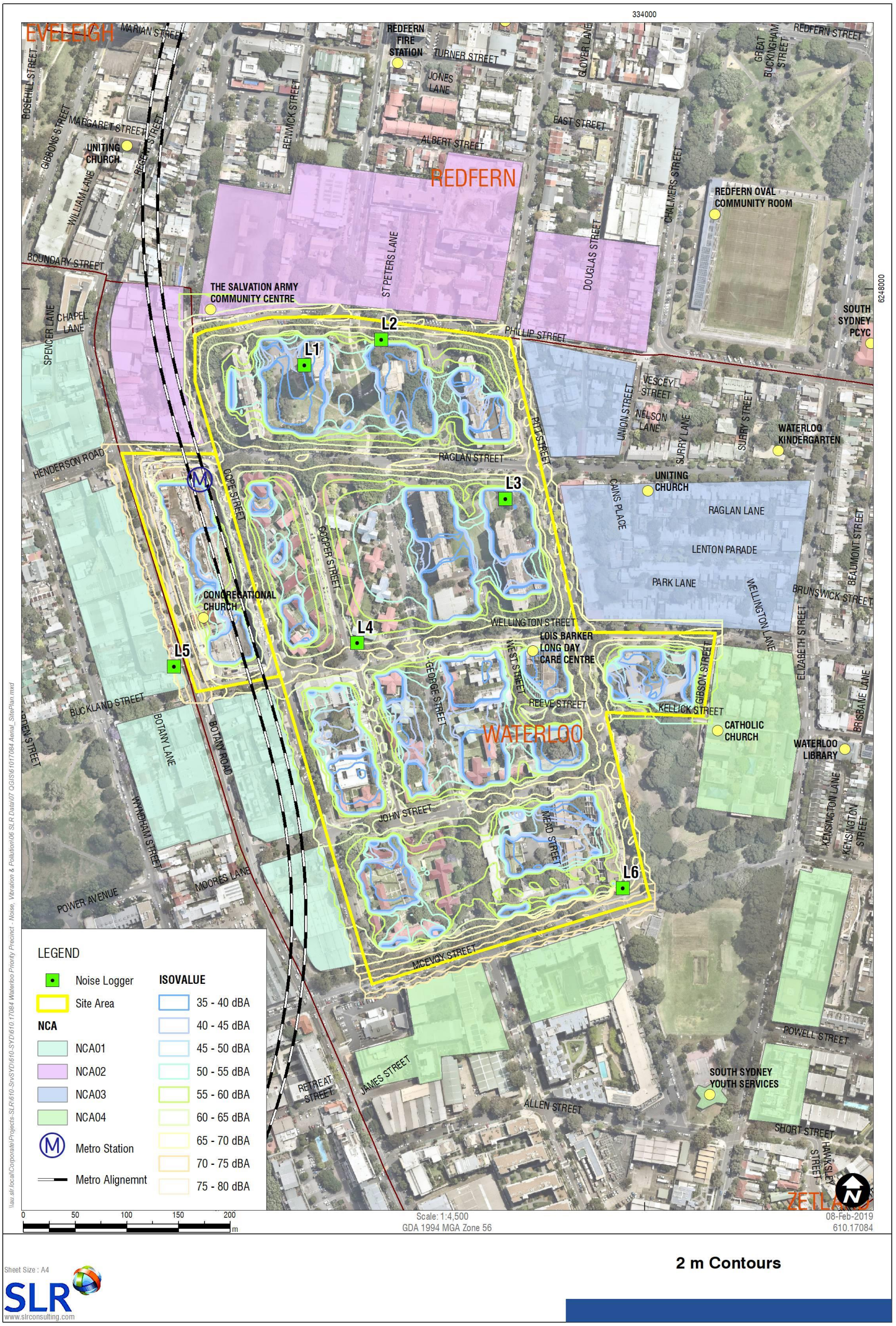


Figure 12 Grid Noise Maps – 17 m elevation

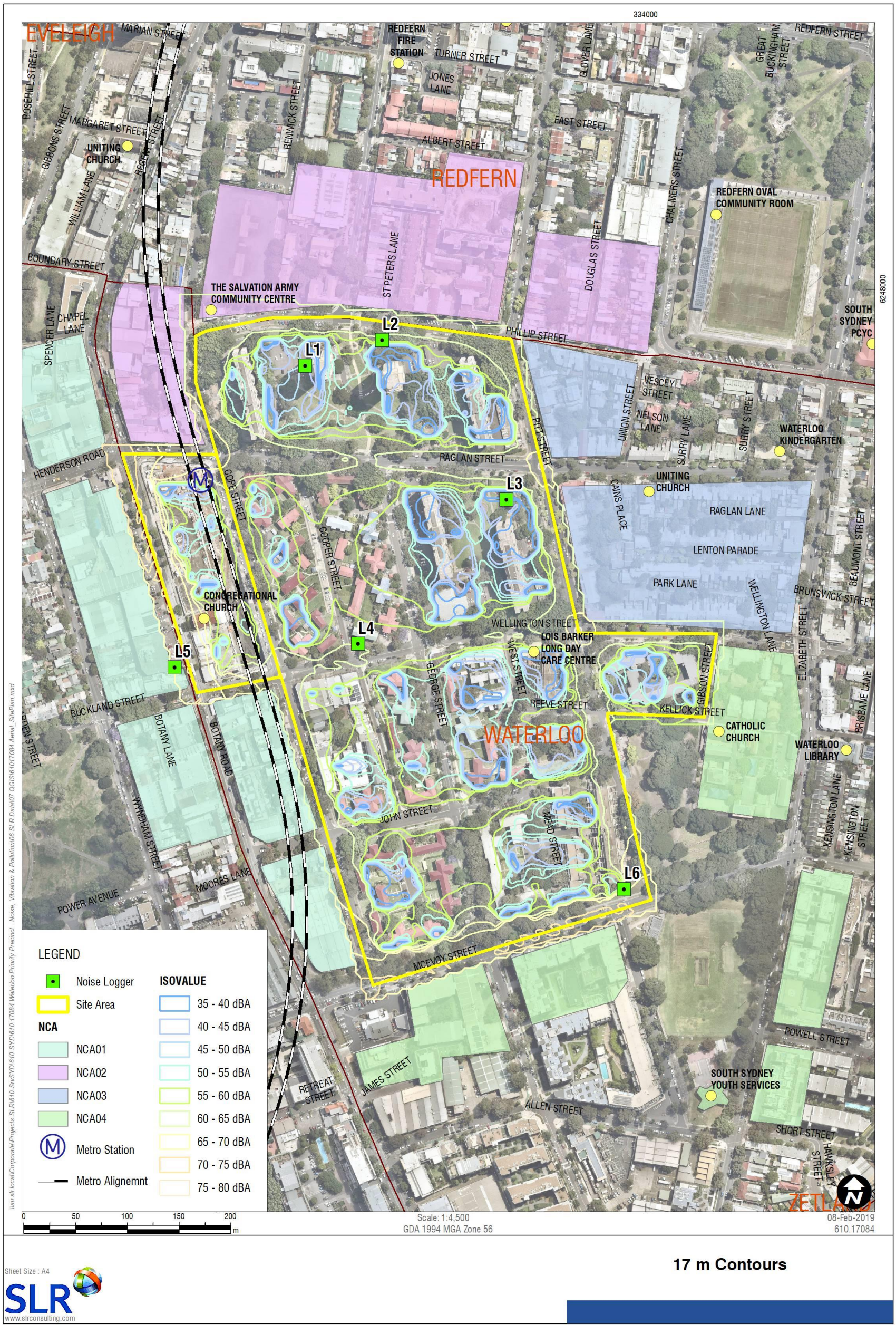
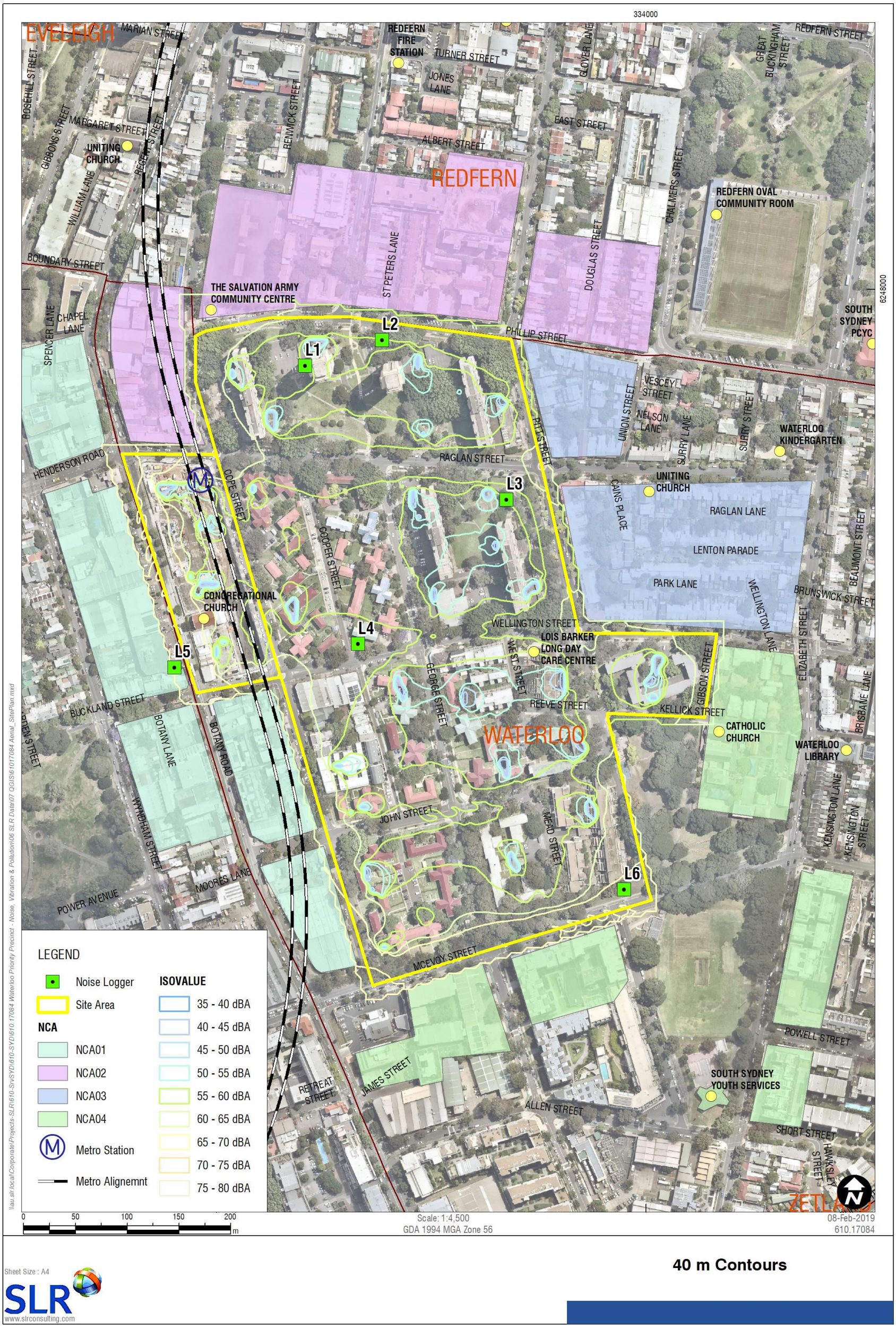


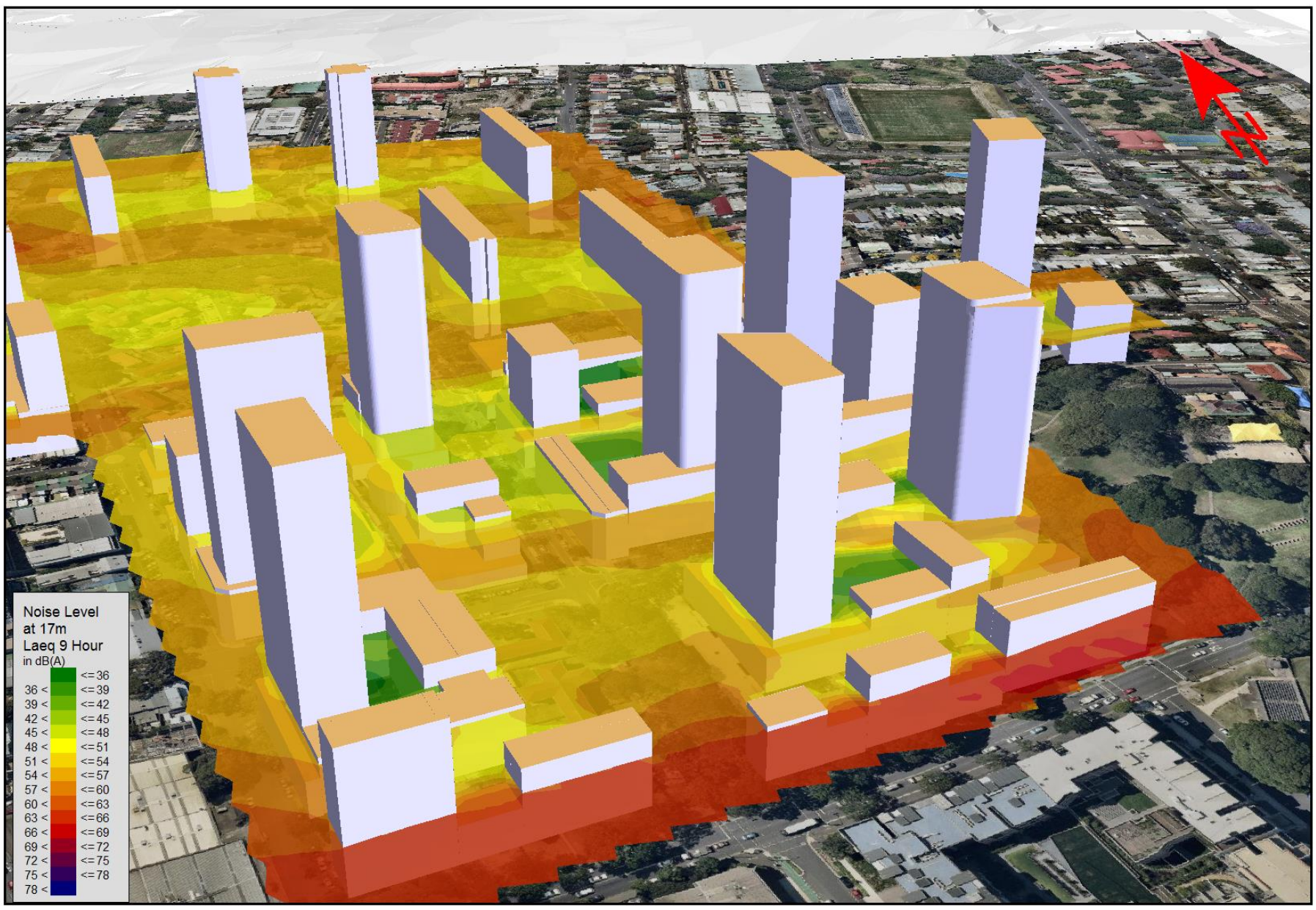
Figure 13 Grid Noise Maps –40 m elevation

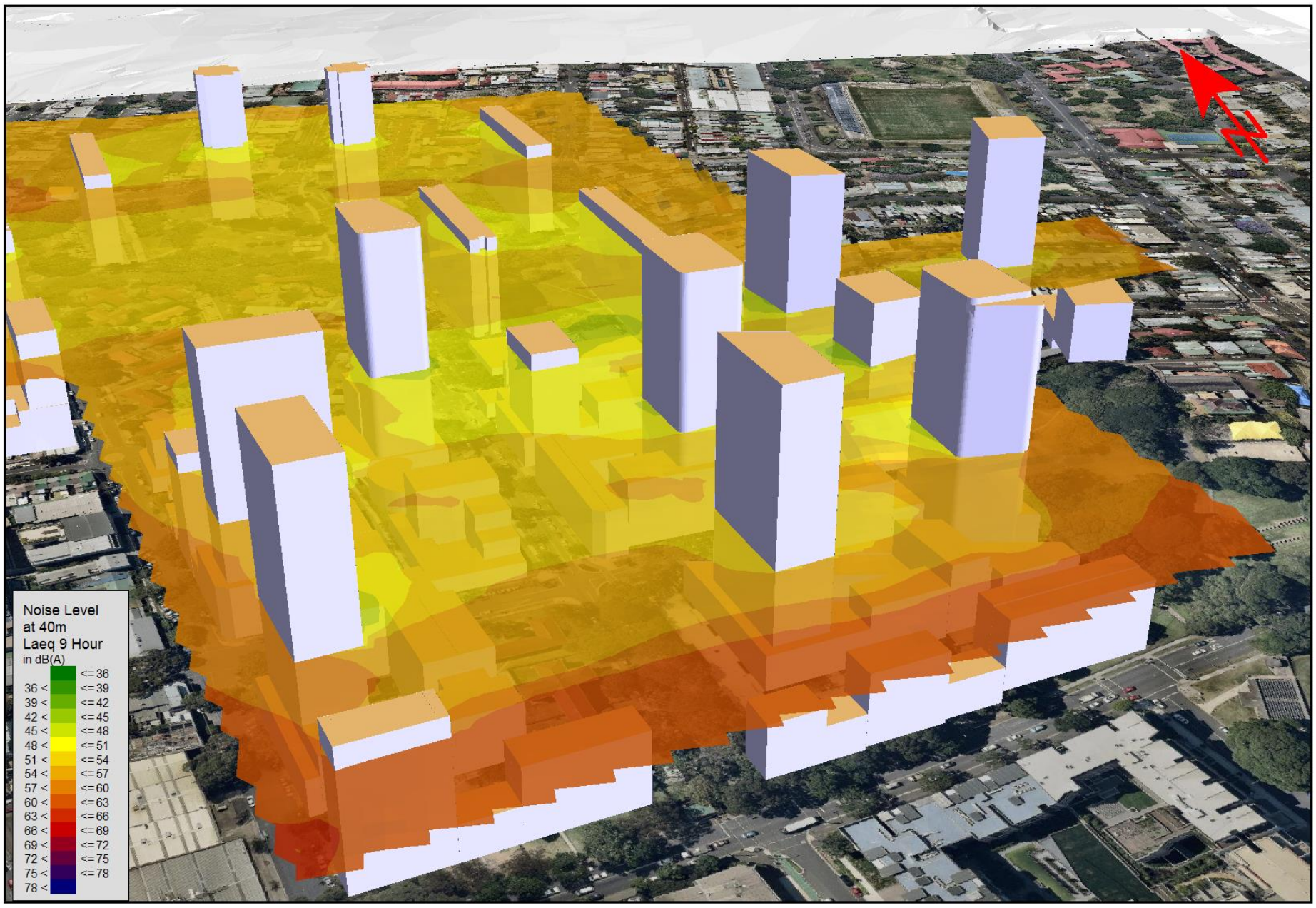


APPENDIX D

Sitewide Future Grid Noise Maps


Noise Level
at 2m
Laeq 9 Hour
in dB(A)
<= 36
36 < <= 39
39 < <= 42
42 < <= 45
45 < <= 48
48 < <= 51
51 < <= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 69
69 < <= 72
72 < <= 75
75 < <= 78
78 <
N


Noise Level
at 17m
Laeq 9 Hour
in dB(A)
<= 36
36 < <= 39
39 < <= 42
42 < <= 45
45 < <= 48
48 < <= 51
51 < <= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 69
69 < <= 72
72 < <= 75
75 < <= 78
78 <
N


N
Noise Level
at 40m
Laeq 9 Hour
in dB(A)
<= 36
36 < <= 39
39 < <= 42
42 < <= 45
45 < <= 48
48 < <= 51
51 < <= 54
54 < <= 57
57 < <= 60
60 < <= 63
63 < <= 66
66 < <= 69
69 < <= 72
72 < <= 75
75 < <= 78
78 <

APPENDIX E

Forecast Traffic Volumes - 2036

Name ID	Car/h (d)	Truck/h(d)	Car/h (n)	Truck/h(n)
Botany Road1	1633	89	343	5
Botany Road2	1833	105	352	6
Botany Road3	1681	99	298	5
Botany Road4	1339	83	290	5
Boundary Street1	12	1	2	0
Boundary Street1	12	1	2	0
Buckland Street1	285	0	57	0
Buckland Street2	112	0	7	0
Cope Street1	14	0	2	0
Cope Street2	200	0	33	0
Cope Street3	59	0	7	0
Cope Street4	28	0	10	0
Cope Street5	33	0	9	0
Cope Street6	0	0	0	0
Elizabeth Street1	981	53	308	5
Elizabeth Street2	1192	53	362	5
Elizabeth Street3	1144	53	349	5
Elizabeth Street4	1299	53	380	5
Elizabeth Street5	1117	29	306	3
Garden Street1	12	1	2	0
George Street1	225	0	37	0
George Street2	124	0	23	0
George Street3	77	8	16	0
George Street4	58	2	13	0
Henderson Road1	1308	30	335	6
Henderson Road2	1559	29	353	6
John Street1	36	0	6	0
John Street2	81	0	25	0
John Street3	104	0	29	0
John Street4	73	0	19	0
John Street5	66	0	13	0
McEvoy Street1	1793	92	437	3
McEvoy Street2	2249	101	487	5
McEvoy Street3	1595	92	352	5
McEvoy Street4	1555	83	345	5
McEvoy Street5	1525	83	318	5
McEvoy Street6	1192	67	218	3
Phillip Street1	200	0	31	0
Phillip Street2	231	0	33	0
Phillip Street3	16	0	4	0

Name ID	Car/h (d)	Truck/h(d)	Car/h (n)	Truck/h(n)
Phillip Street4	155	0	29	0
Phillip Street5	532	0	146	0
Pitt Street1	293	0	77	0
Pitt Street2	366	0	83	0
Pitt Street3	280	0	63	0
Pitt Street4	265	0	59	0
Pitt Street5	275	0	47	0
Pitt Street6	210	0	40	0
Pitt Street7	280	0	61	0
Pitt Street8	41	7	9	0
Raglan Street1	514	0	127	0
Raglan Street2	221	0	40	0
Raglan Street3	270	0	48	0
Wellington Street1	213	0	62	0
Wellington Street2	214	0	36	0
Wellington Street3	292	0	62	0
Wellington Street4	235	0	44	0
Wyndham Street1	1223	42	225	1
Wyndham Street2	631	33	118	1
Wyndham Street3	736	33	150	1
Wyndham Street4	1157	39	258	2
New Lane 1	66	0	19	0
New Lane 2	20	0	4	0
New Lane 2	48	0	11	0
New Lane 3	49	0	12	0
New Lane 3	0	0	0	0
New Lane 4	87	0	20	0
New Lane 5	67	0	22	0
New Lane 6	32	0	8	0
New Lane 6	0	0	0	0
New Lane 7	0	0	0	0
New Lane 8	41	0	5	0
New Lane 9	31	0	5	0
New Lane 10	40	0	8	0
New Lane 10	9	0	3	0
New Lane 11	24	0	3	0
New Lane 12	19	0	5	0
New Lane 13	48	0	13	0
New Lane 14	82	0	22	0
New Lane 15	7	0	10	0

Name ID	Car/h (d)	Truck/h(d)	Car/h (n)	Truck/h(n)
New Lane 16	49	0	2	0
New Lane 17	101	0	22	0
New Lane 18	54	0	24	0
New Lane 19	13	0	3	0
New Lane 20	69	0	18	0
New Lane 21	15	0	3	0
New Lane 22	77	0	22	0
New Lane 23	72	0	16	0
New Lane 24	0	0	1	0
New Lane 25	0	0	0	0
New Lane 26	27	0	1	0

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