St Aloysius' College

SSDA Noise Impact Assessment

Report Number 610.17552-R01

10 August 2018

St Aloysius' College
St Aloysius' College-Main Reception
47 Upper Pitt Street
MILSONS POINT NSW 2061

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St Aloysius' College

SSDA Noise Impact Assessment

PREPARED BY:

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

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610.17552-R01--v2.0	10 August 2018	Nash Cameron Jeffs	A Campbell	Alex Campbell
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1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been engaged by St Aloysius' College (SAC) to prepare a Noise Impact Assessment (NIA) which will be submitted to the Department of Planning and Environment as part of the State Significant Development Application (SSDA) for the proposed redevelopment works at their three campus locations at Kirribilli.

This NIA addresses relevant considerations contained in the State Significant Development Application (SSDA 8669) Secretary's Environmental Assessment Requirements (SEARs) dated 28 August 2017. The Project is seeking full SSDA approval for the proposed main campus works, concept SSDA approval for the Junior School campus, and both concept SSDA and built form approval for the Wyalla campus. As a result, this report predominantly addresses the potential noise impacts associated with the proposed works to the Main Campus in detail. High level, qualitative commentary is provided in relation to the proposed works to the Junior School and Wyalla sites.

This report presents the study methodology, assessment criteria, assessment of noise emissions and noise mitigation recommendations in relation to the following specific areas of acoustic significance:

- Operational noise emissions from regular student activities
- Operational noise emissions from out-of-school-hours events and public functions
- Operational noise emissions from onsite mechanical plant and equipment
- Potential noise and vibration emissions during the construction stage

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

2 PROJECT DESCRIPTION

2.1 Site Overview and Layout

The site is located on the Milsons Point and Kirribilli peninsular on the lower North Shore in Sydney. The main site, at 47 Upper Pitt Street, accommodates the Secondary School and main administration, and comprises a multi-storey building constructed in stages in the 1960's and 70's. The buildings are built up to the street frontage boundaries on three sides and enclose a central courtyard.

Opposite the main site on Upper Pitt Street is "Wyalla", housing the Year 11 and 12 campus and Dalton Hall, which comprises an indoor pool and sports facility. "Wyalla" is a heritage item dating from the 1880's, whilst Dalton Hall was completed within the last 10 years.

The Junior School campus is at 29 Burton Street and accommodates the year 3-6 students. The site contains the former Milsons Point Primary School, which is a heritage item, and newer buildings constructed in the 1990's and 2000's. **Figure 1** shows the site layout and indicates the location of each of the three campuses relative to one another.

Figure 1 Site Layout

Note 1: The Junior Campus is indicated in orange, the Wyalla Campus in red and the Main Campus is indicated in blue.

2.2 Proposed Works

The project involves the redevelopment and refurbishment across the three SAC campuses (shown in **Figure 1**). The relevant works include:

- Staged works to the Main Campus including a new infill building to the courtyard with rooftop landscaping, multi-storey façade openings on the Jeffreys Street and Kirribilli Avenue sides of the building, and the refurbishment of other internal areas.
- Staged refurbishment of “Wyalla” to create more relevant teaching and learning facilities, including a small single storey addition to the heritage building.
- Further internal refurbishment staged works to the balance of the Main Campus is planned as well as a new subterranean sports facility and additional level of teaching and learning to the Junior School and final refurbishment works to the Wyalla building.

2.3 Surrounding Environment

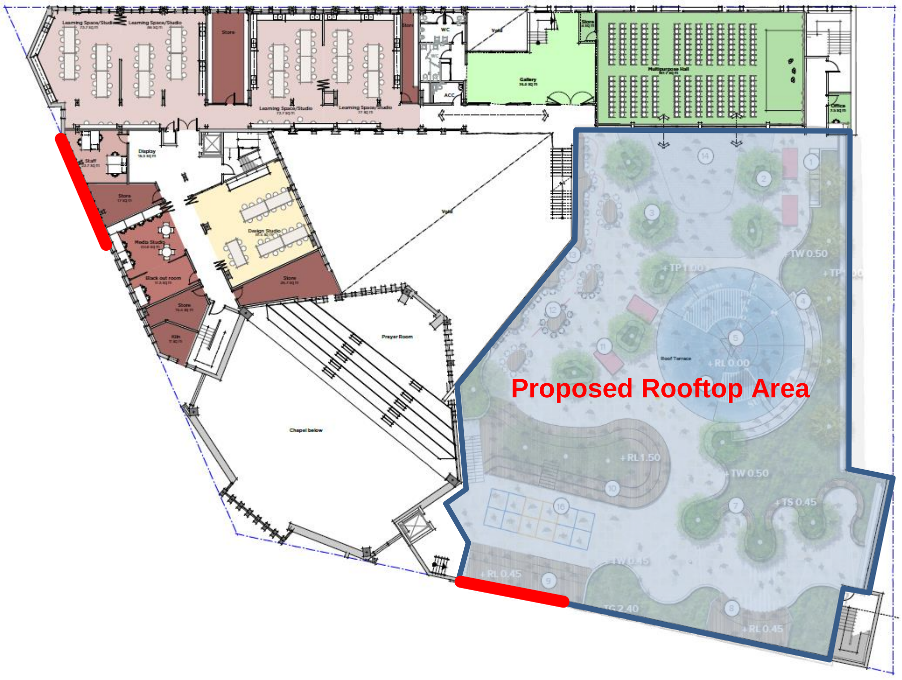
The surrounding environment at each of the three campus locations is comprised predominately of residential developments in all directions which are a mixture of single and double-storey terraces as well as multi-storey apartment buildings. Each of the three campus locations are in close proximity to the Cahill Expressway to the west. Furthermore, the Main Campus is located approximately 100 m north of Sydney Harbour and approximately 200 m northeast of the northern end of the Sydney Harbour Bridge.

2.4 Potential Noise Impacts

The primary aim of this NIA is to identify and assess the operational noise impacts that may affect the surrounding environment and noise-sensitive receivers as a result of the proposed works outlined in **Section 2.2**. The potential noise and vibration impacts which may arise as a result of the proposed works include:

- Noise impacts from regular student activities on the rooftop area of the proposed infill building on the Main Campus (shown in **Figure 2)**.
- Noise impacts from out-of-school-hours events and public functions on the rooftop area of the proposed infill building on the Main Campus (shown in **Figure 2)**.
- Noise impacts from regular student activities emanating from the proposed façade openings on the Jeffreys Street and Kirribilli Avenue side of the Main Campus (shown in **Figure 2)**.
- Noise impacts from building services equipment and mechanical plant located on the roof of the Main Campus.
- Potential noise and vibration impacts from during the construction stage.

Figure 2 Main Campus – Proposed Infill Building and Façade Openings



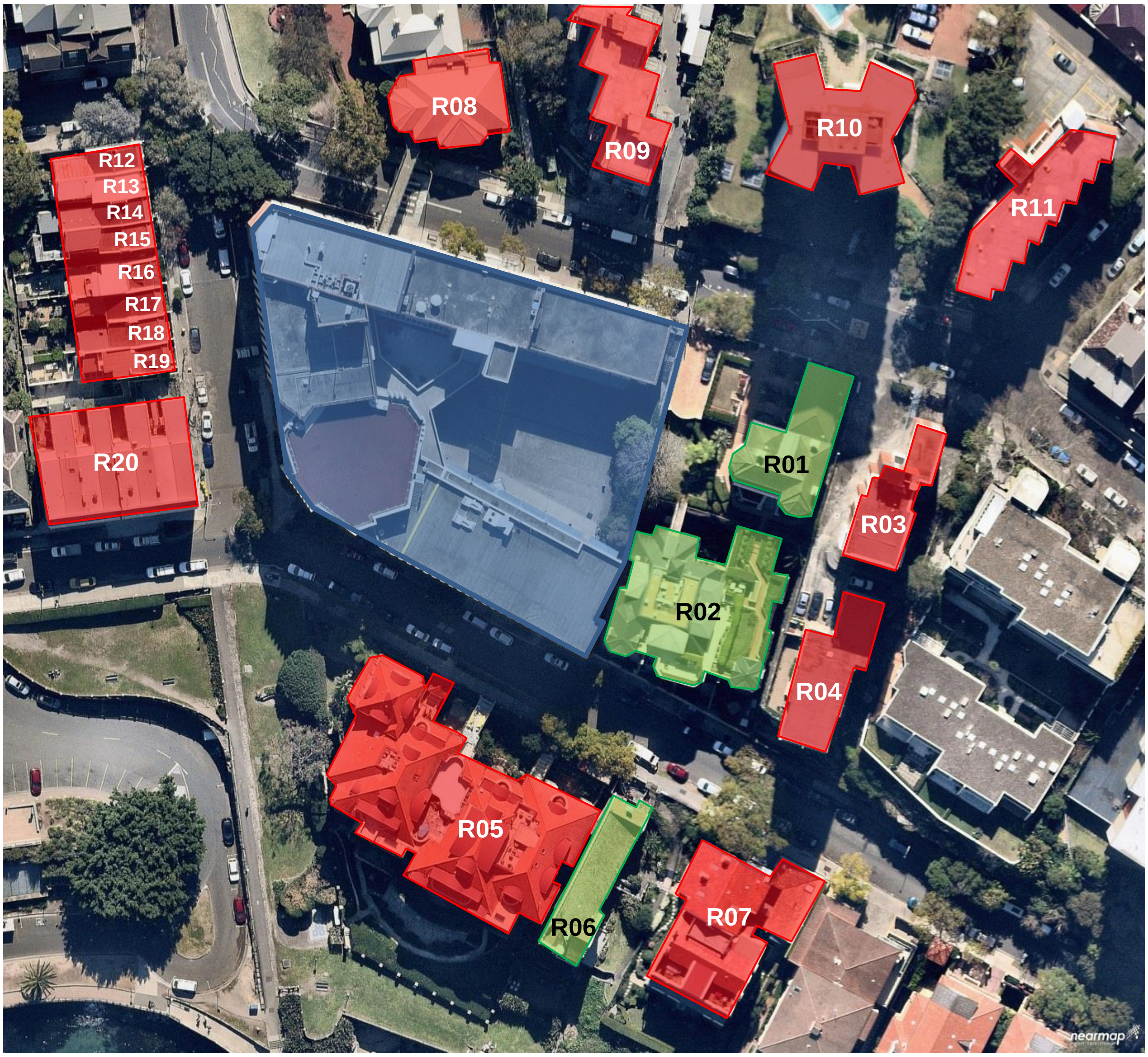
Note 1: The rooftop area of the proposed Main Campus infill building is shaded in blue.

Note 2: The proposed Main Campus facade openings are indicated in red on the eastern (Jeffreys Street) and southern (Kirribilli Avenue) sides of the building.

2.5 Affected Residential Receivers

The residential receivers that may be affected by the proposed works to the Main Campus are presented in **Figure 3**.

Figure 3 Affected Residential Receivers surrounding the Main Campus



Note 1: Affected residential receivers shaded in green have been assigned more stringent criteria (Residential 1) while those shaded in red have been assigned less stringent criteria (Residential 2). This is based on the existing noise exposure of these receivers from the noise survey undertaken. Project specific noise criteria are discussed in detail in **Section 4**.

2.6 SEARs

This NIA addresses relevant considerations contained in the State Significant Development Application (SSDA 8669) Secretary's Environmental Assessment Requirements (SEARs) dated 28 August 2017 (shown in **Figure 4**).

Figure 4 Noise and Vibration Extract from SEARs

7. Noise and Vibration

Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation, including consideration of any public address system, school bell and use of any school hall for concerts etc. (both during and outside school hours). Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land.

→ Relevant Policies and Guidelines:

- *NSW Industrial Noise Policy (EPA)*
- *Interim Construction Noise Guideline (DECC)*
- *Assessing Vibration: A Technical Guideline 2006*
- *Development Near Rail Corridors and Busy Roads – Interim Guideline (Department of Planning 2008)*

3 AMBIENT NOISE ENVIRONMENT

3.1 Unattended Noise Monitoring

In order to characterise the existing acoustical environment at the nearest sensitive receivers, unattended noise monitoring was conducted between Tuesday 10 October and Wednesday 18 October 2017 at the locations shown in **Figure 5** and outlined in **Table 1**.

Figure 5 Ambient Noise Logger Locations

Note 1: An additional noise logger was initially planned for deployment at Wyalla near Dalton Hall however construction works adjacent to the building made the proposed location unsuitable for noise monitoring.

Table 1 Ambient Noise Logger Overview

ID	Location	Monitoring Period	Model	Serial Number
L01	Junior Campus (adjacent to Crescent Place)	10/10/2017 – 18/10/2017	ARL EL-316	16-207-021
L02	Main Campus GF Courtyard	10/10/2017 – 18/10/2017	ARL EL-316	16-306-039
L03	Main Campus Juana Mateo Roof Terrace	10/10/2017 – 18/10/2017	Svantek 957	27580

Instrumentation for the survey comprised of two ARL EL-316 environmental noise loggers (serial numbers 16-207-021 and 16-306-039) and one Svantek 957 (serial number 27580), both fitted with microphone windshields. Calibration of the loggers was checked prior to and following measurements. Drift in calibration did not exceed ±0.5 dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Charts presenting summaries of the measured daily noise data are attached in **Appendix B1-B3.** The charts present each 24 hour period by incorporating the L_{Amax}, L_{Aeq} and L_{A90} noise levels for the corresponding 15 minute periods.

The measured data has been filtered to remove periods affected during adverse weather conditions following consultation of weather reports recorded at the Bureau of Meteorology (BOM) Observatory Hill weather station. The filtered data is shown in **Appendix B1-B3**.

3.1.1 Noise Policy for Industry (NPfI) Rating Background Level (RBL)

The data obtained from the ambient noise monitoring was processed in accordance with the procedures outlined in the NSW *"Noise Policy for Industry"* (EPA, October 2017) to establish the Rating Background Level (RBL) at the nearest noise-sensitive receivers. The results of this analysis are presented in **Table 2**.

Table 2 Measured Ambient Noise Levels Corresponding to NPfI Assessment Time Periods

Location	Daytime[1]	Evening[1]	Night-time[1]
	RBL[2]	RBL	RBL
Junior Campus (adjacent to Crescent Place)	49	47	38
Main Campus GF Courtyard	45	43	37
Main Campus Juana Mateo Roof Terrace	58	56	47

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: The 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.

3.2 Attended Noise Monitoring

In order to identify noise sources contributing to the ambient noise environment at the nearest sensitive receivers, operator attended spot measurements were conducted adjacent to the Main Campus on Jeffreys Street and Kirribilli Avenue.

The attended spot measurements were also used to quantify the level of operational noise emitted from the Main Campus at the residential receivers adjacent to the proposed façade openings on both the Jeffreys Street and Kirribilli Avenue side of the Main Campus. Both measurements were conducted during designated school break periods to ensure the measurements were representative of operational noise emissions from the Main Campus.

A Brüel and Kjær 2260i sound level meter (serial number 2414604) fitted with a microphone windshield was used for the measurements. Calibration of the sound level meter was checked prior to and following measurements. Drift in calibration did not exceed ±0.5 dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Measurements were conducted in accordance with AS 1055.1-1997: *"Acoustics - Description and measurement of environmental noise – General procedures".*

The results of the operator attended noise measurements are presented in **Table 3** alongside a description of the contributing sources and corresponding noise levels at the time of the measurement.

Table 3 Attended Noise Monitoring Results

Receiver Location	Date / Start Time Duration	Primary Noise Descriptor			Comments
		LAeq	LAmax	LA90	
51 Kirribilli Avenue	02/11/2017 / 12:50pm 15 mins	61	83	57	Ambient environment a mixture of consistent road traffic noise from the northern end of the Sydney Harbour Bridge, local wildlife (insects and birds), intermittent construction noise and infrequent vehicle pass-bys on Kirribilli Avenue
22 Jeffreys Street	02/11/2017 / 13:15pm 15 mins	59	76	55	Ambient environment a mixture of noise from student activities, consistent road traffic noise from the northern end of the Sydney Harbour Bridge, distant construction noise and infrequent vehicle and aircraft pass-bys

4 NOISE ASSESSMENT CRITERIA

4.1 Operational Noise – Noise Policy for Industry

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

4.1.1.1 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.

4.1.1.2 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 for this noise impact study is considered to be urban.

4.1.1.3 Project Noise Trigger Levels

The results of the unattended noise monitoring, summarised in **Section 3.1** of this report, have been used to establish the Project Noise Trigger Levels which will be used to assess the potential industrial noise impacts associated with the proposed works to the Main Campus. The project noise trigger levels are the more stringent of the intrusiveness and amenity noise levels and are marked in bold as shown below in **Table 5**.

Table 4 Project Noise Trigger Levels for Surrounding Receivers

Receiver Type	Time of Day	Recommended Amenity Noise Level (dBA)	Measured Noise Level (dBA)		Project Noise Trigger Levels L_{Aeq}(15minute) (dBA)	
			RBL	L_{Aeq}(period)	Intrusiveness	Amenity[1,2]
Residential 1	Day	60	45	55	**50**	58
	Evening	50	43	48	**48**	48
	Night	45	37	44	**42**	43
Residential 2	Day	60	58	62	63	**58**
	Evening	50	56	60	61	**48**[3]
	Night	45	47	57	52	**45**[3]

Note 1: The project amenity noise levels have been converted to 15 minute levels by adding 3 dB in accordance with the NPfI.

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.

Two sets of project specific criteria (Residential 1 and Residential 2) were derived individually from noise loggers L02 and L03 (shown in **Figure 5**) to ensure that each affected residential receiver's existing ambient noise level was represented accurately.

The respective project noise trigger levels have been assigned to each potentially affected residential receiver on the basis of the receiver's location in terms of distance, height and direct line of sight to the northern end of the Sydney Harbour Bridge. The Main Campus and other larger buildings in the area offer significant shielding to residential receivers from road traffic noise originating from the northern end of the Sydney Harbour Bridge. Therefore, those particular receivers have been assigned more stringent and equitable project noise trigger levels due to their lower existing ambient background noise level.

4.2 Operational Noise Criteria – OOH Events

After a comprehensive review of criteria historically used to characterise and assess the potential noise impacts that may occur as a result of infrequent out-of-school-hours events on the rooftop area of the proposed Main Campus infill building, we recommend the following criteria be used:

Table 5 Operational Noise Criteria – OOH Events

Day	Time Periods	Relevant Criteria	Residential 1 Criteria	Residential 2 Criteria
Monday – Sunday	07:00 – 23:00	$L_{Aeq(15min)}$ must not exceed RBL +	48	61

		5 dB		
	23:00 – 07:00	LAeq(15min) must not exceed RBL	37	47

This has been based upon the EPA *Noise Guide for Local Government* and other known similar assessments that have been approved within the Sydney Metropolitan area. It is considered that the above criteria will not apply on New Year's Eve as the cumulative noise from other large scale harbour based events in the area will be significantly higher than any event on SAC grounds.

4.3 Construction Noise Criteria – NSW Environment Protection Authority

4.3.1 Construction Noise Guidelines

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

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

4.3.2 Hours of Construction

The EPA's Guideline recommends confining permissible work times as outlined in **Table 6**.

Table 6 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

4.3.1 Recommended Sound Levels

4.3.1.1 Residential

The EPA's Interim Construction Noise Guideline (ICNG) recommends that the LAeq(15minute) noise levels arising from a construction project, measured within the curtilage of an occupied noise-sensitive premises (ie at boundary or within 30 m of the residence, whichever is the lesser) should not exceed the levels indicated in **Table 7**.

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

Period of Noise Exposure	LAeq(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 + 5 dBA

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

Note 2: The 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.

4.3.2 Construction Noise Assessment Method

The ICNG recognises that people are usually annoyed more by noise from longer-term works than by the same type of works occurring for only a few days. For this reason the ICNG identifies two methods of assessing noise from construction:

- The quantitative assessment method which applies to long-term duration work; and
- The qualitative assessment method which applies to short-term duration work.

Quantitative Assessment Method

The EPA's Guideline recommends using the following quantitative assessment for residential receivers when the noise affected level is not met:

Recommended Standard Hours: Noise affected RBL + 10 dBA

- Where the predicted or measured $L_{Aeq(15minutes)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices in order to meet the noise affected level.
- The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Recommended Standard Hours: Highly Noise affected RBL 75 dBA

- Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours during which the very noisy activities can occur, taking into account:
  - times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences.
  - if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Qualitative Assessment Method

The qualitative method for assessing construction noise is a simplified way to identify the cause of potential noise impacts. It avoids the need to perform complex predictions by using a checklist approach to assessing and managing noise. Short-term means that the works are not likely to affect an individual or sensitive land use for more than three weeks in total.

The following checklist for work practice can be used:

- Community notification.
- Operate plant in a quiet and efficient manner.
- Involve workers in minimising noise.
- Handle complaints.

4.4 Construction Noise Management Levels for Residential Receivers

The results of the unattended noise monitoring (discussed in **Section 3.1** and summarised in **Table 8**) have been used in accordance with the ICNG's quantitative assessment procedure to determine the specific airborne noise goals (management levels) for each of the surrounding residential receivers (presented in **Table 8**). Given the nature of the development, the management levels corresponding to the recommended standard hours outlined in the ICNG have been used exclusively in the construction noise impact assessment.

Table 8 Construction Airborne Noise Management Levels

Receiver Management Level	RBL (dBA)	Noise Affected (RBL + 10 dB)	Highly Noise Affected (75 dB)
Residential 1	45	55	75
Residential 2	58	68	75

Note 1: EPA’s recommended standard construction hours are 7.00 am to 6.00 pm Mon-Fri; 8.00 am to 1.00 pm Sat.

Two different receiver management levels (Residential 1 and Residential 2) were derived individually from noise loggers L02 and L03 (shown in **Figure 5**) to ensure that each receiver’s existing ambient level was represented accurately.

The different receiver management levels have been allocated on the basis of the receiver’s location in terms of distance, height and direct line of sight to the northern end of the Sydney Harbour Bridge. The Main Campus and other larger buildings in the area offer significant shielding to the surrounding residential receivers from road traffic noise originating from the northern end of the Sydney Harbour Bridge. Therefore, those particular receivers have been assigned more stringent and equitable management levels due to their lower existing ambient background level (RBL).

4.5 Vibration Damage Criteria – Surface Structures

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.

4.5.1 British Standard 7385: Part 2 - 1993

In terms of the most recent relevant vibration damage criteria, 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.

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 9** and graphically in **Figure 6**.

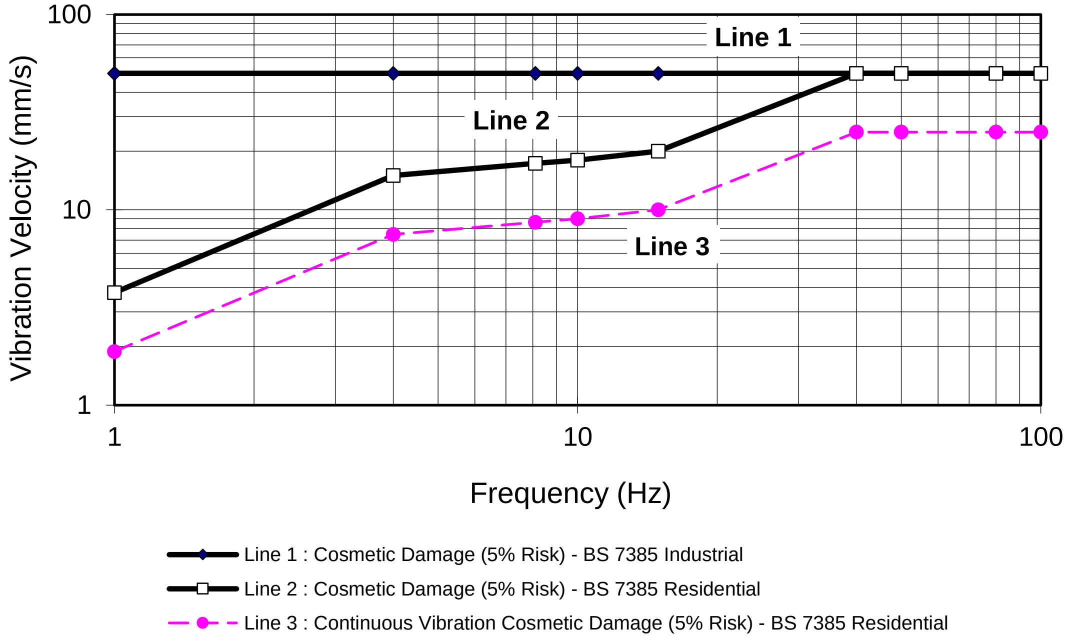
Table 9 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

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

The standard states that the guide values in **Table 9** 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 is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 9** may need to be reduced by up to 50%.

Figure 6 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 9**, and major damage to a building structure may occur at values greater than four (4) 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 9** should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS 2187 specifies that vibration measured should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in **Table 9.**

It is noteworthy that extra to the guide values nominated in **Table 9**, 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."*

4.5.2 German Standard DIN 4150: Part 3-1999

For continuous long-term vibration or repetitive vibration with the potential to cause fatigue effects, DIN 4150 provides the following Peak Particle Velocity (PPV) values as safe limits, below which even superficial cosmetic damage is not to be expected:

- 10 mm/s for commercial buildings and buildings of similar design.
- 5 mm/s for dwellings and buildings or similar design.
- 2.5 mm/s for buildings of great intrinsic value (eg heritage listed buildings).

For short-term vibration events (ie those unlikely to cause resonance or fatigue), DIN 4150 offers the criteria shown in **Table 10**. These are maximum levels measured in any direction at the foundation or in the horizontal axes in the plane of the uppermost floor.

Table 10 DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration

Group	Type of Structure	Peak Particle Velocity (mm/s)			
		At Foundation			Plane of Floor of Uppermost Storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 at 10 Hz increasing to 40 at 50 Hz	40 at 50 Hz increasing to 50 at 100 Hz	40
2	Dwellings and buildings of similar design and/or use	5	5 at 10 Hz increasing to 15 at 50 Hz	15 at 50 Hz increasing to 20 at 100 Hz	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (eg buildings that are under a preservation order	3	3 at 10 Hz increasing to 8 at 50 Hz	8 at 50 Hz increasing to 10 at 100 Hz	8

Note 1: For frequencies above 100 Hz the upper value in this column should be used.

As opposed to the "*minimal risk of cosmetic damage*" approach adopted in BS 7385 (95% probability of no effect), the "*safe limits*" given in DIN 4150 are the levels up to which no damage due to vibration effects have been observed for the particular class of building. "*Damage*" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

4.6 Human Comfort Vibration Criteria

4.6.1 General

Humans are far more sensitive to vibration than is commonly realised. They can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", 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.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2-1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in **Table 11**.

Table 11 Peak Vibration Levels and Human Perception of Motion

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

Table 11 suggests that people will just be able to feel floor vibration at levels of about 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

4.6.2 Human Comfort Criteria for Construction Vibration

British Standard 6472-2008 "*Guide to evaluation of human exposure to vibration in building*" nominates criteria 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. The "low probability of adverse comment" level for residential buildings is:

0.2 to 0.4 $m/s^{1.75}$ (16 hour daytime Vibration Dose Value)

0.1 to 0.2 $m/s^{1.75}$ (8 hour night-time Vibration Dose Value)

BS 6472-2008 provides criteria for continuous, transient and intermittent (in the case of road traffic) 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.

4.7 Construction Vibration - Cosmetic Damage

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

Type of Building	Peak Particle Velocity at Foundation		
	1 Hz to 10 Hz	**10 Hz to 50 Hz**	**50 Hz to 100 Hz**
Dwellings and buildings of similar design and/or use	5 mm/s at 1 Hz to 10 Hz	5 mm/s at 10 Hz increasing to 15 Hz at 50 Hz	15 mm/s at 50 Hz increasing to 20 mm/s at 100 Hz

5 NOISE IMPACT ASSESSMENT

5.1 Main Campus

5.1.1 Noise Model

In order to predict noise levels associated with the proposed works to the Main Campus at the affected residential receivers, a SoundPLAN computer model was developed. SoundPLAN is a software package which enables compilation of a sophisticated computer model comprising 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 sensitive receivers.

5.1.1.1 Operational Noise Standard

Calculations were undertaken using ISO9613 algorithms.

5.1.1.2 Model Inputs

The computer model generates noise emission levels taking into account such factors as the source sound power levels, distance attenuation, ground absorption, air absorption and shielding attenuation, as well as meteorological conditions.

Heights of buildings, screens and other structures were estimated based on site inspection, and aerial photography.

Surface corrections were implemented in the SoundPLAN noise model to account for the proposed hard surfaces and highly reflective materials on the rooftop terrace as set out in the Landscape Plan submitted with the EIS. The complete surface of the rooftop terrace was modelled as hard ground as a worst-case scenario. Any proposed soft-landscaping will have a positive impact by slightly lowering noise emissions.

5.1.1.3 Operational Noise Sources

The major noise sources associated with the Project are shown in **Table 13** alongside their relevant L_{Aeq} sound power levels.

Table 13 Noise Sources – Sound Power Levels

Noise Source	Sound Power Level, dBA (L_{Aeq} per source)
Student Activities	109
Facade Openings	78
OOSH Events	111
MEP Plant - Air Handling Units	86
MEP Plant - Ventilation Fans	97

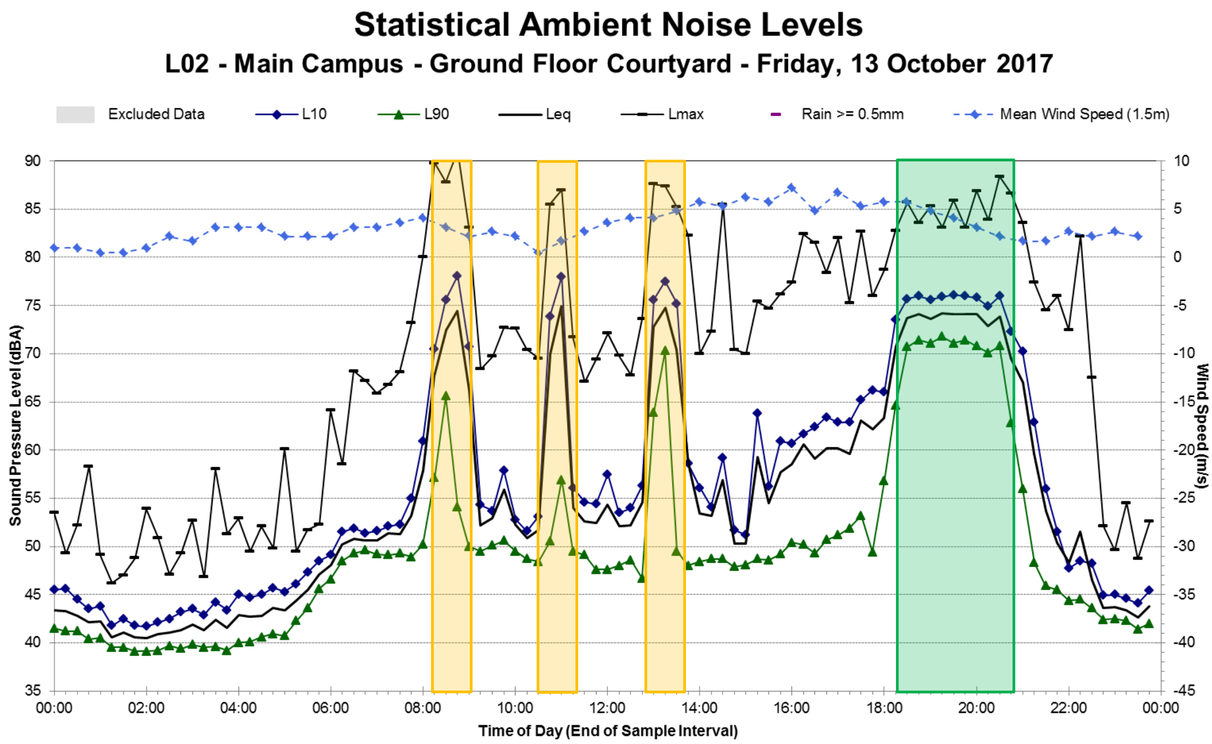
MEP Plant - Toilet Exhaust Fans	64
MEP Plant – Chiller(s)	99

Existing operational noise levels (ie student activities before school and during break times as well as an out-of-school-hours school disco event) were used to derive the sound power levels of the noise sources used in the model. The existing operational noise levels were calculated by taking the logarithmic average of the LAeq levels for defined periods (shown in **Table 14** and illustrated in **Figure 7**) of the ambient monitoring data and were used to calibrate the noise sources in the model.

Table 14 Existing Activity Noise Levels

Location	Operational Emissions
	LAeq (dBA)
Student Activities (Main Campus courtyard)	72
OOSH Event (Main Campus courtyard)	74

Figure 7 Deriving Existing Operational Noise Levels



Note 1: Operational noise levels highlighted in orange were measured during school hours throughout the entire monitoring period and are representative of regular student activities in the Main Campus courtyard. The operational noise levels highlighted in green were measured outside of school hours (school disco) and are representative of out-of-hours events and school functions. The operational noise levels in **Figure 7** were measured at logger location L02.

The noise source's sound power levels used in the noise model are based on a "worst case scenario" to predict and compare the maximum potential noise impacts at the affected residential receivers.

5.1.1.4 Operational Noise Emission Scenarios

The following scenarios were modelled to predict and compare the noise impacts at the surrounding residential receivers:

- Existing student activities (Main Campus courtyard)

- Student activities associated with the proposed Main Campus infill building rooftop
- The addition of the proposed facade openings on Kirribilli Avenue and Jeffreys Street
- OOSH Events associated with the proposed Main Campus infill building rooftop
- Mechanical plant and equipment noise associated with the proposed works to the Main Campus

Acoustic barriers of varying heights were input into the model to predict and compare the amount of mitigation and reduction in noise impacts at the affected residential receivers.

Figure 8 3D Model – Main Campus – Operational Noise Impacts (Student Activities – No Acoustic Barrier)

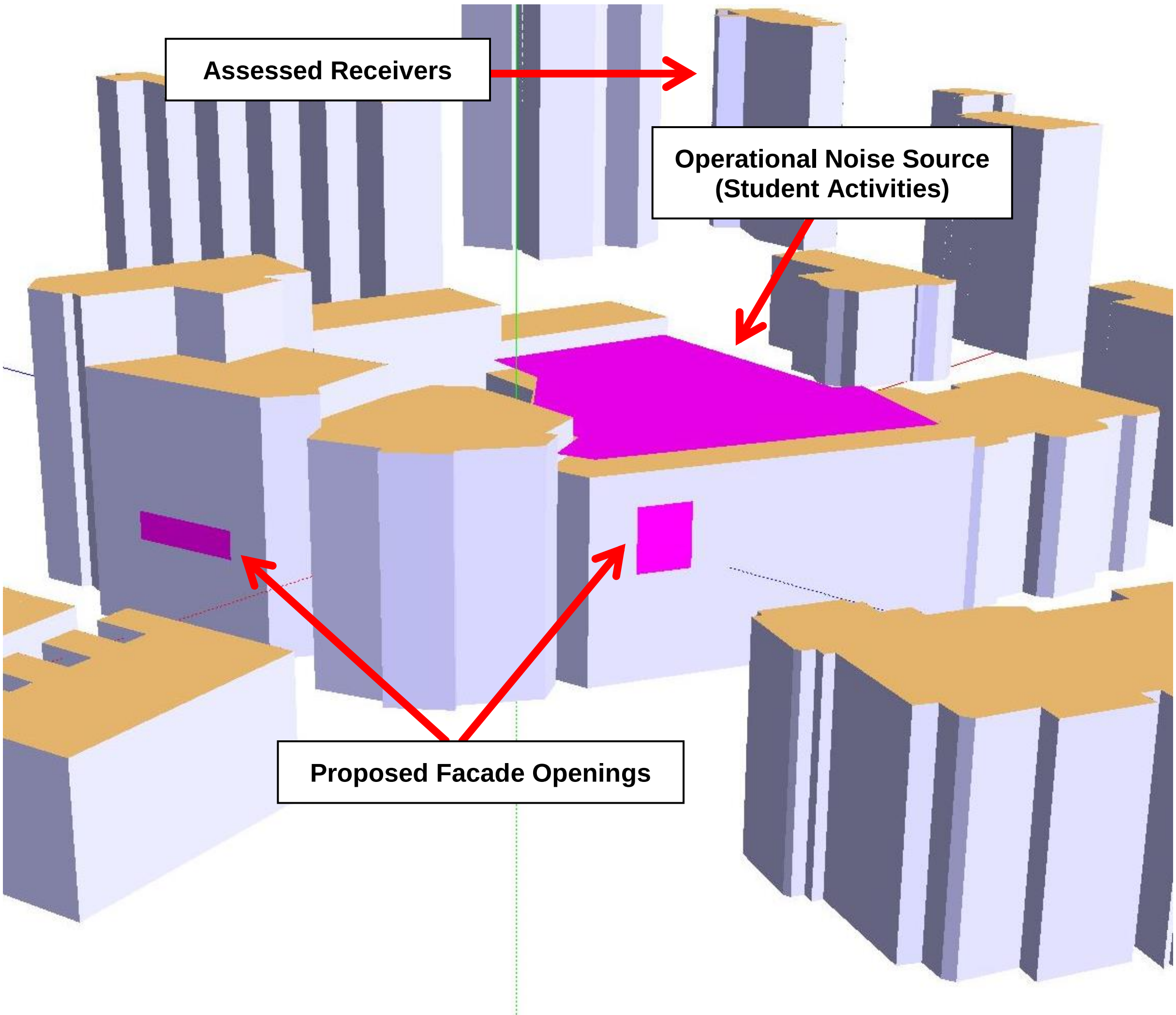
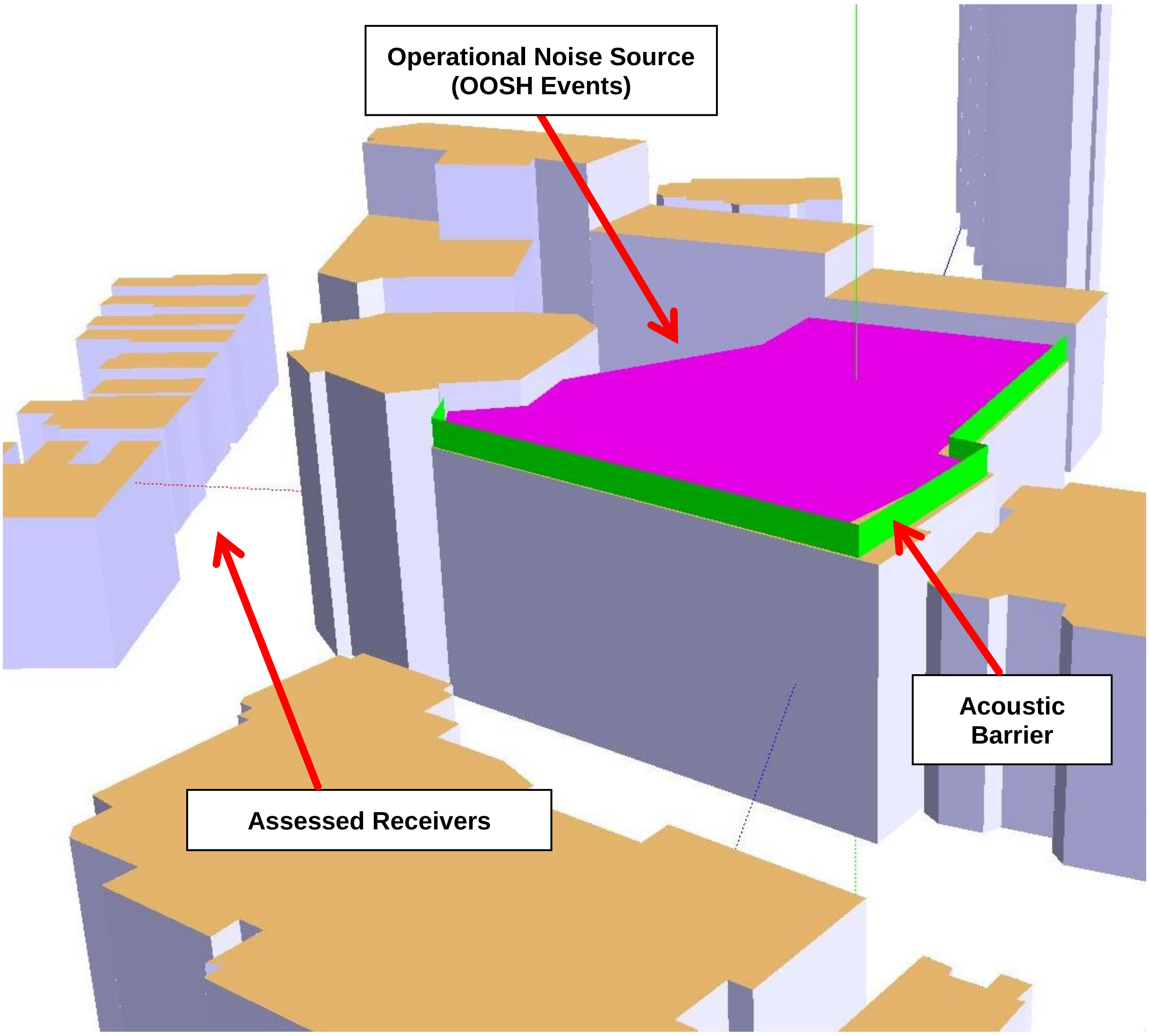


Figure 9 3D Model – Main Campus – Operational Noise Impacts (OOSH Events) with Acoustic Barrier



5.1.2 Noise Sensitive Receiver Locations

The potentially affected receivers are outlined in detail in **Table 15**

Table 15 Noise Sensitive Receivers Surrounding the Main Campus

Receiver ID	Address	Coordinates	
		Northings	Eastings
R01	49 Upper Pitt Street	334852.946	6253183.687
R02	88 Kirribilli Avenue	334836.122	6253153.699
R03	49A Upper Pitt Street	334875.856	6253182.716
R03	49A Upper Pitt Street	334868.942	6253171.076
R04	49B Upper Pitt Street	334859.902	6253143.399
R05	51 Kirribilli Avenue	334793.362	6253119.075
R06	55 Kirribilli Avenue	334818.924	6253106.109
R07	59 Kirribilli Avenue	334841.743	6253105.286
R07	59 Kirribilli Avenue	334839.149	6253092.160

Receiver ID	Address	Coordinates	
		Northings	Eastings
R08	46 Upper Pitt Street	334791.309	6253242.503
R09	48 Upper Pitt Street	334820.201	6253257.636
R10	50 Upper Pitt Street	334860.518	6253239.038
R11	2 Parkes Street	334894.882	6253227.166
R12	32 Jeffreys Street	334729.493	6253231.548
R13	30 Jeffreys Street	334730.145	6253227.139
R14	28 Jeffreys Street	334730.800	6253222.377
R15	26 Jeffreys Street	334731.505	6253218.187
R16	25 Jeffreys Street	334734.568	6253211.396
R17	22 Jeffreys Street	334735.500	6253206.444
R18	20 Jeffreys Street	334733.974	6253201.039
R19	18 Jeffreys Street	334736.337	6253196.534
R20	40-50 Kirribilli Avenue	334733.381	6253177.411

Note 1: Duplicate receivers R03 and R07 refer to single addresses with multiple buildings onsite.

5.1.3 Activity Noise Assessment

5.1.3.1 Predicted Operational Noise Levels – Student Activities (Proposed Infill Rooftop)

Table 16 shows the $L_{Aeq,15min}$ noise levels predicted at the affected residential receivers for the existing operational scenario (student activities in the existing ground floor courtyard area), the proposed scenario (student activities on the proposed infill building rooftop), and for the proposed scenario with two different acoustic barrier options (student activities on the proposed infill building rooftop with either a 1.8 m acoustic barrier or a 2.1 m acoustic barrier).

For all scenarios, the noise levels from the proposed facade openings located on the Kirribilli Avenue and Jeffreys Street sides were included in the calculation. Additionally, the noise levels from the proposed openings were modelled in isolation and were found to have a negligible noise impact on the residential receivers with respect to their project specific criteria.

Table 16 Predicted Operational Noise Levels – Student Activities (Proposed Infill Rooftop)

Receiver ID[1]	Criteria[2]	Existing location $L_{Aeq,15min}$ (dB)[3]	Rooftop, No Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 1.8m Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 2.1m Barrier $L_{Aeq,15min}$ (dB)
R01	50	66	68	64	63
R02	50	70	62	56	55
R03	63	58	62	61	61
R03	63	59	63	63	62
R04	63	62	66	61	61
R05	63	41	59	53	52
R06	50	41	53	49	48
R07	63	38	53	48	48
R07	63	37	52	48	47
R08	63	45	54	51	51
R09	63	57	62	62	62
R10	63	58	62	62	62

Receiver ID[1]	Criteria[2]	Existing location $L_{Aeq,15min}$ (dB)[3]	Rooftop, No Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 1.8m Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 2.1m Barrier $L_{Aeq,15min}$ (dB)
R11	63	57	60	60	60
R12	63	33	38	37	37
R13	63	34	38	38	38
R14	63	35	39	39	39
R15	63	34	40	40	40
R16	63	38	41	41	41
R17	63	40	42	42	42
R18	63	35	43	43	43
R19	63	36	43	43	43
R20	63	40	50	45	44

Note 1: Duplicate residential receivers R03 and R07 refer to single residential addresses with multiple buildings onsite.

Note 2: NSW NPfI daytime project intrusiveness noise level as specified in **Section 4.1** was used for the assessment.

Note 3: Existing LAeq levels are based on the source to receiver predictions using the measured calibrated source levels in the location of the existing ground-floor courtyard.

5.1.3.2 Predicted Operational Noise Levels – OOSH Events (Proposed Infill Rooftop)

Table 17 shows the LAeq noise levels predicted at the affected residential receivers for the existing operational scenario (OOSH Events in the ground floor courtyard area), the proposed scenario (OOSH event on the proposed infill building rooftop), and for the proposed scenario with two different acoustic barrier options (OOSH Events on the proposed infill building rooftop with either a 1.8m acoustic barrier or a 2.1m acoustic barrier).

Table 17 Predicted Operational Noise Levels – OOSH Events (Proposed Infill Rooftop)

Receiver ID[1]	Criteria[2]	Rooftop, No Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 1.8m Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 2.1m Barrier $L_{Aeq,15min}$ (dB)
R01	48	70	65	65
R02	48	64	59	58
R03[1]	61	64	63	63
R03	61	65	65	64
R04	61	67	63	62
R05	61	61	55	55
R06	48	55	51	51
R07[1]	61	55	51	50
R07	61	54	50	49
R08	61	56	53	53
R09	61	64	64	64
R10	61	64	64	64
R11	61	62	62	62
R12	61	39	38	38
R13	61	40	40	40
R14	61	41	40	40
R15	61	41	40	40
R16	61	43	43	43
R17	61	44	44	44

Receiver ID[1]	Criteria[2]	Rooftop, No Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 1.8m Barrier $L_{Aeq,15min}$ (dB)	Rooftop, 2.1m Barrier $L_{Aeq,15min}$ (dB)
R18	61	41	41	41
R19	61	42	41	41
R20	61	52	47	46

Note 1: Duplicate residential receivers R03 and R07 refer to single residential addresses with multiple buildings onsite.
Note 2: NSW NPfI evening project intrusiveness noise level as specified in **Section 4.1** was used for the assessment.

5.1.4 Fixed Mechanical Plant Noise Assessment

5.1.4.1 Project Noise Trigger Levels (NPfI)

The potentially affected receivers and their corresponding project noise trigger levels are outlined in **Table 18** and were used to assess potential operational noise from fixed mechanical plant.

Table 18 Project Noise Trigger Levels for Receivers Surrounding the Main Campus

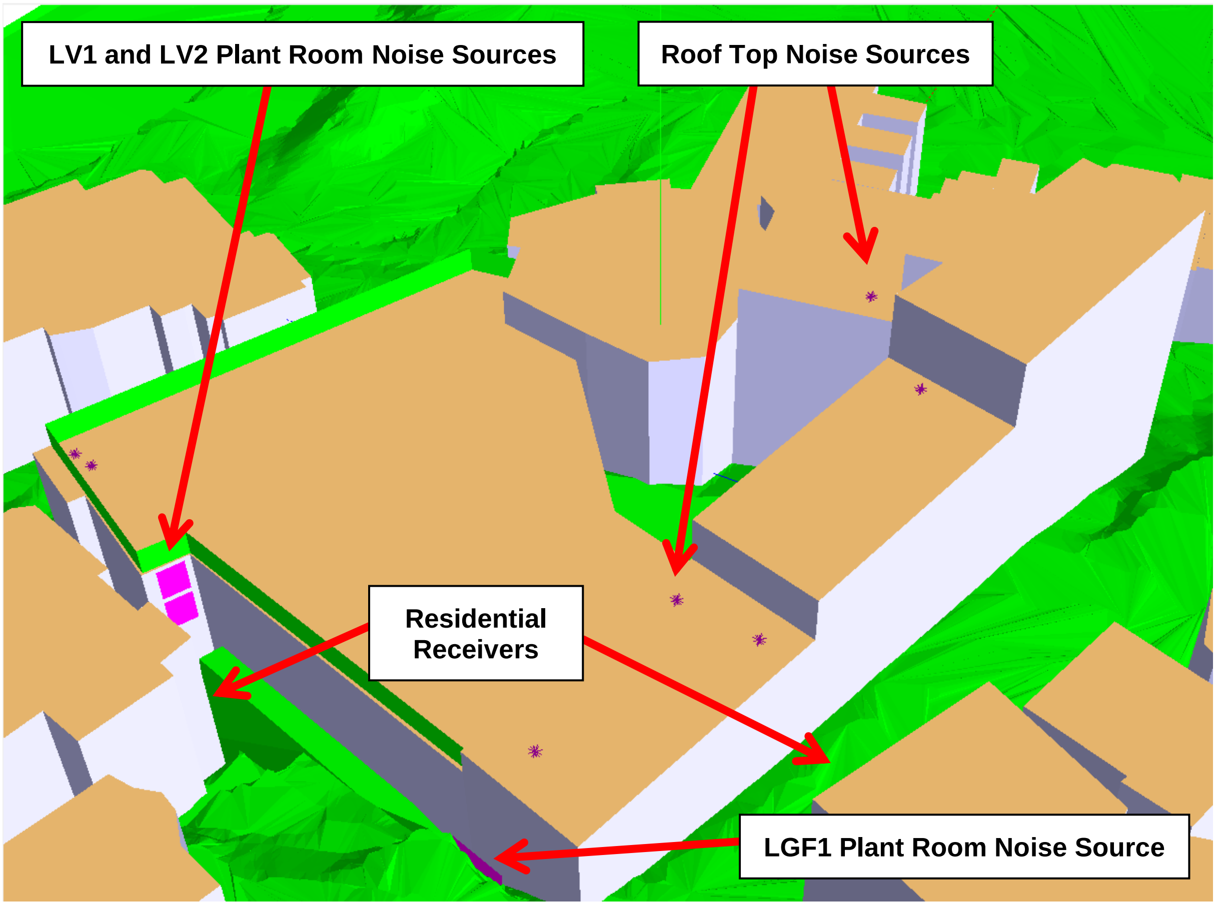
Receiver ID	Address	Coordinates		Project Noise Trigger Levels L_{Aeq}(15minute)		
		Northings	Eastings	Daytime	Evening	Night
R01	49 Upper Pitt Street	334852.946	6253183.687	50	48	42
R02	88 Kirribilli Avenue	334836.122	6253153.699	50	48	42
R03	49A Upper Pitt Street	334875.856	6253182.716	58	48	45
R03	49A Upper Pitt Street	334868.942	6253171.076	58	48	45
R04	49B Upper Pitt Street	334859.902	6253143.399	58	48	45
R05	51 Kirribilli Avenue	334793.362	6253119.075	58	48	45
R06	55 Kirribilli Avenue	334818.924	6253106.109	50	48	42
R07	59 Kirribilli Avenue	334841.743	6253105.286	58	48	45
R07	59 Kirribilli Avenue	334839.149	6253092.160	58	48	45
R08	46 Upper Pitt Street	334791.309	6253242.503	58	48	45
R09	48 Upper Pitt Street	334820.201	6253257.636	58	48	45
R10	50 Upper Pitt Street	334860.518	6253239.038	58	48	45
R11	2 Parkes Street	334894.882	6253227.166	58	48	45
R12	32 Jeffreys Street	334729.493	6253231.548	58	48	45
R13	30 Jeffreys Street	334730.145	6253227.139	58	48	45
R14	28 Jeffreys Street	334730.800	6253222.377	58	48	45
R15	26 Jeffreys Street	334731.505	6253218.187	58	48	45
R16	25 Jeffreys Street	334734.568	6253211.396	58	48	45
R17	22 Jeffreys Street	334735.500	6253206.444	58	48	45
R18	20 Jeffreys Street	334733.974	6253201.039	58	48	45
R19	18 Jeffreys Street	334736.337	6253196.534	58	48	45
R20	40-50 Kirribilli Avenue	334733.381	6253177.411	58	48	45

Note 1: Duplicate receivers R03 and R07 refer to single addresses with multiple buildings onsite.
Note 2: NSW NPfI project noise trigger levels as specified in **Section 4.1** were used for the assessment.

5.1.4.2 Modelling

The location of the proposed mechanical plant as well as the specifications and sound power data of the equipment were provided to SLR by the project Mechanical Engineers (Umow Lai). Umow Lai have also outlined that the mechanical plant will only be operational during school hours with the exception of mechanical ventilation fans operating during the night-time period in Summer for night purge. These inputs were used in the operational noise model (shown in **Figure 10**) to predict potential industrial noise impacts at the surrounding residential receivers (outlined in **Section 2.5)** in accordance with the project noise trigger levels (shown in **Table 18**).

Figure 10 3D Model – Main Campus – Operational Noise Impacts (Mechanical Plant). View facing South-West



5.1.4.3 Acoustic Treatment Requirements

Based on the results from the operational noise model, SLR predicts that compliance with the project noise trigger levels can be achieved. However, acoustic treatment will be required and must be assessed in greater depth in accordance with the project noise trigger levels during the detailed design stage of the Project. For the purpose of this stage of the assessment, SLR recommends the following measures to mitigate the acoustic impact of the proposed mechanical plant:

- Enclosures for chillers located on roof tops including discharge attenuators.
- Attenuators on all air handling units and acoustic rated louvres for mechanical plant rooms.
- Attenuators on all ventilation and exhaust fans.

Detailed enclosure, attenuator and louvre specifications are to be established as the equipment selections are finalised as the design progresses.

5.1.4.4 Maximum Noise Level Event Assessment

Based on a preliminary assessment of the mechanical plant noise source contributions at the surrounding receivers, in conjunction with the hours of operation provided by Umow Lai, SLR has identified a potential for sleep disturbance (as defined in the NPfI) at the surrounding receivers caused by fan operation during the Summer night-time purge scenarios. However, SLR predicts that compliance with the project noise trigger levels for all assessment periods (outlined in **Section 4.1.1.3**) can be achieved if the proposed acoustic treatment measures discussed in **Section 5.1.4.3** are implemented.

5.1.4.5 Corrections for Annoying Noise Characteristics

At this stage, SLR has not identified any mechanical plant that exhibits intrinsic noise characteristics that may result in greater annoyance at the surrounding receivers (as defined in the NPfI). Furthermore, a detailed assessment of the proposed mechanical plant can only be undertaken as the design progresses and the equipment selections are finalised. As such, modifying factor corrections for noise characteristics have not been assessed in detail at this stage of the project, however should be applied where necessary in the detailed design and final mitigation selection.

6 DISCUSSION AND RECOMMENDATIONS

6.1 Main Campus

6.1.1 Operational Noise Levels – Student Activities (Proposed Infill Rooftop)

The results indicate that with an acoustic barrier greater than or equal to 1.8 m in height surrounding the boundary affected zones of the proposed rooftop terrace, compliance with the established relevant criteria is achieved at all surrounding noise sensitive receivers with the exception of R01 and R02. These receivers have more onerous criteria due to being screened from the background traffic noise on the Sydney Harbour Bridge by SAC.

However, despite R01 and R02’s non-compliance with the established absolute noise criteria, it should be noted that with the relocation of the current courtyard social area to the proposed infill building rooftop area, in conjunction with the addition of an acoustic barrier greater than or equal to 1.8 m in height, the noise impact on these receivers is reduced. That is, R01 and R02 will receive a significant net benefit from the proposed change in terms of noise impacts with the addition of an acoustic barrier. As a result, this is considered an acceptable and positive outcome.

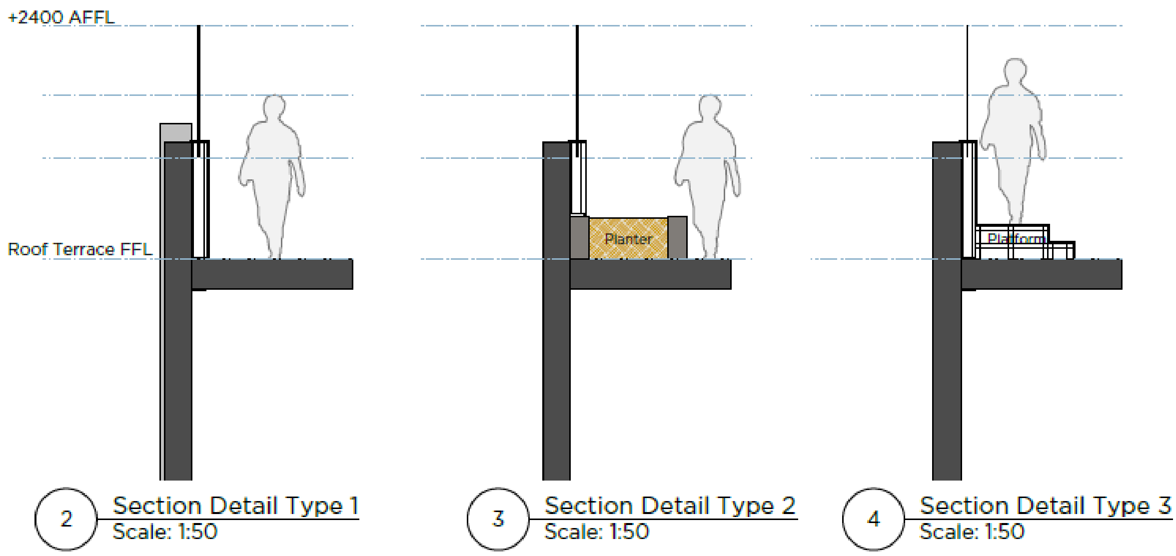
6.1.2 Operational Noise Levels – OOSH Events (Proposed Infill Rooftop)

The results indicate that with an acoustic barrier greater than or equal to 1.8 m in height surrounding the boundary affected zones of the proposed rooftop terrace, compliance with the recommended criteria is achieved at all but eight (8) of the surrounding noise sensitive receivers. The receivers with remaining exceedances are R01, R02, R03, R04, R06, R09, R10 and R11 (shown in **Figure 3**).

However, despite R01 and R02’s non-compliance with the established criteria, it should be noted that with the move from events being held in the existing location to the proposed infill building rooftop area, in conjunction with the addition of an acoustic barrier, a reduction in the noise impact on these receivers from out of school hour events is expected. As a result, this is considered an acceptable and positive outcome.

The exceedances at the remaining six receivers (R03, R04, R06, R09, R10 and R11) are relatively minor – being up to 4 dB, but as low as 1dB with a 2.1 m high acoustic barrier. While this is likely to be considered acceptable considering the relatively infrequent nature of events on the proposed infill building rooftop, the best acoustic performance with respect to compliance is achieved through the use of an acoustic barrier with a minimum height of 2.1 m. Any increase in height above 2.1 m to an acoustic barrier will further decrease impacts. The proposed acoustic barrier (as shown in **Figure 11**) is 2.4 m in height and as a result noise impacts will be lower than those presented in **Table 17**. Additionally, the noise impacts may further be managed and mitigated should SAC develop an event noise management plan in the case of potentially larger events.

Figure 11 Acoustic Barrier Design



Note 1: Acoustic barrier design provided by PMDL on 26 July 2018.

6.1.3 Operational Noise Levels – Proposed Façade Openings

Results from the noise model indicate that the proposed facade openings on Kirribilli Avenue and Jeffreys Street have a negligible noise impact on the residential receivers with respect to their project specific criteria.

6.1.4 Operational Noise Levels – Mechanical Plant Emissions

Based on preliminary results from the operational noise model, SLR predicts that compliance with the project noise trigger levels for all assessment periods (outlined in **Section 4.1.1.3**) can be achieved if the proposed acoustic treatment measures discussed in **Section 5.1.4.3** are implemented following further investigation during the detailed design stage.

6.1.5 Construction Noise Impacts

Based on preliminary calculations involving the operation of plant and equipment representative of the worst case likely construction methodologies, a number of close-by receivers may trigger noise affected or highly affected exceedances in accordance with the management levels stipulated in the ICNG (outlined in **Table 8**). As a result, the Construction Contractor will need to develop mitigation and management strategies in consultation with the surrounding community and local authority.

Once further details surrounding the proposed construction methodology, equipment and phasing is known, it is recommended that the managing contractor produces a comprehensive Construction Noise and Vibration Management Plan in accordance with the framework for compliance established in this report.

6.1.5.1 Construction Noise Mitigation and Management

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

- 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.

6.1.6 Construction Vibration Impacts

Until more specifics regarding construction equipment and methodology are known, a detailed construction vibration assessment is not possible however it is recommended to mitigate any potential impacts using the recommended safe working distances for vibration intensive plant as indicated in **Table 19** taken from Transport for NSW's *Construction Noise Strategy* (2012).

Table 19 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic	Medium Hydraulic	Medium Hydraulic	Medium Hydraulic
Hammer	Hammer	Hammer	Hammer
(900 kg – 12 to 18t excavator) 7 m 23 m	(900 kg – 12 to 18t excavator) 7 m 23 m	(900 kg – 12 to 18t excavator) 7 m 23 m	(900 kg – 12 to 18t excavator) 7 m 23 m

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

6.2 Wyalla

The changes identified at Wyalla from a noise perspective entail the minor increase in the building envelope at ground floor level (no increase in occupancy) and a small increase in the number of Air-Conditioning external condenser units at the same location they are currently placed. As a result, the changes at Wyalla are expected to be negligible in terms of noise impacts and can easily be mitigated to satisfy the required noise criteria

6.3 Junior School

The changes identified at the Junior School campus from a noise perspective entail:

- Rotating the existing outdoor Basketball Court to a new orientation within the school grounds in the same approximate location as it is currently placed. This may have a very minor impact on the noise emissions to the surrounding residences; however this is not expected to be significant.

- A new subterranean basketball court which will open on to a landscaped ‘amphitheatre’ area (to replace the existing amphitheatre space). Due to the increased capacity for sports activity and potential Saturday sports use of the new facility, this change does have the potential to create a noise impact on the surrounding sensitive receivers. However, it is also considered that through appropriate design of the building fabric (folding doors and ventilation system) along with an agreed on management policy this noise impact can be suitably controlled to satisfy the relevant emissions criteria. It is recommended that acoustic treatments be addressed in detail when the Junior School development consent is being sought.

7 CONCLUSION

SLR Consulting Australia Pty Ltd has conducted an assessment of the noise impacts associated with the proposed Masterplan at St Aloysius’ College located on the Milsons Point and Kirribilli peninsular on the lower North Shore in Sydney. This assessment has been carried out in accordance with NSW regulatory requirements and will form part of the State Significant Development (SSD 8669) application to the NSW Department of Planning and Environment in support of the development.

The scope of the assessment involved a survey of the existing noise environment; derivation and establishment of project specific noise criteria; a noise impact assessment relative to appropriate criteria; and, where required, recommendations for noise control measures.

With the implementation of an acoustic barrier (with a minimum height of 2.1 m) around the perimeter of the future rooftop terrace of the infill building on the Main Campus (as discussed in **Section 6**), the proposed changes will reduce the current school noise impacts on the most highly impacted receivers. Overall, the proposed changes are not anticipated to result in adverse operational noise impacts at the surrounding residential receivers based upon the assessment presented in this report.

Acoustic Terminology

1 Sound Level or Noise Level

The terms ‘sound’ and ‘noise’ are almost interchangeable, except that in common usage ‘noise’ is often used to refer to unwanted sound.

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

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

2 ‘A’ Weighted Sound Pressure Level

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

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

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

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

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

3 Sound Power Level

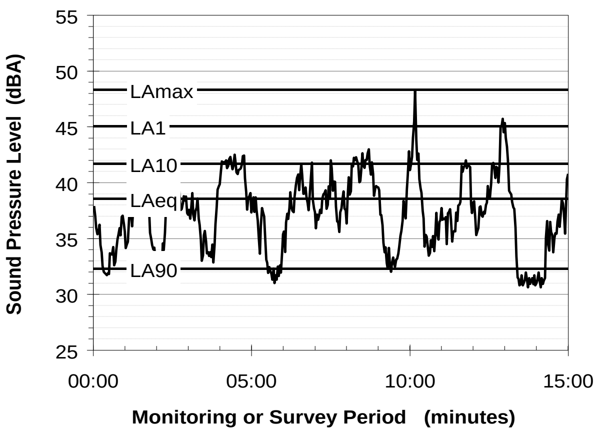
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level 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

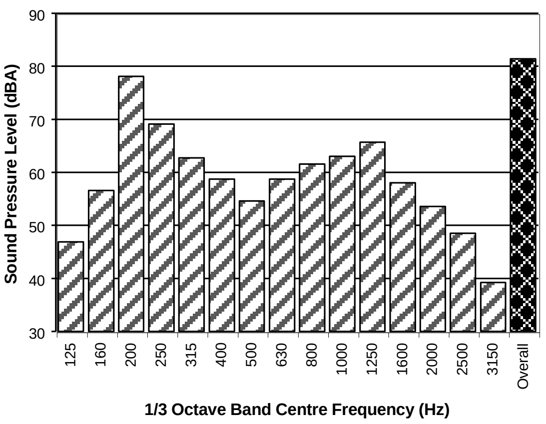
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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 organizations.

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

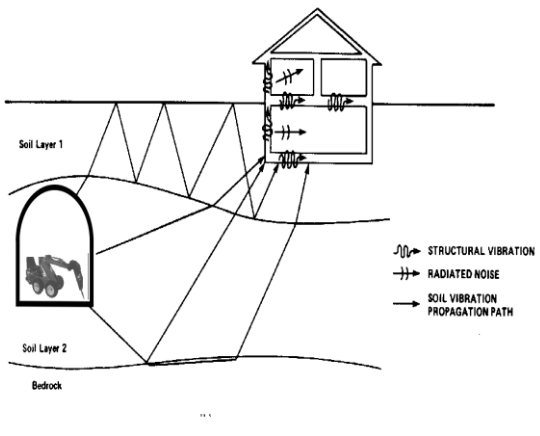
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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.

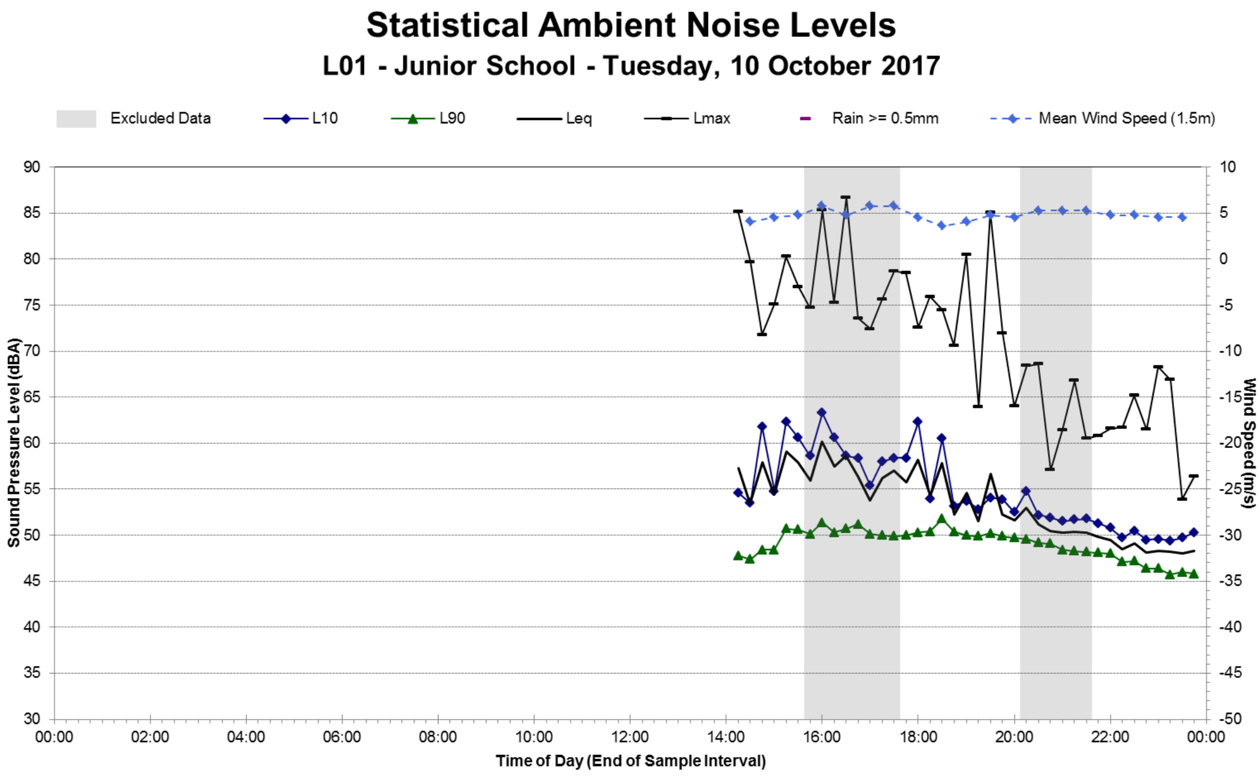
Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents 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

Ambient Noise Monitoring Results (L01)


Statistical Ambient Noise Levels
L01 - Junior School - Tuesday, 10 October 2017
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
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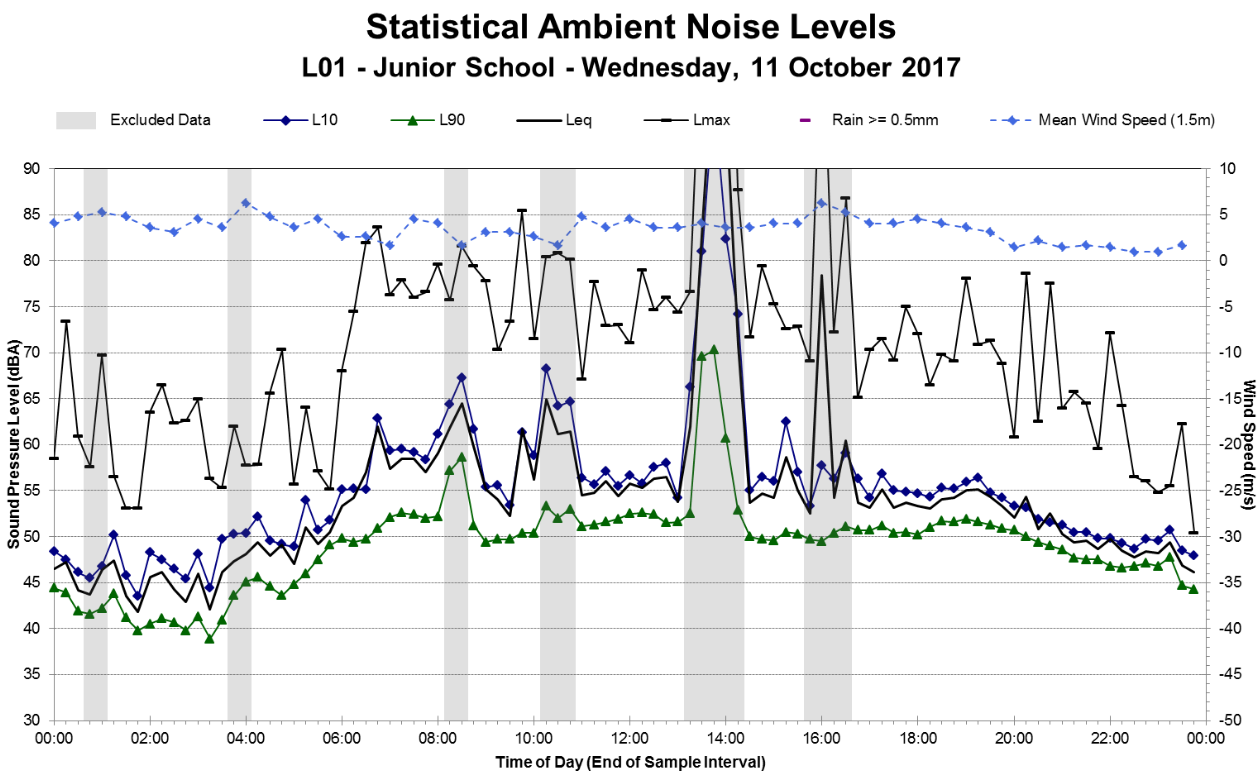
Statistical Ambient Noise Levels
L01 - Junior School - Wednesday, 11 October 2017
Excluded Data
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Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
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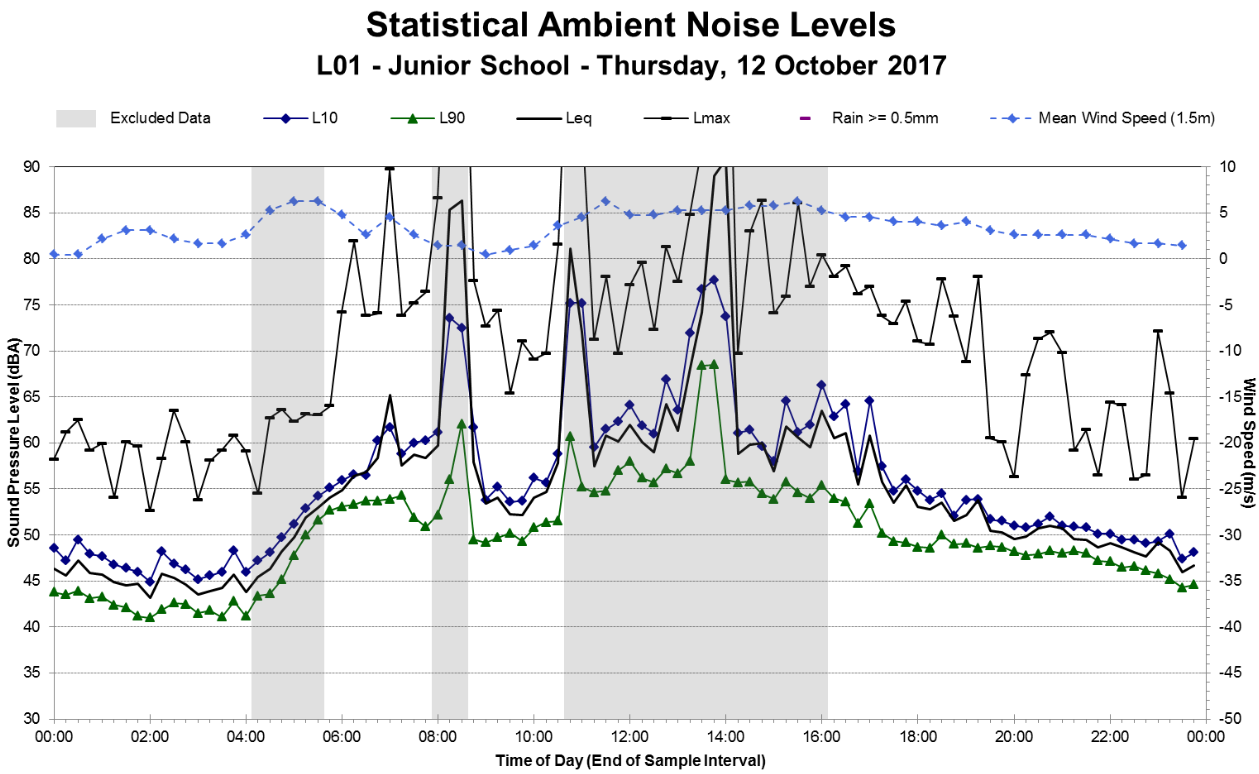
Statistical Ambient Noise Levels
L01 - Junior School - Thursday, 12 October 2017
Excluded Data
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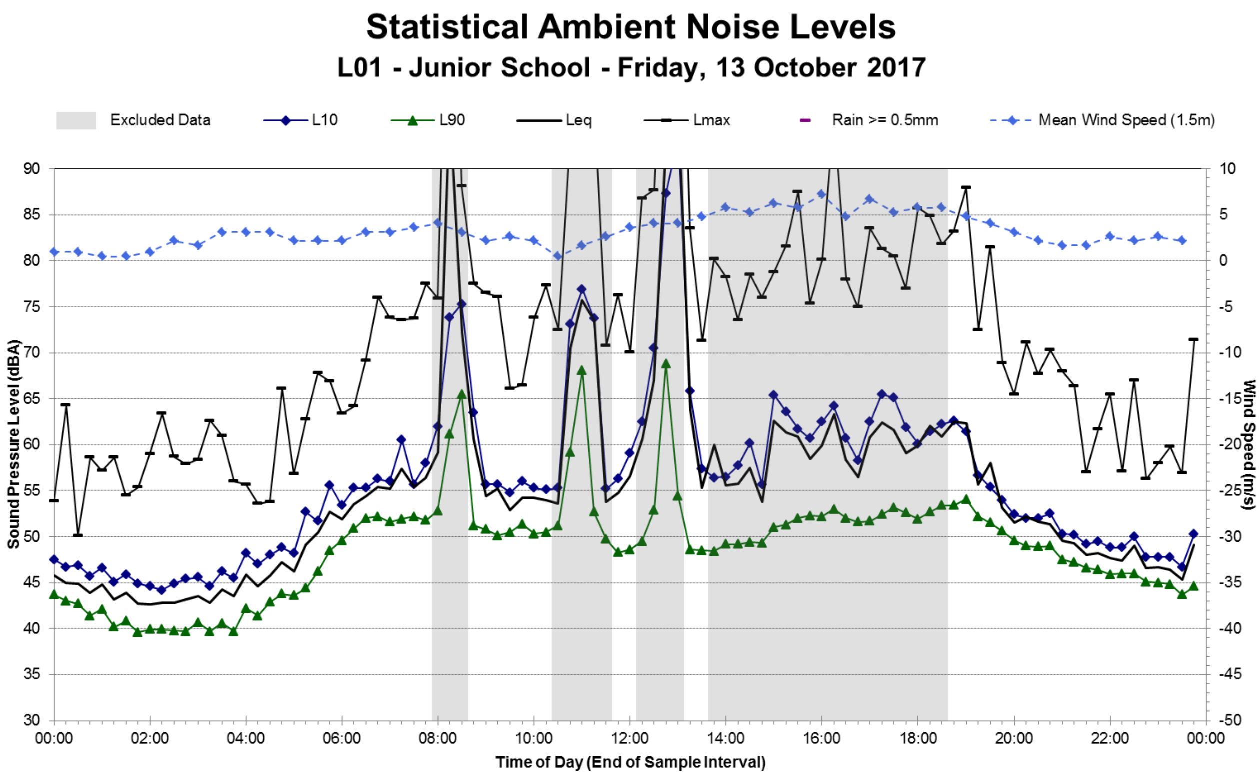
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L01 - Junior School - Friday, 13 October 2017
Excluded Data
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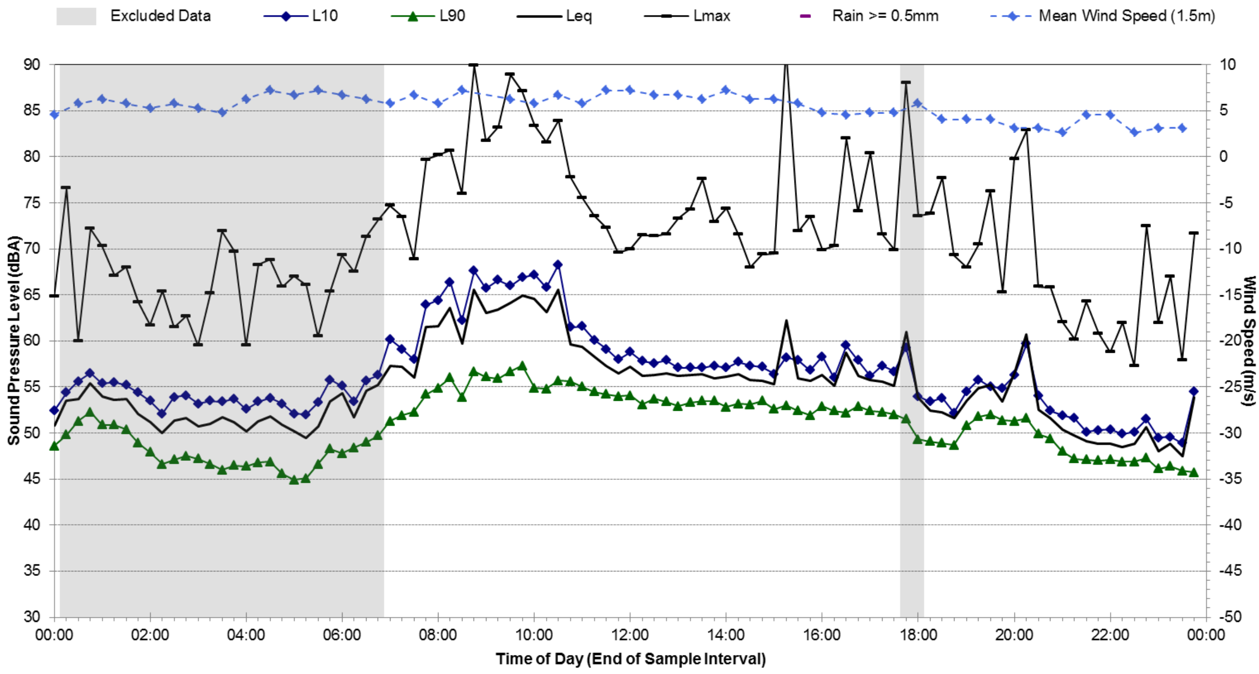
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

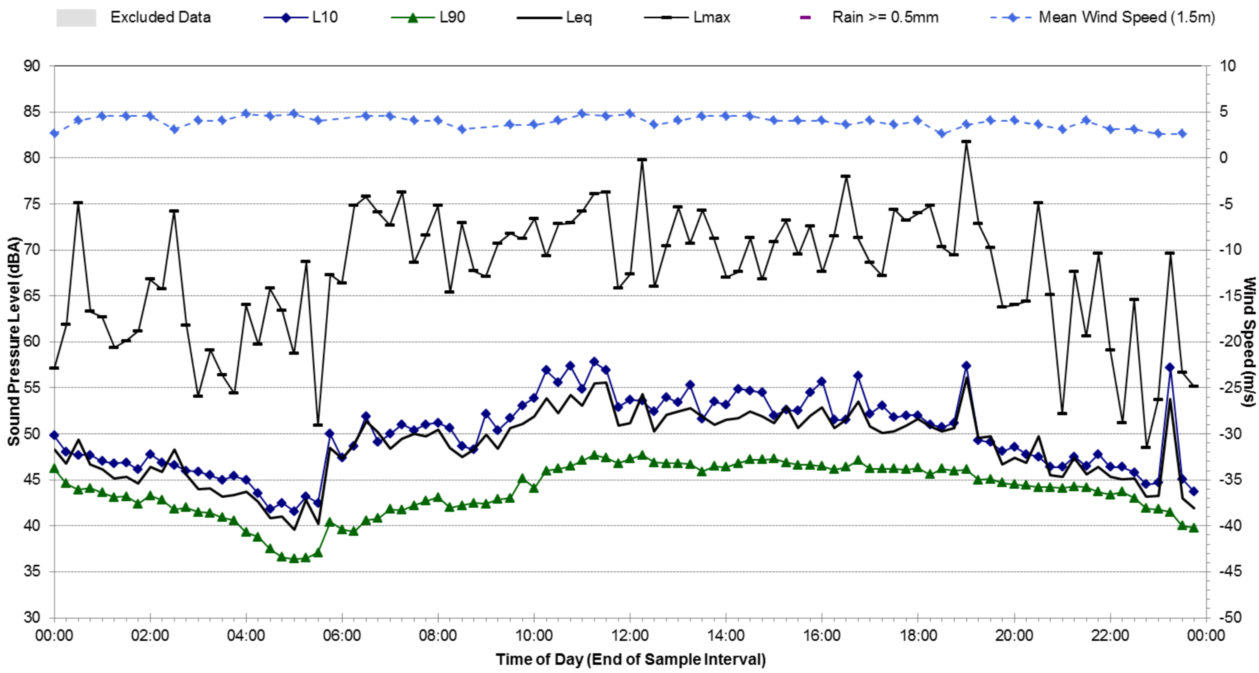
Statistical Ambient Noise Levels

L01 - Junior School - Saturday, 14 October 2017

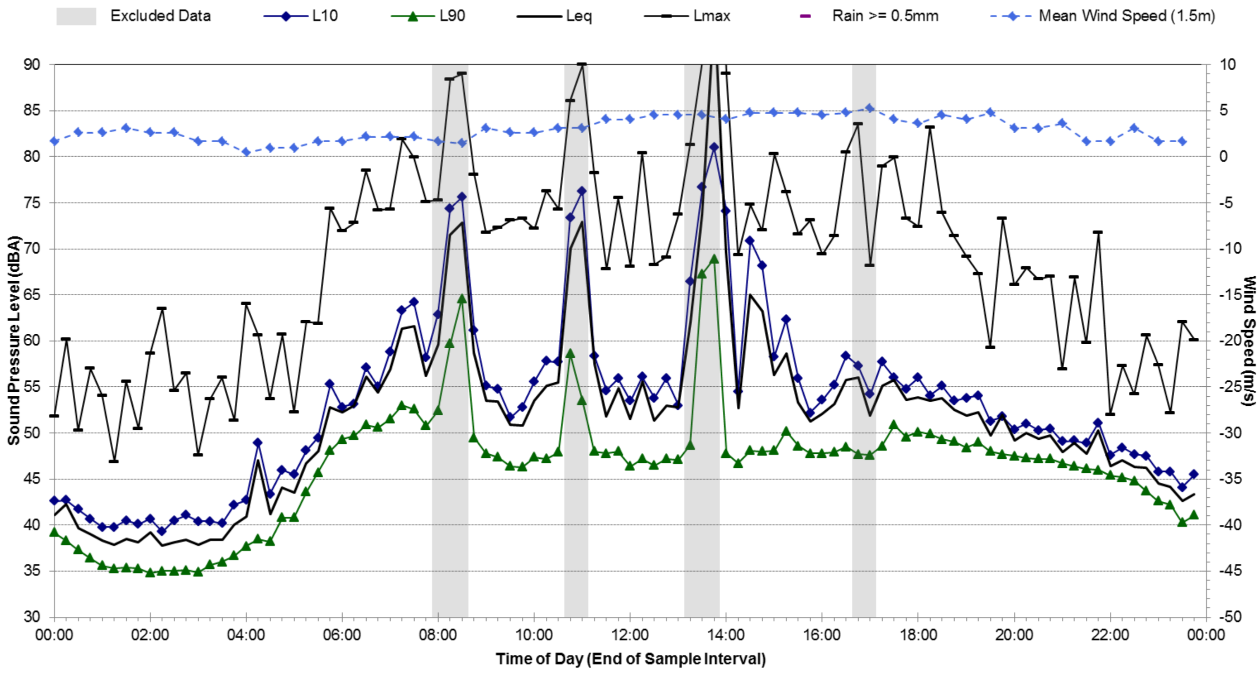


Statistical Ambient Noise Levels

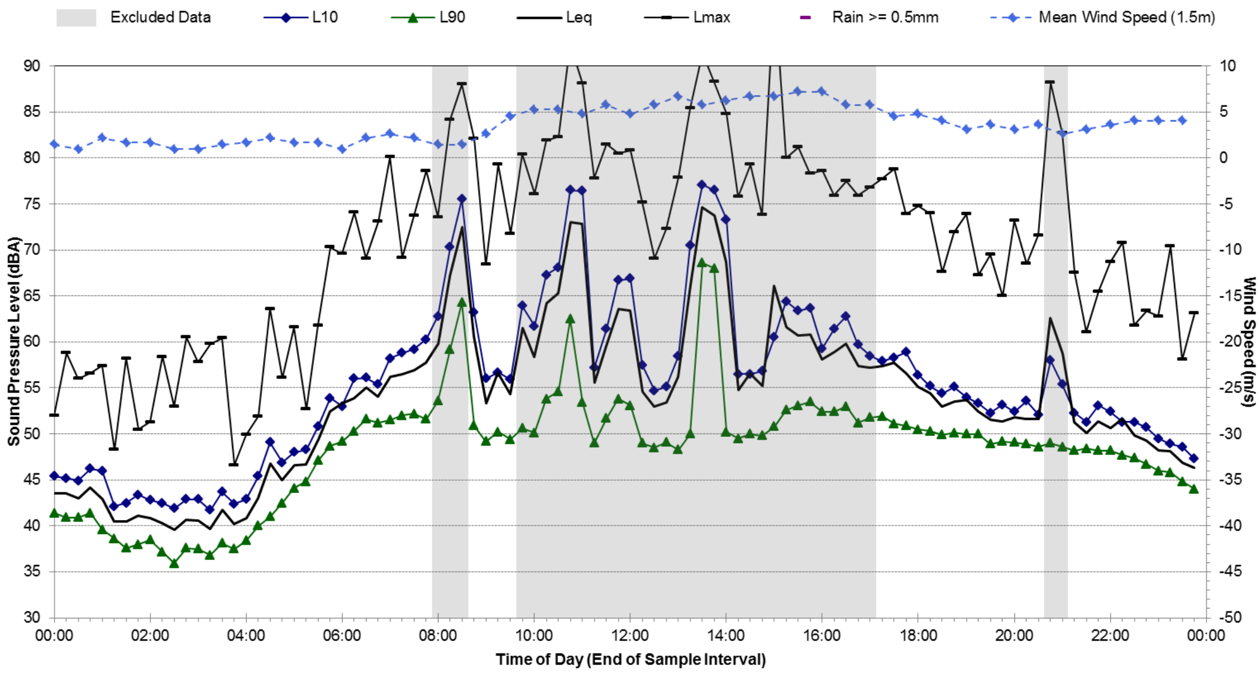
L01 - Junior School - Sunday, 15 October 2017

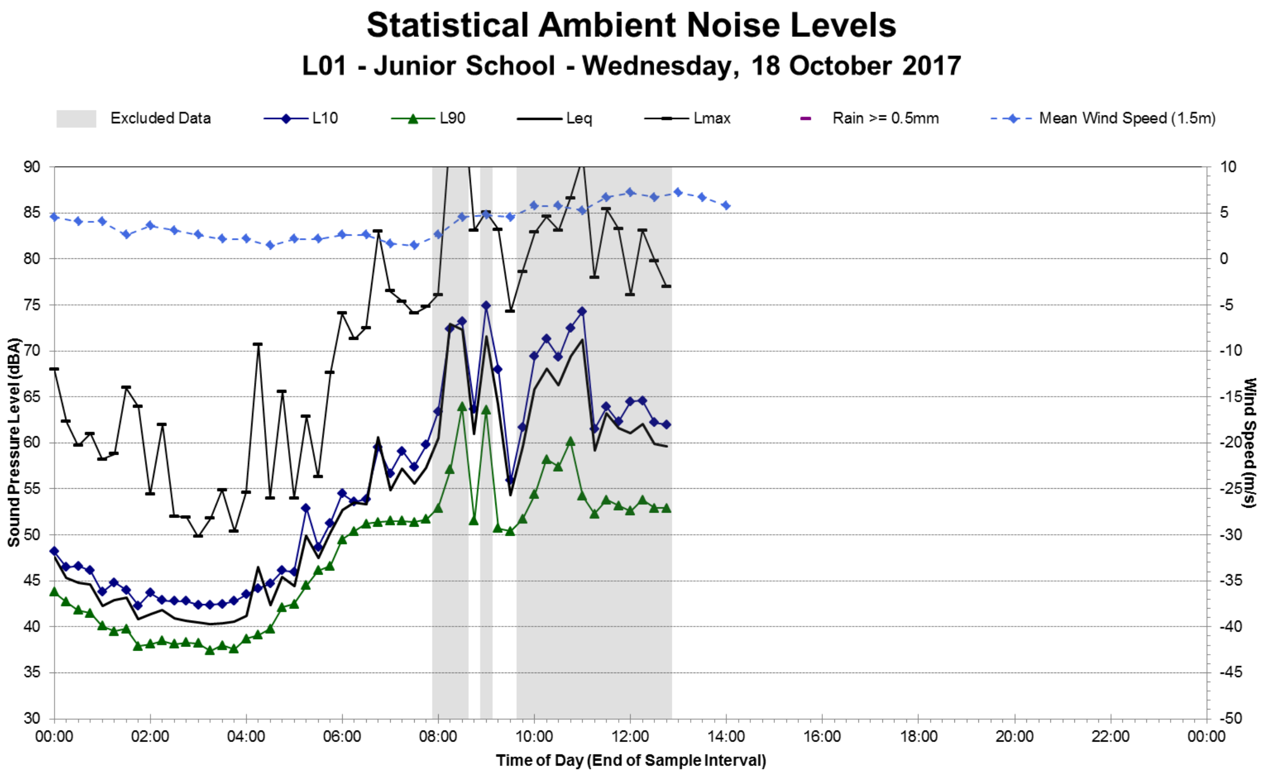


Statistical Ambient Noise Levels
L01 - Junior School - Monday, 16 October 2017



Statistical Ambient Noise Levels
L01 - Junior School - Tuesday, 17 October 2017




Statistical Ambient Noise Levels
L01 - Junior School - Wednesday, 18 October 2017
Excluded Data
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Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
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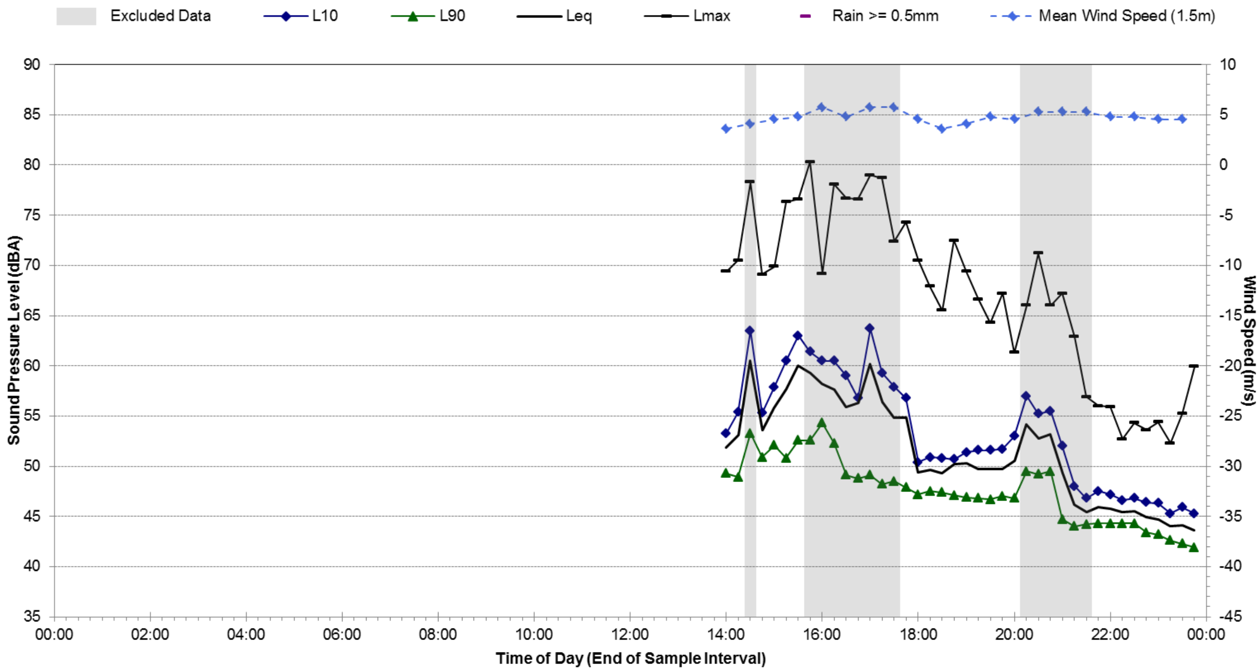
Ambient Noise Monitoring Results (L02)

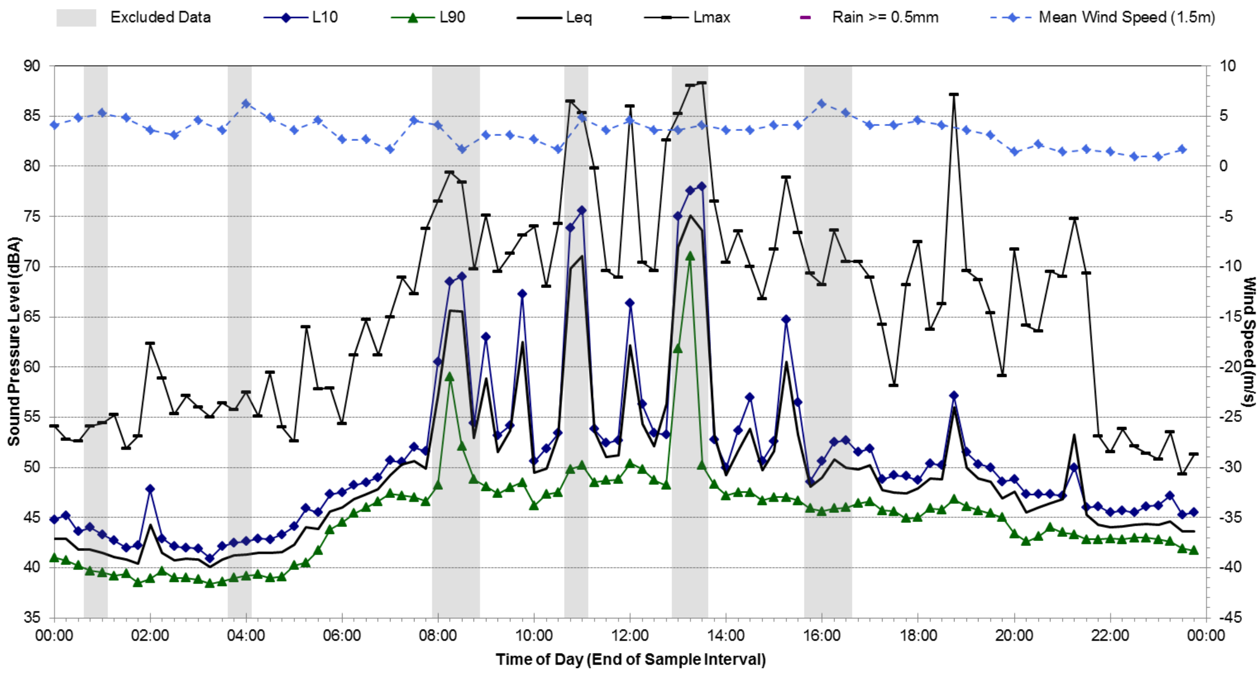
Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Tuesday, 10 October 2017



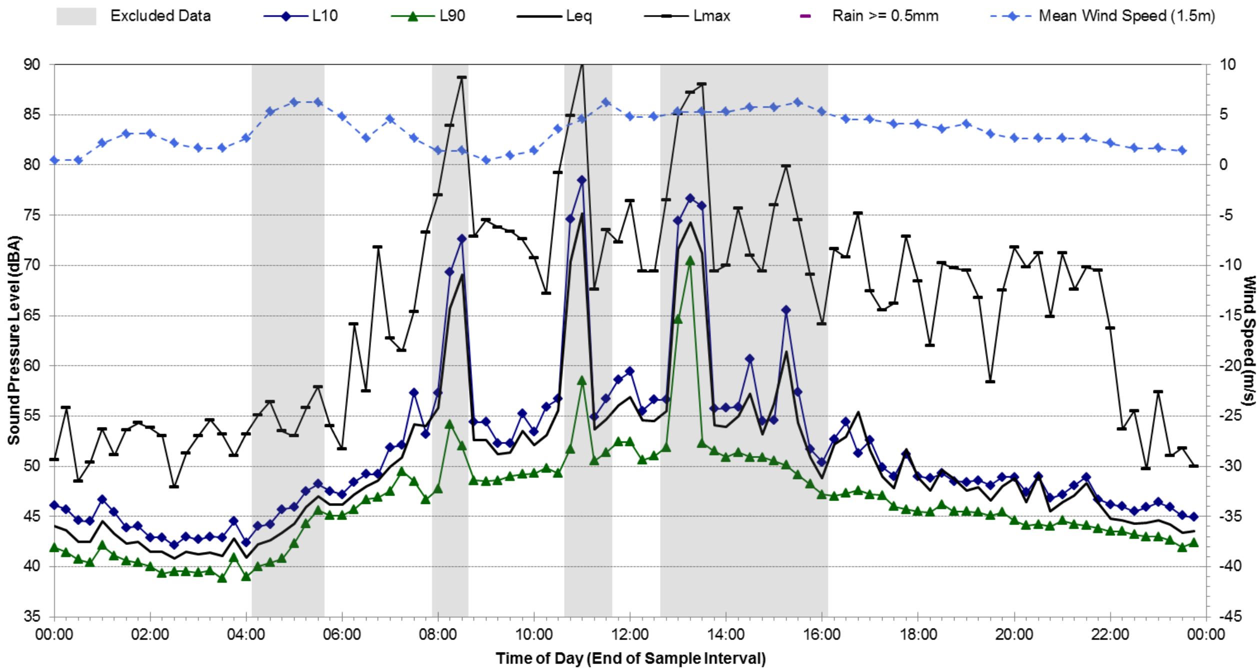
Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Wednesday, 11 October 2017



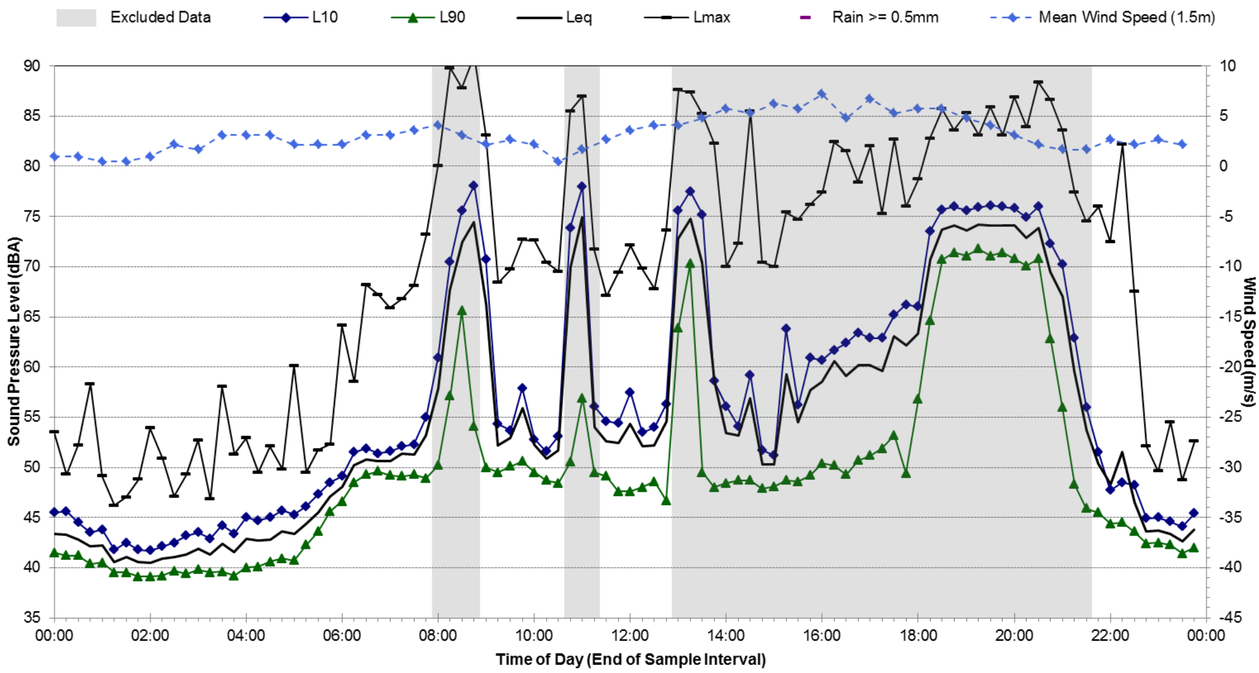
Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Thursday, 12 October 2017



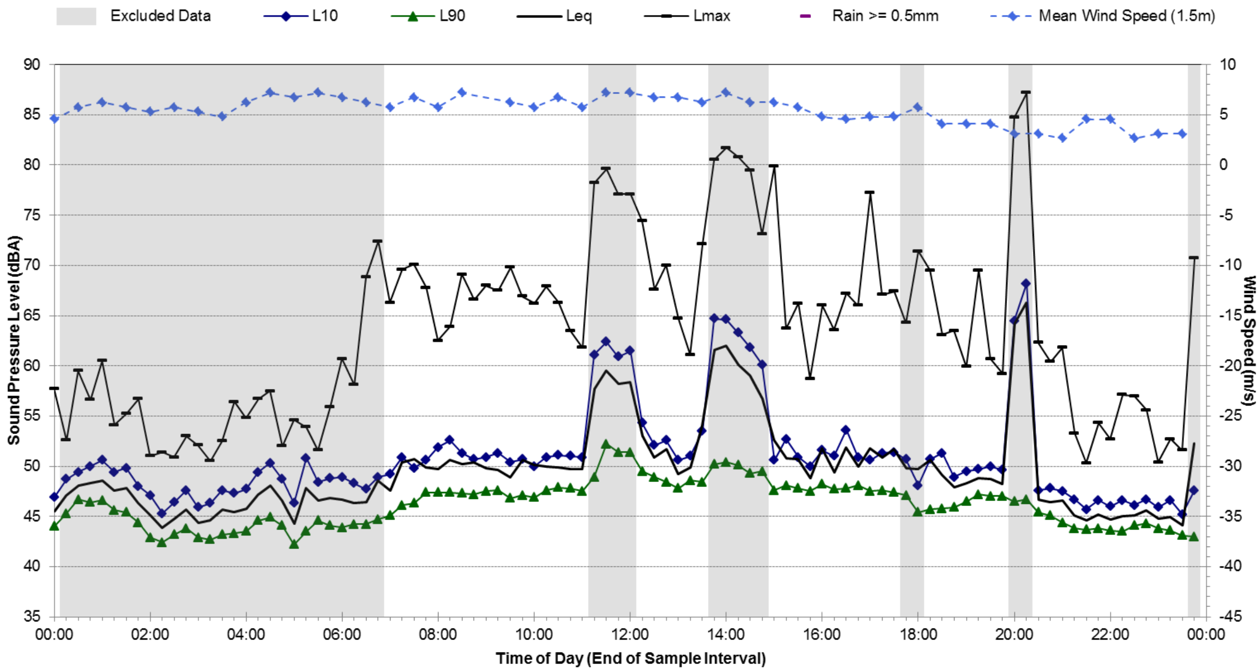
Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Friday, 13 October 2017



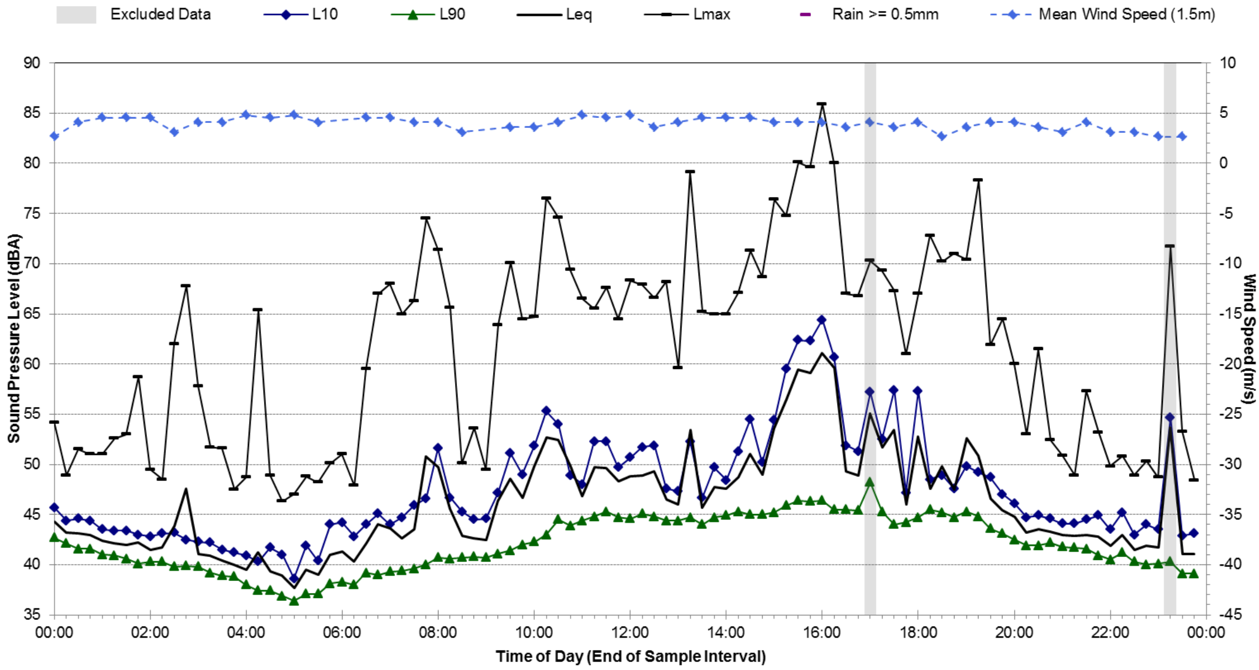
Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Saturday, 14 October 2017



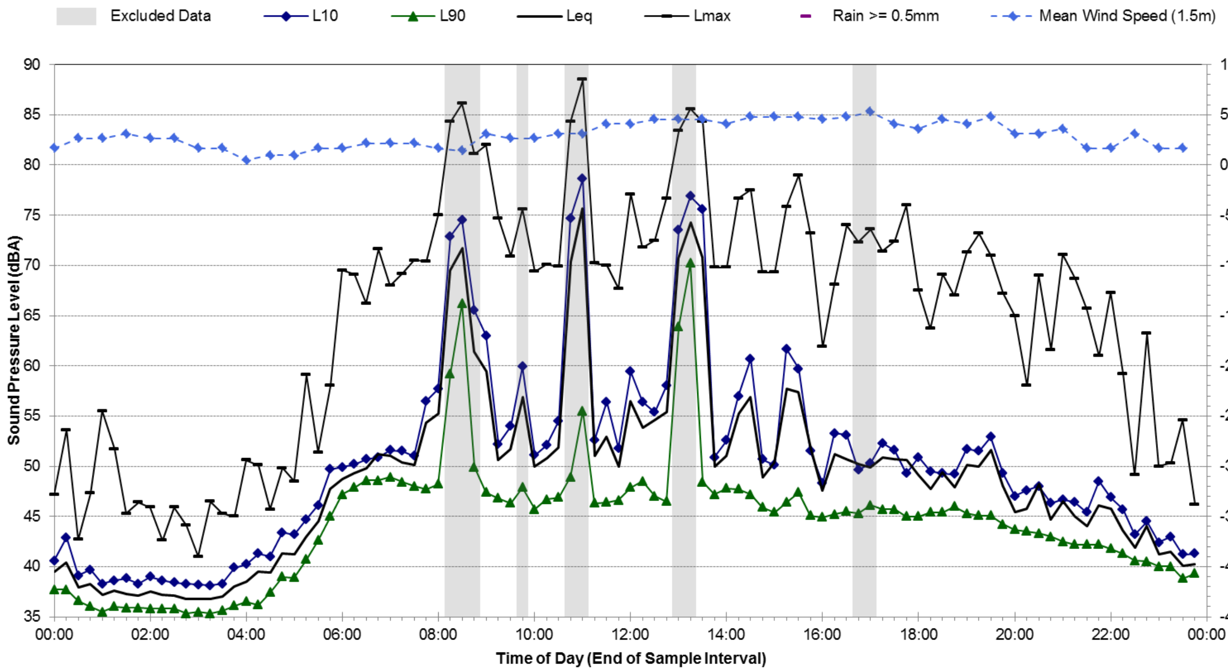
Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Sunday, 15 October 2017



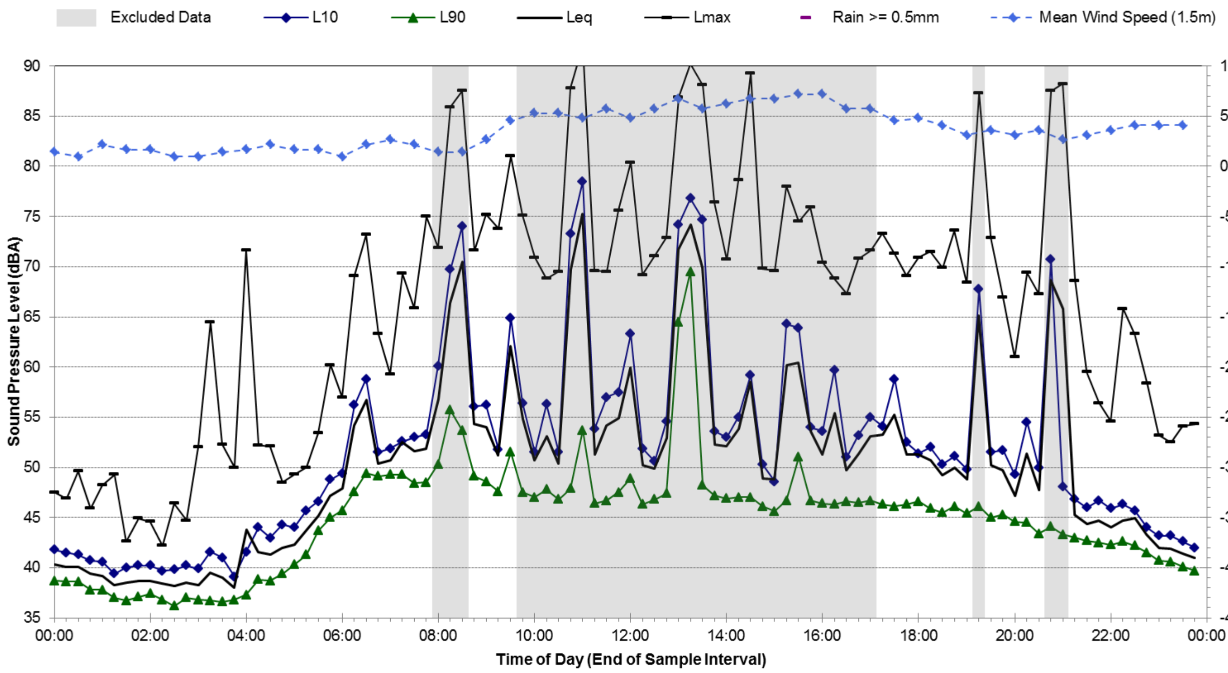
Statistical Ambient Noise Levels

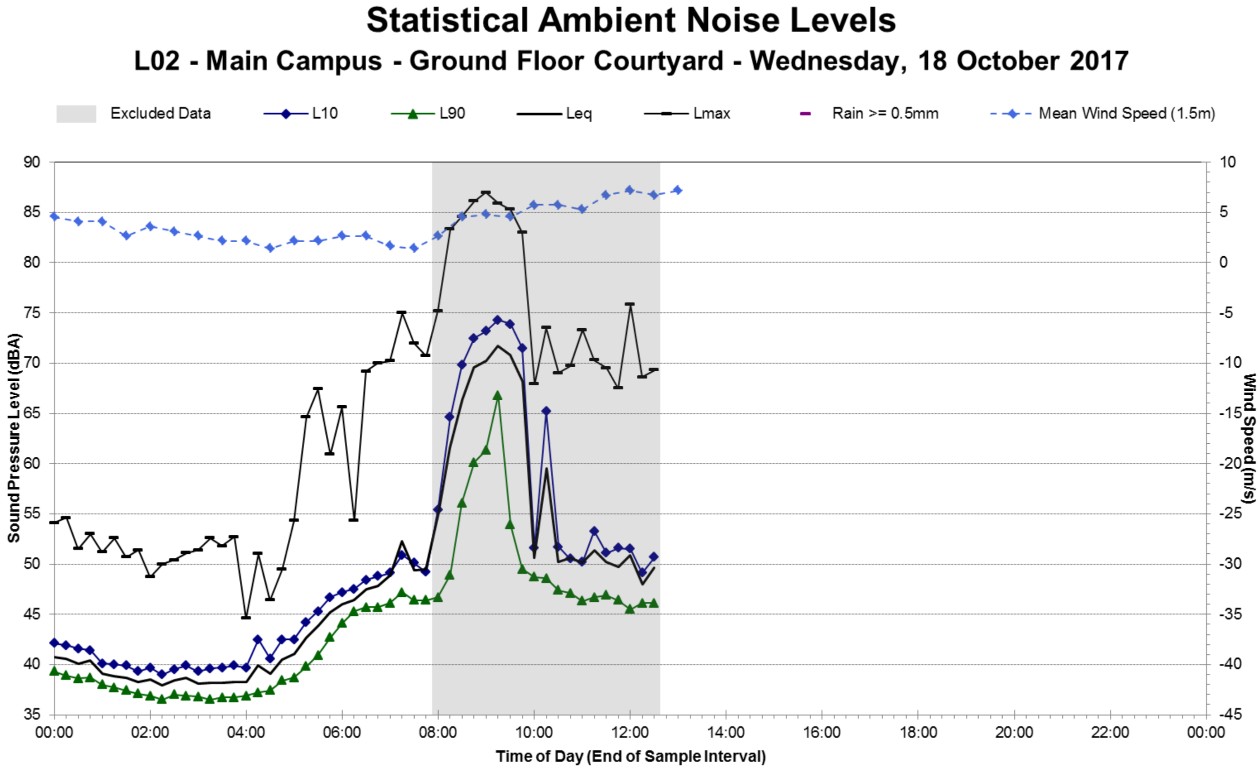
L02 - Main Campus - Ground Floor Courtyard - Monday, 16 October 2017



Statistical Ambient Noise Levels

L02 - Main Campus - Ground Floor Courtyard - Tuesday, 17 October 2017




Statistical Ambient Noise Levels
L02 - Main Campus - Ground Floor Courtyard - Wednesday, 18 October 2017
Excluded Data
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L90
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Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
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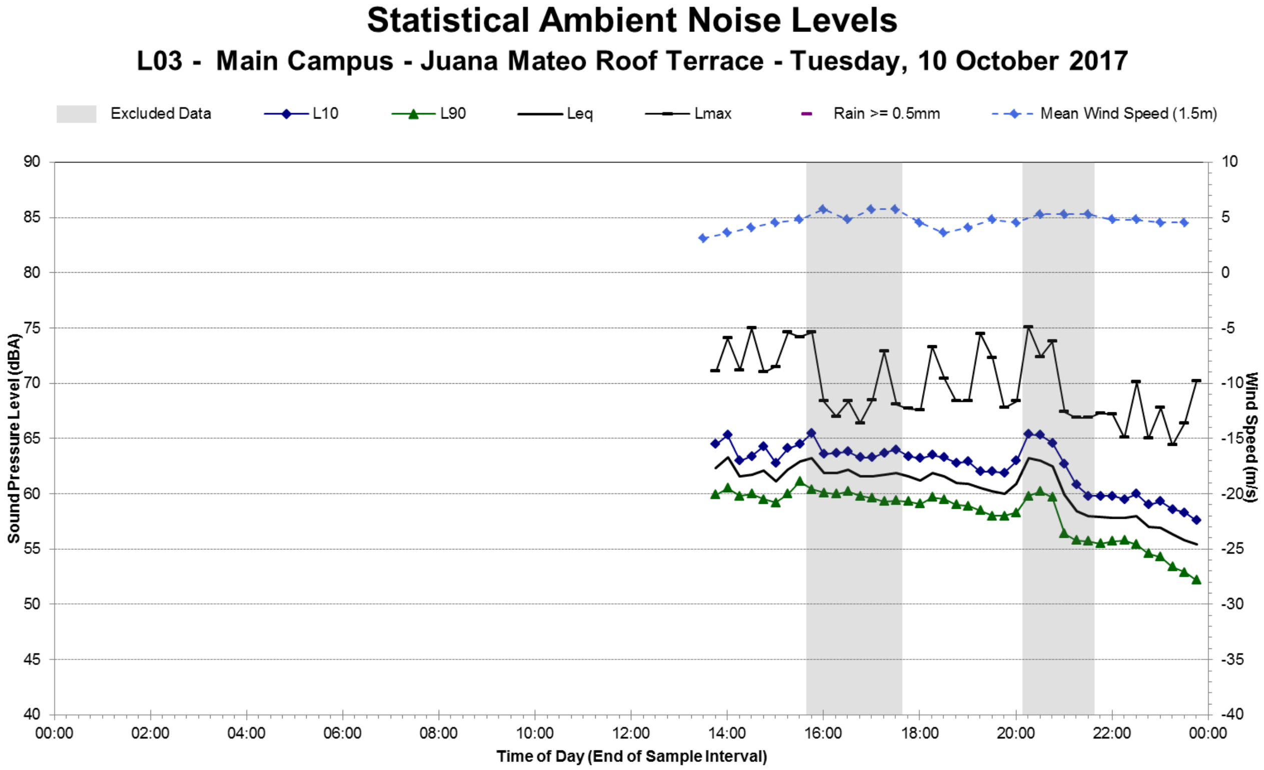
Ambient Noise Monitoring Results (L03)


Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Tuesday, 10 October 2017
Excluded Data
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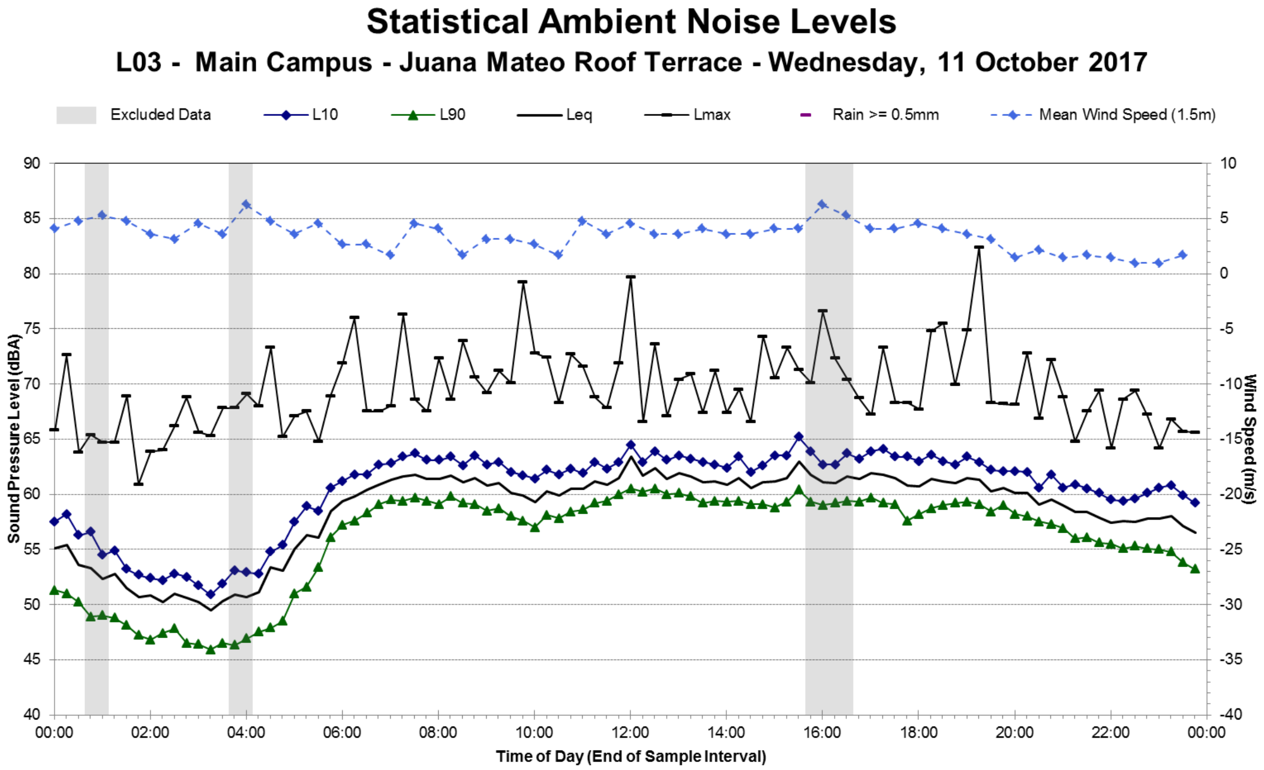
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Wednesday, 11 October 2017
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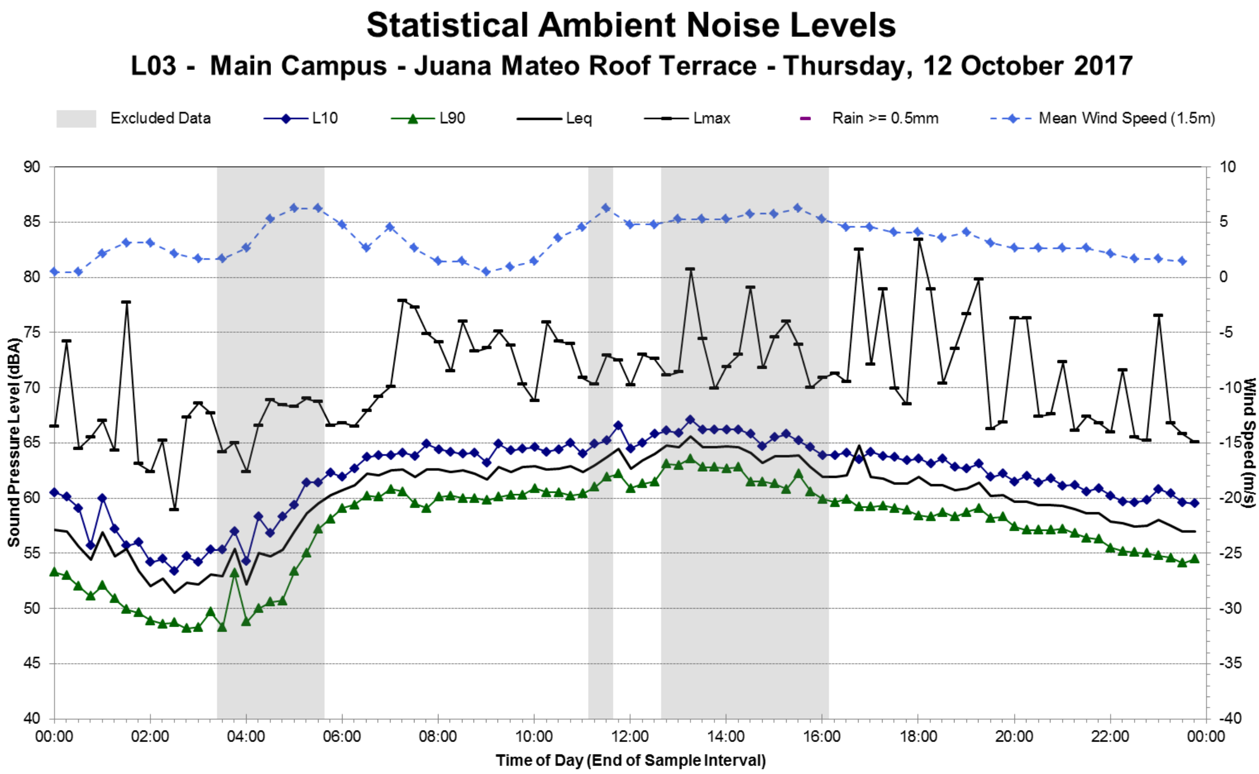
Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Thursday, 12 October 2017
Excluded Data
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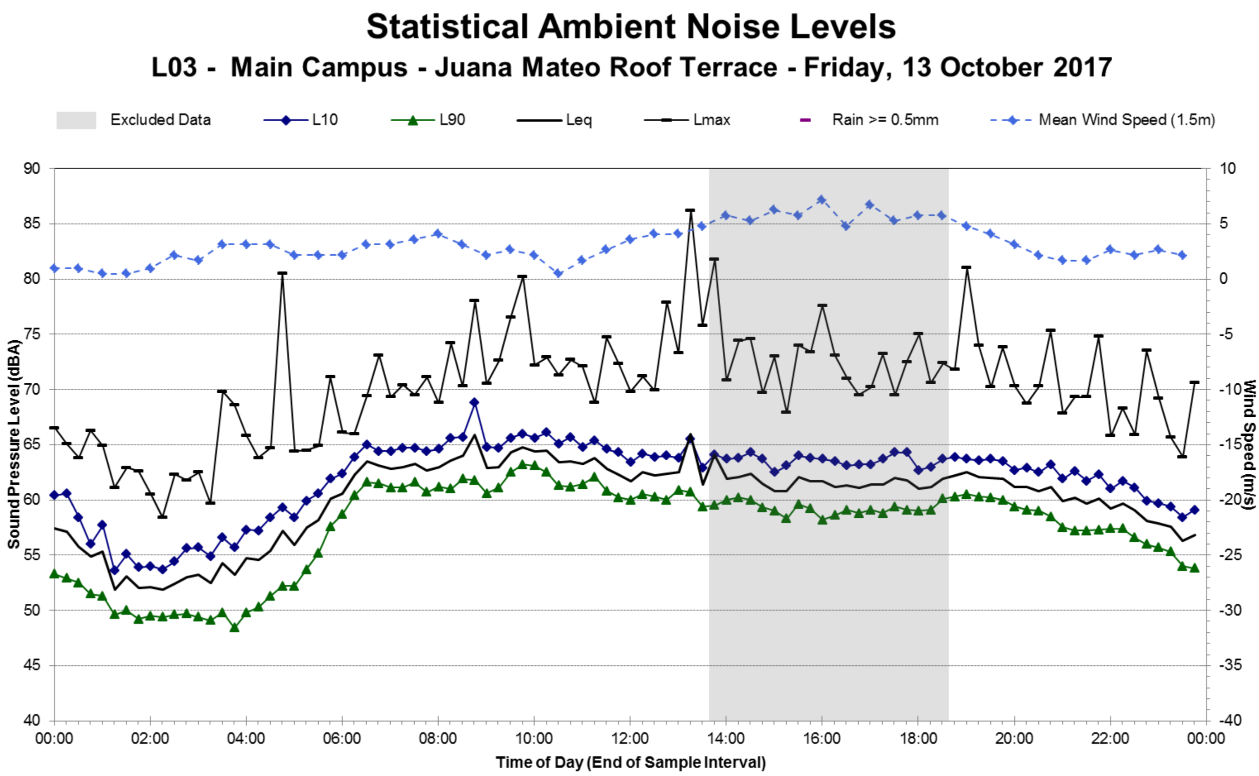
Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Friday, 13 October 2017
Excluded Data
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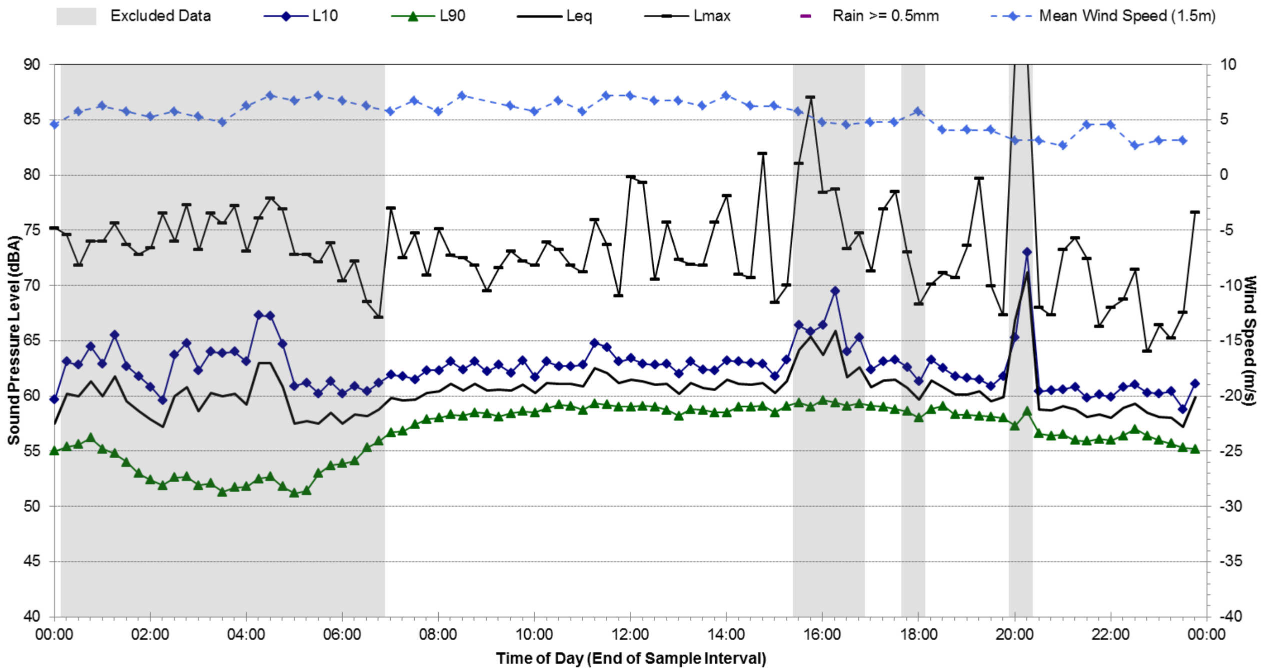
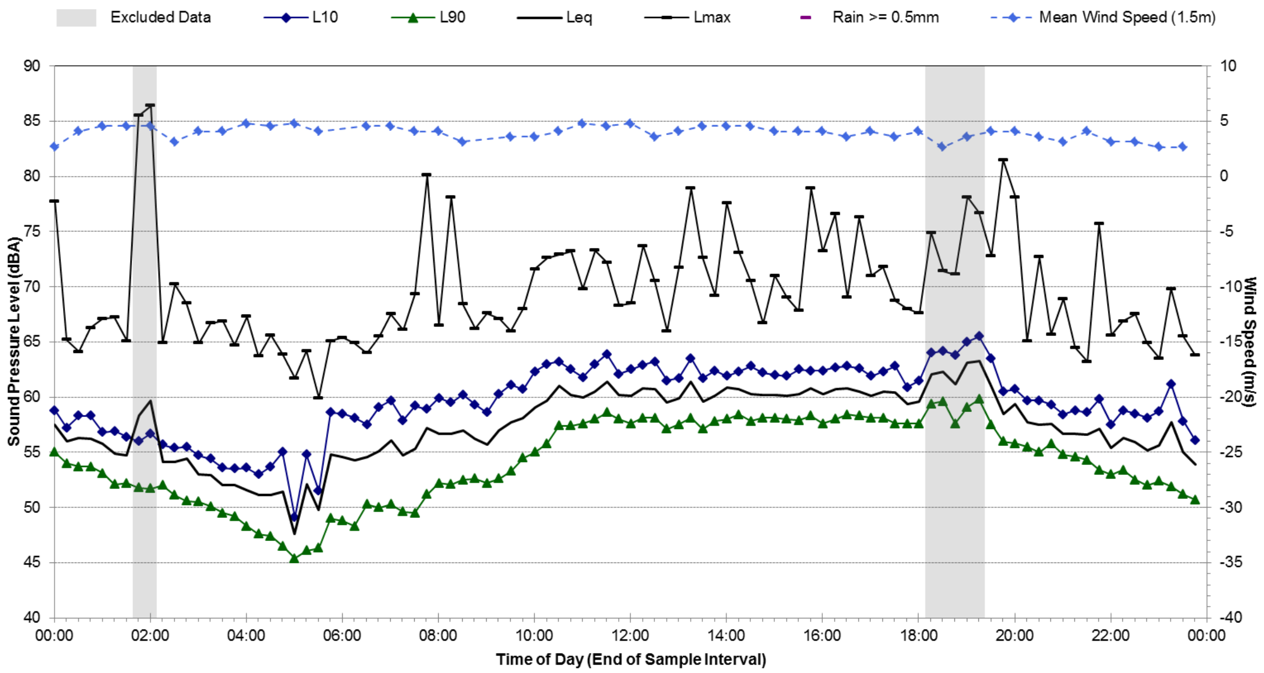
Statistical Ambient Noise Levels

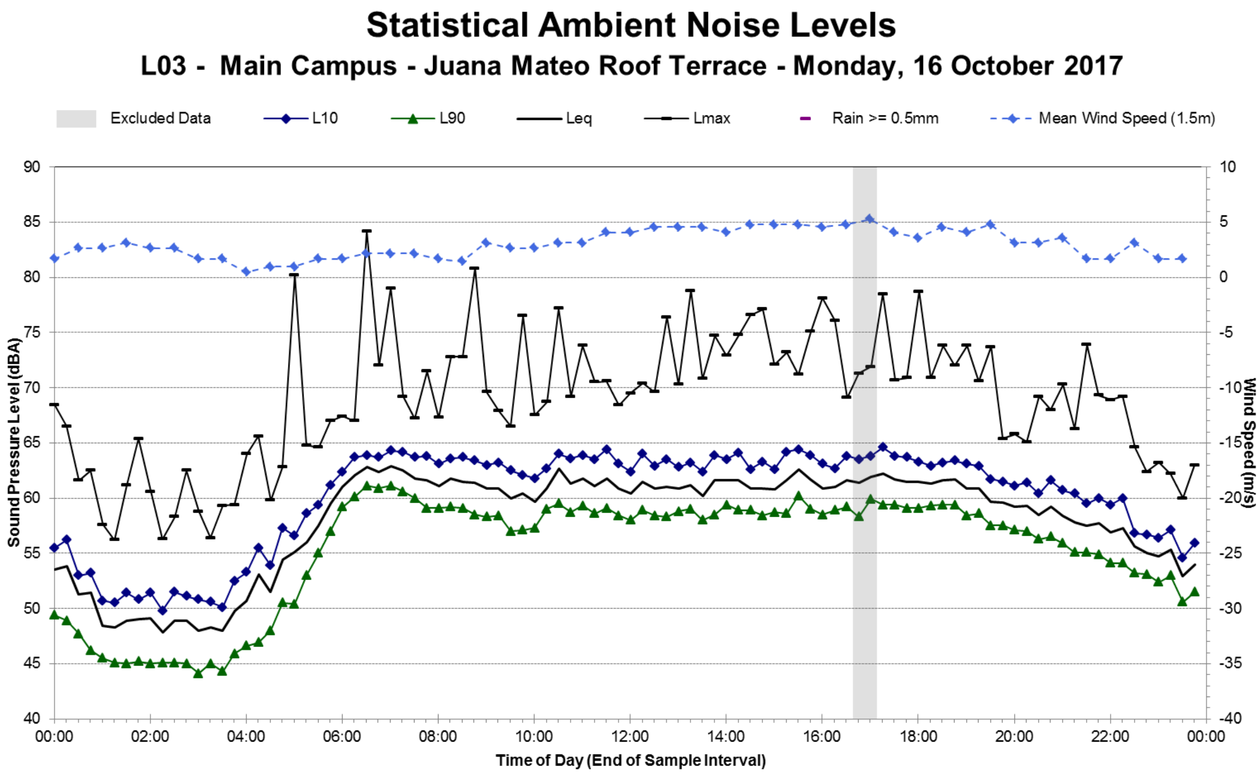
L03 - Main Campus - Juana Mateo Roof Terrace - Saturday, 14 October 2017



Statistical Ambient Noise Levels

L03 - Main Campus - Juana Mateo Roof Terrace - Sunday, 15 October 2017




Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Monday, 16 October 2017
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Rain >= 0.5mm
Mean Wind Speed (1.5m)
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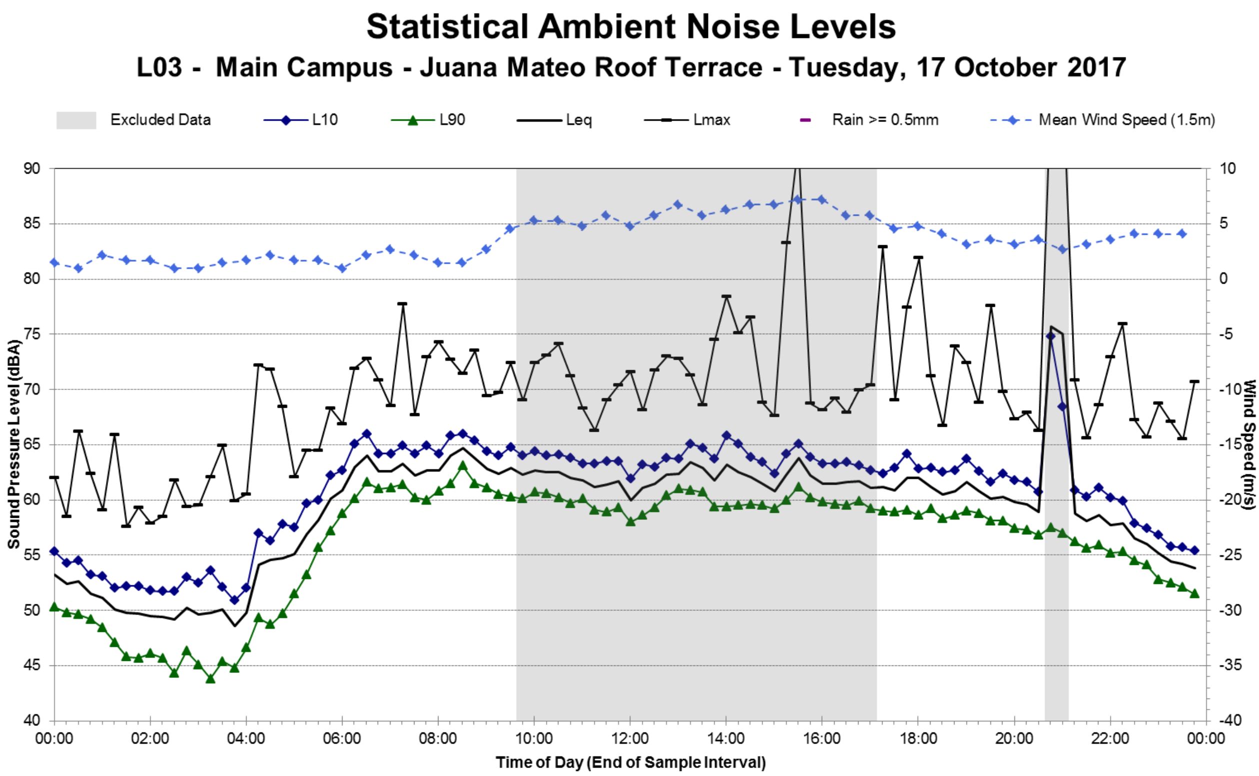
Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Tuesday, 17 October 2017
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Mean Wind Speed (1.5m)
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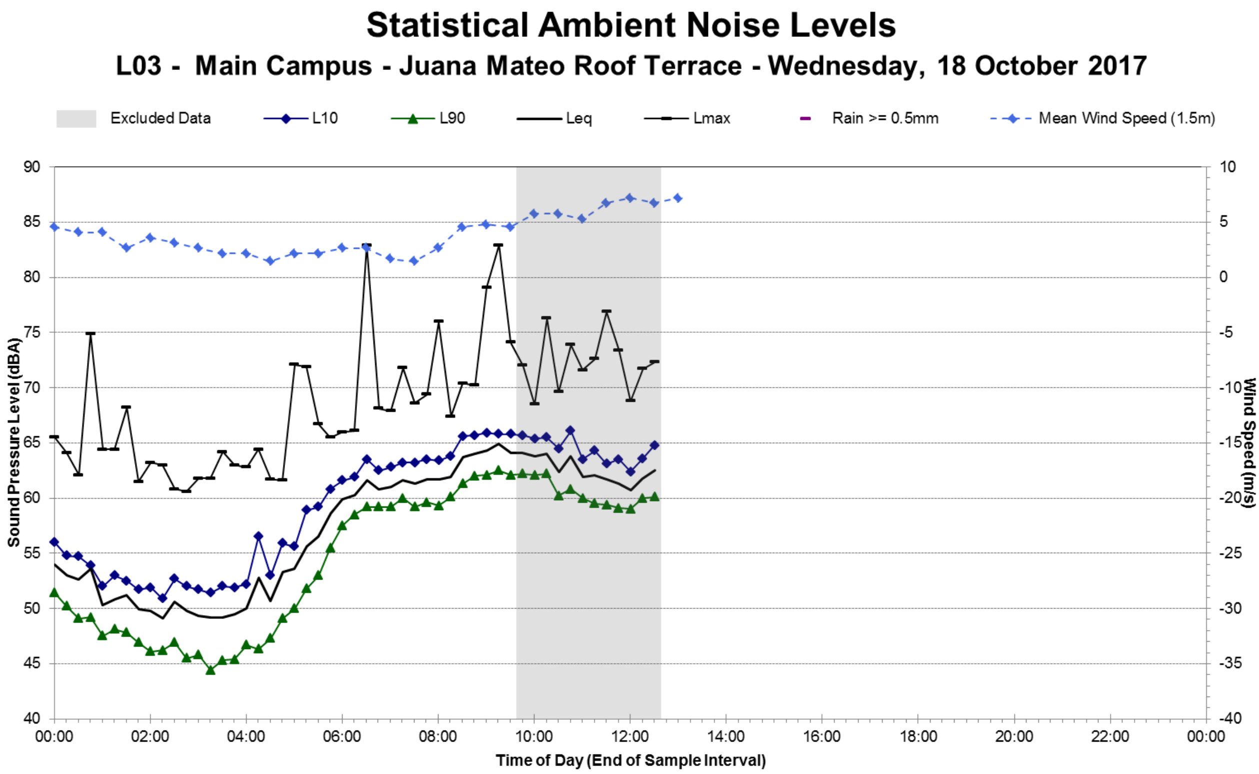
Statistical Ambient Noise Levels
L03 - Main Campus - Juana Mateo Roof Terrace - Wednesday, 18 October 2017
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Wind Speed (m/s)
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