Laing O'Rourke

100 Mount Street

Environmental Noise Impact Report

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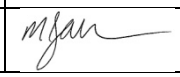
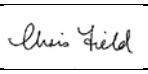
		Signature			
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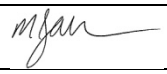
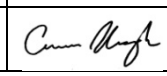
		Signature			
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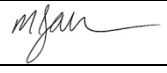
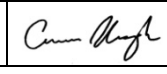
		Signature			
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Contents

Executive Summary

Acoustic considerations associated with the retail and commercial development of 100 Mount St in North Sydney are expected to be primarily associated with short-term construction noise, long-term operational noise from mechanical and electrical plant located at the development, and road traffic noise impacts.

Construction noise impacts from the development will be controlled by managing the construction process to minimise noise generation. Guidance from relevant Australian and international standards and from OEH guidelines will be followed in managing the acoustic impact of the construction activities on surrounding receivers.

The impact of the operation of the development on surrounding receivers will need to be controlled by incorporating noise-control measures into the selection, location and design of the mechanical and electrical services systems.

The development is immediately surrounded by commercial developments, which are less sensitive to noise than residential receivers; however, there are some residential developments (both existing and proposed) within the vicinity of the development. Therefore it is important to control the noise emission from the development to avoid adverse impacts on the acoustic amenity of the surrounding area. This can be achieved through appropriate plant selections and by providing acoustic treatment on associated construction noise sources.

The impact of the surrounding environment on the development can be controlled through design of the façade glazing and building envelope construction. Appropriate design vibration isolation and acoustic mitigation measures will ensure noise impacts internal to the development are also appropriately ameliorated.

The acoustic considerations of this project are in line with other commercial redevelopments within central business districts. With monitoring put in place and careful management practices employed, this application is recommended for approval from an acoustic perspective.

1 Introduction

Arup has been commissioned by Laing O'Rourke (LOR) to conduct a noise impact assessment of the proposed redevelopment of 100 Mount Street, North Sydney. The assessment is to form part of the S75W application for the project.

The development site is located within the North Sydney Business District and is currently occupied by two interconnected pre-existing commercial buildings that are bound by Spring, Walker and Mount Streets and is directly adjoining a commercial and retail property located at 84 Mount Street.

The proposal seeks to redevelop the site by demolishing the pre existing structures and constructing in their place a new 38 Storey mixed retail/commercial tower with an additional 5 below-grade basement levels.

The commercial tower is being targeted to achieve a rating of five stars in accordance with the National Australian Building Environment Rating System (NABERS Energy) and five Green Stars from the Green Building Council of Australia (GBCA).

This acoustic report is based on input information as provided by LOR and has been prepared in accordance with Director General Requirements for the project dated April 2009 as provided by Urbis Planning.

This document identifies key acoustic considerations for the 100 Mount Street development and establishes relevant acoustic criteria. The acoustic design targets have been derived from relevant Australian Standards, Council guidelines and Office of Environment and Heritage (OEH) guidance.

A glossary of the acoustic terminology used in this document is presented in Appendix A.

1.1 Site description

The area surrounding the site is primarily office or retail commercial; however, there are some residential properties in the vicinity of the development.

The nearest commercial properties to the development are located at:

- 84 Mount Street (high rise commercial), immediately adjacent to the development to the west
- 104 – 107 Walker Street (15 storey high-rise office building/commercial), across Walker Street directly to the east
- 99-101 Mount Street (shopping mall and commercial office tower), across Mount Street to the south
- 83 Mount Street (shopping mall and commercial tower), across Mount Street to the south-west
- 86 Walker Street (low level marketplace and 15 storey commercial), across Spring Street to the north
- 77-81 Denison St (commercial/retail and 'Firehouse Hotel' Bar), across Spring Street to the north

- 141 Walker Street (25 storey commercial/retail) across Walker Street to the north east
- 99 Walker Street (25 storey commercial/retail) across Walker Street to the south east

The nearest potentially affected residential receivers are located approximately 120 m to the north of the development at:

- 77 Berry Street, North Sydney (Berry Square Shopping Complex with 35 storey residential above).

All high-level receivers are expected to be exposed to some noise from the rooftop plant space. Adjacent low-level receivers are expected to generally be shielded from rooftop plant noise associated with the development.

In addition to the existing residential tower at 77 Berry Street, two residential developments are proposed to be located approximately 30 m to the north of the development at:

- 86 Walker Street (boutique hotel)
- 77-81 Dennison St (high rise residential apartments)

These receiver locations are provided for information only and will not be discussed further in this report. The cumulative impact from and to future developments will need to be considered during their design.

2 Existing ambient noise levels

A noise survey was conducted at the development site from Monday 11 July 2011 to Wednesday 20 July 2011. Two ARL Ngara environmental noise loggers (serial numbers 87807F and 878080) were set up on the 7th floor rooftop of the existing building at the west of the development site and the 3rd floor balcony of the existing building at the east of the development site, overlooking Walker Street. These positions were chosen taking into account security and access considerations whilst obtaining typical representative ambient noise levels of the area.

Noise logger measurement locations are shown in Figure 1.

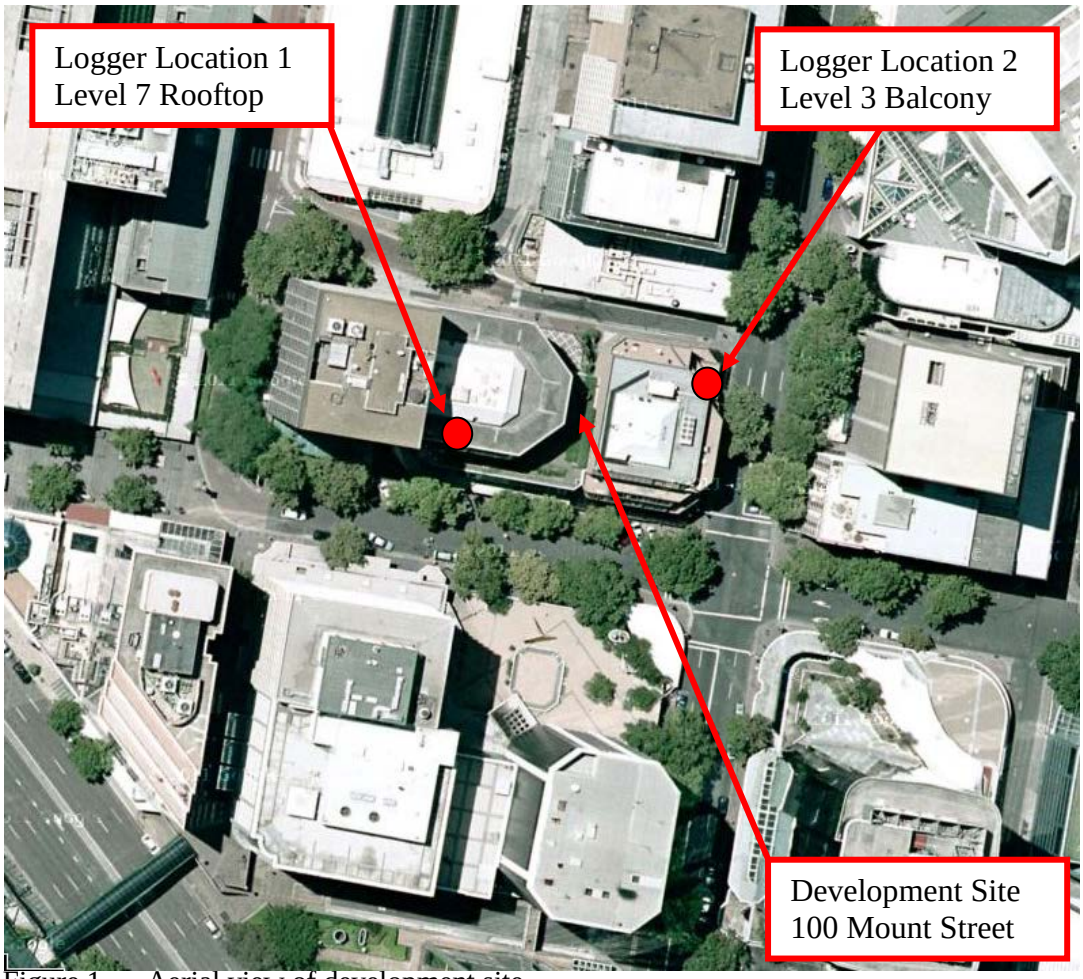

Figure 1 Aerial view of development site

The loggers were set to record continuously with a fast time constant at 15 minute intervals for 9 days in total. Weather patterns were noted during this period and where noise levels were affected the data was not used. Calibration of the loggers was checked prior to and following measurements using a Brüel & Kjær Electronic Calibrator Type 4231 with no significant drift in calibration being recorded.

Table 1 presents a summary of measured noise indices across defined time periods. 24 hour graphs of the entire monitoring period at each noise logger location are also provided in Appendix B for reference.

Table 1 Unattended Measured Ambient Noise Levels

Logger Location	**Time Period**	**Rating Background Level (RBL) – dBA**	**L_{Aeq} (period) - dBA**
Location 1 – Level 7 Rooftop	Day	59	62
	Evening	58	60
	Night	60	59
Location 2 – Level 3 Balcony	Day	63	67
	Evening	62	65
	Night	61	63

It can be seen from the noise levels presented that the ambient noise environment of the area remains fairly consistent and is quite high. This is characteristic of an urban environment such as the North Sydney CBD.

With respect to the noise rooftop noise logger, it can be seen from a review of the daily graphs that measured noise levels were potentially influenced at times by local mechanical plant noise. This is discussed further in Section 4.3.3.3

3 Acoustic considerations

3.1 General acoustic considerations

Noise impacts from a development such as the 100 Mount Street development are generally a mixture of short term construction noise impacts and long-term operational noise impacts. Long-term noise and vibration impacts must be minimised to ensure that the development does not cause an adverse impact on the acoustic amenity of the locale.

Short-term construction noise and vibration impacts are generally higher than long term impacts due to the nature of construction activities, and must be carefully controlled; however, the relatively short duration of construction noise and vibration impacts on offices and residences must be considered against the long-term benefits of the development to the surrounding area.

3.2 Noise and vibration impacts of the development on the environment

Noise impacts on the community from the development after construction is completed are not expected to be significant, however, sources will include:

- Plant and services equipment associated with the development
- Traffic movements to and from parking areas in the development

Noise and vibration impacts from mechanical and electrical plant are discussed further in Section 5.1. The impact of additional traffic created by the development is discussed further in Section 4.3.4.

3.3 External noise and vibration affecting the development

Environmental noise and vibration sources which may affect the development after construction are:

- Plant and services noise from adjacent properties.
- Deliveries to the development and waste collection.
- Traffic noise from Walker Street through the façade.

These issues can be easily resolved with adequate façade glazing and building envelope construction. Traffic vibration is unlikely to be an issue since road traffic generally produces low vibration levels. Ground-borne noise impacts may also occur at levels of vibration which are imperceptible – i.e. the vibration may not be able to be felt by occupants, but the noise generated by the vibration may be audible as a "rumble" within the development.

Vibration levels caused by activities on the site (including plant) should not exceed the levels specified in the OEH Assessing Vibration guideline at any place of different occupancy at and around the site. The Assessing Vibration guideline provides operational vibration criteria for maintaining human comfort within different space uses.

For intermittent sources (e.g. heavy vehicles, intermittent construction), the Assessing Vibration guideline uses the Vibration Dose Value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event.

Intermittent events that occur less than 3 times in an assessment period (either day, 7am to 10pm, or night, 10pm to 7am) are counted as "impulsive" sources for the purposes of the Assessing Vibration guideline.

The vibration limits recommended for maintaining human comfort in residences and offices are shown in Table 1 below.

Location	**Maximum z-axis weighted rms vibration acceleration (m/s^2)**		**Vibration Dose Value ($m/s^{1.75}$)**
	Continuous	Impulsive	Intermittent
Office and retail areas	0.020	0.64	0.40

Table 1: Vibration limits in AS 2670.2 for offices and retail areas

3.4 Internal noise and vibration impacts on the development

Occupants of the proposed development may be affected by noise and vibration generated within the development itself. Potential noise impacts are expected to be from:

- Noise from plant and services equipment associated within the development transmitted via the structure and through the ventilation system.
- Structure-borne noise from lifts.
- Vertical inter-floor noise transfer via the curtain wall.
- Deliveries and collections, along with vehicle movements to and from parking areas.
- Vibration and ground-borne noise from the basement car parking spaces.

3.5 Construction noise and vibration impacts on the surroundings

Construction noise will occur during the process of demolition and construction. For this development, demolition noise will be monitored and work practices will be adopted to ensure that it is maintained at acceptable levels. Vibration impacts due to demolition typically occur when adjoining buildings are affected by demolition practices. This demolition will be staged in such a manner to ensure the work site remains stable thereby minimising any impact occurrence.

Excavation can also cause vibration impacts to adjoining properties. It is advised to undertake excavation adjacent to the boundary using techniques such as rotary saw cutting. This will reduce the generated noise and vibration from these activities.

Another potential source of noise and vibration is the access of construction traffic. In this instance the impact of traffic is expected to be minimal due to the high levels of existing traffic already present in the area.

4 Design criteria

4.1 Internal design levels

Design levels for steady-state internal noise levels within the building are given in Australian Standard AS2107:2000 Acoustics – Recommended design sound levels and reverberation times for building interiors.

These recommended noise levels apply to all steady-state noise sources within the development. Given the location of the development in the North Sydney CBD on Walker Street (which has continuous heavy traffic flows throughout business hours), traffic noise at the development is expected to be approximately steady.

Accordingly, the internal noise levels from the following sources should be controlled to meet the AS2107 noise levels:

- Noise from the ventilation system (expected to be present in all areas of the development)
- Break-in noise from mechanical plant within the development.
- Traffic noise break-in through the façade (expected to be most significant in perimeter areas on the Walker Street façade)
- Noise from rooftop mechanical plant, along with that from surrounding buildings breaking-in through the façade

AS2107 gives both 'satisfactory' and 'maximum' noise levels for different areas within building interiors. Generally, Arup recommends designing to the "maximum" noise levels to provide some noise masking for commercial developments. However, because one or two points of the Green Star IEQ-12 (Internal Noise Levels) may be targeted, the development will likely be required not to exceed the 'satisfactory' noise levels. The criteria of targeted Green Star acoustic points will need to be designed for during the detailed design stage, after it has been confirmed which points are being targeted.

4.1.1 Green Star IEQ-12

In order to achieve Green Star (Office Design v3) compliance for the Interior Environment Quality category, up to two points are awarded where 95% of the project's net lettable area (NLA) does not exceed the 'satisfactory' ambient internal noise levels in accordance with AS/NZS 2107:2000, as follows:

- Building Services Design: One point is awarded where, within the entire base building general office space, noise from the building services does not exceed 40 dBL_{Aeq}
- Overall Building: One point is awarded where within the base building office space, the sound level does not exceed 40 dBL_{Aeq} (assuming open plan offices)

4.2 Room acoustics

AS2107 also provides recommended mid-frequency reverberation times for various areas of buildings. It is recommended that the room acoustics be designed to meet these targets during the detailed design of the 100 Mount Street development.

4.3 Environmental noise

4.3.1 Director General Requirements

The Director General Requirements (DGR) issued in April 2009 state the following with respect to noise impacts:

> *Demonstrate that the proposal will be designed, constructed, operated and maintained so that there is no unacceptable level of noise impacts (including traffic noise) on amenity in the locality.*

In light of the lack of numerical objectives provided, the following sections discuss local and state legislative environmental noise criteria.

4.3.2 North Sydney Council DCP

North Sydney Council Development Control Plan (DCP) 2002 contains guidance on noise emission criteria for commercial developments. The following is an excerpt from the relevant section of the DCP:

Noise production [should] not exceed the following repeatable maximum $L_{Aeq(1hour)}$ level, on weekdays:

Day 7am-6pm: 55dB(A)
Evening 6pm- 10pm: 45dB(A)
Night 10pm-7am: 40dB(A)

and on weekends:

Day 8am-7pm: 50dB(A)
Evening 7pm-10pm: 45dB(A)
Night 10pm-8am: 40dB(A)

or in any case not more than 5 dB(A) above the background level during the day and evening and not exceeding the background level at night when measured at the boundary of the property.

i. Incorporate noise reduction measures on plant and machinery.

ii. Use design features or planning that will reduce noise.

*iii. Incorporate adequate measures for tonal, low frequency, impulsive, or intermittent noise.**

iv. Comply with EPA Industrial Noise Policy 2000 in particular the modification required for acceptable noise level (ANL).

4.3.3 Industrial Noise Policy

The OEH Industrial Noise Policy (INP), released by the EPA in January 2000, is the NSW state guidance for deriving industrial noise criteria. These criteria comprise two components:

- Controlling *intrusive* noise impacts for noise sensitive receivers in the short term; and
- Preserving noise level *amenity* for particular land use areas.

4.3.3.1 Assessing intrusiveness

The intrusiveness criterion of the INP generally states that the equivalent continuous noise level (L_{Aeq}) of industrial sources associated with the development (i.e. mechanical plant) should not be more than 5 dBA above the measured Rated Background Level (RBL) over any 15 minute period.

This is approximately equivalent to the same requirement already discussed under the North Sydney DCP.

4.3.3.2 Assessing amenity

The amenity criterion aims to preserve appropriate levels of industrial noise within defined areas (e.g. urban, suburban, rural, etc). In order to determine the appropriate criteria, the existing L_{Aeq} noise level from industry is measured. If existing industrial noise approaches predefined Acceptable Noise Levels (ANL) for specific area classifications, new industrial noise sources (e.g. mechanical plant) need to be designed in order to not produce noise levels that would cumulatively contribute to a significant exceedance of the recommended ambient industrial noise levels of an area.

For the purpose of this assessment, the area classification has been identified as being 'urban' as defined by the INP.

4.3.3.3 Project specific industrial noise emission criteria

Existing measured ambient noise levels measured at the Level 7 rooftop (i.e. logger location 1) have been processed in accordance with INP principles to derive project specific industrial noise emission criteria. Measured noise metrics as presented in Table 1 are provided again for reference. Resultant intrusive and amenity criteria are presented in Table 2.

Table 2 Project specific industrial noise emission criteria

Assessment period	**Noise Level re 20 µPa (dBA)**				
	ANL (period)	**Measured RBL $L_{A90(15minute)}$**	**Measured $L_{Aeq\ (15minute)}$**	**INP Criteria**	
				Intrusive	**Amenity**
				$L_{Aeq(15minute)}$	**$L_{Aeq(period)}$**
Day	60	59	62	64	52
Evening	50	58	60	63	50
Night	45	60	59	65	49

It should be noted that, due to local influence of mechanical plant, measured ambient noise levels a potentially higher than expected. This equates to a more stringent amenity criterion than may otherwise be prescribed.

Nonetheless, Council criteria presented in Section 4.3.2 are even more stringent than derived INP amenity criteria. As such, North Sydney Council criteria will be adopted as the project specific objective. Further, given the likely operation of the development, the evening time criterion of **45 dBA** will be adopted as the overriding noise objective for this assessment.

4.3.4 Road Noise Policy

In July 2011, the OEH introduced the new Road Noise Policy (RNP) to supersede its predecessor; the Environmental Criteria for Road Traffic Noise (ECRTN). For the purpose of this assessment, both documents recommend the same absolute noise criteria for new developments with the potential to create additional traffic on local roads. These criteria are summarised in Table 3.

Table 3 Road traffic noise criteria

Type of development	**Noise Level re 20 µPa (dBA)**	
	Day (7am-10pm)	**Night (10pm-7am)**
Land use developments with potential to create additional traffic on local roads	$L_{Aeq(1hour)}$ 55	$L_{Aeq(1hour)}$ 50

In addition to the overall noise objectives listed, both policies also stipulate a maximum relative increase in road traffic noise levels. The ECRTN provides the most stringent criterion in this respect. The following is an excerpt from the relevant section of the policy:

In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.

An overall increase in road traffic flows by a factor of approximately 1.6 is required in order to correspond to an increase in road traffic noise by 2 dB. Given the urban setting and the significant existing traffic flows on road networks in the area, the additional traffic noise impacts due to the traffic flows associated with the 100 Mount Street development are expected to be negligible and will not be discussed further in this report.

4.3.5 Construction noise

A construction noise impact assessment for the development will need to be conducted prior to commencement of construction. In the absence of a direction from Council, it is recommended that assessment be made with guidance from the following documentation:

- The OEH Interim Construction Noise Guideline (2009)
- Australian Standard AS 2436 (2010)
- British Standard BS 5228.1 (2009)

4.3.5.1 Extended construction hours

The Interim Construction Noise Guideline (ICNG) provides recommended standard hours for construction in NSW. Table 4 is an excerpt from Section 2.2 of the Guideline relevant to construction hours.

Table 4 ICNG recommended standard hours for construction work

Work type	Recommended standard hours of work*
Normal construction	Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays
Blasting	Monday to Friday 9 am to 5 pm Saturday 9 am to 1 pm No work on Sundays or public holidays

*The relevant authority (consent, determining or regulatory) may impose more or less stringent construction hours.

In order to achieve a more efficient and shorter construction timeframe, it is proposed to extend daily construction hours slightly. The adjusted construction hours will constitute minor impact works and will be restricted to within the hours of 7.00 am to 7,00 pm Monday to Friday and on Satruday within the hours of 7.00 am to 5.00 pm inclusive, with no work on Sundays and Public Holidays. Loading hours are to include 7.00 pm to 11.00 pm Monday to Friday inclusive.

Residential receivers

Table 5 provides ICNG noise criteria for residential receivers for works proposed outside OEH recommended standard hours for construction.

Table 5 ICNG noise criteria for construction works outside standard hours

Time of day	Management level $L_{Aeq(15min)}$	How to apply
Outside recommended standard hours	Noise affected level: RBL +5dB	• A strong justification would typically be required for works outside the recommended standard hours • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

The lowest measured RBL = 58 dBA during evening period (refer Table 1). Therefore, the noise affected level for construction activities conducted outside recommended standard hours will be 58 + 5 = **63 dB(A)**.

Commercial receivers

Section 4.1.3 of the ICNG also provides absolute noise objectives at commercial and industrial receiver locations. The following is an excerpt relevant to commercial receivers:

- Offices, retail outlets: external $L_{Aeq(15min)}$ **70 B(A)**

A preliminary assessment of likely acoustic impacts associated with proposed extended construction hours is discussed further in Section 5.2.1 of this report.

5 Environmental noise and vibration impact assessment

5.1 Mechanical and electrical plant

As discussed, mechanical and electrical plant is to be distributed across Levels 1, 2, 5 and 33 of the development with the main bulk of acoustically significant plant being located on the rooftop (i.e. Level 33). Figure 2 provides an indicative distribution of mechanical, electrical and hydraulic services proposed for the development.

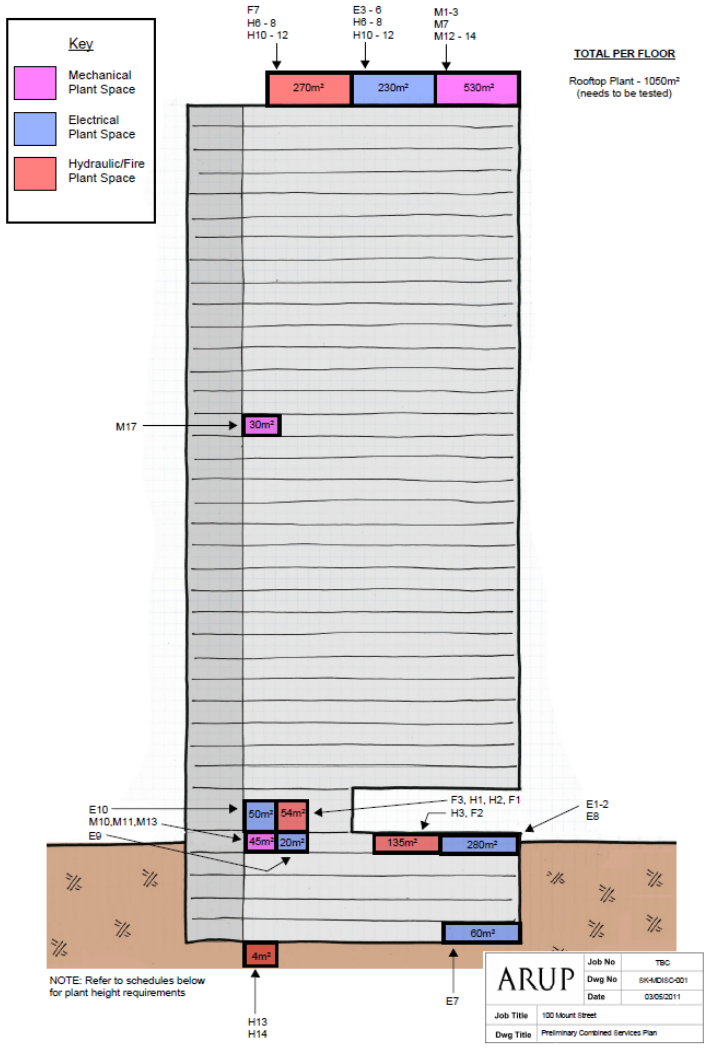

Figure 2 Indicative distribution of mechanical electrical and hydraulic

5.1.1 Level 33 Plant

The main bulk of acoustically significant plant will be located on Level 33 of the development. Noise-generating plant to be located on Level 33 currently includes:

- Water cooled chillers (including associated pumps)
- Boilers (including associated pumps)
- Generator sets
- Exhaust fans

The current design is such that all plant items are enclosed within plant rooms with the exception of the cooling towers aligning the northern facade. Given the proposed height of the building, there are currently no receivers in the immediate vicinity that overlook the rooftop plant. It is understood that roof mounted fans are to be avoided as far as possible in order to preserve the aesthetic of the rooftop.

Figure 3 presents the proposed layout of rooftop plant at the current stage of design.

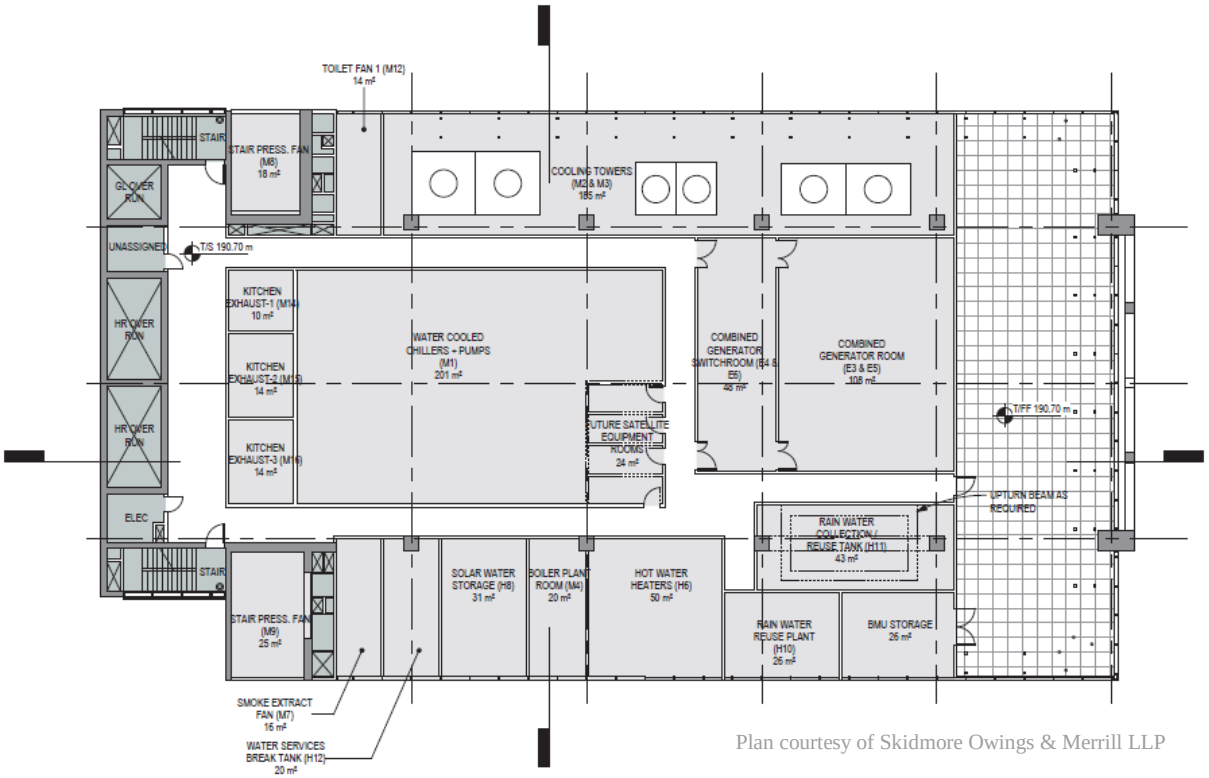

Figure 3 Indicative plant layout – Level 33

At this stage of the design, precise details as to specific mechanical plant schedules and building construction are not available. As such, various assumptions have been made based on the current understanding of the development.

Table 6 provides a schedule of acoustically significant items of plant with assumed operational parameters and corresponding empirically derived sound power levels.

Table 6 Current schedule of mechanical plant items

Item of plant	Type	Power rating (kW)	Sound power level (dBA)	Quantity
Water cooled chiller	Centrifugal	1700	105	2
	Rotary screw	600	98	1
Cooling tower	Induced draft	1250	108	4
Boiler	General purpose	1250	98	2
Diesel generator set	1500rpm	1800	118	2
Chiller/boiler pumps	1440rpm	7.5	89	5

Given that the design currently allows for chillers and boilers to be completely enclosed within plant rooms, it is envisaged that these items of plant will be able to be adequately attenuated via standard engineering solutions (e.g. acoustic louvres, enclosures, etc). This should be addressed during the detailed design stage when specific information becomes available. Attention will also need to be paid to noise and vibration isolation to tenancies within the development below.

Predictions have been made of the likely acoustic impact from cooling towers and diesel generators on the nearest potentially affected receivers. When identifying the nearest potentially affected receivers, it is important to consider both geographical location and relative building elevation. This has been taken into account when conducting calculations to the nearest potentially affected receivers.

Predictions to the nearest identified receivers are presented for the cooling towers and diesel generator sets in the following sections.

5.1.1.1 Cooling Towers

Predicted noise levels from cooling tower plant calculated to the nearest identified potentially affected receivers are presented in Table 7.

Table 7 Predicted noise levels from cooling towers at nearby receivers

Address	Receiver Type	Time Period	Predicted Noise Level L_{Aeq} dB(A)	Criterion	Complies with Criterion?
86 Walker Street	Commercial	Evening	38	45	Complies
141Walker Street	Commercial	Evening	37	45	Complies
77 Berry Street	Residential	Evening	42	45	Complies

The above calculated noise levels are based on the assumption that there will be a solid 5.5 m high barrier aligning the northern edge of the building. In the absence of such a barrier, resultant noise levels are predicted to be in the order of up to 10 dB in excess of the mechanical noise emission objective of 45 dBA.

5.1.1.2 Generator Sets

In practice, testing of the generators will not occur outside the daytime period. It is recommended that this be implemented as part of the operational management. Further, any louvred openings in the generator set plant room will need to be acoustically treated in order to ensure cumulative impacts from mechanical plant during the daytime adhere to Council's noise objectives.

There is a potential that the roof to the generator set plant room will be left off as part of the design. Whilst this would potentially benefit low rise receivers, acoustic impact upon high-rise receivers further afield is worsened. Calculations of noise propagation to residential receivers at 77 Berry Street in the instance of having an open roof genset enclosure result in levels in the order of 56 dBA.

5.1.2 Basement Level 1

There is the potential for a substation to be located aligning the northern facade of Basement Level 1. Details of this substation are not available at this stage of the design, however this will need to be assessed during detailed design in order to ensure adequate noise and vibration isolation measures are implemented to preserve the amenity of receivers both within and external to the development.

5.2 Construction noise

5.2.1 Extension of construction hours

The ICNG states that recommended standard hours for construction work are not mandatory; however, justification for the works must be provided to the relevant authority. As such, a preliminary investigation into the potential acoustic impacts associated with such works is warranted.

The intent is for works conducted during extended hours to comprise only "non noisy or non disruptive" activities. Based on the current understanding of the project, such works will include the following:

- Loading/Unloading activities
- Rubbish removal
- Concrete finishing works
- Installing facade
- All internal works once cladding is installed
- Other similar impact works

Table 8 itemises plant identified as being associated with the proposed construction activities listed. Corresponding sound power levels and spectra used in assessment calculations are also presented as derived using published construction equipment noise levels from the AS 2436[1], BS 5228.1[2] and the

[1] Australian Standard AS2436 (2010) *Guide to noise and vibration control on construction, demolition and maintenance sites*

[2] British Standard BS5228.1 (2009) *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise*

DEFRA[3] construction noise database as well as empirical noise data. Penalties for annoying characteristics such as impulsiveness and tonality have been applied during the assessment process as required by the ICNG.

Table 8 Construction plant and equipment noise levels

Item of Plant	Octave Band Centre Frequency (Hz)								Overall dBA
	63	125	250	500	1k	2k	4k	8k	
Wheeled loader	113	111	104	103	103	100	100	89	108
Wheeled mobile crane	108	104	99	91	92	91	84	78	98
Truck loading/unloading	89	84	85	82	82	80	72	63	86
Forklift	93	91	89	86	84	82	79	78	90
Power float	90	94	91	98	94	95	83	78	100
Electric percussion drill	56	65	70	93	95	96	99	92	103
Angle grinder	88	82	83	91	101	108	104	104	112
Petrol generator	108	105	102	101	100	99	97	93	106
Diesel generator	100	100	98	91	90	91	87	84	97

Based on the sound power spectra presented, construction noise levels for each activityhave been predicted at the nearest commercial and residential receivers across Walker Street and in Berry Street respectively.

Calculation results are summarised in Table 9 with comparison against respective criteria provided for reference. It should be noted that resultant levels do not take into account any potential shielding afforded by intervening building structures.

Table 9 Calculated construction noise levels

Activity	Receiver Location	Resultant Noise Level $L_{Aeq(15min)}$	Criterion	Exeedance
Loading/unloading	Residential (Berry Street)	57 dBA	63 dBA	-
	Commercial (Walker Street)	71 dBA	70 dBA	+ 1 dB
Rubbish removal	Residential (Berry Street)	41 dBA	63 dBA	-
	Commercial (Walker Street)	55 dBA	70 dBA	-
Concrete finishing	Residential (Berry Street)	52 dBA	63 dBA	-
	Commercial (Walker Street)	66 dBA	70 dBA	-
Installing facade	Residential (Berry Street)	50 dBA	63 dBA	-
	Commercial (Walker Street)	64 dBA	70 dBA	-
Internal works	Residential (Berry Street)	n/a	63 dBA	-
	Commercial (Walker Street)	39 dBA	70 dBA	-

[3] Department for Environment Food and Rural Affairs (United Kingdom) (2006), *Update of noise database for prediction of noise on construction and open sites*

It can be seen from the results presented in Table 9 that, with the exception of loading and unloading activities, proposed construction activities schedule to occur outside of standard hours is predicted to be below the noise affected level of RBL + 5dBA. Hence, no significant construction noise impacts on surrounding receivers are expected due to out-of-hours works.

With respect to the 1 dB exceedance at commercial receivers during loading and unloading, this is considered a marginal exceedance, and would not be subjectively noticeable (a change of noise level of 1 dB is subjectively not perceptible). Further, given the proposed hours, such activities are not likely to constitute a significant source of annoyance to commercial receivers.

Notwithstanding the above preliminary investigation into potential acoustic impacts associated with extended construction hours, a detailed construction noise and vibration management plan will need to be developed following a construction noise assessment once more precise construction activity information becomes available.

Appendix A

Acoustic Terminology

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Decibel (dB)

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million : one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound level' (L) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

Some typical noise levels are given below:

Noise Level dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside disco
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber
0	Threshold of hearing

'A'-Weighted Sound Level dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. An increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise. A change of 2 to 3 dB is subjectively barely perceptible.

Frequency

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kilohertz (kHz), eg 2 kHz = 2000 Hz. Human hearing ranges from approximately 20 Hz to 20 kHz. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background LA90 noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

Statistical Noise Levels

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index that allows for this variation. 'A'-weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, eg. dBL_{A10}, 5min or dBL_{A90}, 8hr.

$L_{A90, T}$

Refers to the sound pressure level measured in dB(A), exceeded for 90% of the time interval (T) –i.e. measured noise levels were greater than this value for 90% of the time interval. This is also often referred to the background noise level.

$L_{A10, T}$

Refers to the sound pressure level measured in dB(A), exceeded for 10% of the time interval (T). This is often referred to as the average maximum noise level and is frequently used to describe traffic noise.

$L_{A1, T}$

Refers to the sound pressure level measured in dB(A), exceeded for 1% of the time interval (T). This is often used to represent the maximum noise level from a period of measurement.

Equivalent Continuous Sound Level (L_{Aeq})

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

Reverberation Time (T_{60})

The time, in seconds, taken for a sound within a space to decay by 60 dB after the sound source has stopped is denoted at the reverberation time. The RT is an important indicator of the subjective acoustic within an auditorium. A large RT subjectively corresponds to an acoustically 'live' or 'boomy' space, while a small RT subjectively corresponds to an acoustically 'dead' or 'flat' space.

Examples of typical design reverberation times are provided below:

Mid-frequency Reverberation Time, s	Example
< 0.1	Anechoic
0.1 – 0.4	Call centres
0.4 – 0.6	Library
0.6 – 0.8	Offices / board rooms
0.8 – 1.0	Small auditorium for speech
1.0 – 1.2	Music studios
1.2 – 1.5	Chamber music venues
1.5 – 2.0	Orchestral music venues
2.0 – 3.0	Church
3.0 – 8.0	Cathedral

Vibration

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structureborne noise or human comfort issues respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value.

Vibration amplitude can be expressed as an engineering unit value e.g. 1mms-1 or as a ratio on a logarithmic scale in decibels:

Vibration velocity level, LV (dB) = 20 log (V/V_{ref}),

(where the preferred reference level, V_{ref}, for vibration velocity = 10-9 m/s).

The decibel approach has advantages for manipulation and comparison of data.

Peak Particle Velocity (PPV)

Peak Particle Velocity is the parameter most often used for the quantification of groundborne and structure-borne vibration. It is the maximum positive or negative magnitude of vibration in a defined direction caused by the passage of a wave front during a specified interval. Particle velocity is used in most cases because this parameter has been found to correlate best with the onset of structural damage. It can also be used to provide some guidance on disturbance to people and the sensitivity of equipment and processes to vibration.

Appendix B

Noise Survey

B1 Noise logging location 1 - Level 7 rooftop, 90 Mount Street

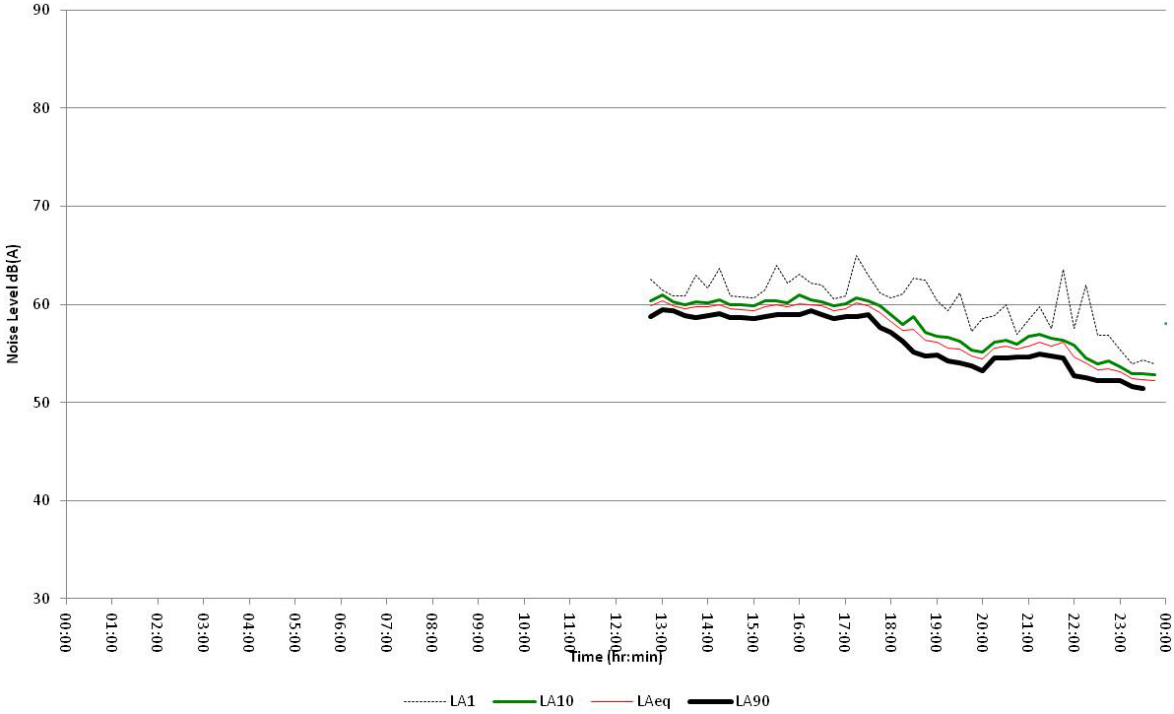

Figure 4 Measured noise levels – Logger location 1 – Monday 11 July, 2011

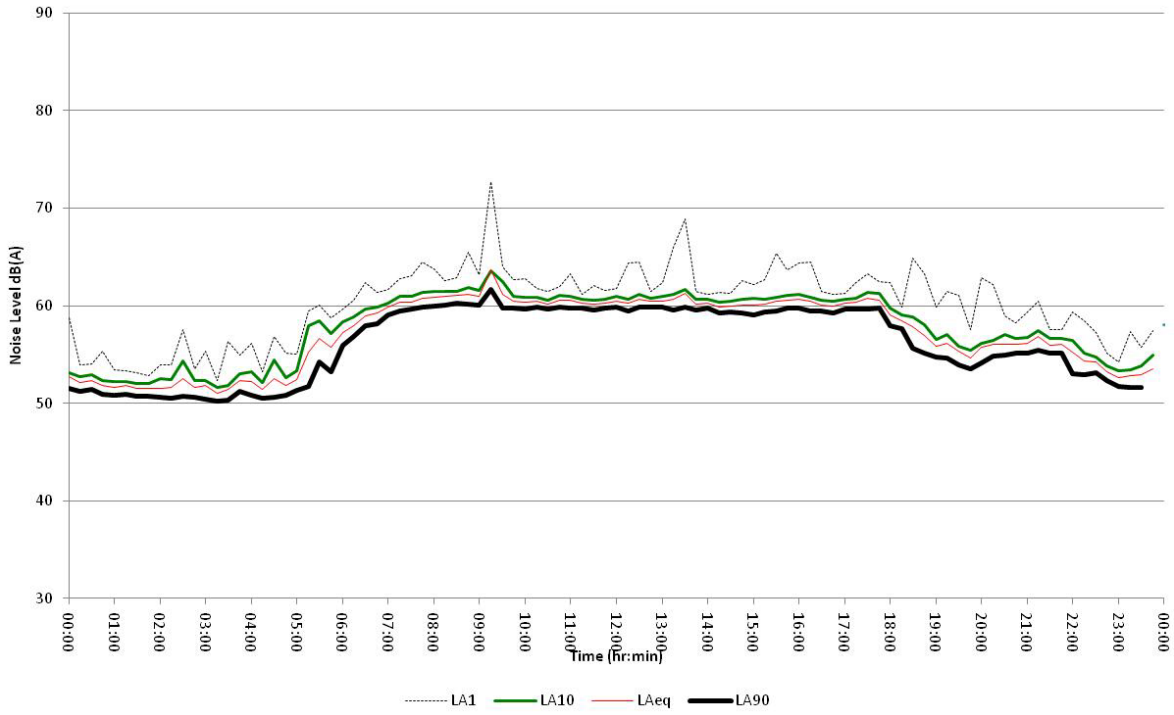

Figure 5 Measured noise levels – Logger location 1 – Tuesday 12 July, 2011

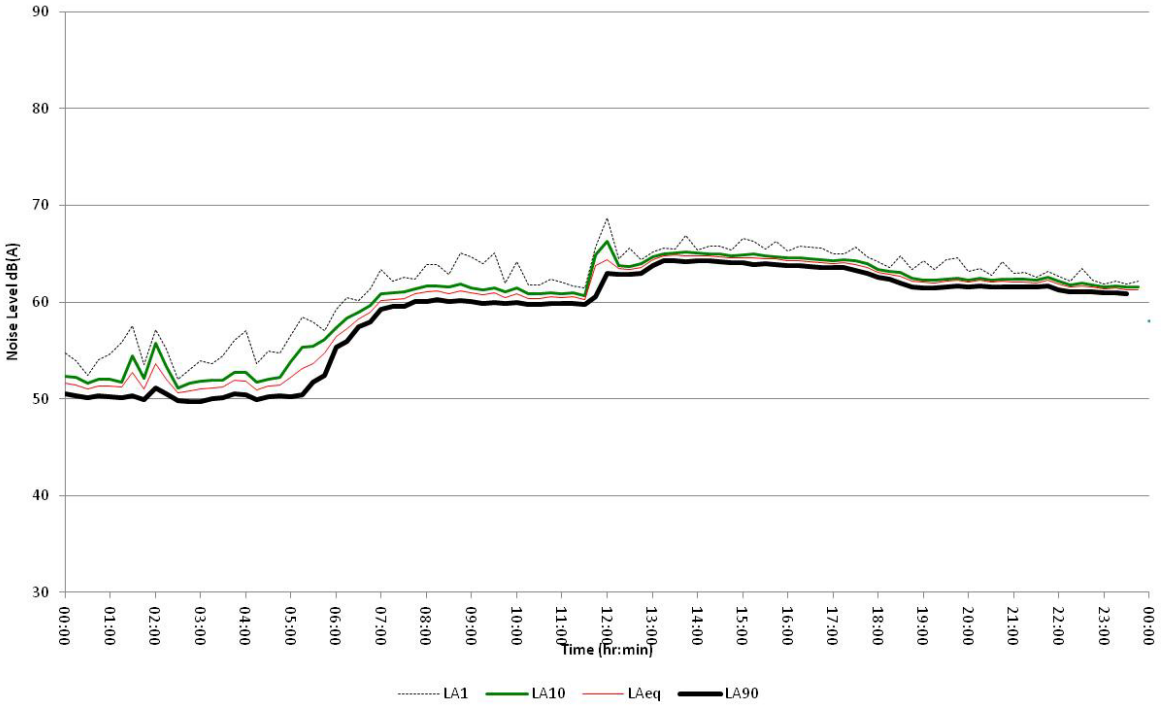

Figure 6 Measured noise levels – Logger location 1 – Wednesday 13 July, 2011

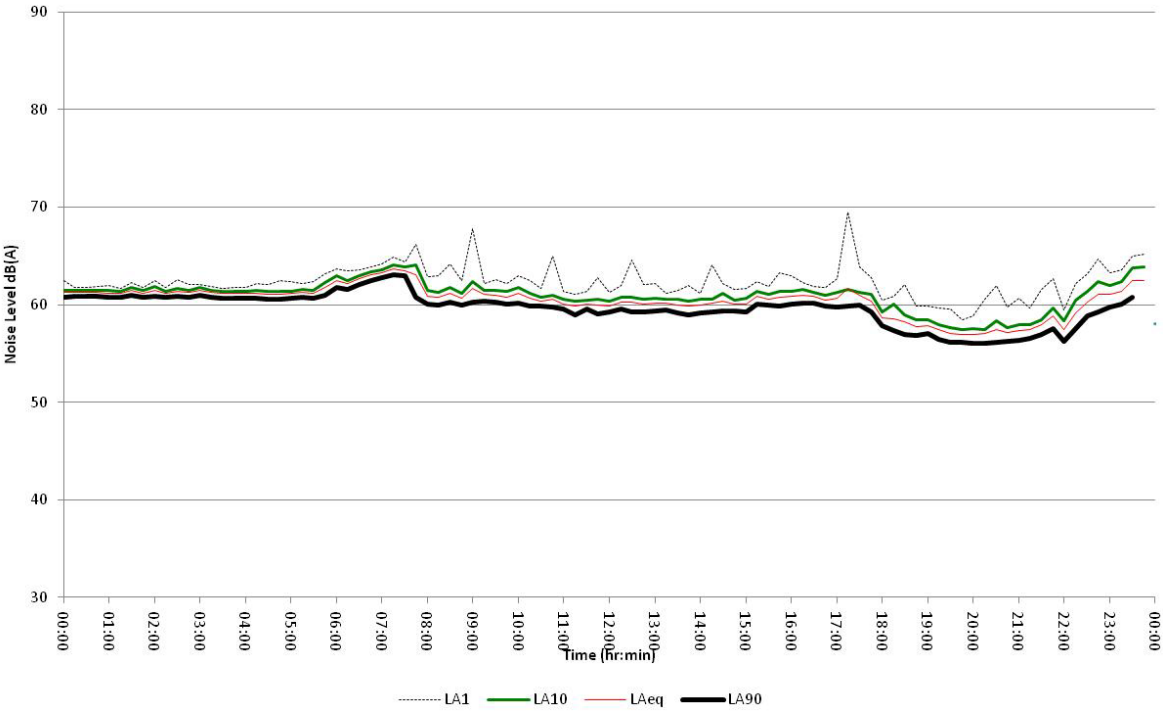

Figure 7 Measured noise levels – Logger location 1 – Thursday 14 July, 2011

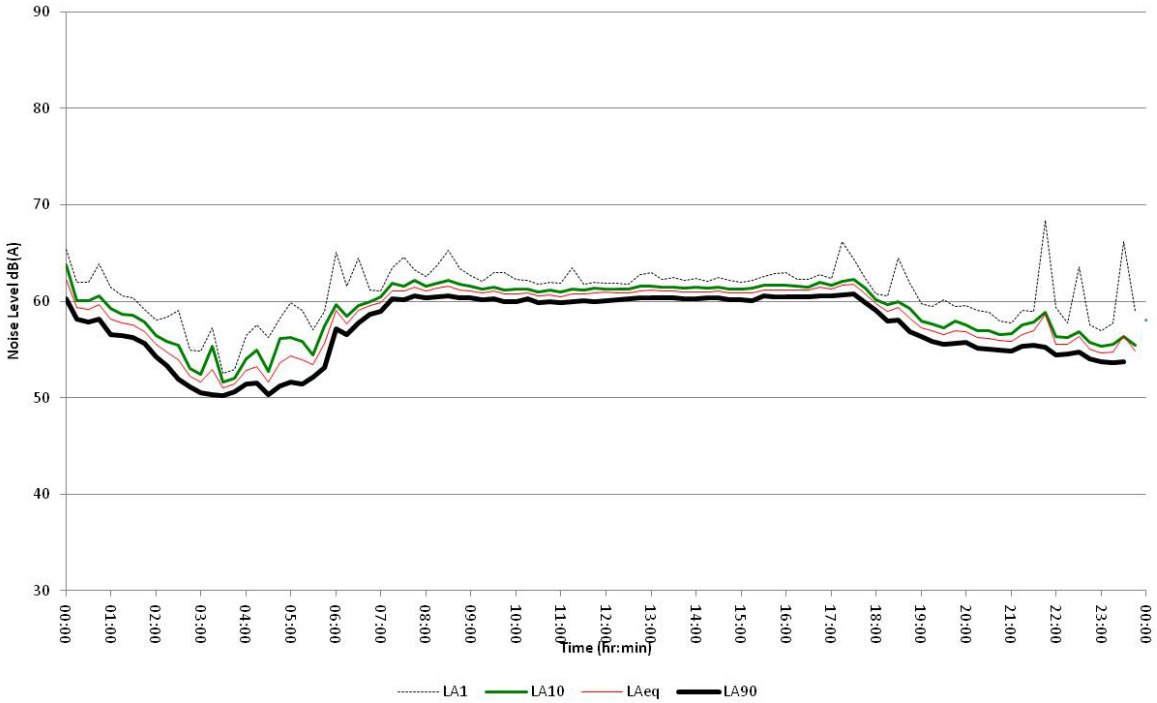

Figure 8 Measured noise levels – Logger location 1 – Friday 15 July, 2011

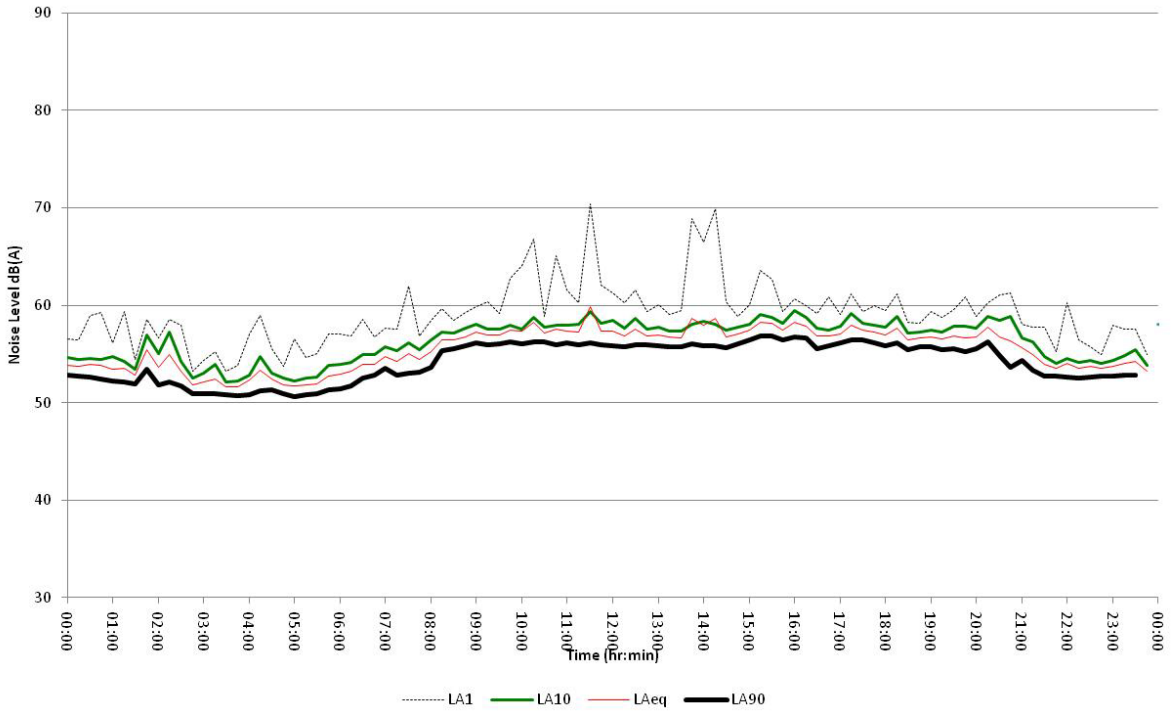

Figure 9 Measured noise levels – Logger location 1 – Saturday 16 July, 2011

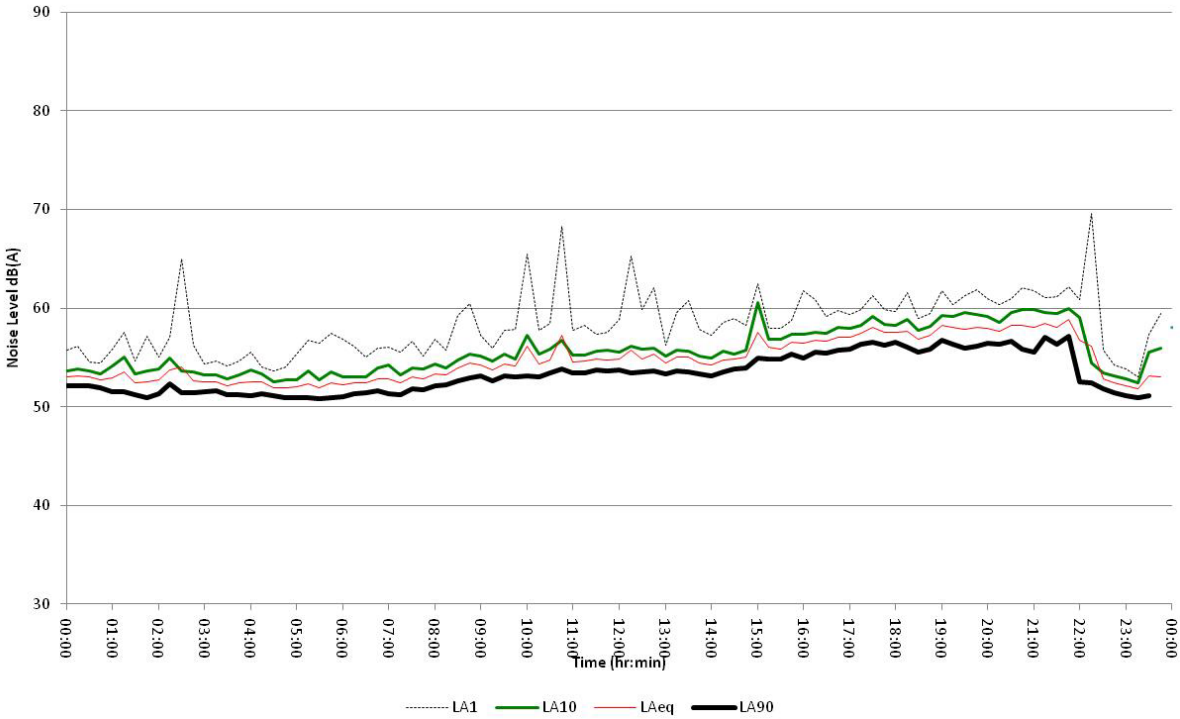

Figure 10 Measured noise levels – Logger location 1 – Sunday 17 July, 2011

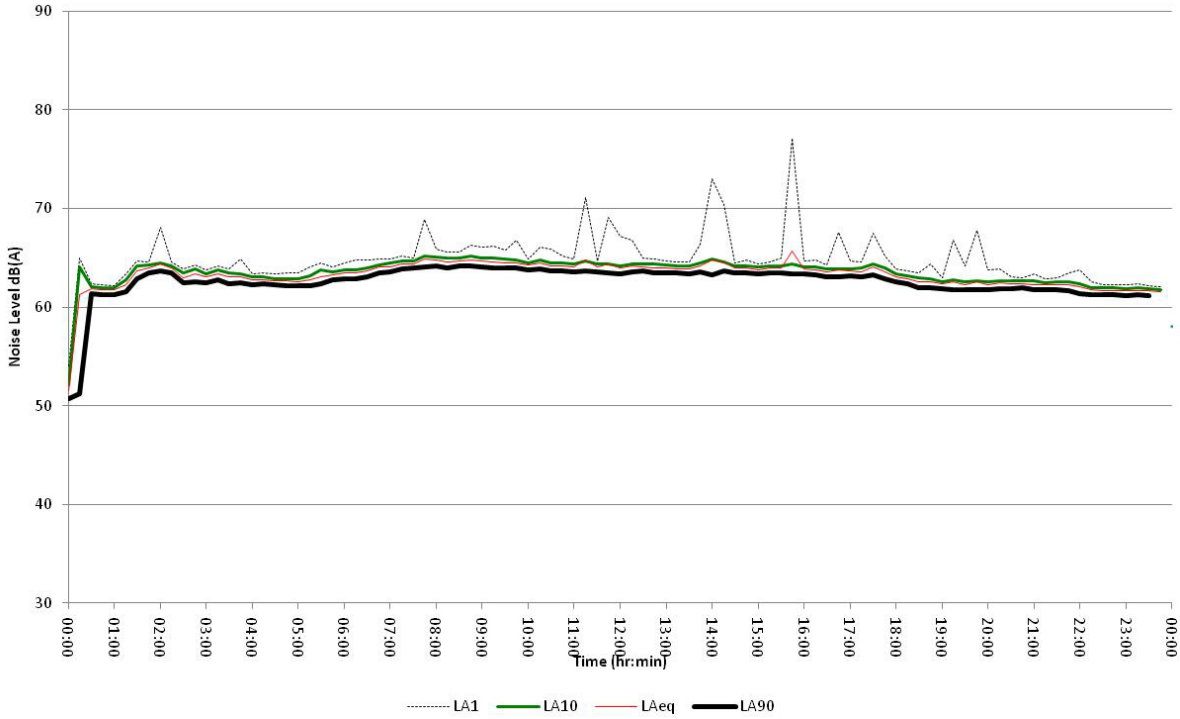

Figure 11 Measured noise levels – Logger location 1 – Monday 18 July, 2011

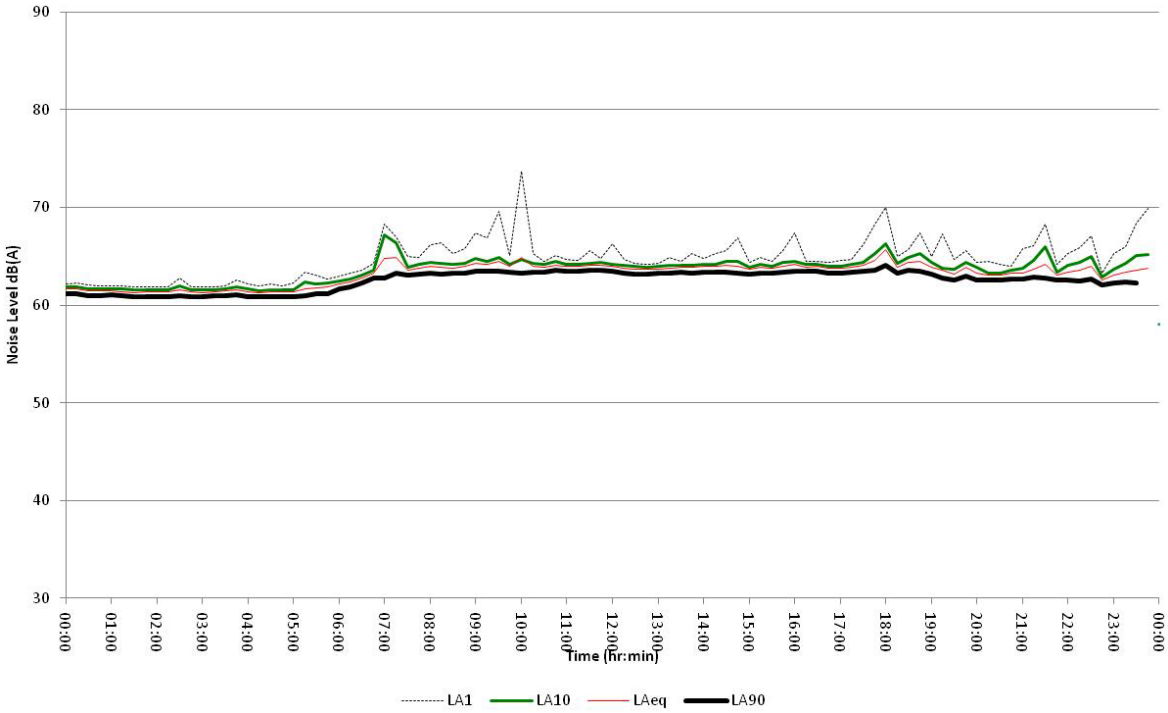

Figure 12 Measured noise levels – Logger location 1 – Tuesday 19 July, 2011

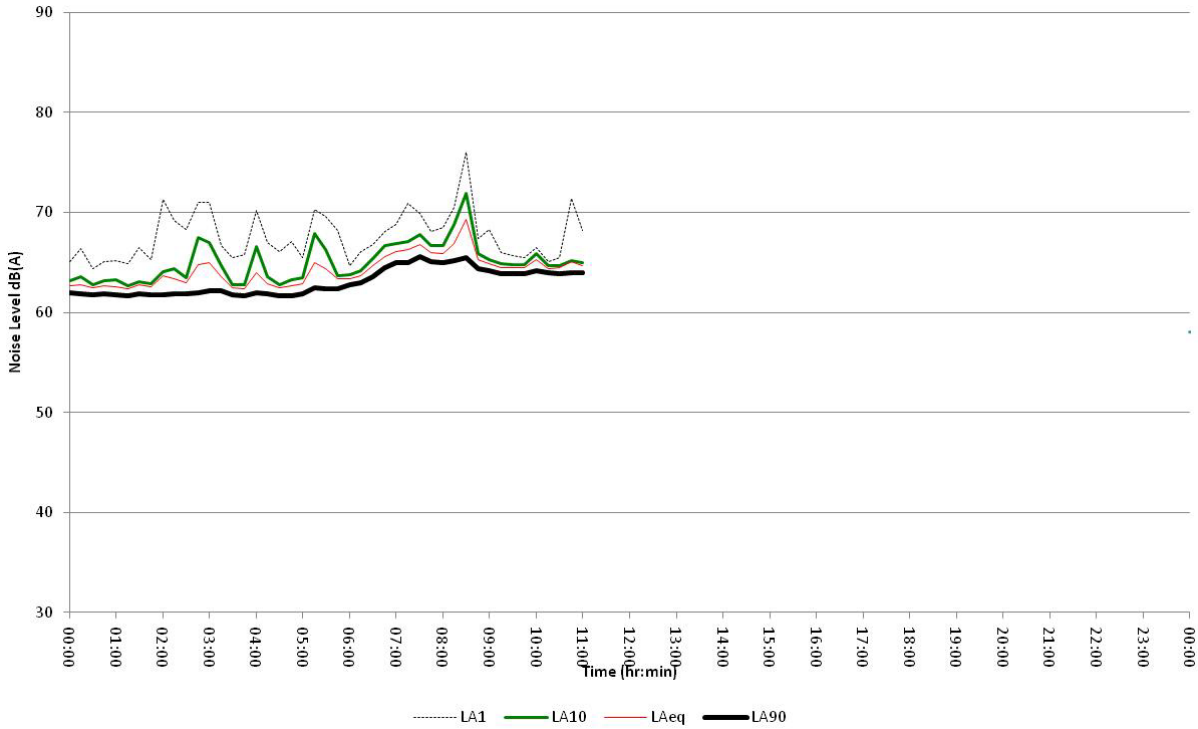

Figure 13 Measured noise levels – Logger location 1 – Wednesday 20 July, 2011

B2 Noise logging location 2 - Level 3 balcony, 100 Mount Street

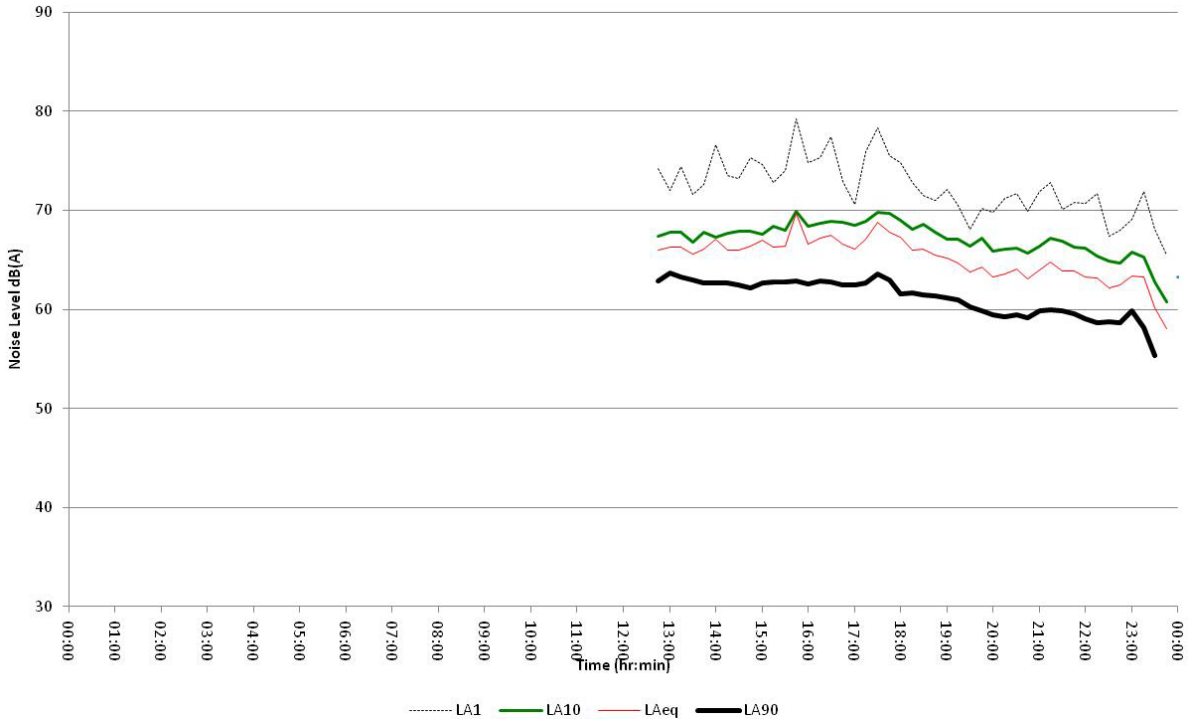

Figure 14 Measured noise levels – Logger location 2 – Monday 11 July, 2011

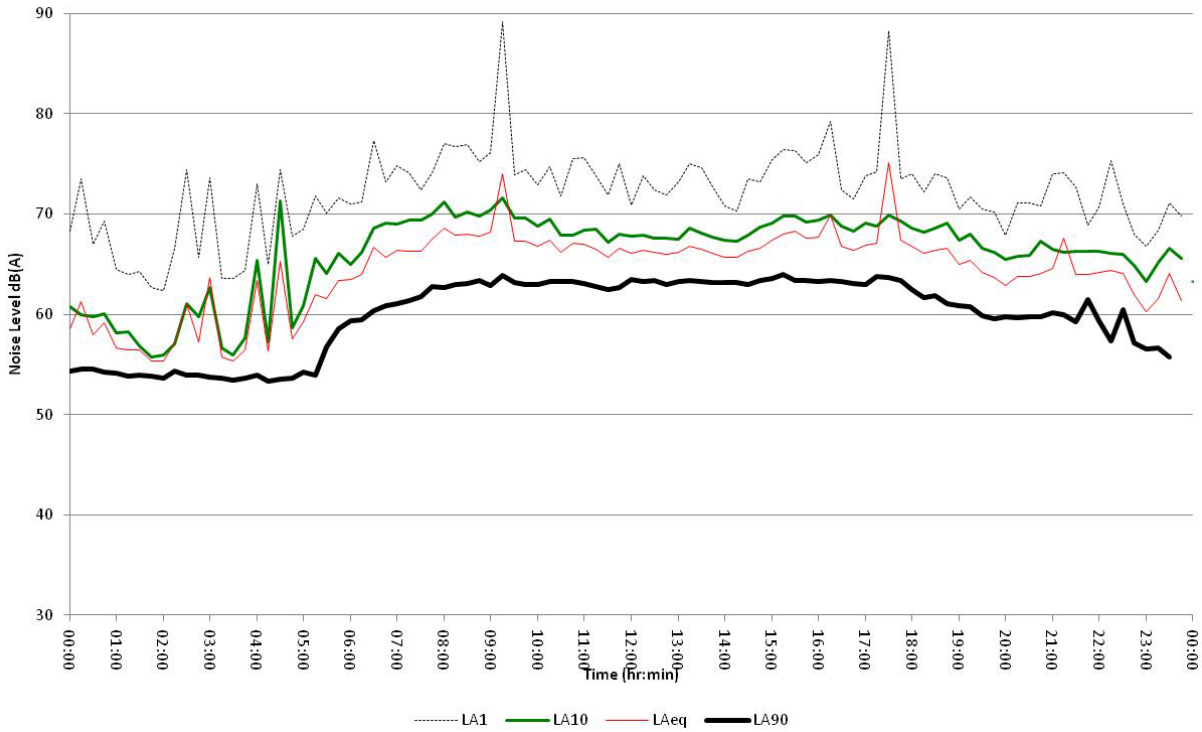

Figure 15 Measured noise levels – Logger location 2 – Tuesday 12 July, 2011

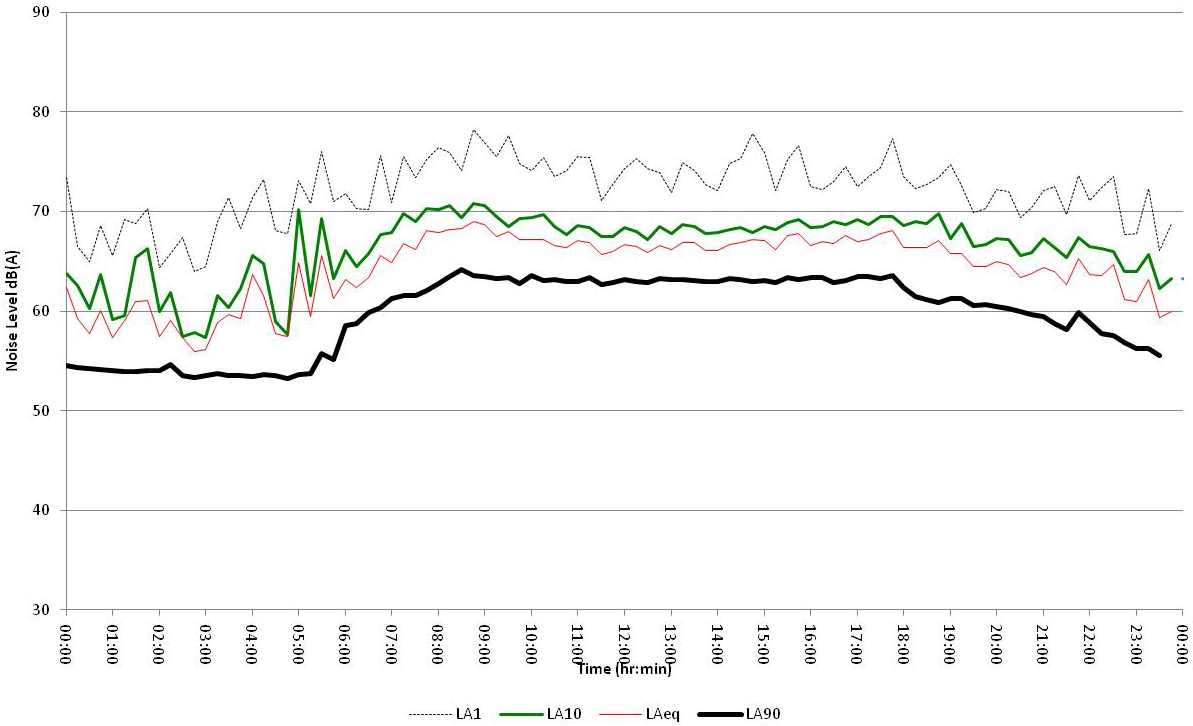

Figure 16 Measured noise levels – Logger location 2 – Wednesday 13 July, 2011

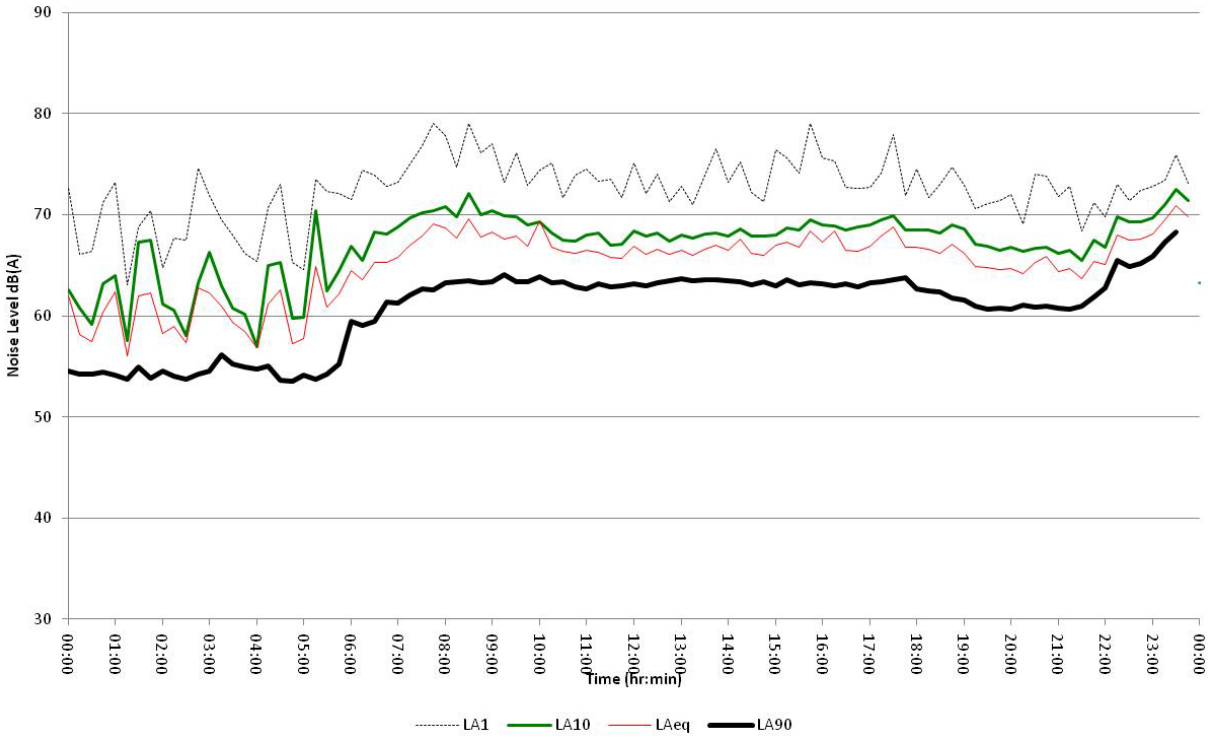

Figure 17 Measured noise levels – Logger location 2 – Thursday 14 July, 2011

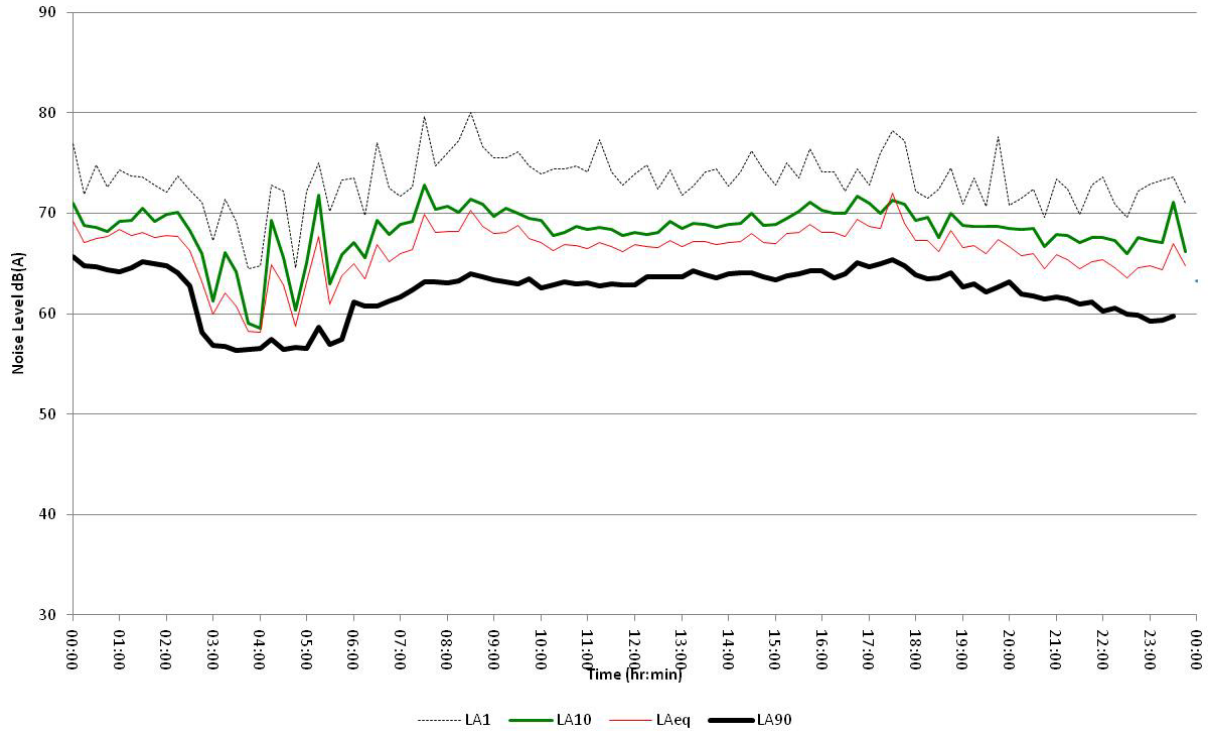

Figure 18 Measured noise levels – Logger location 2 – Friday 15 July, 2011

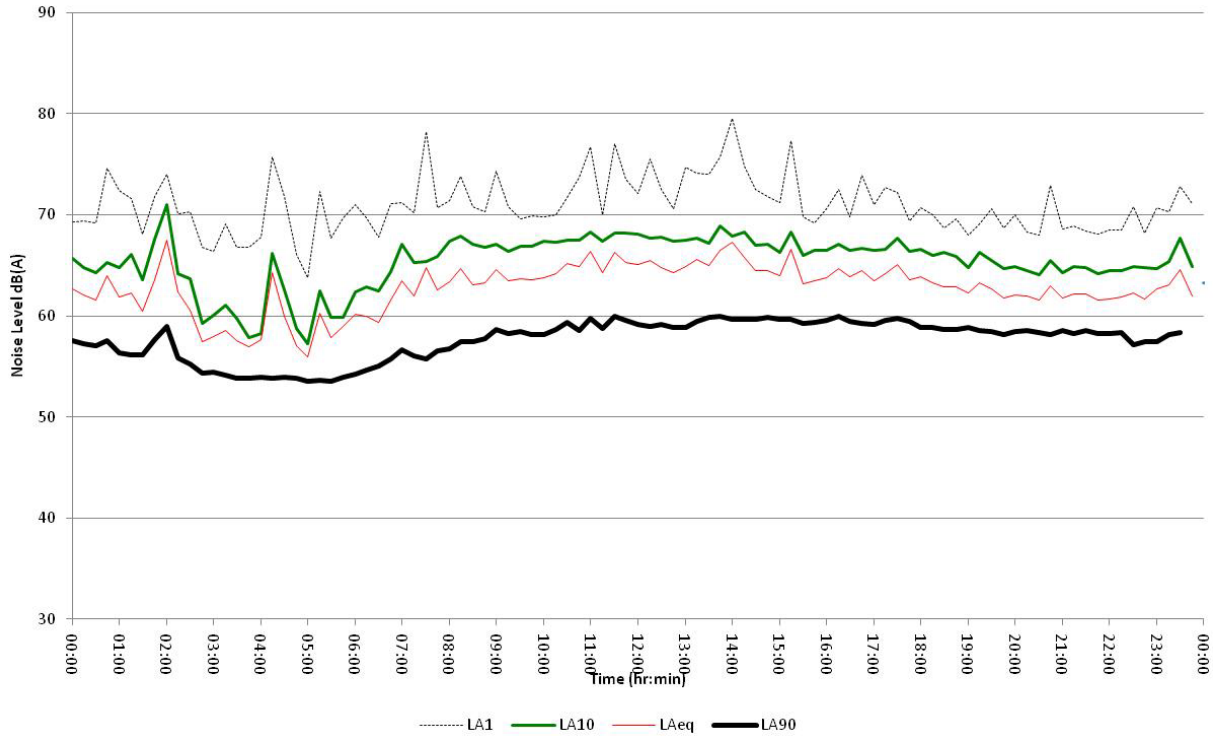

Figure 19 Measured noise levels – Logger location 2 – Saturday 16 July, 2011

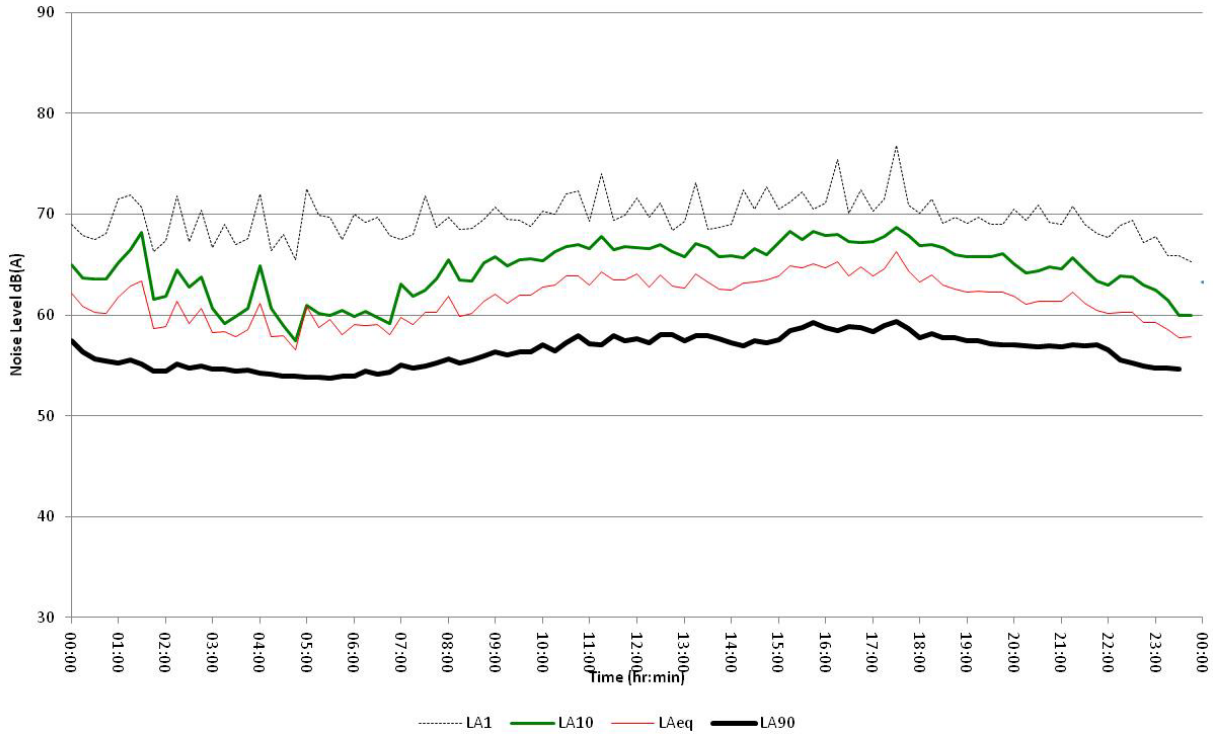

Figure 20 Measured noise levels – Logger location 2 – Sunday 17 July, 2011

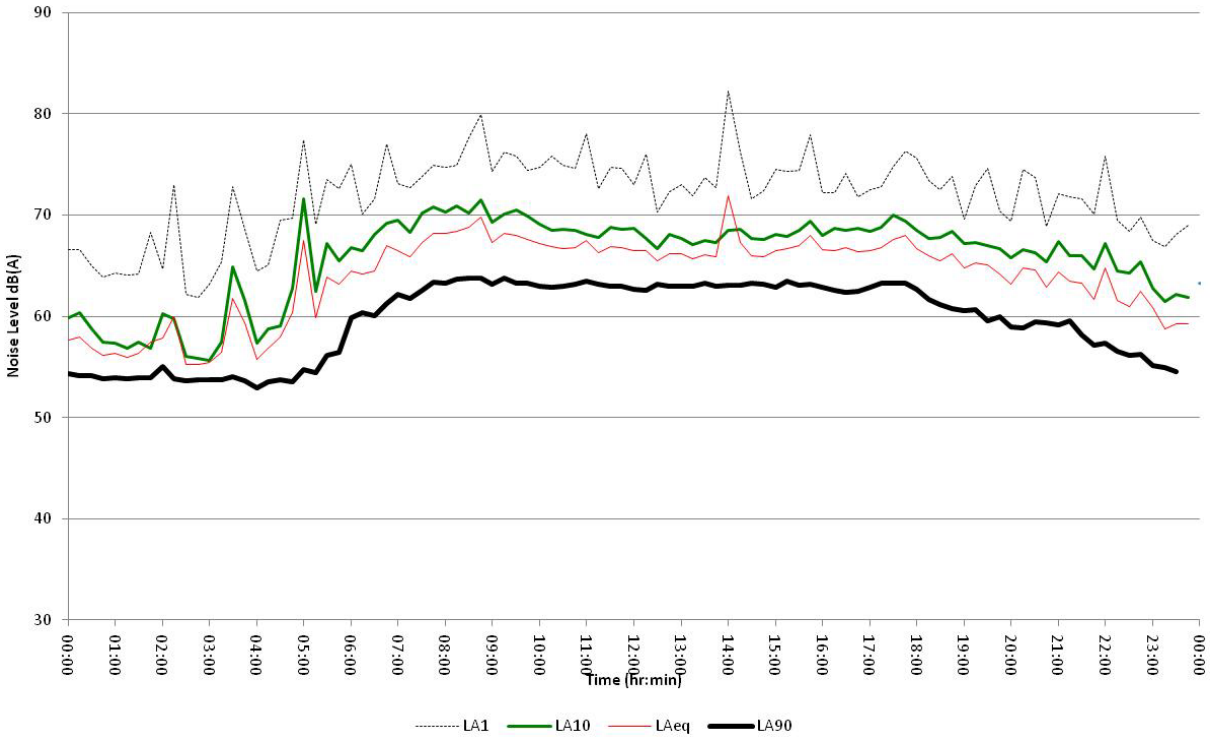

Figure 21 Measured noise levels – Logger location 2 – Monday 18 July, 2011

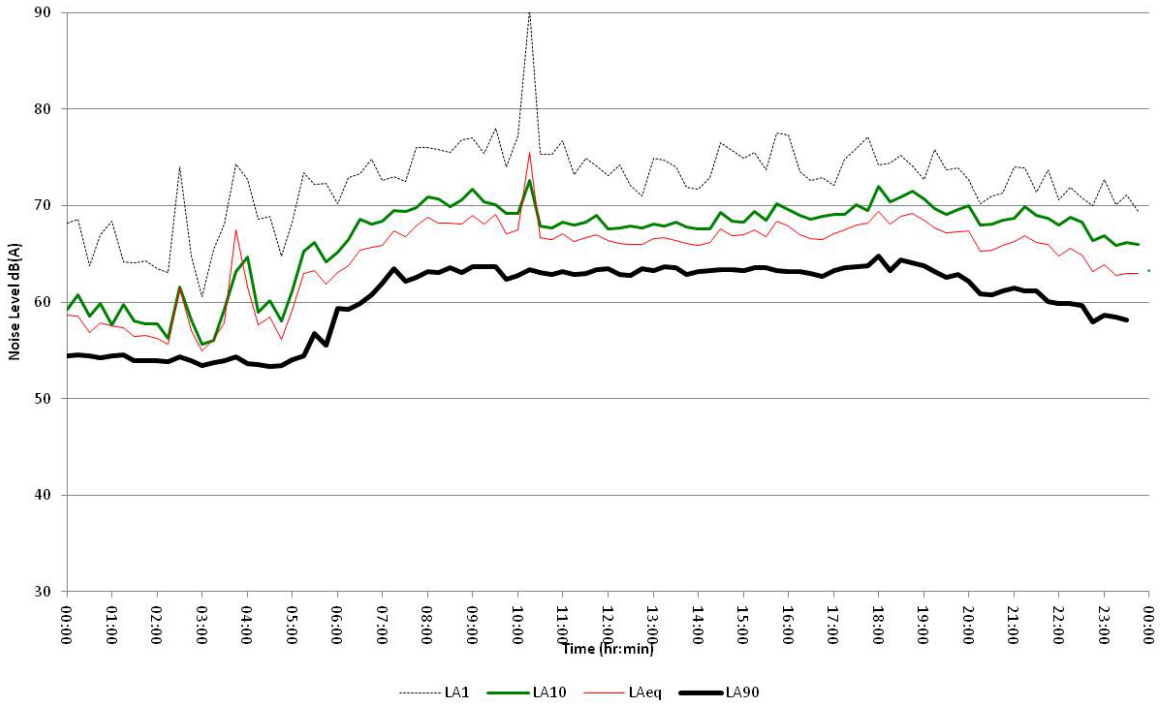

Figure 22 Measured noise levels – Logger location 2 – Tuesday 19 July, 2011

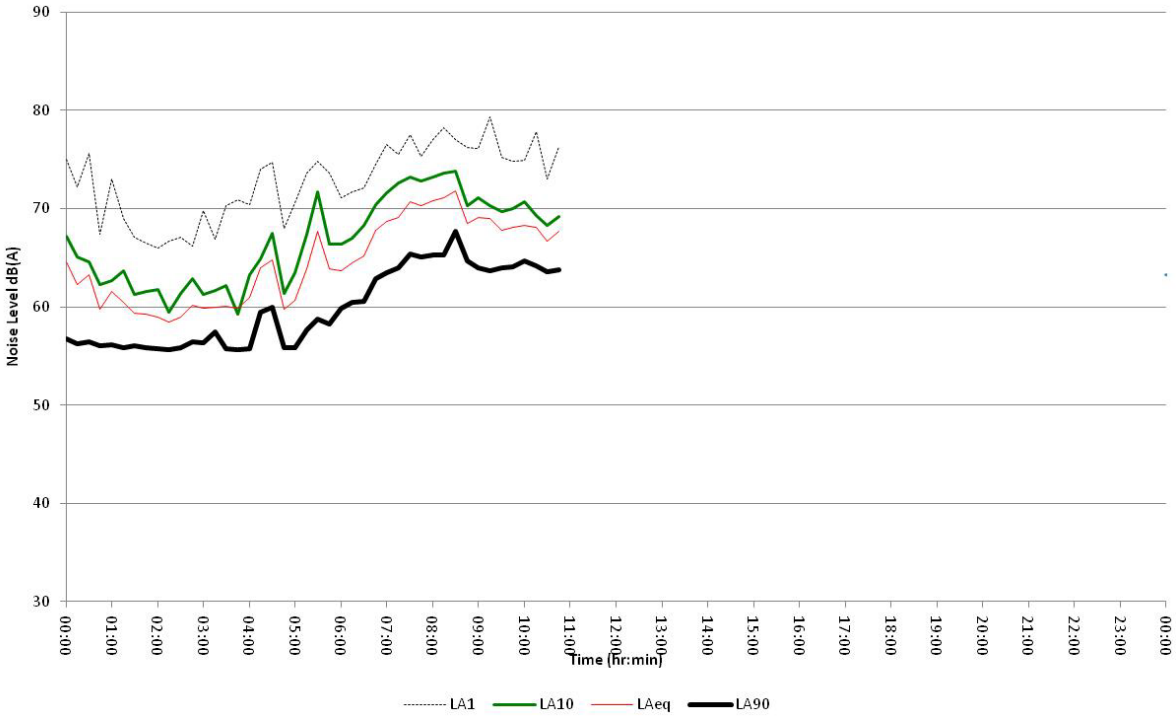

Figure 23 Measured noise levels – Logger location 2 – Wednesday 20 July, 2011