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SYDNEY INTERNATIONAL CONVENTION, EXHIBITION AND ENTERTAINMENT PRECINCT (SICEEP)
DARLING SQUARE - NE PLOT

SSDA7 - Noise and Vibration Assessment

23 October 2014

Revision 4

TG965-01F03 (r4) NE Plot DA

30 1982 2012 ACOUSTIC EXCELLENCE
Sydney Melbourne Brisbane Kuwait
Renzo Tonin & Associates (NSW) Pty Ltd ABN 29 117 462 861
Level 1/418A Elizabeth St SURRY HILLS NSW 2010 | PO Box 877 STRAWBERRY HILLS NSW 2012
P (02) 8218 0500 F (02) 8218 0501 sydney@renzotonin.com.au www.renzotonin.com.au

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Prepared for:	Lend Lease
Address:	30 The Bond 30 Hickson Road Millers Point NSW 2000
Attention:	David Sipinkoski

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Contents

List of tables

List of figures

1 Introduction

This report supports a State Significant Development (SSD) Development Application (DA) submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979.

The Application (referred to as SSDA 7) follows the approval of a staged SSD DA (SSDA 2) in December 2013. SSDA 2 sets out a Concept Proposal for a new mixed use residential neighbourhood at Haymarket referred to as "Darling Square", previously known as "The Haymarket". Darling Square forms part of the Sydney International Convention, Exhibition and Entertainment precinct (SICEEP) Project, which will deliver Australia's global city with new world class convention, exhibition and entertainment facilities and support the NSW Government's goal to "make NSW number one again".

More specifically this subsequent DA seeks approval for mixed use development within the North East development plot of Darling Square and associated public domain works. The DA has been prepared and structured to be consistent with the Concept Proposal DA.

1.1 Overview of proposed development

The proposal relates to a detailed ('Stage 2') DA for a mixed use residential development in the North East Plot of Darling Square together with associated public domain works. The Darling Square Site is to be developed for a mix of residential and non-residential uses, including but not limited to residential buildings, commercial, retail, community and open space. The North East Plot is one of six development plots identified within the approved Concept Proposal.

Under the Concept Proposal, the North East Plot is planned to accommodate a mixed use podium and three residential buildings (NE1, NE2, and NE3) above and within the podium structure. More specifically, this SSD DA seeks approval for the following components of the development:

- Demolition of existing site, improvements, including the existing Sydney Entertainment Centre (SEC)
- Associated tree removal and planting
- Construction and use of a predominantly 6 storey mixed use podium, including:
  - retail floor space and residential lobbies on Ground Level
  - above ground parking
  - residential apartments, and
  - communal facilities.
- Construction and use of three residential buildings above podium
- Public domain improvements surrounding the site, including interim works
- Provision of vehicle access to the development from Harbour Street

- Landscaping works to the podium roof level, and
- Extension and augmentation of physical infrastructure / utilities as required.

1.2 Background

The NSW Government considers that a precinct-wide renewal and expansion of the existing convention, exhibition and entertainment centre facilities at Darling Harbour is required, and is committed to Sydney reclaiming its position on centre stage for hosting world-class events with the creation of SICEEP.

Following an extensive and rigorous Expressions of Interest and Request for Proposals process, a consortium comprising AEG Ogden, Lend Lease, Capella Capital and Spotless was announced by the NSW Government in December 2012 as the preferred proponent to transform Darling Harbour and create SICEEP.

Key features of the Preferred Master Plan include:

- Delivering world-class convention, exhibition and entertainment facilities, including:
  - Up to 40,000m^2 exhibition space
  - Over 8,000m^2 of meeting rooms space, across 40 rooms
  - Overall convention space capacity for more than 12,000 people
  - A ballroom capable of accommodating 2,000 people, and
  - A premium, red-carpet entertainment facility with a capacity of 8,000 persons.
- Providing a hotel complex at the northern end of the precinct.
- A vibrant and authentic new neighbourhood at the southern end of the precinct, now called 'Darling Square', including apartments, student accommodation, shops, cafes and restaurants.
- Renewed and upgraded public domain that has been increased by a hectare, including an outdoor event space for up to 27,000 people at an expanded Tumbalong Park, and
- Improved pedestrian connections linking to the proposed Ultimo Pedestrian Network drawing people between Central, Chinatown and Cockle Bay Wharf as well as east-west between Ultimo/Pyrmont and the City.

On 21 March 2013 a critical step in realising the NSW Government's vision for the SICEEP Project was made, with the lodgement of the first two SSD DAs with the (now) Department of Planning and Environment. The key components of these proposals are outlined below.

1.2.1 Public-Private Partnership SSD DA (SSD 12_5752)

The Public-Private Partnership (PPP) SSD DA (SSDA 1) includes the core facilities of the SICEEP Project, comprising the new, integrated and world-class convention, exhibition and entertainment facilities along

with ancillary commercial premises and public domain upgrades. SSDA1 was approved on 22 August 2013.

1.2.2 Concept proposal (SSD 13_5878)

The Concept Proposal SSD DA (SSDA 2) establishes the vision and planning and development framework which will be the basis for the consent authority to assess detailed development proposals within the Darling Square Site. SSDA2 was approved on 5 December 2013. The Stage 1 Concept Proposal approved the following key components and development parameters:

- Indicative staging of demolition and development of future development plots
- Land uses across the site including residential and non-residential uses
- Street and laneway layouts and pedestrian routes
- Open spaces and through-site links
- Six separate development plots, development plot sizes and separation, building envelopes, building separation, building depths, building alignments, and benchmarks for natural ventilation and solar access provisions
- A maximum total gross floor area of 197,236m^2 (excluding ancillary above ground parking), comprised of:
  - A maximum of 49,545m^2 non-residential GFA, and
  - A maximum of 147,691m^2 residential GFA
- Above ground car parking including public car parking
- Residential car parking rates
- Design Guidelines to guide future development and the public domain, and
- A remediation strategy.

In addition to the approval of SSDA1 and SSDA2, the following approvals have been granted for various stages of Darling Square site:

- Darling Drive (part) development plot (SSDA3) for the construction and use of a residential building (student accommodation) and the provision of associated public domain works approved on 7 May 2014
- North-West development plot (SSDA4) for the construction and use of a mixed use commercial development and public car park building and associated public domain works approved on 7 May 2014, and
- South-West development plot (SSDA5) – construction and use of a mixed use residential development and associated public domain works approved on 21 May 2014.

Approval was also granted on 15 June 2014 for SSDA6 which includes the construction and use of the International Convention Centre (ICC) Hotel and provision of public domain works.

This report has been prepared to support a detailed Stage 2 SSD DA for mixed use development and associated public domain works within Darling Square (SSDA 7), consistent with the approved Concept Proposal (SSDA 2).

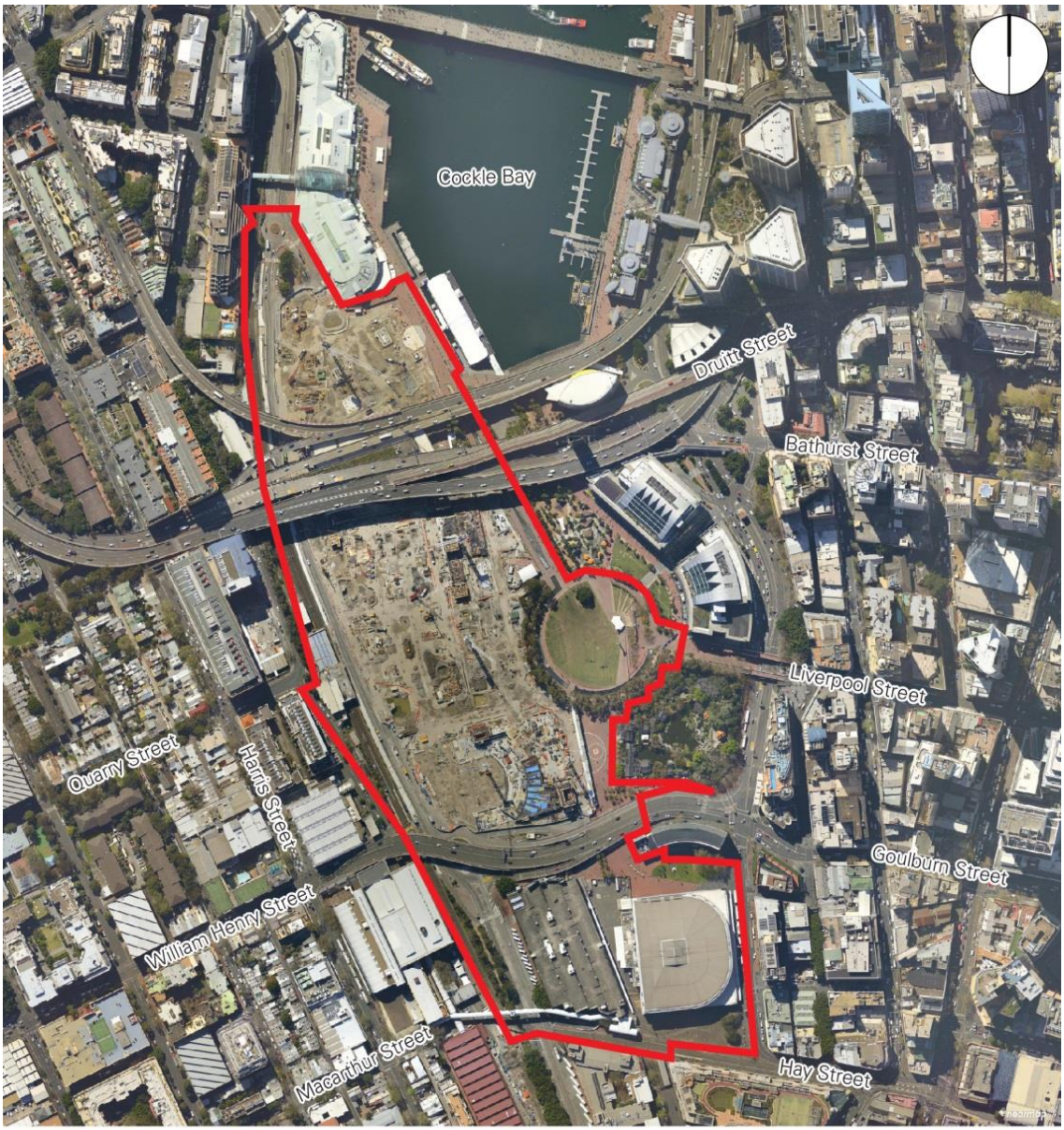
1.3 Site description

The SICEEP Site is located within Darling Harbour. Darling Harbour is a 60 hectare waterfront precinct on the south-western edge of the Sydney Central Business District that provides a mix of functions including recreational, tourist, entertainment and business.

With an area of approximately 20 hectares, the SICEEP Site is generally bound by the light rail Line to the west, Harbourside shopping centre and Cockle Bay to the north, Darling Quarter, the Chinese Garden and Harbour Street to the east, and Hay Street to the south (refer to Figure 1). The Darling Square Site is:

- located in the south of the SICEEP Site, within the northern portion of the suburb of Haymarket
- bounded by the Powerhouse Museum to the west, the Pier Street overpass and Little Pier Street to the north, Harbour Street to the east, and Hay Street to the south, and
- irregular in shape and occupies an area of approximately 43,807m^2.

Figure 1: Aerial photograph of the SICEEP site



The Concept Proposal DA provides for six (6) separate development plots across the Darling Square Site (refer to Figure 2):

- North Plot
- North East Plot
- South East Plot
- South West Plot
- North West Plot, and
- Western Plot (Darling Drive).

The Application Site area relates to the North East Plot and surrounds as detailed within the architectural and landscape plans submitted in support of the DA.

Figure 2: Concept proposal development plots

1.4 Planning approvals strategy

The SICEEP Project has resulted in the lodgement of numerous SSD DAs for the various components of the redevelopment project. Future applications will continue to be lodged in accordance with the Concept Proposal SSD DA for the remaining development plots of Darling Square Site.

1.5 Acoustic assessment requirements

Renzo Tonin & Associates has been engaged to prepare a construction and operational noise and vibration assessment for the NE Plot which provides further detailed assessment following the concept plan application submitted for Darling Square[1].

This report presents an assessment of noise and vibration, in accordance with the Secretary's Environmental Assessment Requirements (SEARs), and in relation to:

- Demolition and construction noise (see Part B of this report)

[1] Renzo Tonin & Associates, TG015-01F05 (rev 7) Stage 1 Acoustic Assessment, 15th March 2013.

- Operational noise emission from the site such as mechanical services, retail uses and public realm (see Part A of this report), and
- Noise onto the site from existing sources such as traffic and light rail (see Part A of this report).

1.5.1 Secretary's Environmental Assessment Requirements (SEARs)

The Secretary's Environmental Assessment Requirements (SEARs) issued by the Department of Planning and Environment for application number SSDA 6626 specifically requires:

> *The EIS shall identify the main noise and vibration generating sources and activities at all stages of construction (including demolition), and any noise sources during operation. Outline measures to minimise and mitigate the potential noise impacts to the surrounding area.*
>
> *Relevant Policies and Guidelines:*
>
> - *NSW Industrial Noise Policy (EPA (EPA, 2000)*
> - *Interim Construction Noise Guideline (DECC, 2009)*
> - *Assessing Vibration: A Technical Guideline (DEC, 2006)*
> - *Environmental Criteria for Road Traffic Noise (EPA, 1999)*

Relevant policies also set out in Item 1of the SEARs include:

- *State Environmental Planning Policy – Infrastructure 2007*
- *Development Near Rail Corridors and Busy Road-Interim Guideline*

The above policies and guidelines have been addressed in this report as follows:

Policy or guideline	Assessment outline	Report section
NSW Industrial Noise Policy (EPA, 2000)	Operational noise from the development and its potential impact on surrounding development.	Section 3
Interim Construction Noise Guideline (DECC, 2009)	Assessment of noise during the construction phase of the development and its potential impact on surrounding development.	Sections 5, 6 and 7
Assessing Vibration: A Technical Guideline (DEC, 2006)	The primary potential for vibration impact generated by the development is during the construction phase.	Sections 5, 6 and 7
	Also referenced in the State Environmental Planning Policy – Infrastructure 2007 with regard to rail vibration.	Section 4.3
Environmental Criteria for Road Traffic Noise (EPA, 1999)	Assessment of road traffic generated by the development on the local road network and its potential impact on surrounding development.	Section 3.2.4
State Environmental Planning Policy – Infrastructure 2007	Assessment of noise onto the development from busy roads and rail corridors.	Section 4

Policy or guideline	Assessment outline	Report section
Development Near Rail Corridors and Busy Road-Interim Guideline	Supporting guideline for the State Environmental Planning Policy – Infrastructure 2007.	Section 4

1.6 Scope of assessment

Further to the Concept Plan Application (SSDA2) acoustic assessment, this report sets out a more detailed assessment and consideration of the specific construction and operational noise and vibration aspects of the NE Plot development. The following outlines the scope of acoustic assessment for the NE Plot with respect to the above policies and guidelines:

- Review the proposed design documentation to identify:
  - The acoustic components of the construction and operation of the NE Plot, in accordance with the SEARs
  - Identify the sensitive receiver locations, including existing receivers affected by construction works, and future receivers affected by operations, and
  - Confirm the existing noise environment at surrounding receiver locations and quantify the applicable noise targets for the NE Plot.
- Carry out a quantitative acoustic assessment of potential impacts and compare against the relevant criteria.
- Where further design development is required to carry out a quantitative assessment, a qualitative assessment has been used to identify in-principle methods by which noise and vibration impact can be addressed in the design.
- Provide description of the assessment methodology to be adopted during the detailed design phase.

2 Existing noise environment and nearest sensitive receivers

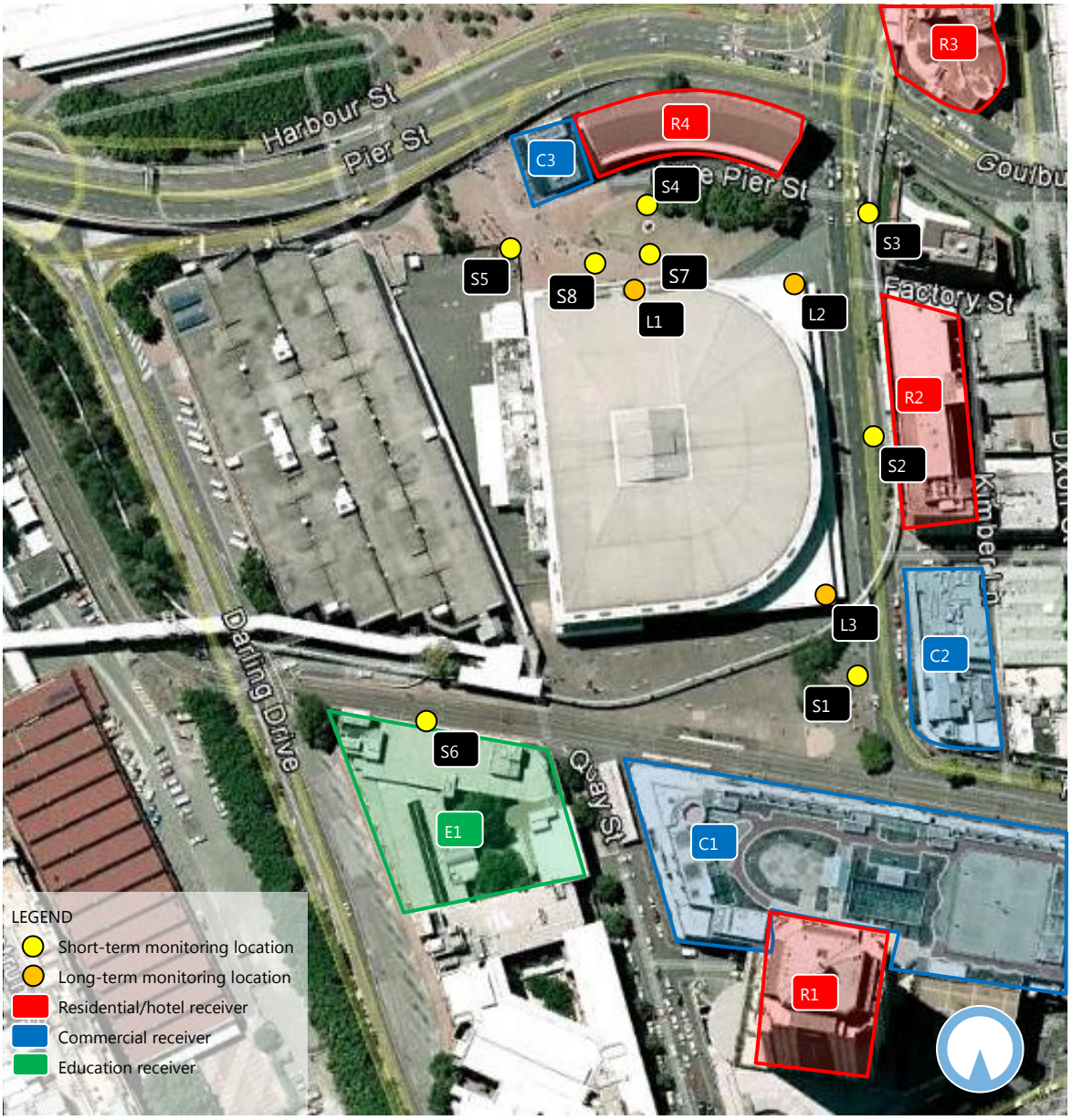
2.1 Nearest sensitive receivers

The nearest potentially affected receivers to the Darling Square site are presented in Table 1. Whilst not all receivers are directly relevant to the assessment of the NE Plot, as cumulative impacts of both operational and construction noise has been considered, all surrounding receptors as identified in the Concept Plan have been outlined. Figure 1 on the following page presents the site and surrounds of the study area along with the assessment locations and measurement locations detailed in this Section.

Table 1: Receiver locations

Receiver ID	Receiver location	Distance from boundary of Site (approx. m)
Residential/hotel receivers		
R1	The Peak Apartments (Market City) - 2 Quay St	70
R2	Holiday Inn Hotel - 68 Harbour St	25
R3	Southern Cross on Harbour (Seasons Darling Harbour) - 38 Harbour St	75
R4	Novotel Rockford Hotel - 17 Little Pier St	30
Commercial receivers		
C1	Market City - 9-13 Hay St	20
C2	Restaurants on Harbour St, between Hay St & Goulburn St	25
C3	Pumphouse - (Heritage building) - 17 Little Pier St	15
Other sensitive receivers		
E1	UTS - Quay St	80

Figure 3: Locality map showing receiver and measurements locations



2.2 Existing noise environment

Noise impact at the residential receiver locations is assessed against noise goals established from the existing noise environment of the area prior to the subject development. Appendix B of the NSW EPA Industrial Noise Policy (INP) presents two methods of determining the background noise levels of an area being '*B1 - Long-term background noise method*' and '*B2 - Short-term background noise method*'. For the subject assessment, a combination of long-term and short-term noise monitoring was undertaken to establish the existing acoustic environment.

Background noise varies over the course of any 24 hour period, typically from a minimum at 3am in the morning to a maximum during morning and afternoon traffic peak hours. Therefore, the NSW *Industrial*

Noise Policy (EPA, 2000) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The INP defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

2.2.1 Long-term noise monitoring

Long-term noise monitoring was carried out from Wednesday, 10 September 2014 to Wednesday, 17 September 2014. The long-term noise monitoring methodology is detailed in Appendix C, and noise level-vs-time graphs of the data are included in Appendix D. The long-term noise monitoring locations are presented in Figure 3 above and Table 2.

Table 2: Long-term noise monitoring location

ID	Address	Description
L1	Sydney Entertainment Centre - North	Noise monitor was located on the lower roof level of the Entertainment Centre. The microphone was positioned 1.85m above the awning in the 'free field', approximately 70m from the Harbour Street curb. Noise data represents the ambient and background noise levels for the northern extends of the north-east plot of Darling Square
L1	Sydney Entertainment Centre - North-East	Noise monitor was located on the lower roof of the Entertainment Centre. The microphone was positioned 1.85m above the awning in the 'free field', approximately 13m from the Harbour Street curb. Noise data represents the ambient and background noise levels for the north-eastern extends of the north-east plot of Darling Square
L3	Sydney Entertainment Centre - South-East	Noise monitor was located on the lower roof of the Entertainment Centre. The microphone was positioned 1.85m above the awning in the 'free field', approximately 54m from the Hay Street curb. Noise data represents the ambient and background noise levels for the south-eastern extends of the north-east plot of Darling Square

Existing background and ambient noise levels are presented in Table 3.

Table 3: Long-term noise monitoring results, dB(A)

Monitoring location	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient noise level		
	Day	Evening	Night	Day	Evening	Night
L1 - Entertainment Centre - North	61	59	55	65	62	59
L2 - Entertainment Centre - North-East	61	59	53	64	63	60
L3 - Entertainment Centre - South-East	58	58	51	63	61	59

Notes: Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
Evening: 18:00-22:00 Monday to Sunday & Public Holidays
Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

2.2.2 Short-term attended noise monitoring

To supplement the long-term noise monitoring, and provide greater detail of the noise environment surrounding the site, short-term noise measurement results have been relied upon. Measurements at the site were undertaken at the following locations during the daytime of Wednesday, 6 February 2013, night time of Friday, 8 February 2013 and evening of Wednesday, 24 September 2014.

Table 4: Short-term noise monitoring locations

ID	Address	Description
S1	Harbour St, near Hay St, Haymarket	Western side of Harbour St, opposite Xi'an Cuisine restaurant, 5m from the curb, in the free field. Noise data represents the existing background and ambient noise incident on the proposed residential development in the south east corner of the precinct.
S2	Harbour St, Holiday Inn Hotel, Haymarket	Eastern side of Harbour St, 10m north of the Holiday Inn lobby entrance, 3.5m from the façade, in the free field. Noise data represents existing background and ambient noise for residents of the Holiday Inn hotel.
S3	Harbour St, near Goulbourn St, Haymarket	Eastern side of Harbour St, in front of the Harbour Plaza building, next to the entrance to the Red Chilli Sichuan Restaurant, 3.5m from the curb, in the free field. Noise data represents the existing background noise for the commercially used Harbour Plaza building.
S4	Novotel Hotel, Little Pier St, Haymarket	South side of Little Pier St, opposite the Novotel lobby, 20m from building, in the free field. Noise data represents existing background noise for residents of the Novotel hotel.
S5	The Pumphouse Restaurant & Bar, Little Pier St, Haymarket	South side of Pumphouse building, public thoroughfare area, 15m from outdoor area of bar, in the free field. Noise data represents existing operational noise levels from licenced venue, incident on proposed residential development.
S6	UTS building, Quay St, Haymarket	North side of the UTS building, facing the light rail lines, 3.5m from the building façade, approximately 5m from the eastern side of the building, in the free field. Noise data represents existing background noise for the UTS educational building.
S7	Sydney Entertainment Centre	North side of Sydney Entertainment Centre, approximately 69m from the Harbour St curb and approximately 10m from the northern façade of the Sydney Entertainment Centre, in the free field. Noise data is representative of the existing background noise at the Novotel hotel.
S8	Sydney Entertainment Centre	North side of Sydney Entertainment Centre, approximately 80m from the Harbour St curb and approximately 5m from the northern façade of the Sydney Entertainment Centre, in the free field. Noise data is representative of the existing background noise at the Novotel hotel.

The equipment used for the noise measurements was a Brüel & Kjær Type 2250 precision sound level analyser which is a Class 1 instrument having an accuracy suitable for field and laboratory use. The instrument was calibrated prior and subsequent to measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All instrumentation complies with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and carries current NATA certification (or if less than 2 years old, manufacturers certification).

A detailed summary of the short-term measurement data is presented for reference in Appendix B.

2.3 Representative noise levels for sensitive receivers

Based on the noise monitoring results, representative background and ambient noise levels have been established for the standard day, evening and night INP assessment periods. This has been carried out for the residential receiver locations only.

Table 5: Representative background and ambient noise levels, dB

Monitoring location	L_{A90} Rating Background Level (RBL)			L_{Aeq} Ambient noise level			Representative Measurement ID
	Day	Evening	Night	Day	Evening	Night	
R1 - Peak Apartments	58	58	51	63	61	59	L3
R2 - Holiday Inn	61	59	53	64	63	60	L2
R3 - Southern Cross on Harbour	61	59	53	64	63	60	L2
R4 - Novotel	61	59	55	65	62	59	L1

Notes: Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
Evening: 18:00-22:00 Monday to Sunday & Public Holidays
Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

PART A - 'Operational' noise assessment

This part of the noise assessment discusses noise impacts associated with the development once constructed, including:

- Noise impacts from the proposed North East Plot development onto existing noise sensitive receivers;
- Noise impacts from the surrounding environment (eg. noise from the light rail and road traffic) onto the North East Plot.

3 Noise emission from the development

3.1 'Operational' noise sources

The proposed mixed use North East (NE) Plot will combine retail, above ground parking, and residential. The operational noise sources associated with the development are considered to be:

- Mechanical plant and equipment, including residential air-conditioners
- Activity associated with restaurants, cafes and other retail uses, including patrons, music and loading docks
- Car park activity from the above ground car parking, and
- Traffic generated by the proposed development onto the existing road network.

This section of the report addresses noise emission associated with these sources at the nearest noise-sensitive receivers in accordance with the SEARs and relevant noise requirements. Where necessary, noise mitigation and/or management measures will be identified.

3.2 Operational noise criteria

3.2.1 EPA industrial noise policy

In accordance with the SEARs, noise impact from the general operation of the proposed development is to be assessed against the NSW Industrial Noise Policy (INP). The assessment procedure in terms of the INP has two components:

- Controlling intrusive noise impacts in the short term for residences
- Maintaining noise level amenity for particular land uses for residences and other land uses.

It is noted that the Concept Plan report set out the intrusiveness and amenity criteria for cumulative assessment of Darling Square. In the case of a large development site such as SICEEP, the cumulative impact of the development to the surrounding receivers should be considered and therefore Table 6 on the following page sets out the established noise criteria for the NE Plot. As it is the amenity criterion that addresses cumulative impact, the criteria is proportioned between the South West, North West, Western and Eastern Plots based upon the distance of each site from the relevant receptor locations. The noise goals for the individual Plots will be subject to review during the design development stage, as where lower noise contributions may be achievable from a specific development Plot, other Plots within Darling Square would be permitted to increase noise emission while still complying with the cumulative target.

It is noted that recent approval for the SW Plot imposed criteria for mechanical plant equipment of background + 5dB(A), applicable at the boundary of the site. Equivalent criteria have been included in Table 6 below for the NE Plot.

Table 6: Darling Square - Industrial noise criteria

Receiver ID	Intrusiveness criteria, $L_{Aeq,15min}$ dB(A)			Amenity criteria[1], $L_{Aeq, period}$ dB(A)			
	Day	Evening	Night	Plot	Day	Evening	Night
R1 - The Peak	63	63	56	SW	53	46	44
				NW	47	40	38
				W	47	40	38
				NE	50	43	41
				SE	54	47	45
				TOTAL	58	51	49
R2 - Holiday Inn	66	64	58	SW	43	40	37
				NW	42	39	36
				W	40	37	34
				NE	54	51	48
				SE	50	47	44
				TOTAL	56	53	50
R3 - Seasons	66	64	58	SW	46	43	40
				NW	47	44	41
				W	45	42	39
				NE	53	50	47
				SE	49	46	43
				TOTAL	56	53	50
R4 - Novotel Rockford	66	64	60	SW	45	41	38
				NW	48	44	41
				W	43	39	36
				NE	54	50	47
				SE	46	42	39
				TOTAL	56	52	49
C1 - Market City	-	-	-	SW	56		
				NW	52		
				W	51		
				NE	53		
				SE	64		
				TOTAL	65 (when in use)		
C2 - Restaurants on Harbour St	-	-	-	SW	47		
				NW	47		
				W	46		
				NE	61		
				SE	62		
				TOTAL	65 (when in use)		
C3 - Pumphouse	-	-	-	SW	52		
				NW	58		
				W	51		
				NE	63		
				SE	51		
				TOTAL	65 (when in use)		

Receiver ID	Intrusiveness criteria, $L_{Aeq,15min}$ dB(A)			Amenity criteria[1], $L_{Aeq, period}$ dB(A)			
	Day	Evening	Night	Plot	Day	Evening	Night
C4 - The Powerhouse	-	-	-	SW	54		
				NW	56		
				W	64		
				NE	48		
				SE	48		
				TOTAL	65 (when in use)		
E1 - UTS	-	-	-	SW	33		
				NW	19		
				W	24		
				NE	18		
				SE	27		
				TOTAL	35 (when in use)		
North West Plot*	63	63	56	-	-		

Note: * Lower noise criteria may be appropriate for areas of the development that are acoustically shielded from surrounding roads and other noise generating development (ie, facing central podiums). Applies at boundary of site.

Table 7 presents the basis of establishing the overall amenity noise criteria for Darling Square. Based on site observations the existing industrial noise contribution have been based on the measured background noise levels with equal proportioning between traffic and mechanical plant. The existing industrial noise levels have been used to modify the amenity criteria in accordance with Table 2.2 of the INP. The high traffic noise environmental criterion has also been considered. No correction to the commercial premise criteria were determined to be required based on the measurement data.

Table 7: Existing industrial noise level for amenity criteria, dB(A)

Location	Time period	Existing RBL	Existing industrial noise	Existing $L_{Aeq(traffic)}$	INP base amenity criteria^	Modified criteria
R1 – Peak Apartments	Day	58	55	63	60	58
	Evening	58	55	61	50	51
	Night	51	48	59	45	49
R2 – Holiday Inn	Day	61	58	64	60	56
	Evening	59	56	63	50	53
	Night	53	50	60	45	50
R3 - Southern Cross on Harbour	Day	61	58	64	60	56
	Evening	59	56	63	50	53
	Night	53	50	60	45	50
R4 – Novotel	Day	61	58	65	60	56
	Evening	59	56	62	50	52
	Night	55	52	59	45	49

Notes: Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
Evening: 18:00-22:00 Monday to Sunday & Public Holidays
Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays
^Residential receiver locations categorised as Urban.

3.2.2 Residential air-conditioners

The Protection of the Environment Operations (Noise Control) Regulation 2008 limits the amount of noise generated in residential areas. Provisions relating to the use of air conditioners on residential premises aim to minimise the impact from this specific noise source.

Noise generated by air conditioners on residential premises is limited by Part 52 'Air conditioners' of the Protection of the Environment Operations (Noise Control) Regulation 2008. The Regulation states that:

- *A person must not cause or permit an air conditioner or heat pump water heater to be used on residential premises in such a manner that it emits noise that can be heard within a habitable room in any other residential premises (regardless of whether any door or window to that room is open):*

  a. Before 8am or after 10pm on any Saturday, Sunday or public holiday, or

  b. Before 7am or after 10pm on any other day.

  Maximum penalty: 100 penalty units in the case of a corporation, 50 penalty units in the case of an individual.

- *A person is not guilty of an offence under subclause (1) in relation to a heat pump water heater if the conduct alleged to give rise to the offence occurs within 6 months after the commencement of this Regulation.*

- *A person is not guilty of an offence under subclause (1) unless:*

  a. the person has, within 7 days after causing or permitting an air conditioner or heat pump water heater to be used in such a manner, been warned by an authorised officer or enforcement officer not to cause or permit the air conditioner or heat pump water heater to be used in that manner, and

  b. the person causes or permits an air conditioner or heat pump water heater to be used in that manner within 28 days after the warning has been given.

- *In this clause: "heat pump water heater" means a device that heats water using the energy generated from the compression of a gas.*

As prescribed in The Protection of the Environment Operations Act 1997 (PEO Act), non-compliance with the above is deemed 'offensive noise', which is defined in the Act as follows:

a. that, by reason of its level, nature, character or quality, or the time at which it is made or any other circumstances:

i. *is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*

ii. *interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*

iii. *that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in any other circumstances prescribed by the regulations.*

3.2.3 Retail uses and Darling Square

Specific use of individual retail premises will be subject to separate applications, of which could include licensed premises. Standard noise policy and criteria applicable to retail type development places the onus of noise control and management upon the operator (noise emitter). The standard noise criteria vary at different times of the day, but are all relative to the existing background noise level at the sensitive receptor location. This is in contrast to road traffic and light rail noise intrusion, which is assessed against a fixed L_{Aeq} noise level criterion.

The typical criteria that apply are as follows:

- Between 7am – 12midnight, at the boundary of the nearest affected residential boundaries/balconies, with an allowance of background noise + 5dB[2];
- Between 12midnight – 7am, at the boundary of the nearest affected residential boundaries/balconies, with an allowance of background noise + 0dB[3];
- Between 12midnight – 7am, noise is also required to be inaudible inside habitable rooms of the residential premises and applies with the windows of the residential premise open or closed.

The result of these standard criteria is that the imposition of noise control is placed firmly on the retail use. Further, the control of noise at the commercial premises does not address noise from the public realm. However the criteria do protect both the internal and external amenity of residential premises without the need for any specific acoustic treatment to the residential building.

On the basis of the current concept plan for retail, noise generating developments such as cafes and restaurants not comply with the standard noise conditions given the proximity of the residential apartments, particularly if external areas are to be utilised and open shop frontages proposed.

An alternative to applying controls at the source of noise is to apply the mitigation measures at the receptor location. In this case, the typical design response would be to design the residential building envelope to control noise intrusion. Design responses could typically include:

- Windows and doors to residential apartments need to remain closed in order for the acceptable level of amenity to be achieved
- Residents may need to be advised of noise – expectations managed, such as in lease notations

[2] Applies in octave band centre frequencies from 31.5Hz to 8kHz.

[3] Applies in octave band centre frequencies from 31.5Hz to 8kHz.

- An acceptable internal noise level needs to be determined – the extent to which noise may still be audible is dependent upon what controls the background noise level inside the apartment (discussed further below), and
- Establishment of a design criterion for the façade system.

3.2.3.1 Comparative to background and fixed noise level criteria

An important aspect of this issue is the difference in noise criteria applicable to retail type operations, when compared with other sources such as road traffic, light rail and aircraft. As outlined above, the criteria for assessing noise from retail type development at residential receptors is compared against the prevailing background noise level. It is the emergence of noise above the background noise level that both determines how audible the noise may be.

By comparison, the noise criteria for road traffic, trains or aircraft are fixed noise levels relevant to the type of receptor location and are therefore independent of the prevailing background noise level inside the residential premises. These criteria do not necessarily address the audibility of noise, but rather set a fixed noise level at which the particular noise source is considered acceptable. In these cases the control of noise can be readily addressed by the building envelope, as the outside noise can be reduced down to the prescribed level.

However when the background noise level is relevant to the assessment, the blocking out of external noise by the building envelope can also reduce the internal background noise level within an apartment. As a result, the more the external noise is reduced, so too is the background noise level.

Given this complexity, the use of a criteria related to the background noise levels, particularly in octave bands is not readily adopted for developing sites such as Darling Square.

3.2.3.2 City of Sydney DCP

It is noted that the development is not assessed under Sydney DCP 2012, however this has been referred for general guidance only. Section 4.2.3.11 'Acoustic privacy' of the City of Sydney Development Control Plan 2012 sets out the following relevant guidelines, inclusive of fixed noise level criteria:

> *"(2) Where necessary, a residential development is to include acoustic measures to reduce the impact of noise from external sources.*
>
> *(3) Development is to incorporate measures that reduce the entry of noise from external sources into dwellings.*
>
> *(4) Where possible, the attenuation of noise at its source is preferred. Where this option is adopted, the applicant will need to demonstrate that the measures to be undertaken:*
>
> *(a) have the consent of relevant parties associated with that noise source; and*
>
> *(b) last for the life of the development proposal.*

(7) The repeatable maximum LAeq (1 hour) for residential buildings and serviced apartments must not exceed the following levels:

(a) for closed windows and doors:

(i) 35dB for bedrooms (10pm-7am); and

(ii) 45dB for main living areas (24 hours).

(b) for open windows and doors:

(i) 45dB for bedrooms (10pm-7am); and

(ii) 55dB for main living areas (24 hours).

(8) Where natural ventilation of a room cannot be achieved, the repeatable maximum LAeq (1hour) level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:

(a) 38dB for bedrooms (10pm-7am); and

(b) 48dB for main living areas (24 hours).

(9) These levels are to include the combined measured level of noise from both external sources and the ventilation system operating normally.

As the criteria does not stipulate the type of noise source that the criteria is applicable to, it is assumed to be applicable to all sources of noise typical of the city environment, which would include patron and pedestrian noise.

3.2.3.3 AS2107:2000

Australian Standard 2107:2000 sets recommended internal noise levels for steady/quasi-steady state sounds such as road traffic noise. Noise from patrons and the public is not necessarily steady/quasi-steady state and therefore have not been relied upon.

3.2.3.4 AAAC Star Ratings

The Association of Australian Acoustical Consultants (AAAC) also provides guidance on internal noise levels within residential premises[4]. The AAAC guideline and star rating system adopts an L_{Aeq} criteria for continuous noise sources, similar to the City of Sydney Policy, but also includes an average L_{AMax} criteria for intermittent noises. Table 8 presents the external noise intrusion criteria from the rating system.

[4] Association of Australian Acoustical Consultants (AAAC), Nov 2009, Acoustical Star Ratings For Apartments and Townhouses

Table 8: AAAC Star Ratings for Residential Internal Noise Levels

Descriptor	AAAC Star Rating and Internal Noise Level				
	2 Star	3 Star	4 Star	5 Star	6 Star
Bedrooms					
Continuous noises L_{Aeq} ≤	36dB(A)	35dB(A)	32dB(A)	30dB(A)	27dB(A)
Intermittent noises ave L_{Amax} ≤	50dB(A)	50dB(A)	45dB(A)	40dB(A)	35dB(A)
Other habitable rooms including open kitchens					
Continuous noises L_{Aeq} ≤	41dB(A)	40 dB(A)	37 dB(A)	35 dB(A)	32dB(A)
Intermittent noises ave L_{Amax} ≤	55dB(A)	55 dB(A)	50 dB(A)	45 dB(A)	40dB(A)

Notes: Measurements are made in bedrooms and any nominated habitable rooms. Bedrooms are measured over a period between 2200hrs and 0700hrs. Noise measurements in other habitable rooms are undertaken between 0600 to 2400hrs. In any event the measurement period must be representative of the noise being measured. Measurements must include LAeq and LAmax.

3.2.3.5 WHO Guidelines

The Guidelines for Community Noise developed by the World Health Organisation (WHO) seek to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments. The WHO guidelines suggest that to avoid sleep disturbance, indoor guideline values for bedrooms are L_{Aeq} 30 dB(A) for continuous noise and single noise events should not exceed more than L_{Amax} 45 dB(A) approximately ten times per night.

3.2.3.6 Retail noise criteria summary

Preliminary assessment has been based upon the current City of Sydney DCP. Further consideration may need to be given to the expected standard of residential occupancy and it would be beneficial to measure and reference other deemed satisfactory developments.

3.2.4 Road traffic noise

Noise impact as a result of increased traffic generated on the surrounding road network is required to be assessed in accordance with the EPA Environmental Criteria for Road Traffic Noise (ECRTN) as prescribed in the SEARs. This aspect of the project was assessed on a site wide cumulative basis in the Concept Plan acoustic assessment[5]. The assessment revealed compliance with the SEAR's and therefore further discussion has not been included in this assessment report.

3.3 Assessment and recommendations

3.3.1 Mechanical plant noise

Detailed specifications of mechanical services equipment that would otherwise allow an acoustic assessment of noise emission from the site are not available for this Application report. In line with the

[5] Renzo Tonin & Associates, TG015-01F05 (rev 7) Stage 1 Acoustic Assessment, 15th March 2013.

approval process for development within the City of Sydney area, detailed assessment of operational noise emission from mechanical services equipment should form a conditional requirement of the development, to be satisfied prior to the issue of the construction certificate.

While the intent of this assessment is to identify potential impacts at sensitive receivers surrounding the site, the acoustic objectives of the INP will also be desired to be met at sensitive receptors within Darling Square, being situated in closer proximity to any new mechanical plant equipment. Therefore the nearest most sensitive receptors to operational noise from the development will generally be the residential occupancies of Darling Square, and therefore will be the determining locations for the acoustic design. By satisfying the relevant criteria at sensitive receptors within Darling Square, compliance should readily be achieved at surrounding noise sensitive receptors.

Mechanical plant such as rooftop exhausts, air-conditioning and refrigeration associated with the development should be assessed at the time of detailed design and selection, having regard to nearby residential and commercial properties surrounding the development, and to future development within Darling Square. Any noise emissions from building services associated with the NE Plot shall be acoustically treated, where necessary, to comply with relevant Government policies. Although at this stage details of mechanical plant have not been finalised, the following review of NE Plot design has been carried out and noise management measures are provided for mechanical plant servicing the proposed development.

The NE Plot design currently includes the following primary mechanical plant and equipment:

- Retail tenancy air-conditioning
- Retail kitchen and toilet exhausts
- Residential air-conditioners
- Residential kitchen and toilet exhausts
- Car park exhaust and supply fans

While a kitchen exhaust fan is to be located on the roof of NE2, the majority of retail and car park associated plant and equipment will be located within the building rather than rooftop locations, therefore reducing noise emission from the site to surrounding areas. This includes air-conditioning equipment for the retail areas. While discharge and intake will need to be ducted to external locations, sufficient scope is considered to be provided for any necessary acoustic treatment along these paths.

Residential air-conditioners are proposed to be located in acoustically treated areas at various levels or on the rooftop of the primary towers. In any case, strategic location, selection of low noise level condensers (Day/night mode) and potential localised acoustic treatment is expected to be required for control of noise from residential air-conditioner units.

Other residential equipment such as kitchen and toilet exhausts, which are to be horizontally discharged from each apartment, are typically low noise level equipment and are adequately attenuated via the required ductwork.

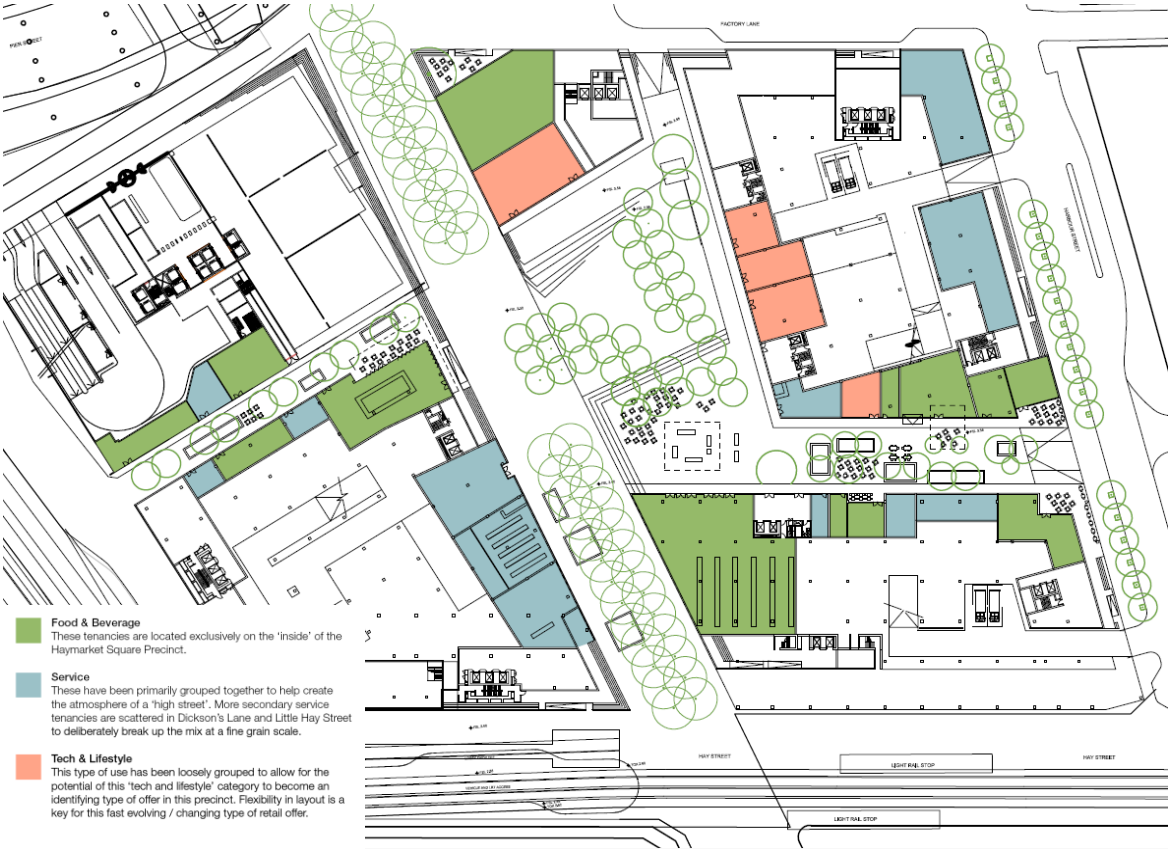
Notwithstanding the above, note should be taken of the following:

- Acoustic assessment of mechanical services equipment should be undertaken during the detail design phase of the development to ensure that the cumulative noise of all equipment does not exceed the applicable noise criteria. Development Consent Conditions typically require detailed assessment of mechanical plant and equipment prior to issue of the Construction Certificate.
- Noise control treatment can affect the operation of the mechanical services system. An acoustic engineer should be consulted during the initial design phase of mechanical services system to reduce potential redesign of the mechanical system.
- Mechanical plant noise emission can be controlled by appropriate mechanical system design and implementation of common engineering methods, which may include:
  - procurement of 'quiet' plant
  - strategic positioning of plant away from sensitive neighbouring premises to maximise intervening acoustic shielding between the plant and sensitive neighbouring premises
  - commercially available acoustic attenuators for air discharge and air intakes of plant
  - acoustically lined and lagged ductwork
  - acoustic barriers between plant and sensitive neighbouring premises
  - partial or complete acoustic enclosures over plant
- The specification and location of mechanical plant should be confirmed prior to installation on site, and
- Fans shall be mounted on vibration isolators and balanced in accordance with Australian Standard 2625 '*Rotating and Reciprocating Machinery – Mechanical Vibration*'.

3.3.2 Restaurants, cafes and retail operations (licensed and unlicensed)

This application does not define specific uses for each of the retail premises, and each use within the NE Plot will be subject to specific development applications. Notwithstanding, a high level assessment has been carried out for the indicative food & beverage premises and outdoor seating layout within the precinct, being the primary sources of noise emission from the retail component. Based on the indicative concept plan layout presented in Figure 4, the food & beverage and outdoor areas associated with the NE Plot are situated along the eastern, western and southern facades addressing the Darling Square and Harbour Street.

Figure 4: Indicative Darling Square ground floor retail plan



The nearest most sensitive receivers to the NE Plot retail component surrounding the site are hotels to the north and the east along Harbour Street. Noise levels from any uses are expected to be lower than the existing acoustic environment along Harbour St. These receptor locations are not considered significant constraints for the development of the proposed retail sector. Notwithstanding, these receptors should be considered in any detailed study of the future retail uses.

However the most sensitive receivers with respect to the retail uses will be residential apartments within Darling Square. While it is expected that this matter will require further detailed design and consideration, the following presents a conceptual design solution for Darling Square, a master planned, mixed use precinct situated at Darling Harbour in the middle of the CBD:

- Residential premises exposed to high external noise levels as a result of retail type and public realm activities will need to close windows in order to meet acceptable acoustic amenity objectives within dwellings. Alternative solutions for ventilation will be provided where windows and doors are required to be closed,
- 2.4m deep awnings are to be provided for all retail areas,
- The building envelope (primarily glazing system and floor/ceiling of first floor apartments above retail) will be designed to mitigate the intrusion of noise from external sources,

- Retail type premises will be designed such that they minimise noise transfer via the floor/ceiling to first floor apartments where they are located below a residential apartment, and
- Retail operations, particular use of outdoor areas is likely to be restricted to between 7am and 12 midnight only.

3.3.2.1 Future external noise levels

The noise assessment for SSDA7 has focussed on the lower levels of residential premises which will be most exposed to noise from Darling Square ground floor uses and activities. As the specific uses of retail type tenancies and use of the Darling Square are not defined, measurement results of areas considered to be similar to the future Darling Square site have been used for reference. We note that preliminary noise modelling of external areas associated with the retail type component also indicated noise levels in the order of L_{Aeq} 65-70dB(A) at the façade of first floor residential apartments. By reference to the L_{A1} noise levels, the maximum noise levels are generally within 10dB(A) of the L_{Aeq} and therefore satisfying the City of Sydney L_{Aeq} noise goals in bedrooms would also satisfy the WHO maximum noise level criteria of 45dB(A). Further supporting measurements and/or modelling be carried out during the design development process once detailed retail uses are established.

Table 9: Measured noise levels of comparable acoustic environments

Location	$L_{Aeq\ Period}$			$L_{A1\ period}$		
	Day	Evening	Night	Day	Evening	Night
Darling Walk	65	65	64	71	71	69
Harbourside, Darling Harbour	66	71	64	72	76	71

Notes Measurements carried out by Wilkinson Murray ref: Report No. 10232 NMP 120912 SF Version A

3.3.2.2 In-principle design recommendations

A preliminary assessment has been carried out for lower level residential apartments located above retail uses and addressing Darling Square in order to provide an indication of the potential acoustic mitigation measures and demonstrate that the noise objectives can be practically achieved. Acoustic treatment to apartments on higher floors and less exposed orientations would have reduced acoustic requirements.

Assuming external noise levels at the façade of first floor residential premises ('free field' level) to be between 65 and 70dB(A), the following in-principle building envelope treatments are likely to be required when considering the internal noise level criteria set out within the City of Sydney DCP 2012. The acoustic recommendations focus on the window/door glazing as it is typically the weakest element of the building envelope in regard to noise intrusion.

Table 10: Indicative acoustic treatment options, External noise level L_{eq} 65 to 70dB(A)

Room type	Internal criteria	Façade element	Acoustic rating (Rw)	Indicative construction
Bedroom	L_{Aeq} 35	Glazing	35 – 42*	• 10.38mm laminated glazing with acoustic seals, up to Laminated double glazed, insulated glazing unit, or • Balcony operable glazing and secondary single glazing.
Living Rooms and other habitable Areas	L_{Aeq} 45	Glazing	28 - 33	• 6.38mm laminated glazing with acoustic seals, up to 10.38mm laminated glazing with acoustic seals or • Balcony operable glazing and secondary single glazing.

Notes: Bedroom - 12m^2 floor area, glazing area 5.5m^2
Living Room - 30m^2 floor area, glazing area 12m^2
Wall construction is recommended to have an acoustic performance 10-15dB greater than the specified glazing.
* Higher Rw performance expected that is not directly relative to the dB difference in external noise level.

It is noted that the floor/ceiling construction of first floor apartments is also expected to require acoustic treatment, however will be dependent upon the nature of the ground floor use. Given that the building construction will comprise a concrete slab separating the ground floor retail and first floor residential occupancies, acoustic upgrade is likely to be in the form of a supplementary acoustically sealed ceiling in the retail tenancy.

Consideration of existing operations, such as licensed premises (Pumphouse), also needs to be given in terms of their potential to affect the acoustic amenity of the future residential development. As noted above, the control of noise from such premises is best achieved at the source; however an existing premise may not readily controlled either through negotiation with operators or legislation. It is noted that the OLGR considers order of occupancy when assessing noise complaints and therefore it should not be expected that a premises will comply with the standard noise criteria when encroachment has occurred by a new residential receiver. It is noted that measurement carried out in proximity to the Pumphouse revealed noise levels lower than 70dB(A) at the alignment of the future NE Plot building. Where necessary, affected residential premises should be designed in accordance with the principles outlined above.

3.3.3 Car park and loading dock activity

As the car parks and loading docks are situated within the core of the building, noise emission is not expected to impact any surrounding receivers. Noise from these activities will be most pertinent with regards to the amenity of residential apartments within the NE Plot, particularly where they back directly onto the car park area. This aspect should be addressed during the design development of the building so as to ensure appropriate acoustic separation is provided between the car park and residential uses.

4 Road traffic and light rail noise onto the development

In accordance with the SEARs, impact from road and rail should be assessed in accordance with the NSW State Environmental Planning Policy (Infrastructure) 2007 (known as the 'ISEPP').

With regard to road traffic, all of the surrounding roads are identified as being below 40,000AADT [http://www.rta.nsw.gov.au/publicationsstatisticsforms/downloads/traffic_volume_maps/uts_esa_map_16.pdf] and therefore do not require assessment in accordance with the ISEPP. Notwithstanding, the design of buildings may still give regard to road traffic noise intrusion. Typically single pane glazed systems with acoustic seals would be sufficient for road related noise intrusion at the subject site.

Potential noise and vibration impact form operation of the light rail was assessed in the concept plan and at previous detail development applications. The NE Plot is sufficiently removed from the light rail corridor and will also be acoustically shielded by the future buildings, of the SW and SE Plots.

PART B - Construction assessment

This part of the assessment discusses construction noise and vibration impacts associated with the proposed North East Plot development onto existing noise and vibration sensitive receivers.

5 Projected program and schedule

5.1 Darling Square development program

At this stage of the development the program for construction of Darling Square is not confirmed and will be dependent upon both the approvals process and market factors. However an indicative development program is set out below, in order to provide an indication of the potential overlap in works. It is noted that approval has already been granted for Demolition, West Plot, South West Plot and North West Plot.

- Car Park Demolition — Late 2014 to early 2015
- West Plot — Early 2015 to late 2016
- North West — Mid 2015 to early 2017
- South West — Mid 2015 to late 2017
- Demolition Entertainment Centre — Early 2016 to mid 2016
- **North and North East — Mid 2016 to early 2019**
- South East — Early 2018 to mid 2020

The indicative program above suggests that there will be periods where more than one section of Darling Square will be under construction; however they are expected to be at different stages of development. For the NE Plot excavation and structures work, this assessment has considered the potential cumulative impact of the North, North-East and South-East sites.

5.2 Construction hours

The proposed construction hours are to be consistent with the approved construction hours for the Stage 1 Concept Plan (SSDA2), and are presented in Table 11.

Table 11: Proposed work hours

	Monday to Friday	Saturday	Sunday/ Public holiday
Work Hours	7:00am to 7:00pm	7:00am to 5:00pm	No work

It is possible that some works will need to occur outside the hours set out above, although specific details of this are not known at this stage of the development. The justification for these out-of-hours works is that they would be in areas that would impact on and potentially put at risk the general public if undertaken during the standard work hours. The delivery of large items such as structural steel beams may also be undertaken at night so as to reduce potential interruptions to road traffic.

5.3 Construction Traffic

Delivery of most plant, equipment and materials to the site will be undertaken during standard work hours. However, during the various stages of construction works, there will be instances where oversized deliveries are necessary. Oversized movements can cause disruptions to the existing traffic, and can be a potential hazard for road users. Therefore there is a requirement for these vehicles to move during off-peak hours when traffic volumes are typically at a minimum, thereby ensuring road user and public safety and minimising disruption to road network users.

Traffic generated during the construction phase is expected to be minimal in comparison to the existing road traffic surrounding the site. Major truck movements for spoil removal during the demolition phase and delivery of concrete during the construction are estimated to average four vehicles per hour. The impact from construction generated traffic is therefore assessed not to be material in the content of existing traffic conditions, hence is not discussed further in this report.

6 Construction noise and vibration objectives

6.1 Construction noise objectives

6.1.1 Construction noise management levels

The ICNG sets out noise management levels (NMLs) and guidelines as to how they are to be applied. Table 12 below sets out the ICNG NMLs for residential receivers (reproduced from Table 2 of the ICNG) modified only with the project specific standard hours.

Table 12: Noise management levels at residential receivers

Time of Day	NML $L_{Aeq\ (15\ min)}$	How to Apply
Project standard hours: - Monday to Friday 7am to 7pm - Saturday 7am to 5pm - No work on Sundays or public holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB(A)	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 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Table 13 following sets out the noise management levels for various noise-sensitive land use developments, including commercial premises.

Table 13: Noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

Notes: Noise management levels apply when receiver areas are in use only.

As identified for residential receivers, at all other noise sensitive receivers a highly affected noise objective of $L_{Aeq(15min)}$ 75dB(A) shall apply. Construction activity noise above this level should be handled as described in Table 12 above.

6.1.2 Site specific construction noise objectives

From the existing background noise levels reported in Section 2.2, the site specific construction noise objectives are summarised in Table 14.

Table 14: Construction noise management levels (NMLs) for Darling Square

Receiver ID	Day - Noise Management Level, $L_{Aeq,15min}$ dB(A)
R1 - The Peak	68
R2 - Holiday Inn	71
R3 - Seasons	71
R4 - Novotel Rockford	71
C1 - Market City	70[1, 2]
C2 - Restaurants on Harbour St	70[1, 2]
C3 - Pumphouse	70[1, 2]
E1 - UTS	45[1, 3]

Notes:
1. Noise management levels apply when receiver areas are in use only.
2. NML applies to external areas
3. NML applies to internal areas

6.2 Construction vibration objectives

6.2.1 Disturbance to building occupants

For disturbance to human occupants of buildings, we refer to DECC's 'Assessing Vibration; a technical guideline', published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. Vibration sources are defined as Continuous, Impulsive or Intermittent. Table 15 provides a definition and examples of each type of vibration.

Table 15: Types of vibration

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, ie. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced below. In this assessment, commercial premises are included in the 'Offices, schools, educational institutions and places of worship' category of Table 16 below.

Table 16: Preferred and maximum levels for human comfort

Location	Assessment period [1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration [3] (Weighted RMS Acceleration, m/s^2, 1-80Hz)					
Critical areas [2]	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night time	0.020	0.014	0.040	0.028
Workshops	Day- or nighttime	0.04	0.029	0.080	0.058
Impulsive vibration [3] (Weighted RMS Acceleration, m/s^2, 1-80Hz)					
Critical areas [2]	Day or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92
Intermittent vibration [4] (Vibration Dose Values, VDV, $m/s^{1.75}$, 1-80Hz)					
Critical areas[2]	Day or night-time	0.10		0.20	
Residences	Daytime	0.20		0.40	
	Night-time	0.13		0.26	
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40		1.60	
Workshops	Day or night-time	0.80		1.60	

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (eg. relevant standards) should be referred to. Source: BS 6472-1992
3. For continuous and impulsive vibration the preferred and maximum values are weighted acceleration rms values (m/s^2)
4. For intermittent vibration the preferred and maximum values are vibration dose values (VDVs), based on the weighted acceleration values ($m/s^{1.75}$)

6.2.2 Structural damage to buildings

Limits for construction generated vibration have been determined using the vibration limits set out in the German Standard DIN 4150 Part 3-1999 Structural Vibration in Buildings – Effects on Structures.

The German standard DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures", also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum limit of vibration at low frequencies for commercial and industrial buildings is 20mm/s. For dwellings it is 5mm/s and for particularly sensitive structures (e.g. historical with preservation orders etc.), it is 3mm/s. These limits increase as the frequency content of the vibration increases. These values are presented in Table 17 below and are generally recognised to be conservative.

Table 17: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg. buildings under a preservation order)	3	3 to 8	8 to 10	8

7 Construction noise assessment

7.1 Equipment list and source noise levels

Noise generated from the site will vary depending on the level and specific type of activity carried out, as well the number of items of plant equipment operating at any one time. Table 18 provides the Sound Power Levels (LW) of plant likely to be used during the Project construction period for the North, North-East and South-East sites Plots.

Table 18: Construction plant source levels - For each Plot

Equipment Type	Indicative Size	Indicative No. of Equipment per phase		Sound Power Level, dB(A) Lw re: 1pW
		Excavation	Construction	L_{Aeq}
Air Compressor - Silenced	8 kW	-	1	109
Backhoe	8 t	2	1	100
Backhoe with Hydraulic Breaker	67 kW	2	-	116
Cherry Picker	6 t	-	1	106
Concrete Pump	6 t	1	1	103
Concrete Saw	9 kg	1	-	119
Concrete Vibrator	2 kW	-	1	97
Crane - Mobile	55t	-	1	98
Crane - Diesel	22 t	-	2	104
Excavator w bucket	45 t	2	-	105
Excavator w bucket	12 t	1	-	102
Generator - Diesel	100 kVA	-	2	94
Hoist - Twin cage high speed Alimak	0.5 t	-	1	96
Piling - Rotary bored cast in-situ	110 t	1	1	111
Pneumatic Hand Tools (general)		2	1	111
Pneumatic Jack Hammer	20 kg	2	-	121
Power Generator	28 kg	1	1	102
Roller - Vibratory (pad foot)	20 t	1	1	108
Truck - Cement Mixer	26 t	-	4 p/hr	104
Water Cart	10-12t	1	1	107
Welders - welding & cutting steel piles		1	1	101

Note: Source:- Renzo Tonin & Associates Construction Noise Database (QTD-06 (rev 5))
LA1 only noted for equipment potentially used during the night period (as noted in the Construction Program in Appendix C)

7.2 Predicted Noise Levels

7.2.1 During standard (daytime) construction hours

Noise emissions were determined by modelling the noise sources, receiver locations, and operating activities, based on the information presented above. Due to the nature of construction works, each aspect or stage of construction is to be carried out consecutively (rather than concurrent). Predicted noise levels have therefore been modelled for each stage and inclusive of the cumulative impact of all three Plots (N, NE and SE).

Table 19 following presents a summary of the predicted L_{Aeq} noise levels for each stage of the Darling Square project during standard (day time) construction hours. Noise predictions have been conservatively assessed on the basis of the following:

- All plant and equipment for each stage operating concurrently
- No acoustic shielding has been assumed for future structures on site. As the site works progress, acoustic shielding will be provided by the constructed structures to some locations. The modelling conservatively assumes a clear unobstructed site.
- A 30dB(A) reduction from outside to inside for adjacent UTS building assuming closed windows.
- No consideration of site hoardings or other forms of shielding have been considered in the modelling

Table 19: Summary of predicted L_{Aeq} levels (standard construction hours)

Receiver ID	Noise management level, dB(A)	Predicted L_{Aeq} noise levels, dB(A)	
		Excavation	Construction - structures
R1 - The Peak	68	82	74
R2 - Holiday Inn	71	87	79
R3 - Seasons	71	79	71
R4 - Novotel Rockford	71	82	74
C1 - Market City	70[1]	88	80
C2 - Restaurants on Harbour St	70[1]	87	79
C3 - Pumphouse	70[1]	84	76
E1 - UTS	45[2]	57	49

Notes: 1 - NML applies to external areas
2 - NML applies to internal areas

Noise impacts during the excavation and primary construction of the South West, North West and West Plots of Darling Square have been predicted and compared to the noise management levels for the day period. Exceedance of the noise management levels are predicted for the construction works. The primary locations predicted to be affected are identified as the Novotel Rockford, Holiday Inn and The Peak. On the basis of these findings, consideration should be given to the following recommendations

specific to the management of noise impact at those locations. General recommendations for the site wide management of noise are also provided.

7.3 Recommendations

The following at-source control and management measures should be considered for the management of noise from construction works to reduce potential noise impacts. The management measures are focused on minimising unnecessary noise generation from the site and the extent and duration of peak noise levels.

Table 20: Construction noise management measures

Measure	Detail
Source controls	
Noise barriers	Where possible, stage development so that structures provide acoustic shielding to sensitive receiver locations. Construct the proposed solid site hoarding as soon as practical. Where possible, stationary equipment should be located to make most use of the solid hoarding. Barriers or enclosures around stationary plant should also be considered where it is required to be located in close proximity to sensitive receivers.
Location equipment	Loading/unloading zones and stationary plant such as generators should where practicable be located away from the most sensitive receivers, in this case the nearest buildings of the adjacent school.
Equipment selection	Use the quietest and least vibration emitting construction methods where feasible and reasonable.
Limit equipment in use	Only the equipment necessary for the upgrade works will be used at any time. Avoid any unnecessary noise when carrying out manual operations and when operating plant Simultaneous operation of noisy plant and equipment within discernible range of a sensitive receiver should be avoided/ limited where possible.
Limit activity duration	Any equipment not in use for extended periods shall be switched off. For example, heavy vehicles should switch engines off whilst being unloaded.
Reversing alarms	Alternative reverse alarm, such as 'quackers' should be installed where feasible and reasonable.
Management measures	
Implement community consultation measures	Inform community of construction activity and potential impacts
Develop good relations	Good relations with building occupants should be established at the beginning of the works and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the building occupants should be adequately trained and experienced in such matters.
Work staging	Where practical, stage works so that that intrusive works are carried out at least noise sensitive periods.

Measure	Detail
Site inductions	All employees, contractors and subcontractors are to receive a Project induction. The environmental component may be covered in toolboxes and must include: • all relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries), and • environmental incident procedures
Complaints management procedure	A management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
Noise monitoring	Noise and vibration monitoring should be carried out for any identified sensitive works, where monitoring could be used to proactively identify noisy works that may be otherwise managed and mitigated.

8 Vibration assessment

8.1 Vibration sources

The vibration generated from demolition and construction works associated with the North East Plot will vary depending on the level and type of activity carried out at each site during each activity. Typical plant and equipment in use have been identified in Table 18.

Table 21 below identifies the dominant vibration generating plant and equipment. Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. Typical levels of ground vibration from these sources are shown in Table 21.

Table 21: Construction plant vibration levels

Plant Noise Source	Indicative Size	PPV Vibration (mm/s) at distance from plant					
		5m	10m	15m	20m	30m	40m
Bobcat		<0.5					
Backhoe/ Excavator & Breaker	Light	4.5	1.3	-	0.4	0.2	0.15
Excavator (travelling)	Medium	8.0	3.4	1.6	-	-	-
Excavator (digging)	Medium	5.8	4.0	1.0	-	-	-
Excavator & Breaker	Heavy	10.5	2.5	-	-	-	-
Excavator (travelling)	Heavy	8.0	3.4	1.6	-	-	-
Piling - Rotary bored cast in-situ		11.4	6.4	-	5.6	-	-
Pneumatic Jack Hammer		2	1	0.2	0.1	<0.1	<0.1
Roller - Vibratory (pad foot)	12t	15.1	10.3	3.2	-	-	-
Truck & Trailer	≤45t net	14.5	10.3	3.4	-	-	-
Water Cart	10-12t	0.2					

Notes: Source – Renzo Tonin & Associates database

8.2 Vibration Assessment

Vibration generated by construction plant was estimated at various distances and expected vibration impacts are shown in Table 22 below.

Table 22: Construction plant vibration levels

Approx. Distance	Assessment on potential vibration impacts		
	Structural damage risk	Human disturbance	Vibration monitoring
<20 m	Low risk of structural damage	Medium risk of adverse comment as a result of any rock breaking, excavator use and jackhammer	Vibration monitoring may be required (see Section 7.3.2).

Approx. Distance	Assessment on potential vibration impacts		
	Structural damage risk	Human disturbance	Vibration monitoring
20-<30 m	Low risk of structural damage	Low risk of adverse comment	Vibration monitoring may be required (see Section 7.3.2)
30-<70 m	Very Low risk of structural damage	Very Low risk of adverse comment	Not required
>70 m	Very Low risk of structural damage	Very Low risk of adverse comment	Not required

Due to the distance between the site and the nearest receivers, the risk of structural damage is assessed as being low. However, there is medium risk of adverse comment as a result of vibration generated by rock breaking, excavator travelling and jackhammers at receiver surrounding residential type receivers as the occupants may feel some vibration.

8.3 Vibration Control Measures

8.3.1 Recommended Minimum Buffer Distances

Based on available data from a database containing vibration measurements from past projects and from library information, Table 23 below presents the recommended minimum working distances for high vibration generating plant.

Table 23: Recommended minimum working distances for vibration intensive plant

Plant item	Rating / description	Min. working distance, m	
		Cosmetic damage[2]	Human response[3]
Bobcat	Travelling	1 (nominal)	Avoid contact with structure
Jackhammer	Hand held	1 (nominal)	Avoid contact with structure
Large Hydraulic Hammer	1600 kg	5	73
Excavator	<=30 Tonne (travelling/ digging)	5	15
Truck Movements[1]	Travelling loaded	5	10

Notes:
1. Renzo Tonin & Associates project files, databases & library
2. Based on DIN4150.3 Group 1 Buildings
3. For residential receivers

Site specific buffer distances shall be determined where vibration significant plant items, in particular large rock hammers/breakers, operate within cosmetic damage minimum working distances detailed in Table 23 above. Where this occurs, minimum buffer distances to affected receivers shall be determined by site measurements prior to the commencement of the regular use of the vibration significant plant on site. The site specific minimum working distance shall be maintained in order to comply with relevant vibration limits.

8.3.2 Vibration management measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers:

- At the commencement of operation for each plant or activity on site, which has the potential to generate significant vibration levels, attended vibration monitoring should be undertaken so to refine the recommended minimum working distances set out in Table 23 and provide a site-specific table of minimum working distances
- Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller rock breakers, using alternative processes or establishment of larger minimum working distances.
- Carry out additional vibration monitoring when construction activities are at the nearest point to the nearby sensitive structures. This monitoring may signal to the contractor by way of a buzzer or flashing light, when levels approach/exceed the recommended limits.
- Before, during and after the demolition and construction stages we recommend preparation of a dilapidation report on the state of the existing buildings sharing the property boundary with the site.
- It is further recommended that a vibration complaints management system be established prior to the commencement of these works.

9 Conclusion

Renzo Tonin & Associates has completed an assessment of noise and vibration in regard to the operation and construction phases of the North East Plot of Darling Square (SSDA7), being part of the SICEEP. The assessment has been carried out in accordance with the policies and guidelines specified in the Secretary's Environmental Assessment Requirements (SEARs). Where relevant the report has presented recommended mitigation and management measures for the control of noise and vibration for both the construction and operational phases of the development. The report has also identified where additional detailed assessment may be required during the design development phase of the project.

APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse Weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient Noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period	The period in a day over which assessments are made.
Assessment Point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background Noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L_{90} noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{eq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound Absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Manned measurement results

ID	Location	Date	Time	Desc	Overall dB(A)	Octave band centre frequency - Hz dB(Z)									Comments
						31.5	63	125	250	500	1k	2k	4k	8k	
1	Harbour St Restaurants	6/02/2013	12:02pm - 12:17pm	L_{10}	68	75	77	71	66	65	63	60	55	39	Noise sources: traffic on Harbour St, pedestrians, mech plant, restaurants Traffic count - 69
				L_{eq}	66	72	73	68	64	64	60	57	52	53	
				L_{90}	59	66	64	63	60	57	53	48	42	53	
			2:52pm - 3:07pm	L_{10}	66	72	74	69	66	63	61	57	52	41	Noise sources: traffic on Harbour St, pedestrians, mech plant, restaurants Traffic count - 72
				L_{eq}	66	69	75	68	64	64	61	56	52	53	
				L_{90}	59	64	64	62	60	56	53	47	41	49	
		8/02/2013	10:47pm - 10:55pm	L_{10}	65	72	71	66	63	62	61	57	50	36	Noise sources: Road traffic, pedestrian activity, mech plant audible between traffic, Cold Rock. L_{90} controlled by mech plant and distant traffic.
				L_{eq}	63	69	69	65	61	61	59	55	47	45	
				L_{90}	59	65	64	62	59	57	54	49	42	48	
		9/02/2013	12:07am - 12:22am	L_{10}	64	68	69	66	63	61	60	56	49	33	Noise sources: All restaurants closed. 15-20 ppl sitting outside McDonalds. Music from Covent Garden hotel audible. L_{90} controlled by mech plant.
				L_{eq}	61	66	67	64	60	58	57	52	45	46	
				L_{90}	57	63	63	60	57	55	52	46	39	46	
2	Harbour St - Holiday Inn	6/02/2013	12:23pm - 12:38pm	L_{10}	70	73	75	72	68	66	65	62	56	32	Noise sources: Traffic, pedestrians, distant mech plant. Vehicle count - 88
				L_{eq}	67	70	74	69	66	64	62	59	54	45	
				L_{90}	59	66	65	62	60	56	53	48	41	52	
			2:28pm - 2:44pm	L_{10}	68	76	74	69	66	64	64	59	54	34	Noise sources: Traffic, pedestrians, distant mech plant. Vehicle count - 76
				L_{eq}	65	73	71	67	64	61	61	57	53	51	
				L_{90}	57	65	65	62	59	55	52	47	39	56	
		8/02/2013	11:55pm - 12:10am	L_{10}	66	70	73	69	64	62	62	58	50	32	Noise sources: L_{90} controlled by mech plant from SEC. Local traffic on Harbour St, dist traffic on Goulbourn St. Pedestrian activity. ~15 patrons outside JB's bar - generally inaudible above pedestrians.
				L_{eq}	64	68	71	67	61	60	60	58	52	37	
				L_{90}	57	63	63	61	58	55	52	46	39	39	
		9/02/2013	12:34am - 12:49am	L_{10}	67	68	74	68	64	63	63	59	52	29	Noise sources: Road traffic on Harbour St & distant traffic on Goulburn St and pedestrians.
				L_{eq}	65	66	74	67	64	62	60	56	51	40	

ID	Location	Date	Time	Desc	Overall dB(A)	Octave band centre frequency - Hz dB(Z)									Comments
						31.5	63	125	250	500	1k	2k	4k	8k	
				L_{90}	56	62	62	59	57	54	51	46	38	38	
3	Harbour St - Harbour Plaza	6/02/2013 6/02/2013	12:51pm - 01:06pm	L_{10}	72	80	78	74	69	68	67	63	59	35	Noise sources: Road traffic on Harbour St and Goulburn St. Traffic queuing at intersection. Vehicle count - 80
				L_{eq}	69	78	75	71	67	65	64	60	56	44	
				L_{90}	62	69	69	64	62	59	57	52	47	49	
			2:11pm - 2:27pm	L_{10}	69	77	76	71	68	65	64	59	54	41	Noise sources: Road traffic on Harbour St and Goulburn St. Traffic queuing at intersection. Vehicle count - 96
				L_{eq}	66	74	73	71	67	63	61	57	52	48	
				L_{90}	62	70	68	64	62	59	57	52	46	52	
		8/02/2013	10:58pm - 11:13pm	L_{10}	66	78	76	71	66	64	61	57	52	37	Noise sources: L_{90} controlled by mech plant and traffic idling at intersection. Distant traffic, pedestrians. Crowd departing SEC after 11pm.
				L_{eq}	64	75	73	69	64	62	59	55	49	43	
				L_{90}	61	69	68	64	61	58	55	51	44	46	
		9/02/2013	12:11am - 12:27am	L_{10}	67	75	73	70	65	63	62	58	52	36	Noise sources: L_{90} controlled by mech plant and traffic idling at intersection. Distant traffic, pedestrians.
				L_{eq}	64	71	71	69	63	60	59	55	49	41	
				L_{90}	59	64	64	61	58	55	54	49	42	41	
4	Novotel	6/02/2013	1:08pm - 1:23pm	L_{10}	63	74	73	68	64	60	57	54	52	30	Noise sources: Road traffic on Harbour St, and Goulburn St. L_{90} controlled by distant traffic and mech plant. Insects intermittent.
				L_{eq}	61	71	70	67	62	58	55	51	47	34	
				L_{90}	58	66	66	62	59	56	52	48	41	36	
			1:24pm - 1:40pm	L_{10}	63	73	72	67	63	60	58	56	50	29	Noise sources: Road traffic on Harbour St, and Goulburn St. L_{90} controlled by distant traffic and mech plant. Insects intermittent.
				L_{eq}	61	71	70	65	62	58	56	53	47	43	
				L_{90}	58	66	65	61	59	56	52	48	42	45	
		8/02/2013	11:37pm - 11:53pm	L_{10}	62	73	71	67	62	59	57	54	48	29	Noise sources: L_{90} controlled by mech plant and dist traffic. SEC crowds dispersed. Typical pedestrian activity.
				L_{eq}	60	70	69	64	60	57	55	52	45	44	
				L_{90}	58	67	65	61	58	55	52	48	41	47	

ID	Location	Date	Time	Desc	Overall dB(A)	Octave band centre frequency - Hz dB(Z)									Comments
						31.5	63	125	250	500	1k	2k	4k	8k	
		9/02/2013	12:31am - 12:48am	L_{10}	59	68	70	65	60	56	54	51	45	33	Noise sources: L90 controlled by mech plant from SEC and above Pumphouse/Novotel. Pumphouse closed.
				L_{eq}	58	66	67	62	58	55	52	49	42	42	
				L_{90}	55	63	63	58	56	53	50	45	38	46	
5	Pumphouse	6/02/2013	12:54pm - 1:09pm	L_{10}	63	71	72	69	64	60	58	53	50	30	Noise sources: L_{90} controlled by fountain located under Pier St overpass. Mech plant from Novotel, traffic on Goulburn St and Harbour St. Patron noise from Pumphouse indistinguishable from pedestrians.
				L_{eq}	61	69	70	66	62	59	56	51	48	38	
				L_{90}	59	65	66	62	60	56	53	48	42	41	
			1:29pm - 1:44pm	L_{10}	63	72	72	68	64	61	58	54	50	26	
				L_{eq}	62	69	70	66	62	59	56	52	48	41	
				L_{90}	60	66	66	62	61	57	54	49	44	38	
		8/02/2013	10:42pm - 10:57pm	L_{10}	67	71	72	74	69	64	62	58	54	25	Noise sources: L_{10} controlled by music playing from Pumphouse (doors open) and mech plant from SEC and Novotel. No patrons visible in Pumphouse. Fountain not operating. Pedestrians. Light traffic on overpass.
				L_{eq}	65	70	70	71	67	62	61	56	51	40	
				L_{90}	63	66	67	66	63	59	56	52	47	36	
		8/02/2013	11:21pm - 11:36pm	L_{10}	66	75	72	78	66	64	61	56	50	31	Noise sources: Pumphouse closed, but music still playing, controlling L_{90}. Higher pedestrian activity due to patrons departing SEC event. Fountain off.
				L_{eq}	65	73	70	75	65	62	59	54	49	39	
				L_{90}	62	71	67	67	62	59	55	50	43	36	
		9/02/2013	12:50am - 1:05am	L_{10}	60	66	68	64	62	58	56	51	44	39	Noise sources: BG controlled by mech plant from SEC and Pumphouse/Novotel. Pumphouse closed.
				L_{eq}	59	64	66	62	60	57	54	49	41	53	
				L_{90}	57	62	62	58	58	55	51	45	37	53	
6	UTS	6/02/2013	12:01pm - 12:16pm	L_{10}	62	69	72	66	63	60	56	52	46	34	Noise sources: Two tram pass-bys (corner squeal, impulsive at expansion joints in concrete). Distant mech plant and traffic from CBD. Traffic, incl. trucks on Harbour St.
				L_{eq}	61	70	70	65	61	59	57	52	48	51	
				L_{90}	55	63	63	60	56	53	50	44	37	56	

ID	Location	Date	Time	Desc	Overall dB(A)	Octave band centre frequency - Hz dB(Z)									Comments
						31.5	63	125	250	500	1k	2k	4k	8k	
			2:38pm - 2:53pm	L_{10}	62	70	72	68	63	60	57	53	45	32	Noise sources: Three tram pass-bys (corner squeal, impulsive at expansion joints in concrete). Distant mech plant and traffic from CBD. Traffic, incl. trucks on Harbour St.
				L_{eq}	61	69	70	65	61	59	56	52	48	37	
				L_{90}	55	64	63	61	57	53	49	43	36	39	
		8/02/2013	11:48pm - 12:03pm	L_{10}	59	73	71	65	61	57	55	49	43	29	Noise sources: Road traffic on Darling Drive. L_{90} controlled by distant traffic and mech plant from CBD. Two light-rail pass-bys.
				L_{eq}	62	74	71	64	61	58	59	51	47	40	
				L_{90}	55	66	63	60	56	52	49	43	36	38	
7	Sydney Entertainment Centre	24/09/14	10:48pm - 10:51pm	L_{10}	58	67	67	63	59	56	53	49	47	35	Noise sources: Road traffic on Harbour Street. L_{90} controlled by distant traffic and mech plant from the Novotel.
				L_{eq}	57	65	65	61	58	55	52	48	43	32	
				L_{90}	56	63	62	59	56	54	51	46	37	26	
			10:55pm - 11:10pm	L_{10}	59	69	68	64	59	56	54	50	41	31	Noise sources: Road traffic on Harbour Street. L_{90} controlled by distant traffic and mech plant from the Novotel.
				L_{eq}	57	67	66	63	58	55	53	48	40	30	
				L_{90}	56	64	63	59	56	53	50	45	37	26	
8	Sydney Entertainment Centre	24/09/14	11:11pm - 11:20pm	L_{10}	59	71	68	65	61	57	54	49	41	32	Noise sources: Road traffic on Harbour Street and Pier Street. L_{90} controlled by distant traffic and mech plant from the Pumphouse.
				L_{eq}	58	68	66	63	59	55	53	48	40	30	
				L_{90}	56	65	63	59	57	53	50	45	37	26	

APPENDIX C Long-term noise monitoring methodology

C.1 Noise monitoring equipment

A long-term unattended noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave band data	Logger location(s)
RTA06 (NTi Audio XL2, with low noise microphone)	Type 1	1/1	L1, L2, L3

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4230 or 4231 calibrator. No significant drift in calibration was observed.

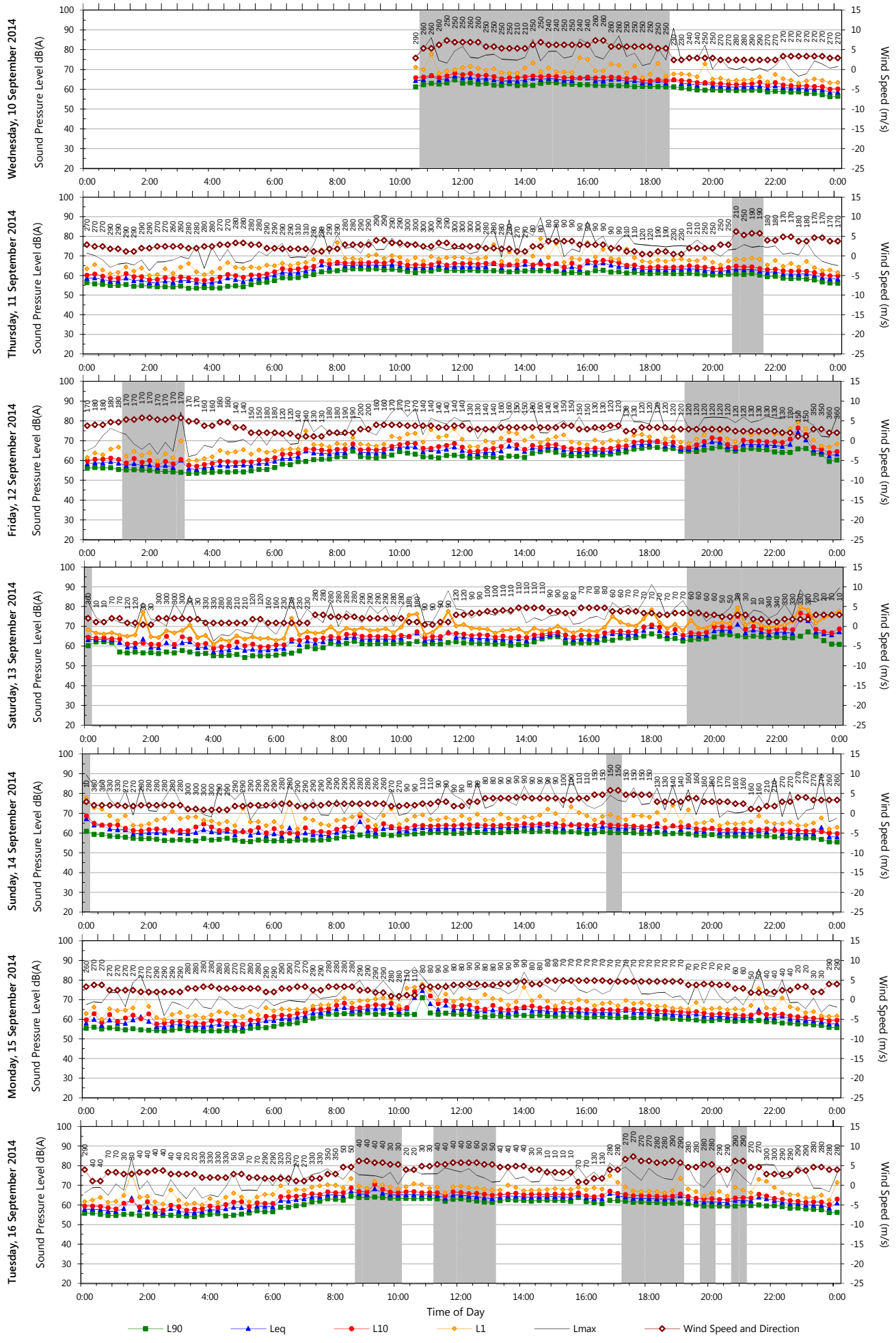
C.2 Meteorology during monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NSW INP. Determination of extraneous meteorological conditions was based on data provided by the Bureau of Meteorology (BOM), for a location considered representative of the noise monitoring location(s). However, the data was adjusted to account for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10m above ground level. The correction factor applied to the data is based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

C.3 Noise vs time graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. Measurement sample periods are usually ten to fifteen minutes. The Noise -vs- Time graphs representing measured noise levels, as presented in this report, illustrate these concepts for the broadband dB(A) results.

APPENDIX D Long-term noise monitoring results

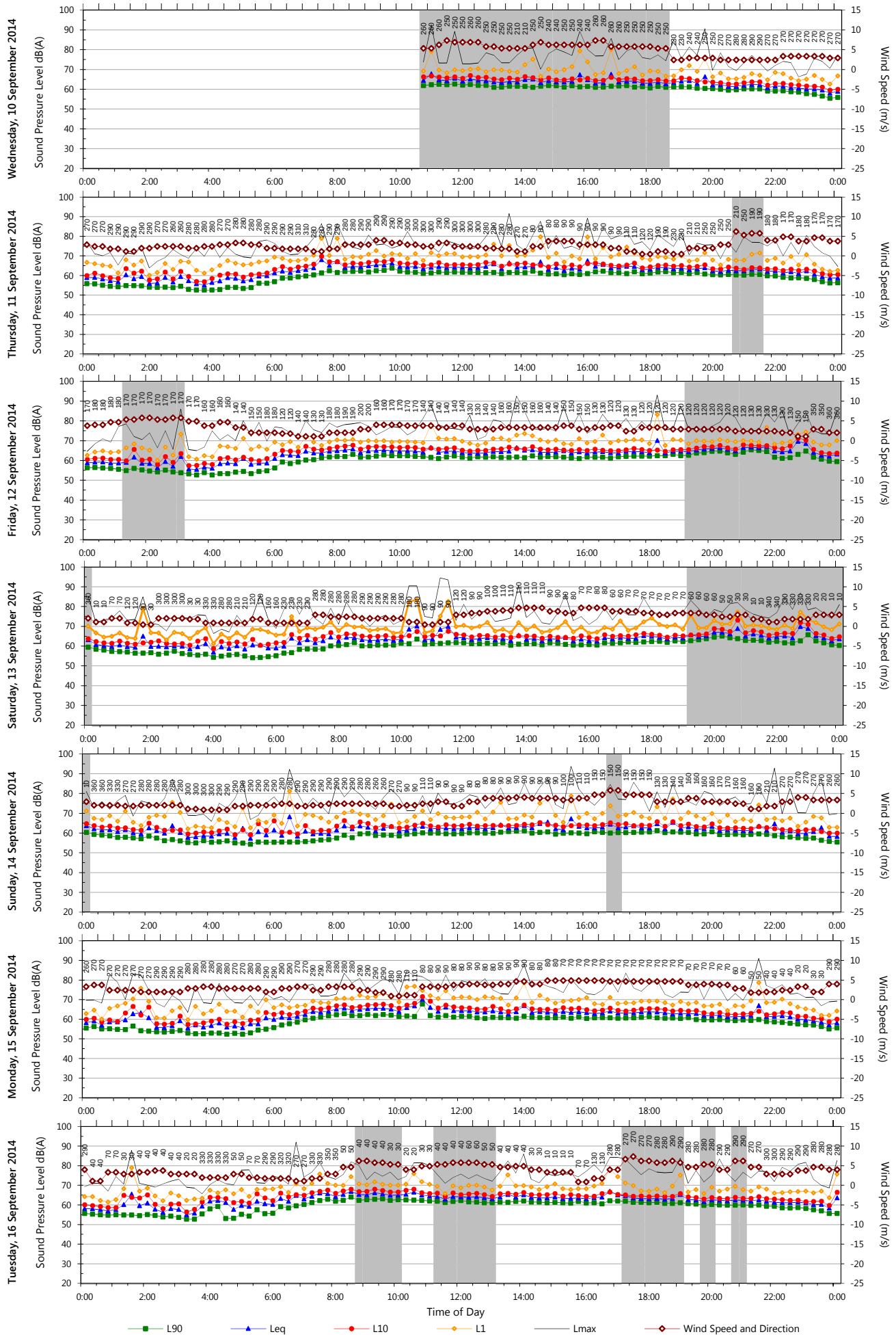


Data File: 2014-09-10_SLM_000_123_Rpt_Report.txt

Template QTE-05B (rev 109) Sydney Logger Graphs

Unattended Monitoring Results

Location: L2 - Sydney Entertainment Centre awning (north-east)

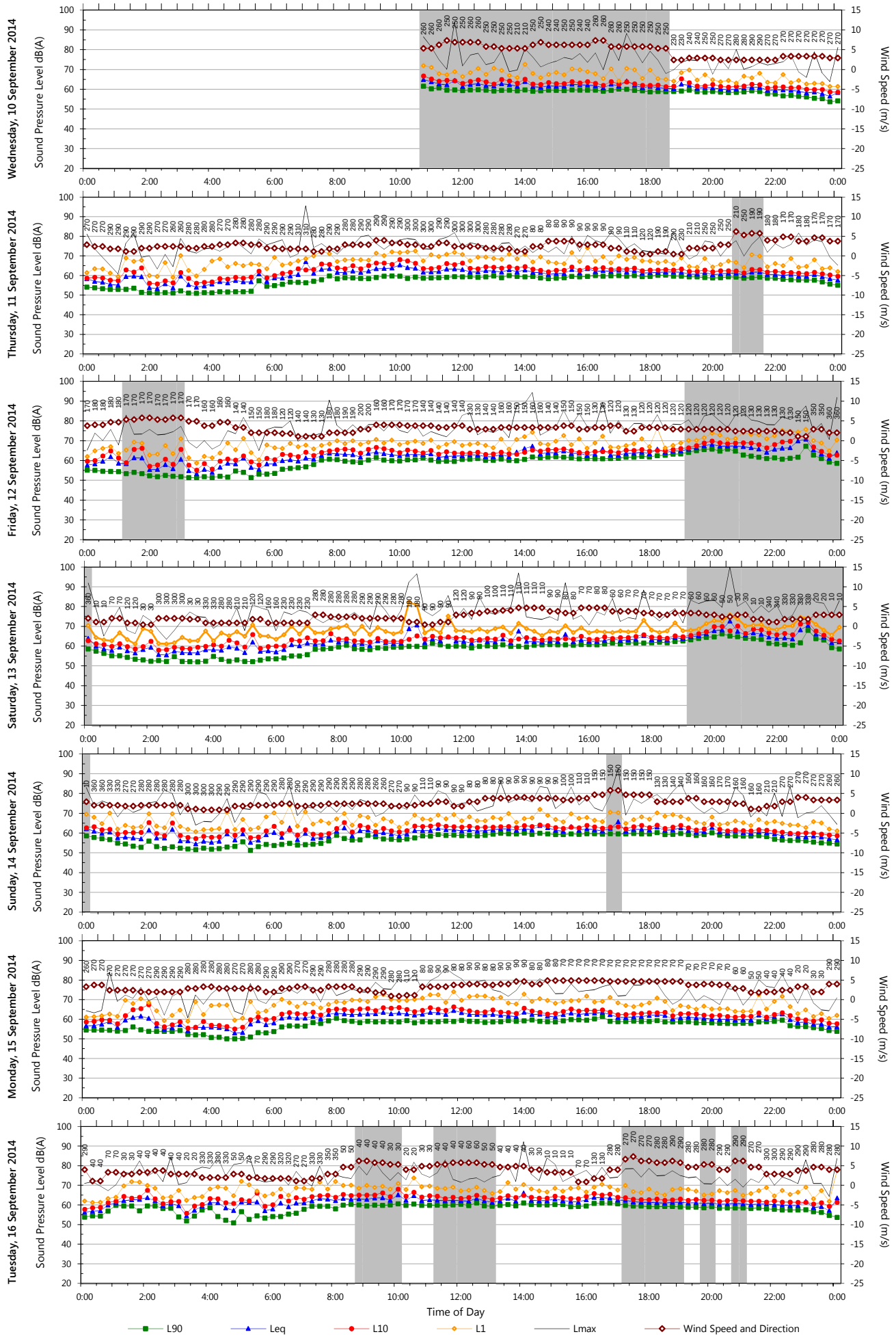


Data File: 2014-09-10_SLM_000_123_Rpt_Report.txt

Template QTE-05B (rev 109) Sydney Logger Graphs

Unattended Monitoring Results

Location: L3 - Sydney Entertainment Centre awning (south-east)



Data File: 2014-09-10_SLM_000_123_Rpt_Report.txt

Template QTE-05B (rev 109) Sydney Logger Graphs