

# ST LEONARDS HEALTH ORGANISATION RELOCATION (SHOR)

## Operational Noise & Vibration Assessment

24 January 2018

Savills Project Management

TJ514-03F02 Operational Noise & Vibration Assessment (rev B)

## Document details

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## Document control

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We have prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

The information contained herein is for the purpose of acoustics only. No claims are made and no liability is accepted in respect of design and construction issues falling outside of the specialist field of acoustics engineering including and not limited to structural integrity, fire rating, architectural buildability and fit-for-purpose, waterproofing and the like.

Supplementary professional advice should be sought in respect of these issues.

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# 1 Introduction

This report supports a State Significant Development Application (SSDA) submitted to the Department of Planning and Environment pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the St Leonards Health Organisations Relocation (SHOR) Project at the Royal North Shore Hospital (RNSH).

The SSD Application relates to the Concept Plan Approval for the Royal North Shore Hospital, St Leonards which was approved in April 2007 (MP 06\_0051). This application is SSD by way of Ministerial declaration pursuant to Section 89(C) of the EP&A Act, the order for which was published on 13 October 2017.

This proposal relates specifically to the construction of a new building on the south-western edge (identified as site 4A under the Concept Plan) of the RNSH Campus. Uses proposed include health-related commercial uses, retail and a child care centre.

This report has been prepared having regard to the Secretary's Environmental Assessment Requirements (SEARs) issued for the project.

Renzo Tonin & Associates were engaged by Savills Project Management to conduct an operational noise assessment in accordance with Condition 8 of the SEARs for the proposed St Leonards Health Organisation Relocation (SHOR) located on southern end of the Royal North Shores Hospital, Reserve Road, St. Leonards. More specifically, this report will provide in principle noise and vibration amelioration methods to reduce any potential acoustic impacts to nearby affected receivers during its operational usage.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

This assessment has been based on the following architectural and mechanical service drawings and specifications.

**Table 1: Drawings and Documents Reviewed**

| Drawing/Document Title                                             | Reference number | Date     | Revision |
|--------------------------------------------------------------------|------------------|----------|----------|
| <b>Architectural Drawings prepared by BVN Architecture Pty Ltd</b> |                  |          |          |
| Precinct Plan - Proposed                                           | AR-A-00-10       | 01.06.17 | A        |
| Site Plan - Proposed                                               | AR-A-00-11       | 01.06.17 | A        |
| Site Section – A & B                                               | AR-A-00-13       | 23.02.17 | A        |
| Site Section – C & D                                               | AR-A-00-14       | 23.02.17 | A        |
| Contract Site Plan – Proposed                                      | AR-A-00-40       | 27.02.17 | A        |
| GA Plan – Basement Level 1                                         | AR-B-B1-01       | 24.02.17 | A        |
| GA Plan – Basement Level 2                                         | AR-B-B2-01       | 24.02.17 | A        |

| Drawing/Document Title                                                                             | Reference number | Date     | Revision |
|----------------------------------------------------------------------------------------------------|------------------|----------|----------|
| GA Plan - Ground Level                                                                             | AR-B-00-01       | 30.10.17 | B        |
| GA Plan – Ground Level NLA Increase                                                                | AR-B-00-20       | 02.03.17 | A        |
| GA Plan – Level 1                                                                                  | AR-B-01-01       | 23.02.17 | A        |
| Access Floor Plan – Level 1                                                                        | AR-B-01-02       | 03.03.17 | A        |
| GA Plan – Level 1 – NLA Increase                                                                   | AR-B-01-20       | 02.03.17 | A        |
| GA Plan – Typical Level (levels 2-5, 7-9)                                                          | AR-B-02-01       | 23.02.17 | A        |
| GA Plan – Level 6 (Warm Shell)                                                                     | AR-B-06-01       | 23.02.17 | A        |
| GA Plan – Plant Level 10                                                                           | AR-B-10-01       | 28.02.17 | A        |
| GA Plan – Plant Level 10 with Skylight                                                             | AR-B-10-01       | 24.02.17 | A        |
| Roof Plan                                                                                          | AR-B-11-01       | 24.02.17 | A        |
| Roof Plan with Skylight                                                                            | AR-B-11-02       | 24.02.17 | A        |
| Section A-A                                                                                        | AR-D-XX-01       | 24.02.17 | A        |
| Section B-B                                                                                        | AR-D-XX-02       | 24.02.17 | A        |
| Elevation – North West                                                                             | AR-C-XX-01       | 24.02.17 | A        |
| Elevation – North East                                                                             | AR-C-XX-02       | 24.02.17 | A        |
| Elevation – South West                                                                             | AR-C-XX-03       | 24.02.17 | A        |
| Elevation – South East                                                                             | AR-C-XX-04       | 08.11.17 | C        |
| <b>Mechanical Services Drawing &amp; Equipment Schedule prepare by Wood &amp; Grieve Engineers</b> |                  |          |          |
| Basement 1 HVAC Layout                                                                             | M-20B1           | 02.03.17 | A        |
| Basement 2 HVAC Layout                                                                             | M-20B2           | 02.03.17 | A        |
| Ground Floor HVAC Layout                                                                           | M-2000           | 02.03.17 | A        |
| Level 1 HVAC Layout                                                                                | M-2001           | 02.03.17 | A        |
| Typical Levels 2-5 & 7-9 HVAC Layout                                                               | M-2002           | 02.03.17 | A        |
| Level 6 HVAC Layout                                                                                | M-2006           | 02.03.17 | A        |
| Plant Level HVAC Layout                                                                            | M-2010           | 02.03.17 | A        |
| Roof Level HVAC Layout                                                                             | M-2011           | 02.03.17 | A        |
| Air Schematic                                                                                      | M-4100           | 02.03.17 | A        |
| Heating Water Schematic                                                                            | M-4010           | 02.03.17 | A        |
| Chilled and Condenser Water Schematic                                                              | M-4000           | 02.03.17 | A        |
| Mechanical Services Performance Specification                                                      | 30833-SYD-M      | 02.03.17 | A        |

## 2 Project Description

### 2.1 Background

The subject site is located within the hospital grounds of RNSH, and is identified as Site 4a, within Precinct 4.

The site forms part of a wider Concept Plan approval for the redevelopment and renewal of RNSH (MP 06\_0051). On 13 April 2007, approval was granted for a Concept Plan, including proposed building envelopes (height, bulk, scale), associated GFA and land use, site preparatory works, and road networks.

The Concept Plan proposed staged renewal of the entire campus through the nomination of eight precincts and a six-stage construction and delivery strategy. Since concept approval, redevelopment of the following buildings has been completed:

- Kolling Institute Research Building;
- Acute Services Building;
- Clinical Services Building;
- Community Services Building; and
- Multi-Storey Car Park with capacity for 567 spaces.

Under the Concept plan, the subject site is identified as Precinct 4, comprising of Site 4a and Site 4b.

Approval for demolition of existing buildings currently located on Precinct 4 and adjoining areas of the RNSH Campus was obtained as part of a Review of Environmental Factors (REF) under Part 5 of the EP&A Act 1979, dated August 2016. The Part 5 approval also included regrading of land for landscaping purposes and some landscaping works. Other works that have been carried out on site, and were covered under the REF include refurbishment of the existing buildings (Building 33, 35, 36 and the Douglas Building) and other civil infrastructure upgrades.

The Concept Plan has undergone several modifications, with the most recent modification relating to the subject site. Modification 7 (MP 06\_0051 MOD 7 - Modification to Concept Plan building footprint in Precinct 4a) was lodged on December 2016 and approved by the DP&E on 20 July 2017. The modification amended the building footprint originally approved for Site 4a under the Concept Plan and consolidated the commercial floor plate design, allowing a more efficient commercial floor plate and an improved design response for the site.

This report identifies and provide quantitative assessment of main noise and vibration generation sources during its operation and outlines measures to mitigate the potential noise impacts on surrounding residential and commercial premises.

## 2.2 Overview of Proposed Development

This SSD Application seeks approval for works proposed to Precinct 4 (Site 4A and Site 4B) and some adjoining public domain grounds. Specifically, consent is sought for the following:

- Construction of a 10-storey building with a total GFA of 30,977m<sup>2</sup> comprising of the following uses:
  - 28,615m<sup>2</sup> of health-related employment generating uses;
  - 658m<sup>2</sup> lobby;
  - 241m<sup>2</sup> café;
  - 902m<sup>2</sup> child care facility;
  - 561m<sup>2</sup> basement storage and miscellaneous.
- Construction of 2 basement levels with 115 car parking spaces and 1 car wash bay;
- Subdivision of the existing land parcel into the following additional allotments:
  - Proposed Lot 41 (Area 8,049 m2);
  - Proposed Lot 42 (Area 64 m2); and
  - Proposed Lot 40 (Residue Lot comprising the RNS hospital precinct)
- Improved east-west connectivity of the 4A+4B precinct through an at grade pedestrian access way interconnecting Herbert Street (east) to Reserve street (west);
- Creation of an additional easement along the southern alignment of the site for unrestricted vehicular access; and
- Associated public domain and landscaping works.

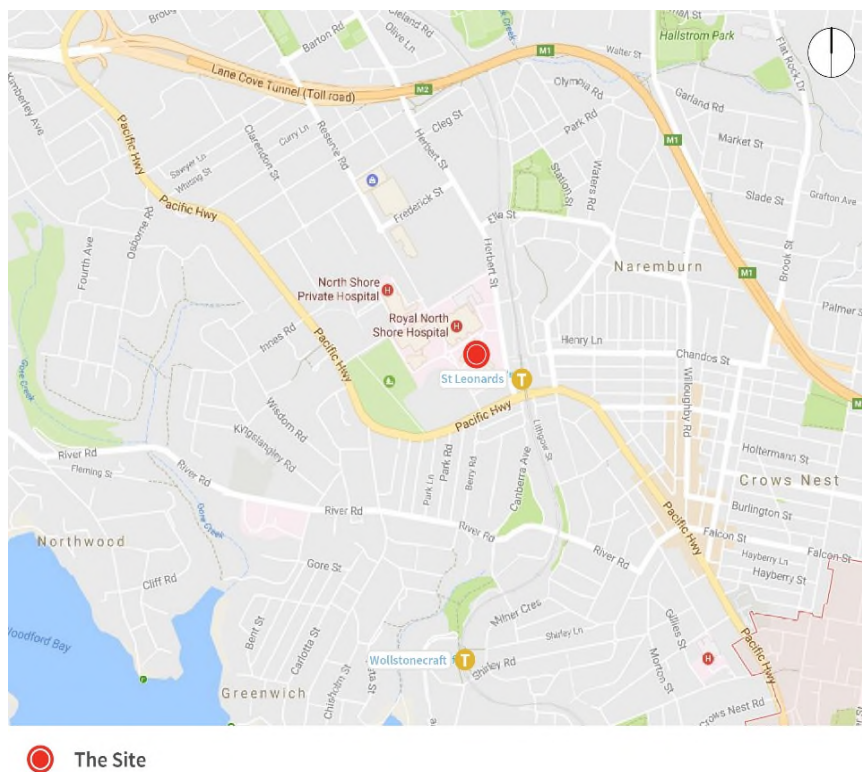
## 2.3 The Site

The RNSH Campus is situated approximately 6.5 km north of Sydney CBD and 3 km south west of Chatswood. The RNSH precinct is located within Willoughby City Council LGA, less than 200 metres from St Leonards Station.

The subject site (Precinct 4) is located at the southern edge of the RNSH Campus with direct frontage to Reserve Road (west of the site).

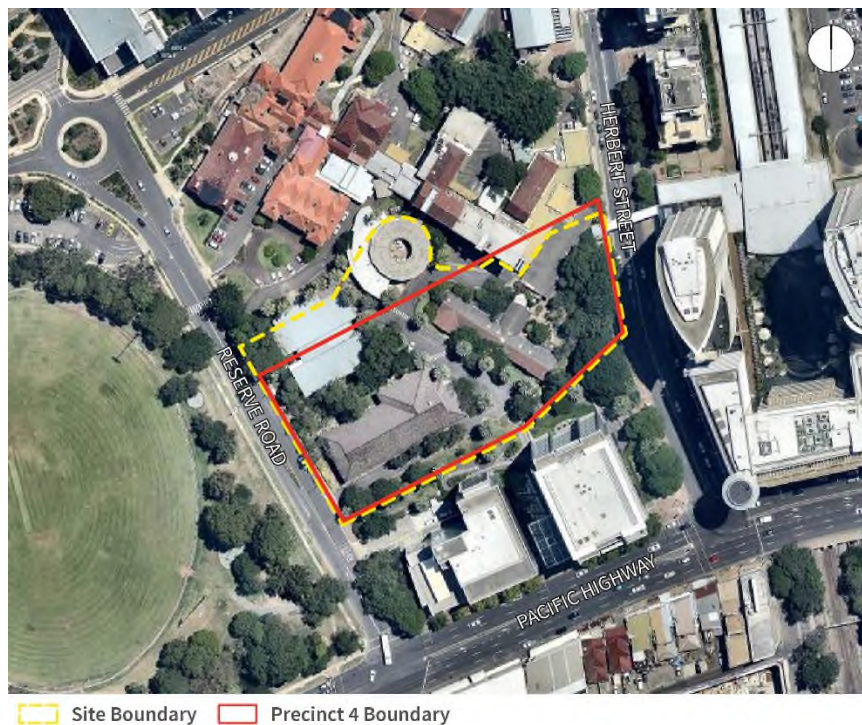
The land is owned by the Health Administration Corporation. Precinct 4 currently forms a part of the Royal North Shore Hospital campus, legally described as Lot 210 under DP 1172133. Total site area of the existing campus is 11.38 hectares.





**Figure 1: Site Location Context Plan**

Source: Ethos Urban



**Figure 2: Site and Precinct Boundary**

Source: Ethos Urban

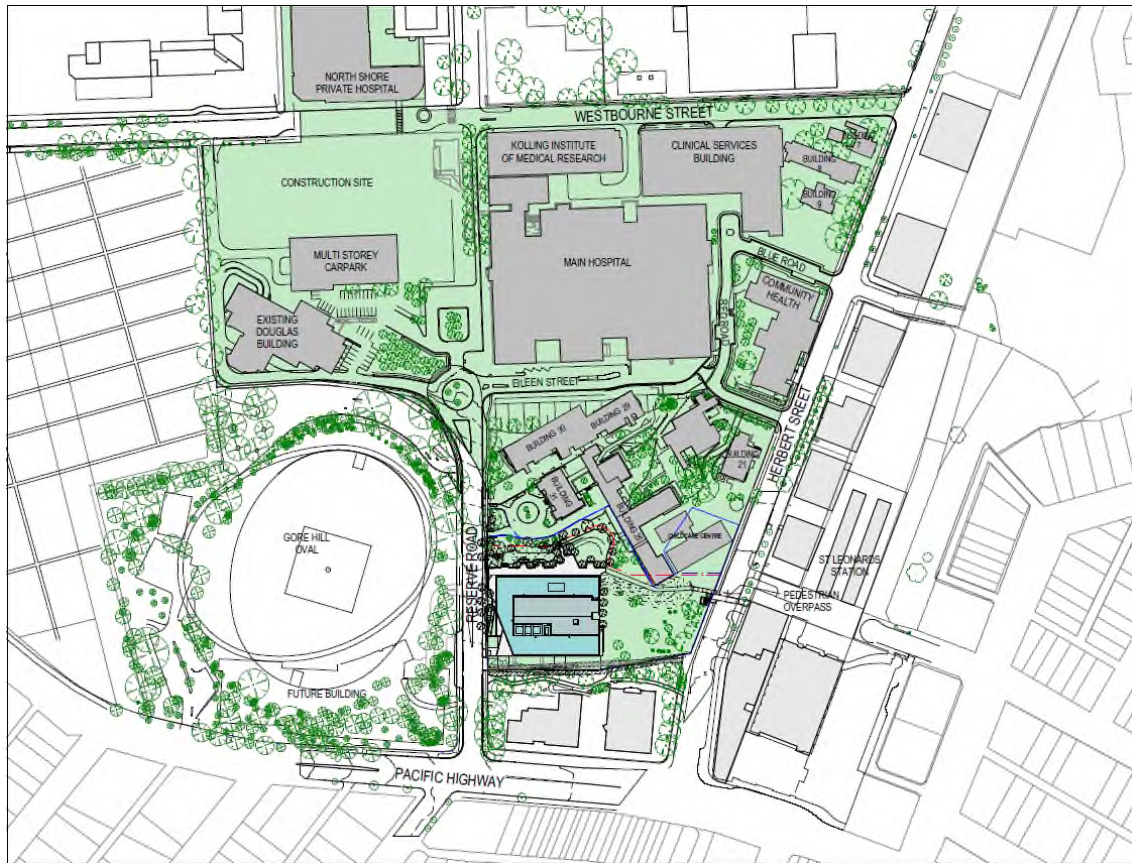


Figure 3: Proposed Precinct Plan *Source: BVN*

## 2.4 Operational Noise Sources

Review of the development has identified the following components as the main sources of noise and vibration generation during its operation;

- Noise emission from mechanical and refrigeration plant located on the roof
- Noise emission from outdoor play area of the child care tenancy located on Level 1

It is our understanding the proposed health building will operate 24/7 with its major mechanical and refrigeration plant running continuously.

The proposed operating hours of the child centre will be Monday to Friday between 6:45am and 6:00pm. It is assumed the outdoor area of the child care will not be in full use until at least 15minute after its official opening time of 6:45am ie. operating time of outdoor play area is from 7am to 6pm.

## 2.5 Nearest Affected Premises

The following noise sensitive receivers were identified from our site inspection and using aerial photography of the surrounding area to be the nearest affected receivers.



**Table 2: Sensitive receiver locations**

| Receiver | Address                                                                                           | Description                                                                                                                         |
|----------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| R1       | Building 31 (Vanderfield Building) of the Royal North Shores Hospital, Reserve Road, St. Leonards | Two storey office building (RNSH Fundraising and Volunteers) located approximately 30m to the north of proposed building on site    |
| R2       | Building 36 of the Royal North Shores Hospital, Reserve Road, St. Leonards                        | Four storey office building (RNSH OH&S) located approximately 20m to the north-east of proposed building on site                    |
| R3       | 3 Herbert Street, St. Leonards                                                                    | Multi-level residential building with retail shops the lower floors located approximately 82m east of the proposed building on site |
| R4       | 207 Pacific Highway, St. Leonards                                                                 | Multi-storey commercial building located approximately 19m to south of the proposed building on subject site.                       |

Figure 4 provides details of the site, surrounding environment and noise monitoring location.

**Figure 4: Location of proposed building on site, surrounds and receiver & monitoring locations**

### 3 Existing Noise Environment

A long-term noise logger was installed on site from 06/02/17 to 15/02/17 at location M1 to establish existing site background noise levels. The noise logger records noise levels on a continuous basis and store data every fifteen minutes. The noise logger was calibrated before and after measurements and no significant deviation in calibration was noted. The noise monitoring equipment used here complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as Type 2 instruments suitable for field use. The graphical recorded outputs from long term noise monitoring are included in APPENDIX B.

The results of the long-term noise monitoring have been summarised in accordance with Industrial Noise Policy (INP) requirements published by NSW Environmental Protection Authority (EPA) and are presented in Table 3 below.

**Table 3: Measured Site Background Noise Level ( $L_{A90}$ )**

| Noise Monitoring                                                                |                                        | Representative Background Noise Levels in dB(A) |                      |                    |
|---------------------------------------------------------------------------------|----------------------------------------|-------------------------------------------------|----------------------|--------------------|
| Location                                                                        | Duration                               | Day <sup>1</sup>                                | Evening <sup>2</sup> | Night <sup>3</sup> |
| M1 - Building 38 of the Royal North Shores Hospital, Reserve Road, St. Leonards | Monday 06/02/17 and Wednesday 15/02/17 | 50                                              | 46                   | 43                 |

Notes:

Day, Evening & Night assessment periods are defined in accordance NSW EPA's Industrial Noise Policy as follows.

1. Day is defined as 7:00am to 6:00pm, Monday to Saturday; 8:00am to 6:00pm Sundays & Public Holidays.
2. Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays
3. Night is defined as 10:00pm to 7:00am, Monday to Saturday; 10:00pm to 8:00am Sundays & Public Holidays

The above representative background noise levels ( $L_{A90}$ ) are used in defining external noise emission limits from the development such as mechanical ventilation and air-conditioning systems in accordance to relevant NSW Government authorities.

The acoustic environment at the location of the long-term noise monitoring M1 is similar to noise-sensitive receivers at R1, R2 and R4 therefore the background noise levels determined at M1 is suitable for defining noise emission limits at R1, R2 and R4. It is noted that the background noise levels at potentially most-affected noise-sensitive receiver R3 ie. west facing apartments on Herbert Street is expected to be higher than location M1 as the residences are exposed to road traffic noise from Herbert Street and Pacific Highway.

At this early stage of the development where schedule of mechanical plant and equipment is indicative RT&A have adopted the background noise levels from monitoring location M1 as "representative" for receiver location R3 to allow for a preliminary quantitative noise assessment.

The effect of utilising quieter background noise levels sets more stringent criteria for mechanical plant noise emitted to the residences (R3) therefore will result in conservative recommendations on acoustic treatment of mechanical plant and equipment.

A long-term noise survey can be undertaken in accordance to the INP at a location that is more representative of the noise environment of the residential receivers at R3 during detailed design stage quantify the difference background noise levels and where necessary revise the noise mitigation measures provided within this report.

## 4 Relevant Acoustic Criteria

### 4.1 NSW EPA Industrial Noise Policy

Noise from mechanical and refrigeration plant to other nearby buildings and surrounding environs shall be controlled to comply with the NSW EPA Industrial Noise Policy as required by Condition 8 of SEARs for the site.

The assessment procedure in terms of the NSW EPA 'Industrial Noise Policy' (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.

**Intrusive Noise Impacts** – According to the EPA's INP, the intrusiveness of a mechanical noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the  $L_{Aeq}$  descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A).

The intrusiveness criterion is summarised as follows:

$$L_{Aeq} \leq L_{A90} \text{ background noise level plus 5dB(A)}$$

**Protecting Noise Amenity** – To limit continuing increases in noise levels, the maximum ambient noise level within an area from noise sources other than industrial (eg mechanical plant) should not normally exceed the acceptable noise levels specified in Table 2.1 of the policy.

Where the proposed noise source contains prominent impulsive or other annoying characteristics then adjustments to reduce the criteria shall be made as specified in NSW EPA 'Industrial Noise Policy' (INP).

#### 4.1.1 Building Services Noise Emission Limit

Noise from building services equipment such as ventilation fan and air conditioning systems during the day and night periods are recommended to be pursuant to EPA INP 'intrusiveness criterion' discussed above. Based on the noise monitoring results presented in Table 3 appropriate day, evening and night noise limits were established for the development as shown in Table 4 below.

**Table 4: Building Services External Noise Emission Limits**

| Assessment / Receiver Location                                | Noise Limits for Building Services Equipment Operating During |                      |                             |
|---------------------------------------------------------------|---------------------------------------------------------------|----------------------|-----------------------------|
|                                                               | Day <sup>1</sup>                                              | Evening <sup>2</sup> | Night <sup>3</sup>          |
| Boundary of a neighbouring residential or commercial property | 50 plus 5 = 55 dB(A)                                          | 46 plus 5 = 51 dB(A) | 43 plus 5 = <b>48 dB(A)</b> |

| Assessment / Receiver Location | Noise Limits for Building Services Equipment Operating During |                      |                    |
|--------------------------------|---------------------------------------------------------------|----------------------|--------------------|
|                                | Day <sup>1</sup>                                              | Evening <sup>2</sup> | Night <sup>3</sup> |

Notes:

Day, Evening & Night assessment periods are defined in accordance NSW EPA's Industrial Noise Policy as follows.

1. Day is defined as 7:00am to 6:00pm, Monday to Saturday; 8:00am to 6:00pm Sundays & Public Holidays.
2. Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays
3. Night is defined as 10:00pm to 7:00am, Monday to Saturday; 10:00pm to 8:00am Sundays & Public Holidays

Given that the mechanical and refrigeration plant can operate during both day and night the more stringent assessment period is night-time. Therefore, by complying with the noise criterion at night, compliance is automatically achieved during the daytime and evening operations.

Where necessary, noise amelioration treatment will be provided to ensure the design comply with the noise levels recommended by EPA.

## 4.2 Childcare Outdoor Noise

The "AAAC Guideline for Child Care Centre Acoustic Assessment" published by the Association of Australian Acoustical Consultants is relevant guide for the noise impact assessment of child care centres. The guideline sets criteria for noise generated in the outdoor play areas to protect reasonable acoustic private of nearby residential and commercial receivers.

### 4.2.1 Residential Receivers

The following noise criteria as presented in the AAAC guideline have been adopted for the operation of the outside play area of the proposed child care centre impacted nearby affected residences.

**"Outdoor Play Up to 2 hours (total) per day** - The  $L_{Aeq,15\ min}$  noise level emitted from the outdoor play area shall not exceed the background noise level by more than 10 dB at the assessment location.

**More than 2 hours per day** - The  $L_{Aeq,15\ min}$  noise level emitted from the outdoor play area shall not exceed the background noise level by more than 5 dB at the assessment location.

The assessment location is defined as the most affected point on or within any residential receiver property boundary. Examples of this location may be:

- 1.5 m above ground level, or
- on a balcony at 1.5 m above floor level, or
- outside a window on the ground or higher floors."

It is our understanding the outside play area will be used for more than 2 hours in total per day.

Therefore, the following criterion has been adopted for the proposed centre:

$$L_{Aeq,15\text{minute}} \leq \text{Background noise level} + 5\text{dB(A)}$$

Therefore, based on the above criterion and the background noise levels presented in Table 3, the applicable noise limits are as follows.

**Table 5: Operation Noise Criterion at Residential Receivers for Use of Outdoor Play Area**

| Receiver Location                                                                                                | Time                     | Operational Criterion at Residential Receiver $L_{Aeq, 15\text{minute}}$ |
|------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------------------------------------------------------|
| R3 – Apartment balconies and windows from Levels 4 to 27 of the residential tower at 3 Herbert St, St. Leonards. | Day Time<br>(7am to 6pm) | $50 + 5 \leq 55 \text{ dB(A)}$                                           |

Notes:

Day assessment periods are defined in accordance NSW EPA's Industrial Noise Policy as follows.

1. Day is defined as 7:00am to 6:00pm, Monday to Saturday; 8:00am to 6:00pm Sundays & Public Holidays.
2. Proposed business hour of child care is 6:45am to 6pm. It is assumed full usage of outdoor play area is does not start till after 7am.
3. Minimum distance between proposed outdoor area on Level 1 and R3 is 82m.

The outdoor play area is only used during the day thus only day time criterion is applicable.

#### 4.2.2 Commercial Receivers

The following noise criteria as presented in the AAAC guideline have been adopted for the operation of the outside play area of the proposed child care centre impacting nearby commercial receivers.

*"The  $L_{Aeq,15 \text{ min}}$  noise level emitted from the Child Care Centre shall not exceed 65dB(A) when assessed at the most affected point at of within any commercial property boundary."*

Therefore, the applicable noise criterion for Receivers R1, R2, R3 (Levels 1 to 3) & R4 is **65dB(A)** inside any retail or commercial tenancy.



## 5 Noise Assessment of Mechanical Plant

### 5.1 Proposed Plant Equipment & Location

All major mechanical plant and equipment associated with the operation of the base building and tenancy spaces have been proposed to be located on the roof. Chillers, pumps, boilers and air handling units to be installed in plantrooms on the roof with louvred openings for discharge and outside air intakes. Fans, cooling towers and associated pumps are to be installed outside the plantrooms.

Table 6 below presents the schedule of proposed mechanical plant equipment for the roof and roof plant rooms.

**Table 6: Roof Mechanical Equipment Schedule**

| Equipment Type                                                                                     | Schedule Plant Item ID                                                  | Proposed Location              |
|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------|
| Cooling Towers                                                                                     | CT-01, CT-02 & CT-03                                                    | Roof                           |
| Chillers                                                                                           | CH-01, CH-02                                                            | Roof plant room                |
|                                                                                                    | CH-03                                                                   | Roof                           |
| Pumps                                                                                              | CDWP-01, CDWP-02, CDWP-03, CHWP-01, CHWP-02, CHWP-03, HHWP-01 & HHWP-02 | Roof plant room                |
| Air handling units                                                                                 | AHU-BB-W, AHU-BB-SE, AHU-BB-NE & AHU-TN-01                              | Roof plant room                |
| Boilers                                                                                            | BU-01 & BU-02                                                           | Roof plant room                |
| <b>Fans</b>                                                                                        |                                                                         |                                |
| Carpark Exhaust                                                                                    | CPXF-BB-01,                                                             | Roof                           |
| Carpark Supply                                                                                     | CPSF-BB-01                                                              | Basement fan room              |
| Loading Dock Exhaust                                                                               | LDXF-BB-01                                                              | Roof                           |
| Base Building General Exhaust                                                                      | GNX-BB-01, GNX-BB-02                                                    | Roof                           |
| Tenant General Exhaust                                                                             | GNXF-TN-01                                                              | Roof                           |
| Base Building Garbage Exhaust                                                                      | GBXF-BB-01                                                              | Roof                           |
| Base Building Kitchen Exhaust                                                                      | KXF-BB-01                                                               | Roof                           |
| Base Building Kitchen Make-up                                                                      | KMUF-BB-01                                                              | Ground floor - Tenancy ceiling |
| Kitchenette Exhaust                                                                                | KNXF-BB-01                                                              | Level 1 - Tenancy ceiling      |
| Tenant Kitchen Exhaust                                                                             | KXF-TN-01                                                               | Roof                           |
| Tenant Kitchen Make-up                                                                             | KMUF-TN-01                                                              | Roof                           |
| Base Building Toilet Exhaust                                                                       | TXF-BB-01, TXF-BB-02, TXF-BB-03                                         | Roof                           |
| Tenant Toilet Exhaust                                                                              | TXF-TN-01                                                               | Roof                           |
| Stair Pressurisation <sup>1</sup>                                                                  | SPF-01, SPF-02                                                          | Roof                           |
| Smoke Exhaust <sup>1</sup>                                                                         | SEF-01                                                                  | Roof                           |
| <b>Notes:</b>                                                                                      |                                                                         |                                |
| 1. Only used during fire emergence or scheduled testing therefore does not form part of assessment |                                                                         |                                |

## 5.2 Noise Issues

Noise emission from the discharge and intake of the cooling towers and fans, and break-out noise from plantroom openings has potential to impact on nearby noise-sensitive neighbours to the proposed development. The nearest existing residential and commercial buildings potentially impacted by operation of roof top plant equipment has been identified and shown in Figure 4 and Table 2 above.

Plant and equipment on roof can operate any time during day or night, the worst-case scenario will be when all the base building and tenancy equipment are operating at the same time during the night time period (10pm and 7am). Our acoustic modelling and recommendations for noise mitigation are based on compliance with worst-case scenario.

## 5.3 Sound Power of Noise Sources

At this stage of the development majority of the mechanical plant items has not been finalised and therefore its sound power level data, where this is the case RT&A have selected specific plant from manufacturers catalogue based mechanical performance requirements (capacity and/or flow rates) specified in the Mechanical Services Performance Specification prepared by Wood & Grieve Engineers.

### 5.3.1 Sound Power Levels of Cooling Towers

The sound power levels associated with three cooling towers selected for this development are outlined in the Table 7 below.

**Table 7: Selected Cooling Tower Sound Power levels (SWL)**

| Item Designation     | Manufacturer/ Model | Octave Band Sound Power Level in dB |     |     |     |    |    |    |    | Sound Pressure Level @ in dB(A) |
|----------------------|---------------------|-------------------------------------|-----|-----|-----|----|----|----|----|---------------------------------|
|                      |                     | 63                                  | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                                 |
| CT-01, CT-02 & CT-03 | BAC PCT1116-P3-N    | 109                                 | 106 | 101 | 93  | 89 | 84 | 79 | 69 | 78 @1.5m                        |

### 5.3.2 Sound Power Levels of Fans

The sound power levels associated with the building ventilation fans proposed for this development are outlined in the Table 8 below. Fan models and associated sound power spectra were selected from Fantech based on airflow rates specified in the Mechanical Services Specification.

**Table 8: Proposed Fan Sound Power levels (SWL)**

| Item Designation             | Model                   | Noise Type | Octave Band Sound Power Level in dB |     |     |     |    |    |    |    | Sound Pressure Level @3m in dB(A) |
|------------------------------|-------------------------|------------|-------------------------------------|-----|-----|-----|----|----|----|----|-----------------------------------|
|                              |                         |            | 63                                  | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                                   |
| CPXF-BB-1<br>Carpark Exhaust | Fantech<br>AP1004LP9/19 | Inlet      | 85                                  | 85  | 90  | 92  | 95 | 99 | 92 | 78 | 82                                |
|                              |                         | Outlet     | 84                                  | 84  | 88  | 91  | 94 | 96 | 90 | 77 | 79                                |

| Item Designation                                 | Model                    | Noise Type | Octave Band Sound Power Level in dB |     |     |     |    |    |    |    | Sound Pressure Level @3m in dB(A) |
|--------------------------------------------------|--------------------------|------------|-------------------------------------|-----|-----|-----|----|----|----|----|-----------------------------------|
|                                                  |                          |            | 63                                  | 125 | 250 | 500 | 1k | 2k | 4k | 8k |                                   |
| CPSF-BB-1<br>Carpark Supply                      | Fantech<br>AP1006CP12/37 | Inlet      | 89                                  | 84  | 88  | 87  | 83 | 80 | 76 | 70 | 68                                |
|                                                  |                          | Outlet     | 92                                  | 87  | 89  | 88  | 84 | 81 | 78 | 73 | 69                                |
| LDXF-BB-01<br>Loading dock exhaust               | Fantech<br>AP0502JP6/17  | Inlet      | 78                                  | 77  | 84  | 79  | 82 | 83 | 82 | 79 | 68                                |
|                                                  |                          | Outlet     | 79                                  | 72  | 83  | 79  | 81 | 83 | 81 | 79 | 68                                |
| GNXF-BB-01 & 02<br>Base building general exhaust | Fantech<br>AP0504JP6/11  | Inlet      | 71                                  | 81  | 80  | 75  | 70 | 67 | 64 | 57 | 57                                |
|                                                  |                          | Outlet     | 70                                  | 81  | 81  | 74  | 70 | 68 | 64 | 58 | 57                                |
| GNXF-TN-01<br>Tenant general exhaust             | Fantech<br>AP0806BP14/15 | Inlet      | 77                                  | 74  | 84  | 85  | 83 | 76 | 69 | 53 | 66                                |
|                                                  |                          | Outlet     | 83                                  | 81  | 87  | 86  | 83 | 79 | 75 | 66 | 67                                |
| GBXF-BB-01<br>Base building garbage exhaust      | Fantech<br>AP0504AP5/16  | Inlet      | 72                                  | 79  | 75  | 77  | 73 | 69 | 66 | 54 | 58                                |
|                                                  |                          | Outlet     | 75                                  | 76  | 77  | 73  | 71 | 69 | 67 | 63 | 56                                |
| KXF-BB-01<br>Base building kitchen exhaust       | Fantech<br>AP0804AP10/14 | Inlet      | 84                                  | 79  | 95  | 94  | 89 | 80 | 75 | 70 | 74                                |
|                                                  |                          | Outlet     | 86                                  | 86  | 89  | 94  | 94 | 93 | 88 | 81 | 78                                |
| KMUF-BB-01<br>Base building kitchen make-up      | Fantech<br>AP0804AP10/10 | Inlet      | 84                                  | 79  | 95  | 94  | 89 | 80 | 75 | 70 | 74                                |
|                                                  |                          | Outlet     | 86                                  | 86  | 89  | 94  | 94 | 93 | 88 | 81 | 78                                |
| KNXF-BB-01<br>Kitchenette Exhaust                | Fantech<br>AP0312JP3/10  | Inlet      | 75                                  | 84  | 83  | 81  | 77 | 70 | 67 | 63 | 62                                |
|                                                  |                          | Outlet     | 77                                  | 83  | 84  | 81  | 76 | 69 | 67 | 64 | 61                                |
| KXF-TN-01<br>Tenant Kitchen Exhaust              | Fantech<br>AP0804AP10/10 | Inlet      | 84                                  | 79  | 95  | 94  | 89 | 80 | 75 | 70 | 74                                |
|                                                  |                          | Outlet     | 86                                  | 86  | 89  | 94  | 94 | 93 | 88 | 81 | 78                                |
| KMUF-TN-01<br>Tenant Kitchen Make-up             | Fantech<br>AP0804AP10/10 | Inlet      | 84                                  | 79  | 95  | 94  | 89 | 80 | 75 | 70 | 74                                |
|                                                  |                          | Outlet     | 86                                  | 86  | 89  | 94  | 94 | 93 | 88 | 81 | 78                                |
| TXF-BB-01,02,03<br>Base Building Toilet Exhaust  | Fantech<br>AP0806BP14/15 | Inlet      | 77                                  | 74  | 84  | 85  | 83 | 76 | 69 | 53 | 66                                |
|                                                  |                          | Outlet     | 83                                  | 81  | 87  | 86  | 83 | 79 | 75 | 66 | 67                                |
| TXF-TN-01<br>Tenant Toilet Exhaust               | Fantech<br>AP0806BP14/15 | Inlet      | 77                                  | 74  | 84  | 85  | 83 | 76 | 69 | 53 | 66                                |
|                                                  |                          | Outlet     | 83                                  | 81  | 87  | 86  | 83 | 79 | 75 | 66 | 67                                |

### 5.3.3 Sound Power Levels of Other Major Plant on Roof

The sound power levels associated with chillers, pumps, boilers and air handling units selected for this development are outlined in the Table 9 below. Pump and AHU model and make were selected based on capacity and airflow rates specified in the Mechanical Services Specification.

**Table 9: Selected/Proposed Chillers, Pumps, Boilers & AHUs Sound Power levels (SWL)**

| Item Designation          | Manufacturer/ Model                                              | Octave Band Sound Power Level in dB |      |      |      |      |      |      |      | Sound Pressure Level in dB(A) |
|---------------------------|------------------------------------------------------------------|-------------------------------------|------|------|------|------|------|------|------|-------------------------------|
|                           |                                                                  | 63                                  | 125  | 250  | 500  | 1k   | 2k   | 4k   | 8k   |                               |
| CH-01,02                  | Smardt Water Cooled Chiller                                      | 83.4                                | 82.4 | 85.4 | 85.4 | 90.4 | 86.4 | 79.4 | 83.4 | 85@1m                         |
| CH-03                     | Smardt Air Cooled Chiller                                        | 74.6                                | 81.4 | 77.8 | 76   | 78.8 | 73.4 | 74   | 72.7 | 75@1m                         |
| CHWP-01, CHWP-02          | Derived previous project measures of Grundfos pumps <sup>1</sup> | 86                                  | 84   | 83   | 81   | 88   | 82   | 78   | 69   | 77@1m                         |
| CHWP-03                   | Derived previous project measures of Grundfos pumps <sup>1</sup> | 80                                  | 78   | 77   | 75   | 82   | 76   | 72   | 63   | 71@1m                         |
| CDWP-01, CDWP-02, CDWP-03 | Derived previous project measures of Grundfos pumps <sup>1</sup> | 92                                  | 90   | 89   | 87   | 94   | 88   | 84   | 75   | 83@1m                         |
| HHWP-01, HHWP-02          | Derived previous project measures of Grundfos pumps              | 80                                  | 78   | 77   | 75   | 82   | 76   | 72   | 63   | 71@1m                         |
| AHU-BB-W                  | GJ Walker AM 200 (ref Flakt Woods) <sup>2</sup>                  | 73                                  | 85   | 68   | 57   | 60   | 61   | 56   | 50   | -                             |
| AHU-BB-SE                 | GJ Walker AM 200 (ref Flakt Woods) <sup>2</sup>                  | 73                                  | 85   | 68   | 57   | 60   | 61   | 56   | 50   | -                             |
| AHU-BB-NE                 | GJ Walker AM 156 (ref Flakt Woods) <sup>2</sup>                  | 73                                  | 85   | 68   | 57   | 60   | 61   | 56   | 50   | -                             |
| AHU-TN-01                 | GJ Walker AM 66 (ref Flakt Woods) <sup>2</sup>                   | 66                                  | 78   | 62   | 51   | 53   | 51   | 46   | 42   |                               |
| BU-01, BU-02              | Simons 800kW Boiler <sup>2</sup>                                 | 100                                 | 85   | 86   | 81   | 80   | 78   | 73   | 69   | 75 @1m                        |

Notes:

1. Calculated from previous project measurements of Grundfos pumps with similar flow rates to WGE performance specification
2. Sound power spectra from previous project based on similar kW capacity and/or flow rates to WGE performance specification
3. Boiler sound power spectra from previous project adjusted to match manufacturer's 75dB @1m sound pressure specification.

## 5.4 Recommendations

Based on the equipment selection outlined in Table 7, Table 8 and Table 9 and worst-case scenario where all plant are operating at design loads during night time period (10pm to 7am), the following recommendations are provided for control of external noise emission to comply noise levels outlined in Table 4 above.

**Table 10: Recommended Acoustic Treatment for Control of External Noise Emission from Proposed Mechanical Plant**

| Plant Item                                                    | Recommended Acoustic Treatment                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                         |                                                                                                                                                                            |
|---------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                               | Case Radiated                                                                                                                                                                                                                                                                                                                      | Intake Side                                                                                                                                                             | Discharge Side                                                                                                                                                             |
| Cooling Towers & Associated Pumps                             |                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                         |                                                                                                                                                                            |
| Cooling Towers: CT-01, CT-02, CT-03                           | Install 6.3m height acoustic screen to east and south side of the plant area for the cooling and associated pumps as indicated in Figure 5 below. Acoustic screen shall be of solid construction such as fibre cement sheeting, Colorbond, masonry or Hebel and at least 1.5m higher than top of the cooling towers (4.8m height). |                                                                                                                                                                         |                                                                                                                                                                            |
| And Pumps: CDWP-01, CDWP-02, CDWP-03                          | No acoustic treatment is required for west side of the plant area and standard visual louvres may be installed.                                                                                                                                                                                                                    |                                                                                                                                                                         |                                                                                                                                                                            |
|                                                               | No acoustic treatment is required for the open top of this plant area.                                                                                                                                                                                                                                                             |                                                                                                                                                                         |                                                                                                                                                                            |
| Fans                                                          |                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                         |                                                                                                                                                                            |
| CPXF-BB-1<br>Carpark Exhaust                                  | Wrap fan casing and ductwork/silencer 1m either side of fan with 1 layer of barium-loaded vinyl (minimum density of 4kg/m2) equivalent to Pyrotek Soundguard Wavebar                                                                                                                                                               | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.8m long circular silencer C2P-100 (refer to Silencer 1 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.8m long circular silencer C2P-100 (refer to Silencer 1 in Table 11 below). |
| CPSF-BB-1<br>Carpark Supply<br>(Located in basement fan room) | Install fan inside fan room as per Mechanical Services Drawing M-20B1 Rev A                                                                                                                                                                                                                                                        | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech1.8m long circular silencer C2-100 (refer to Silencer 2 in Table 11 below).   | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.8m long circular silencer CP-100 (refer to Silencer 2 in Table 11 below).  |
| LDXF-BB-01<br>Loading dock exhaust                            | No treatment required                                                                                                                                                                                                                                                                                                              | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). |
| GNXF-BB-01 & 02<br>Base building general exhaust              | No treatment required                                                                                                                                                                                                                                                                                                              | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). |
| GBXF-BB-01<br>Base building garbage exhaust                   | No treatment required                                                                                                                                                                                                                                                                                                              | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). |
| GNXF-TN-01<br>Tenant General Exhaust                          | No treatment required                                                                                                                                                                                                                                                                                                              | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.15m long circular silencer C2-050 (refer to Silencer 3 in Table 11 below). |

| Plant Item                                                                                           | Recommended Acoustic Treatment                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                        |                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                      | Case Radiated                                                                                                                                                                                                                                                                                                                                              | Intake Side                                                                                                                                                            | Discharge Side                                                                                                                                                            |
| KXF-BB-01<br>Base building<br>kitchen exhaust                                                        | Wrap fan casing and ductwork/silencer 1m either side of fan with 1 layer of barium-loaded vinyl (minimum density of 4kg/m <sup>2</sup> ) equivalent to Pyrotek Soundguard Wavebar                                                                                                                                                                          | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). |
| KMUF-BB-01<br>Base building<br>kitchen make-up<br>(Located in ceiling space of ground level tenancy) | Install fan inside ceiling or plant room of tenancy                                                                                                                                                                                                                                                                                                        | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). |
| KNXF-BB-01<br>Kitchenette<br>Exhaust<br>(Located in ceiling space of level 1 tenancy)                | Install fan inside ceiling or plant room of tenancy                                                                                                                                                                                                                                                                                                        | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 0.6m long circular silencer C2-031 (refer to Silencer 5 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 0.6m long circular silencer C2-031 (refer to Silencer 5 in Table 11 below). |
| KXF-TN-01<br>Tenant Kitchen<br>Exhaust                                                               | Wrap fan casing and ductwork/silencer 1m either side of fan with 1 layer of barium-loaded vinyl (minimum density of 4kg/m <sup>2</sup> ) equivalent to Pyrotek Soundguard Wavebar                                                                                                                                                                          | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). |
| KMUF-TN-01<br>Tenant Kitchen<br>Make-up                                                              | Wrap fan casing and ductwork/silencer 1m either side of fan with 1 layer of barium-loaded vinyl (minimum density of 4kg/m <sup>2</sup> ) equivalent to Pyrotek Soundguard Wavebar                                                                                                                                                                          | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). |
| TXF-BB-01,02,03<br>Base Building<br>Toilet Exhaust                                                   | No treatment required                                                                                                                                                                                                                                                                                                                                      | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). |
| TXF-TN-01<br>Tenant Toilet<br>Exhaust                                                                | No treatment required                                                                                                                                                                                                                                                                                                                                      | Provide sound attenuator to intake side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). | Provide sound attenuator to discharge side of fan with equivalent insertion loss to a Fantech 1.5m long circular silencer C2-080 (refer to Silencer 4 in Table 11 below). |
| <b>Chillers &amp; Pumps</b>                                                                          |                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                        |                                                                                                                                                                           |
| Smardt Water<br>Cooled Chiller:<br>CH-01, 02<br>And<br>Pumps:<br>CHWP-01, CHWP-02, CHWP-03           | Install chillers and pumps inside Chiller plantroom as per Mechanical Services Drawing M-2010 Rev A. Install an acoustic louvre with equivalent insertion loss to Fantech SLB2 (refer to Louvre 2 in Table 11 below) to external wall (north) opening as indicated in Figure 5 below. Walls and roof/ceiling of plantroom shall comply with Section 5.4.1. |                                                                                                                                                                        |                                                                                                                                                                           |

| Plant Item                                                                                                                                | Recommended Acoustic Treatment                                                                                                                                                                                                                                                                                                                           |             |                |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------------|
|                                                                                                                                           | Case Radiated                                                                                                                                                                                                                                                                                                                                            | Intake Side | Discharge Side |
| CH-03                                                                                                                                     | Install Fantech SLB1 acoustic louvre to south side of CH-03 plant area as in Figure 5 below.                                                                                                                                                                                                                                                             |             |                |
| Smardt Air Cooled Chiller                                                                                                                 | No acoustic treatment is required for the open top of this plant area.                                                                                                                                                                                                                                                                                   |             |                |
| Boilers:<br>BU-01, BU-02<br>Pumps:<br>HHWP-01,<br>HHWP-02                                                                                 | Install boilers and pumps inside boiler plantroom as per Mechanical Services Drawing M-2010 Rev A. Install an acoustic louvre with equivalent insertion loss to Fantech SLB2 (refer to Louvre 2 in Table 11 below) to external wall (south) opening as indicated in Figure 5 below. Walls and roof/ceiling of plantroom shall comply with Section 5.4.1. |             |                |
| AHU-BB-NE & AHU-TN-01                                                                                                                     | Install AHUs inside AHU plantroom 1 as per Mechanical Services Drawing M-2010 Rev A. Install an acoustic louvre with equivalent insertion loss to Fantech SLB1 (refer to Louvre 1 in Table 11 below) to external wall (north) opening as indicated in Figure 5 below. Walls and roof/ceiling of plantroom shall comply with Section 5.4.1.               |             |                |
| AHU-BB-SE                                                                                                                                 | Install AHUs inside AHU plantroom 2 as per Mechanical Services Drawing M-2010 Rev A. Install an acoustic louvre with equivalent insertion loss to Fantech SLB1 (refer to Louvre 1 in Table 11 below) to external wall (south) opening as indicated in Figure 5 below. Walls and roof/ceiling of plantroom shall comply with Section 5.4.1.               |             |                |
| AHU-BB-W                                                                                                                                  | Install AHUs inside AHU plantroom 3 as per Mechanical Services Drawing M-2010 Rev A. Standard visual louvre may be installed to external wall (north) opening as indicated in Figure 5 below. Walls and roof/ceiling of plantroom shall comply with Section 5.4.1.                                                                                       |             |                |
| Notes                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                          |             |                |
| 1. Treatment will require to be revised where Mechanical Contractor select different plant, plant location and/or duct work configuration |                                                                                                                                                                                                                                                                                                                                                          |             |                |

The acoustic performance requirements of the recommended silencers and acoustic louvres to intake and discharge are outlined in the Table 11 below.

**Table 11: Octave Band Insertion Loss of Recommended Silencers**

| Recommended Attenuator                                                             | OCTAVE BAND CENTRE FREQUENCY (Hz) |     |     |     |    |    |    |    |
|------------------------------------------------------------------------------------|-----------------------------------|-----|-----|-----|----|----|----|----|
|                                                                                    | 63                                | 125 | 250 | 500 | 1K | 2K | 4K | 8K |
| Silencer 1: Fantech C2P-100 1800mm long circular attenuator or approved equivalent | 8                                 | 11  | 19  | 27  | 29 | 27 | 23 | 19 |
| Silencer 2: Fantech C2-100 1800mm long circular attenuator or approved equivalent  | 6                                 | 8   | 13  | 22  | 19 | 13 | 12 | 10 |
| Silencer 3: Fantech C2-050 1150mm long circular attenuator or approved equivalent  | 5                                 | 7   | 11  | 18  | 21 | 17 | 15 | 12 |
| Silencer 4: Fantech C2-080 1500mm long circular attenuator or approved equivalent  | 5                                 | 8   | 12  | 22  | 23 | 16 | 15 | 10 |
| Silencer 5: Fantech C2-031 600mm long circular attenuator or approved equivalent   | 3                                 | 6   | 9   | 15  | 21 | 17 | 14 | 13 |
| Fantech SBL1 300mm deep acoustic louvre or approved equivalent                     | 4                                 | 7   | 9   | 13  | 14 | 12 | 12 | 8  |
| Fantech SBL2 600mm deep acoustic louvre or approved equivalent                     | 5                                 | 10  | 14  | 22  | 27 | 25 | 21 | 17 |



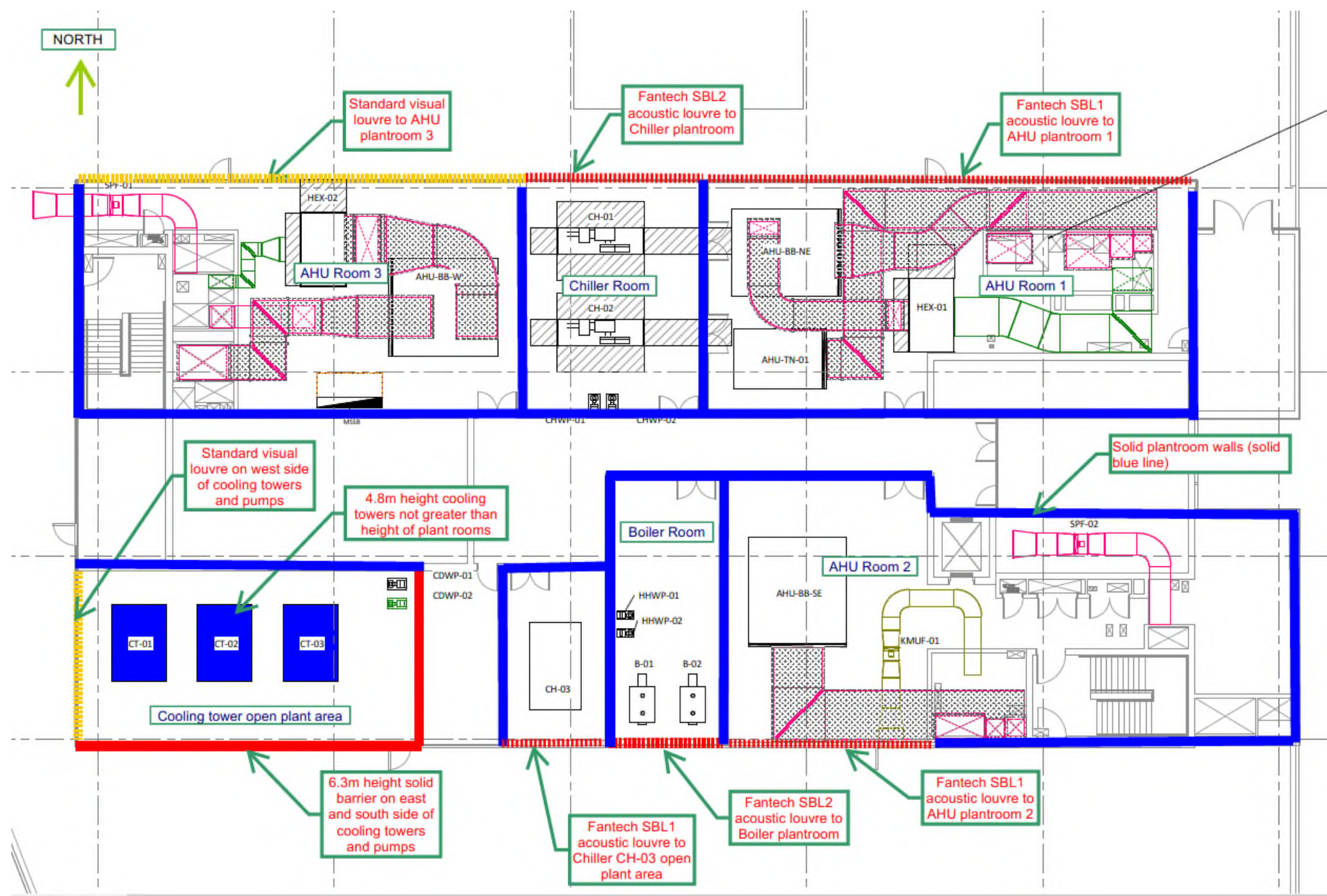


Figure 5: Recommended Acoustic Treatment to Roof Plant Compounds

#### 5.4.1 Additional Plantroom Requirements

- s1. Plant room walls as indicated in Table 5 above shall be of a solid construction such as masonry, Hebel or dry wall with insulation in cavity and full-height ie extending to roof
- s2. Roof of all plant rooms shall be of a solid construction such as concrete or metal deck roof with plasterboard ceiling and insulation in cavity.
- s3. Access door into plantrooms shall be minimum 45mm thick solid-core timber door with full perimeter acoustic seals
- s4. Any small gaps around frame of acoustic louvre shall be sealed on both sides with a mastic sealant. Large gaps shall be packed through its depth with acoustic insulation. Both sides of gap shall be sealed with metal angles using an approved acoustic sealant
- s5. All gaps and penetrations in the external wall and roof/ceiling of the plant room shall be sealed airtight using an approved mastic sealant equivalent to Promat Fyerguard Promoseal with specify gravity of 1.6.

#### 5.4.2 Vibration Isolation

The following vibration isolation advice is provided for control of structure-borne noise into building structure;

- s1. Pumps, chillers and cooling towers should be vibration isolated off the roof slab with spring isolation mounts that incorporate neoprene rubber base and have a 50mm minimum static deflection. All associated duct and pipes shall be vibration isolated from support structure using resilient mounts
- s2. Fan shall be vibration isolated off slab soffit using neoprene/spring hangers having a minimum static deflection of 25mm
- s3. Air handling units shall be vibration isolated off plinth with neoprene mounts
- s4. Roof mounted fans shall be vibration isolated off roof slab or support structure with neoprene mounts
- s5. Fans shall be isolated from duct work on inlet and discharge side of fan with flexible connectors
- s6. Ductwork supported from the concrete soffit shall be isolated with neoprene hangers.
- s7. Ductwork associated with supply and exhaust fans shall not be fixed into riser walls adjoining apartments

- s8. If it is necessary to fix ductwork to walls of riser shafts, the fixings shall be minimised and ductwork shall be vibration isolated from the riser or any adjoining construction using neoprene mounts or equivalent. A clear gap shall be maintained between ductwork and riser walls.
- s9. Where applicable, fan plant room walls shall be of solid construction (full-height plasterboard or masonry) with sound-rated access door.
- s10. Where applicable, penetrations shall be sized for mechanical ducts passing through building slabs or plant room walls to allow a uniform clearance of 10-20mm around the item and this space shall be packed through its depth with acoustic insulation. The joints on both sides shall be sealed on both sides with metal angles using approved acoustic sealant.

#### **5.4.3 Compliance certification**

- s11. The levels shall be measured using a sound level meter complying with AS 1259, Part 2 – Sound Level Meters, Type 1 – Precision.
- s12. Internal noise compliance tests shall be conducted over a 1 minute period with all plant operating at normal rated speed. The ambient noise level shall also be obtained with all plant turned off. The measurements shall be carried out when ambient noise levels are sufficiently low to obtain a valid measurement and corrected for the ambient noise level. The noise level contribution from all plant when operating in isolation or in combination with any other plant shall not exceed the criteria in Section 4.1.
- s13. An allowance of 3 dB(A) (subtracted from the noise level contribution determined in accordance with the preceding clause) may be applied when measurements are made in rooms which are uncarpeted for the time being. However, this does not preclude the Sub-Contractor from complying with the requirements of Section Section 4.1 when the rooms are finally carpeted.
- s14. Where both mechanical and hydraulic plant noise are audible, the total noise level from all plant operating shall include noise contribution from all mechanical and all hydraulic plant running contemporaneously at normal rated speed.
- s15. Noise levels shall be conducted in typical spaces on every level within the building as directed by the Principal's acoustic consultant.
- s16. External noise compliance measurements shall be conducted over a 15-minute period with all plant operating at normal rated speed. The ambient noise level will all plant turned off shall be measured immediately after. Measurements shall only be conducted when ambient noise levels are sufficiently low to obtain a valid measurement and shall be corrected for the ambient noise level. The noise contribution from all measured mechanical services plant when operating in isolation or in combination with any other plant shall not exceed the criteria in Section 4.1.

- s17. The external noise emission criteria specified in Section 4.1 are applicable at any boundary or other noise sensitive location as determined by the Principal's acoustic consultant.
- s18. Where the ambient external noise level prevents noise levels being measured at the boundary of nearby affected premises, extrapolation of measurements closer to the noise source is permitted.
- s19. The Principal reserves the right to test plant noise emission and noise intrusion in order to determine their conformance with each of the criteria nominated in this specification.
- s20. A Noise Compliance Report detailing the results of mechanical plant noise levels measured in accordance with this specification shall be presented to the Principal.

## 5.5 Predicted Noise Levels at Nearest Receivers

External noise emissions from the proposed mechanical plant were predicted by modelling the noise sources, receiver locations, building facades, and possible noise control treatments using the internationally recognised environmental noise prediction computer program CadnaA (version 4.5).

The noise prediction models take into account:

- Location of noise sources and receiver locations;
- Height of sources and receivers;
- Separation distances between sources and receivers;
- Shielding from building and intervening structures;
- Break-out noise from plant room openings;
- Implementation of recommend noise mitigation measure in Section 5.4 above

Figure 6 and Figure 7 below are graphical representations of the predicted noise levels at facades of nearby residential and commercial buildings using CadnaA software.



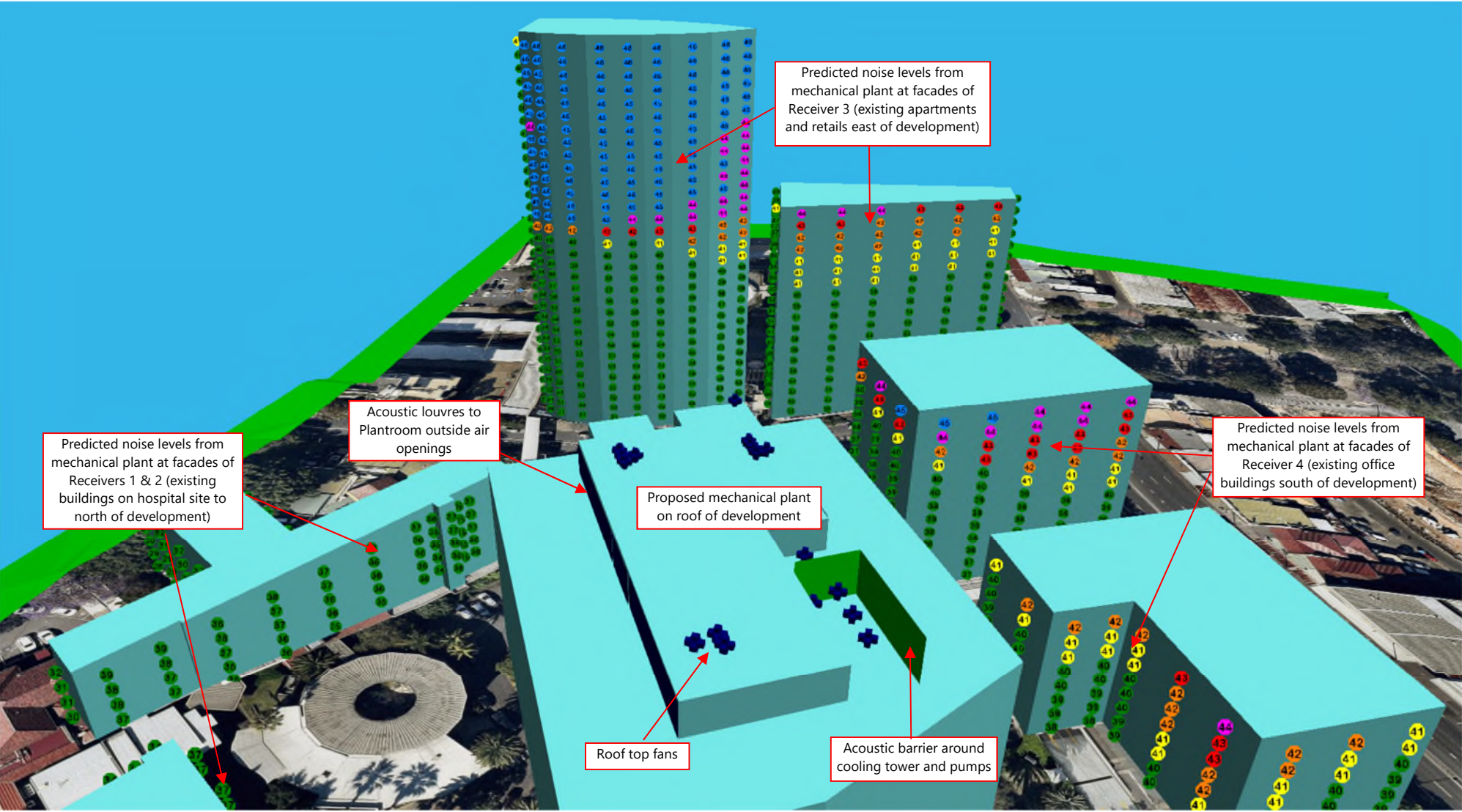
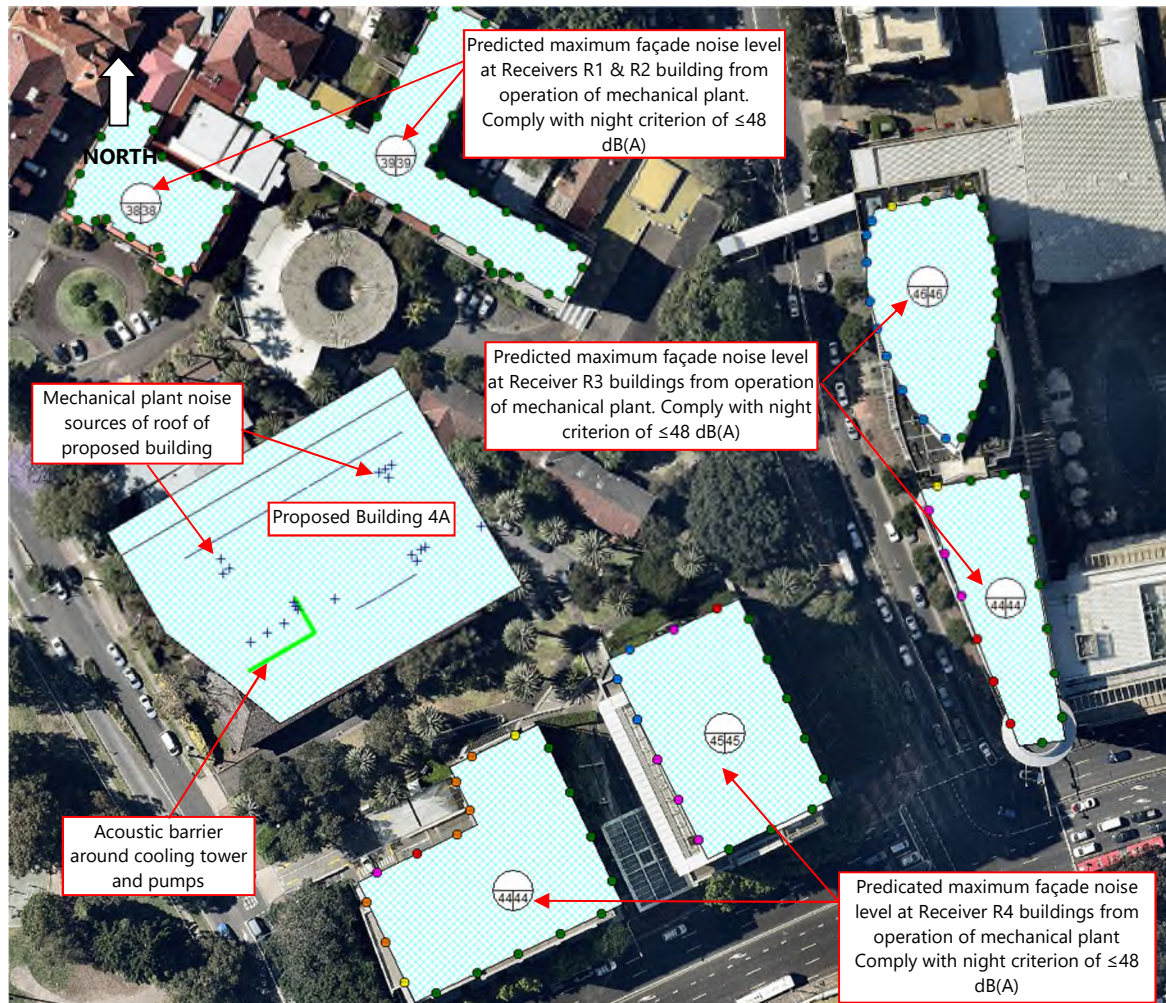


Figure 6: Predicted Noise Levels at Nearest Building Facades (3D) from Proposed Mechanical Plant



**Figure 7: Predicted Maximum Noise Levels at Nearest Buildings from Proposed Mechanical Plant**

The predicted noise levels shown in Figure 6 and Figure 7 have demonstrated with the implementation of the noise and vibration mitigation measures described in Section 5.4 operational noise from proposed mechanical plant to comply with the Project noise criteria defined in Table 4 at the nearest affected residential and commercial receivers.

## 6 Noise Assessment of Childcare Outdoor Play Area

### 6.1 Proposed Child Care Centre

The child care facility is located on first floor with approximately 700m<sup>2</sup> of outdoor play area. The proposed facility will be used for the day care of up to 100 children. The proposed breakup of children in each age group is as follows:

- 16 x 0-2 year old
- 40 x 2-3 year old
- 44 x 3-6 year old

Children playrooms and amenities, administration areas and staff amenities will be located within the tenancy.

The proposed operating hours of the centre will be Monday to Friday between 6:45am and 6:00pm. Outside play area is assumed to be scheduled for use any time from 7am to 6pm.

## 6.2 Operational Noise Issue

Operational noise from the use of the outdoor play area has potential to impact on nearby existing neighbours to the child care centre.

The outdoor play area is situated on the southern part of the first floor and the nearest affected neighbours were identified as the commercial neighbours (R4) on the site southern boundary, commercial neighbours (R2) to the north-east of site, and residential/retail neighbour (R3) to the far east across Herbert Street as shown in Figure 8 and Table 12 below. Receivers R1 shown in Figure 4 above are not affected by noise emitted from the outdoor play area.

**Table 12: Nearest Noise Sensitive Receivers to Outdoor Play area**

| Receiver | Description                                                                                                                                                                                                                                              |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R2       | South-east façade of the 4-storey office building with windows facing new development                                                                                                                                                                    |
| R3       | Apartments with windows and balconies facing Herbert Street on Levels 4 to 26 and retails on Levels 1 to 3 with windows or glazed façade facing Herbert Street – at 3 Herbert Street, St. Leonards. Retail windows/glazed external wall are fixed glass. |
| R4       | Northern facade of the 7-storey office buildings approximately 19m south of the outdoor play area – 207 Pacific Highway, St. Leonards. All windows of the office building are fixed glass.                                                               |

The worst-case scenario will be when all the age groups are utilising the outdoor play area during the same outdoor play session.



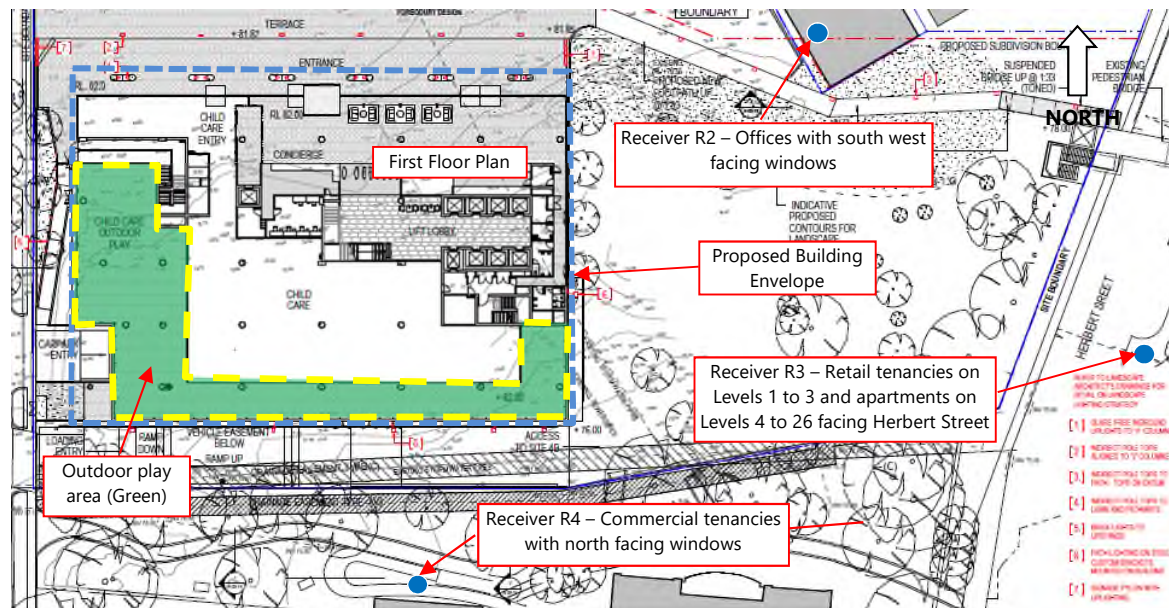


Figure 8: Locality map showing child care outdoor area, surrounds and receiver locations

Noise impacts are assessed to these nearest receivers and where necessary noise mitigation measures are recommended to comply with noise criteria established in Section 4.2 above.

### 6.3 Sound Power of Noise Source

The AAAC Guideline for Child Care Centre Acoustic Assessment provides typical sound power levels of children of different age group playing. The sound power levels recommended in the AAAC guideline were used in the noise calculations for the outside play areas. The sound power levels obtained from the guideline are adjusted to take into consideration the number of children in each age group and in each outside play area to enable prediction of noise levels to receiver locations.

Based on the anticipated number of children in the outside play areas, the source noise levels used in this assessment are shown in Table 13 below in terms of sound power levels. As a worst-case scenario, it has been assumed that all age groups use the outdoor play area during the same play session and each group has half of the children engaged in active type play activities (ie children free play) and other half in passive activities.

Table 13:  $L_{Aeq}$  Sound Power Level of Children Playing Outside in dB(A) re.1pW

| Noise Sources     | $L_{Aeq}$ Sound Power Level |
|-------------------|-----------------------------|
| 16 x 0-2 year old | 81 dB(A)                    |
| 40 x 2-3 year old | 92 dB(A)                    |
| 44 x 3-6 year old | 94 dB(A)                    |

Notes: 1. Source noise levels based on 50% active type activities eg children free play and 50% passive type activities

## 6.4 Predicted Noise Levels at Nearest Receivers

Noise emissions from the proposed outdoor play area were predicted by modelling the noise sources, receiver locations, building facades, and possible noise control treatments using the internationally recognised environmental noise prediction computer program CadnaA (version 4.5).

The noise prediction models take into account:

- Location of noise sources and receiver locations;
- Height of sources and receivers;
- Separation distances between sources and receivers;
- Shielding from building and intervening structures;
- Attenuation from a minimum 1.2m height solid balustrade around perimeter of outdoor play area

Figure 9 and Figure 10 below are graphical representations of the predicted noise levels at facades of nearby residential and commercial buildings using CadnaA software.

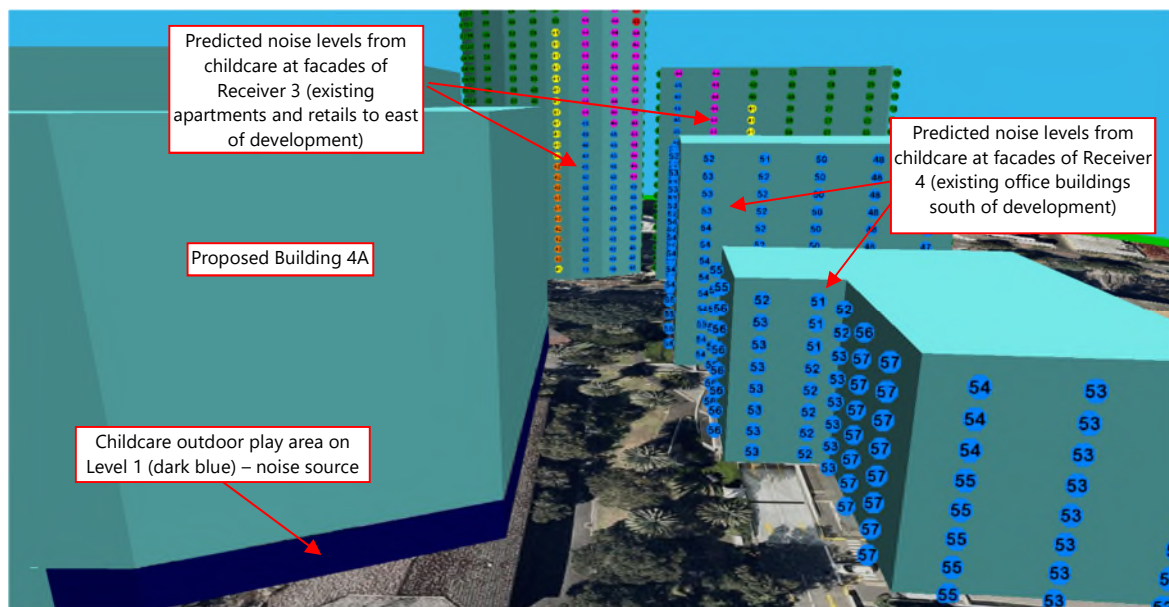


Figure 9: Predicted Noise Levels at Nearest Building Facades (3D) from Outdoor Play Area



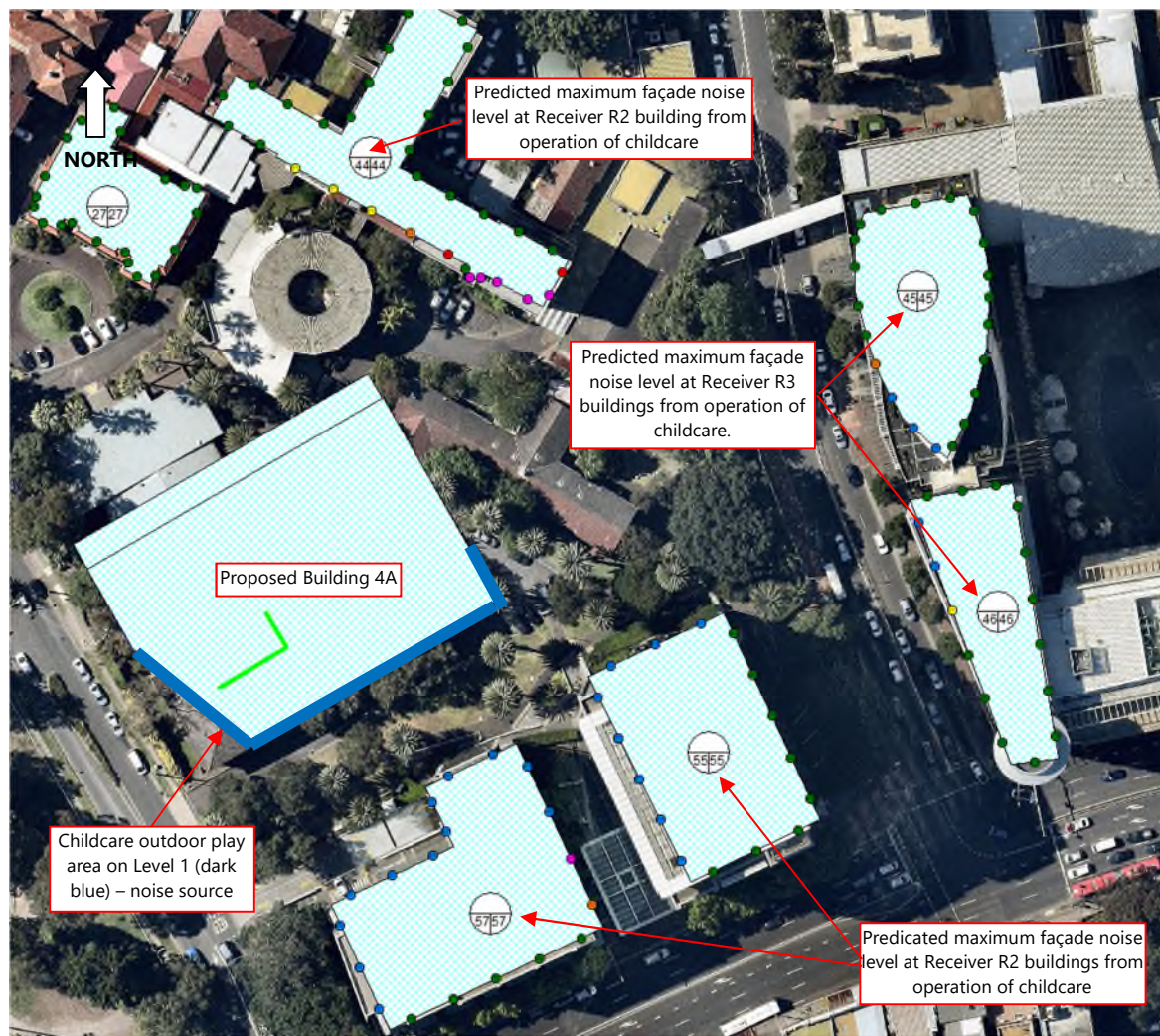


Figure 10: Predicted Maximum Childcare Noise Levels at Nearest Buildings

## 6.5 Assessment of Noise Levels at Nearest Receivers

Based on the sound power levels presented in Table 13 noise emitted to the nearest affected receivers (R2, R3 & R4) are calculated using modelling software and compared to its relevant acoustic criteria discussed in Section 4.2 above.

Table 14: Predicted Noise Levels at Nearest Affected Receivers

| Assessment/Receiver Location                                                 | Level              | Predicted Maximum Sound Pressure Level <sup>1</sup><br>L <sub>Aeq</sub> , dB(A) | Receiver Criterion L <sub>Aeq</sub> ,<br>dB(A) | Compliance (Yes/No) |
|------------------------------------------------------------------------------|--------------------|---------------------------------------------------------------------------------|------------------------------------------------|---------------------|
| R2 – Office building within the hospital site                                | Ground to Level 3  | 24 <sup>2</sup><br>[44 dB(A) externally]                                        | 65 or less                                     | Yes                 |
| R3 – Residential levels of mixed-use building to east of development         | Level 4 to 26      | 45                                                                              | 55                                             | Yes                 |
| R3 – Commercial/retails levels of mixed-used building to east of development | Ground to Level 19 | 26 <sup>2</sup><br>[46 dB(A) externally]                                        | 65 or less                                     | Yes                 |

| Assessment/Receiver Location               | Level             | Predicted Maximum Sound Pressure Level <sup>1</sup><br>L <sub>Aeq</sub> , dB(A) | Receiver Criterion L <sub>Aeq</sub> ,<br>dB(A) | Compliance (Yes/No) |
|--------------------------------------------|-------------------|---------------------------------------------------------------------------------|------------------------------------------------|---------------------|
| R4 – Office buildings south of development | Ground to Level 9 | 37 <sup>2</sup><br>[57dB(A) externally]                                         | 65 or less                                     | Yes                 |

Notes:

1. Predicted external noise levels are 1m from façade or window.
2. It is conservatively estimated that typical 6mm fixed glass window or façade provided a minimum 20dB sound reduction.

The predicted noise levels in Table 14 above have shown operational noise from the outdoor play area to comply with the Project noise criteria defined in Section 4.2.1 and 4.2.2 at the nearest affected residential and commercial receivers. Therefore additional acoustic treatment to the outdoor play area is not required.

## 7 Conclusion

Renzo Tonin & Associates have completed an operational noise assessment of the proposed Health Services Administration Building (Site 4A) at the Royal North Shore Hospital, St Leonards in accordance with Condition 8 of the SEARs.

Proposed mechanical and refrigeration plant located on the roof of the development has been identified as main source of noise impacts to existing surrounding residential and commercial premises. Details of noise and vibration mitigation measures has been provided in Section 5.4 of this report to ensure that plant equipment will not either singularly or in total emit noise levels which exceed the day or night time noise limits defined by EPA Industrial Noise Policy.

Our noise modelling of the outdoor play area of the proposed childcare has found operational noise emitted from the facility to comply with the AAAC Guideline for Child Care Centres Acoustic Assessment" published by the Association of Australian Acoustical Consultants. No additional acoustic measure is required for the proposed outdoor play area.

## 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 L90 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:<br>0dB The faintest sound we can hear<br>30dB A quiet library or in a quiet location in the country<br>45dB Typical office space. Ambience in the city at night<br>60dB CBD mall at lunch time<br>70dB The sound of a car passing on the street<br>80dB Loud music played at home<br>90dB The sound of a truck passing on the street<br>100dB The sound of a rock band<br>115dB Limit of sound permitted in industry<br>120dB Deafening                                            |
| dB(A)              | A-weighted decibels. The A-weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in 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. |
| dB(C)              | C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.                                                                                                                                                                                                                                                                                                    |
| 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 <sub>Max</sub>   | The maximum sound pressure level measured over a given period.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| L <sub>Min</sub>   | The minimum sound pressure level measured over a given period.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

|                      |                                                                                                                                                                                                                                                                                                                                                            |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L <sub>1</sub>       | The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.                                                                                                                                                                                                                                                        |
| L <sub>10</sub>      | The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.                                                                                                                                                                                                                                                       |
| L <sub>90</sub>      | The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).                                                                                                                                                                                                                          |
| L <sub>eq</sub>      | 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 <sub>eq</sub> 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.                                                                                                                                                                                                                                                                                    |

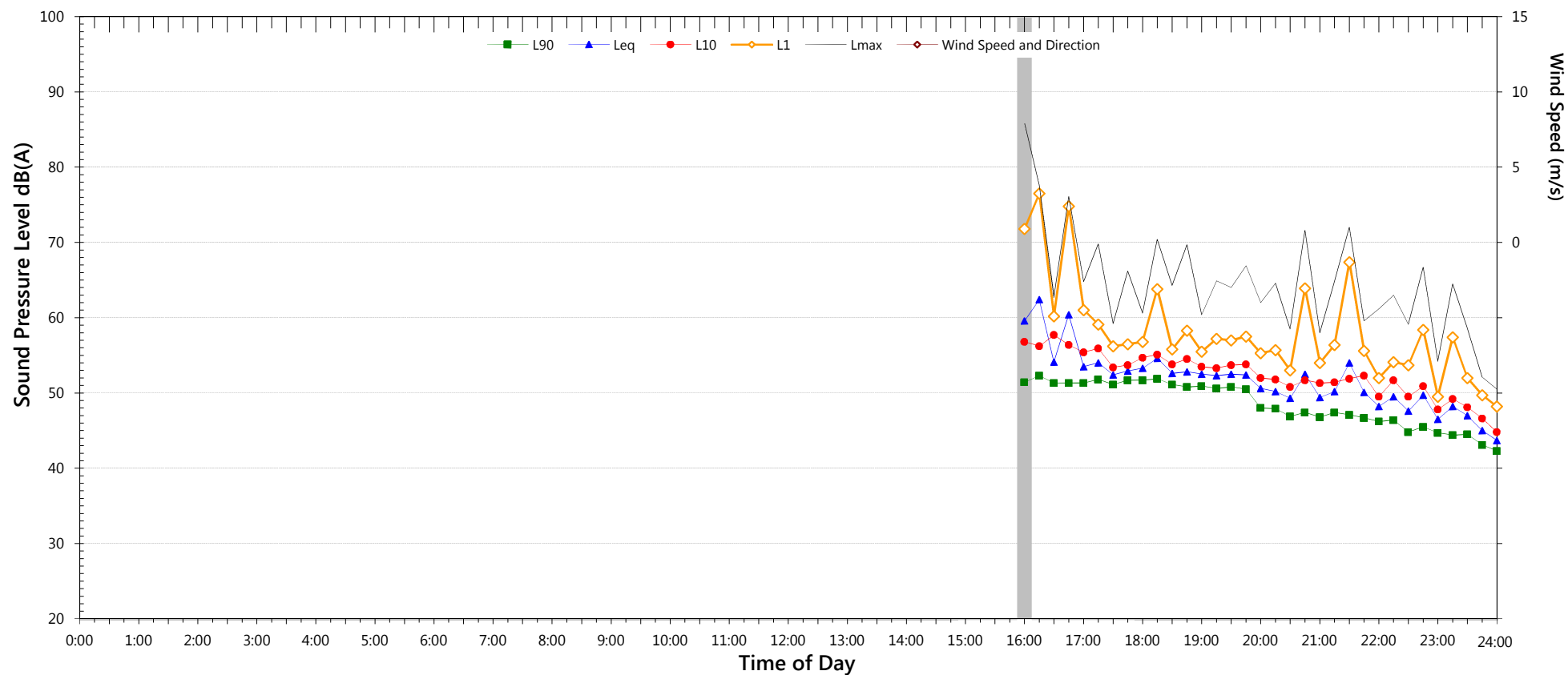


## **APPENDIX B**      Long-term noise monitoring results

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Monday, 6 February 2017



| NSW Industrial Noise Policy (Free Field) |                  |                      |                      |
|------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                               | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                          | -                | 46.7                 | -                    |
| LA <sub>eq</sub>                         | -                | 51.9                 | -                    |

| Night Time Maximum Noise Levels            |      | (see note 7) |      |
|--------------------------------------------|------|--------------|------|
| L <sub>Max</sub> (Range)                   | 66.7 | to           | 69.4 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range) | 18.2 | to           | 21.8 |

Notes:

- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- Graphed data measured in free-field; tabulated results facade corrected

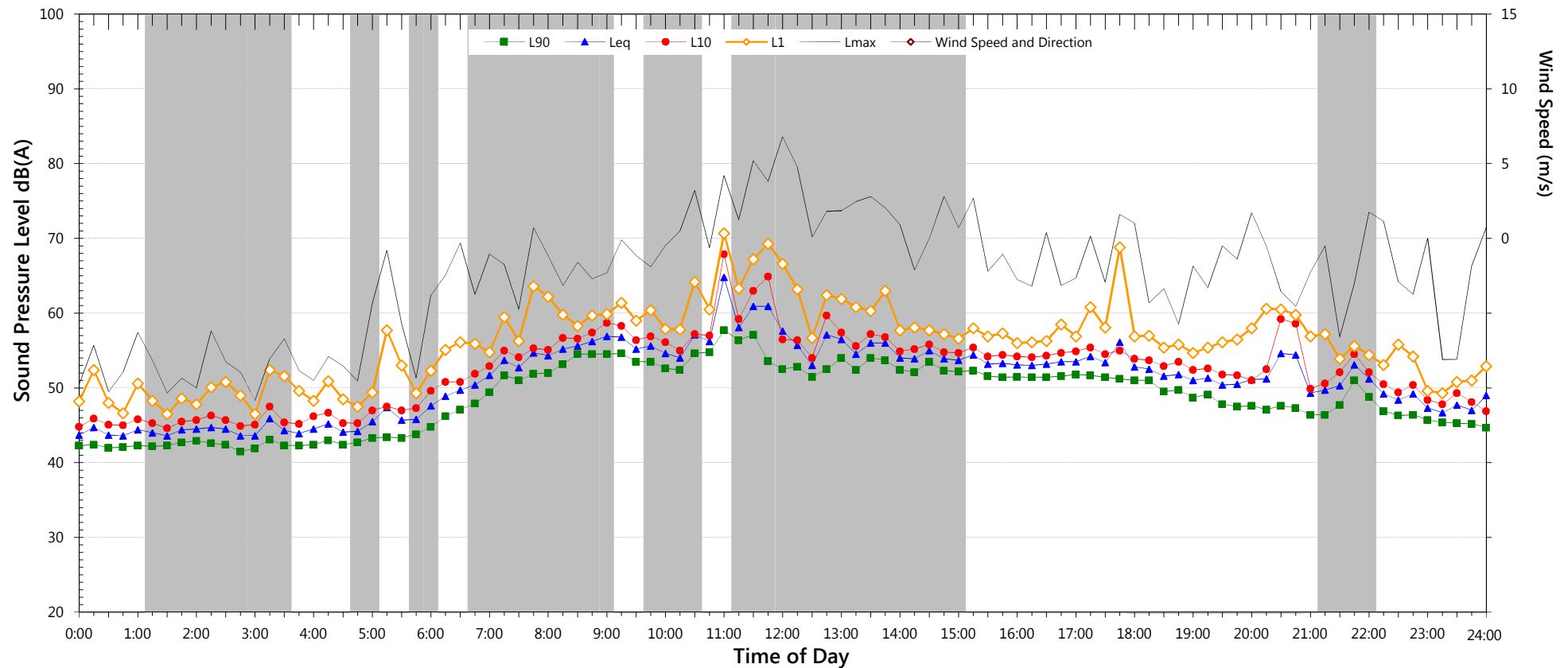
| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 56.9     | 49.2               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 61.7     | 51.8               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 53.1     | 46.6               |

- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Tuesday, 7 February 2017



| NSW Industrial Noise Policy (Free Field) |                  |                      |                      |
|------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                               | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                          | -                | -                    | -                    |
| LA <sub>eq</sub>                         | -                | -                    | -                    |

| Night Time Maximum Noise Levels            |      | (see note 7) |      |
|--------------------------------------------|------|--------------|------|
| L <sub>Max</sub> (Range)                   | 71.5 | to           | 72.3 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range) | 18.3 | to           | 23.8 |

Notes:

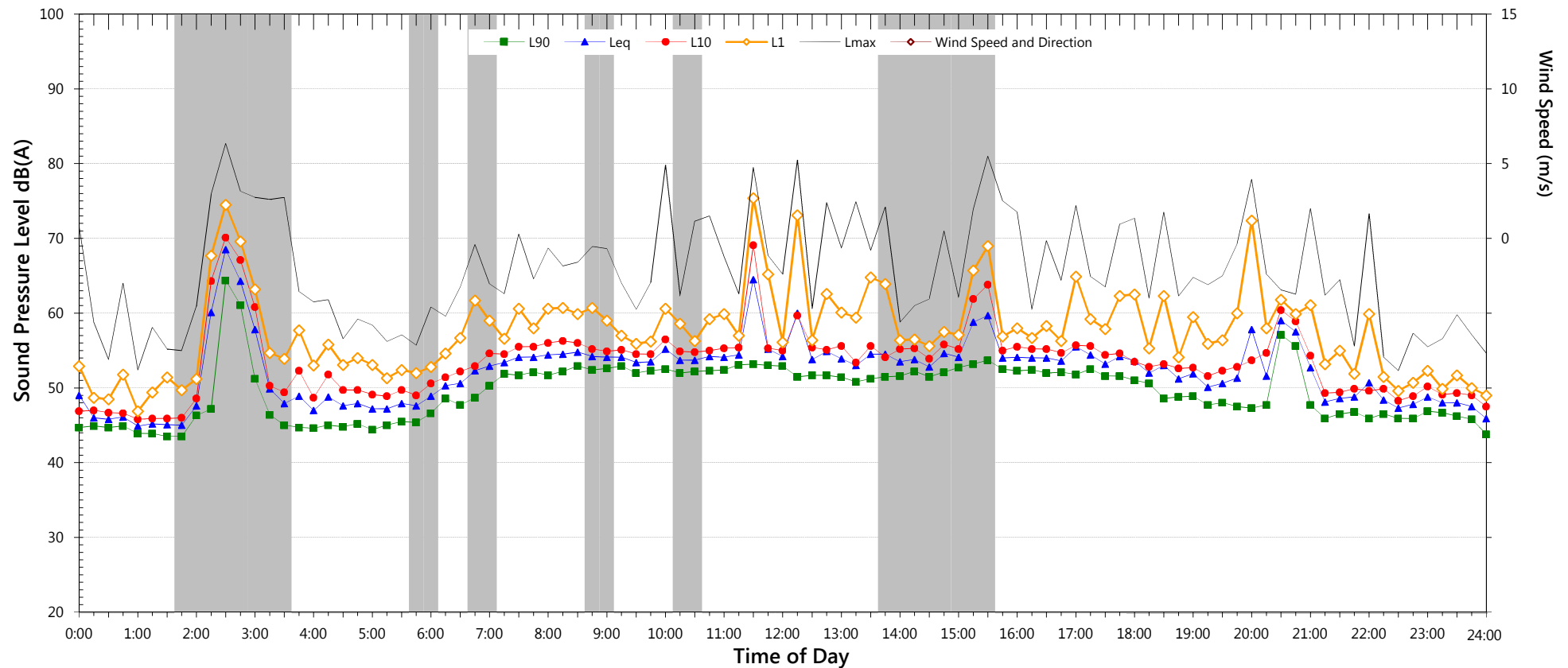
- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Graphed data measured in free-field; tabulated results facade corrected
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 57.5     | 50.3               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 64.9     | 53.0               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 53.3     | 47.7               |

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Wednesday, 8 February 2017



| NSW Industrial Noise Policy (Free Field)     |                  |                      |                      |
|----------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                                   | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                              | -                | 45.9                 | 43.1                 |
| LA <sub>eq</sub>                             | -                | 53.5                 | 47.2                 |
| Night Time Maximum Noise Levels (see note 7) |                  |                      |                      |
| L <sub>Max</sub> (Range)                     | 65.8             | to                   | 65.8                 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range)   | 15.4             | to                   | 17.0                 |

Notes:

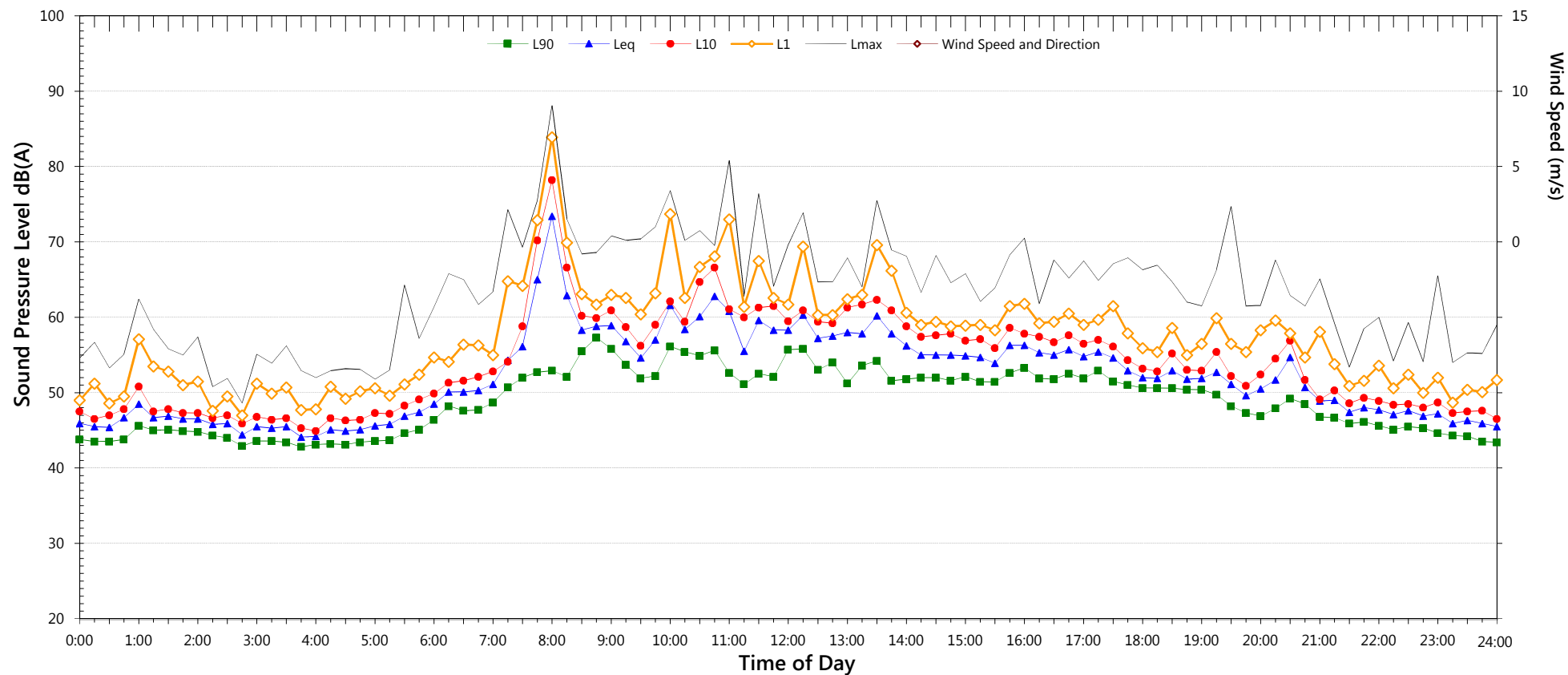
- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Graphed data measured in free-field; tabulated results facade corrected
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 57.5     | 49.7               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 61.1     | 52.9               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 53.1     | 47.3               |

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Thursday, 9 February 2017



| NSW Industrial Noise Policy (Free Field)     |                  |                      |                      |
|----------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                                   | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                              | 51.2             | 45.9                 | 42.6                 |
| LA <sub>eq</sub>                             | 60.6             | 51.1                 | 47.1                 |
| Night Time Maximum Noise Levels (see note 7) |                  |                      |                      |
| L <sub>Max</sub> (Range)                     | 65.5             | to                   | 73.7                 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range)   | 15.6             | to                   | 22.7                 |

Notes:

- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- Graphed data measured in free-field; tabulated results facade corrected

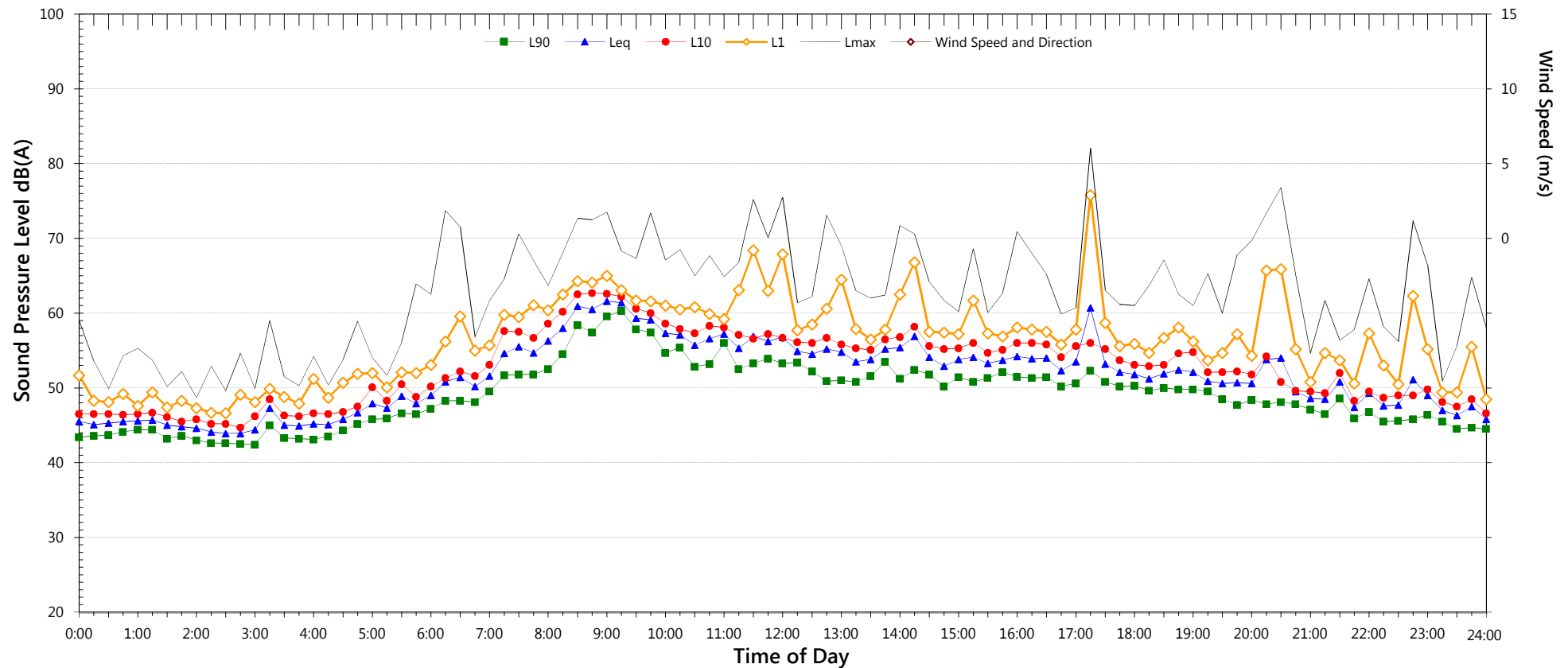
| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 61.9     | 49.6               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 68.3     | 53.5               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 52.4     | 46.6               |

- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Friday, 10 February 2017



| NSW Industrial Noise Policy (Free Field) |                  |                      |                      |
|------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                               | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4,5</sup> |
| L <sub>90</sub>                          | 50.6             | 46.5                 | 42.7                 |
| LA <sub>eq</sub>                         | 56.6             | 51.1                 | 46.8                 |

| Night Time Maximum Noise Levels            |      | (see note 7) |      |
|--------------------------------------------|------|--------------|------|
| L <sub>Max</sub> (Range)                   | 71.0 | to           | 72.4 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range) | 16.5 | to           | 23.3 |

Notes:

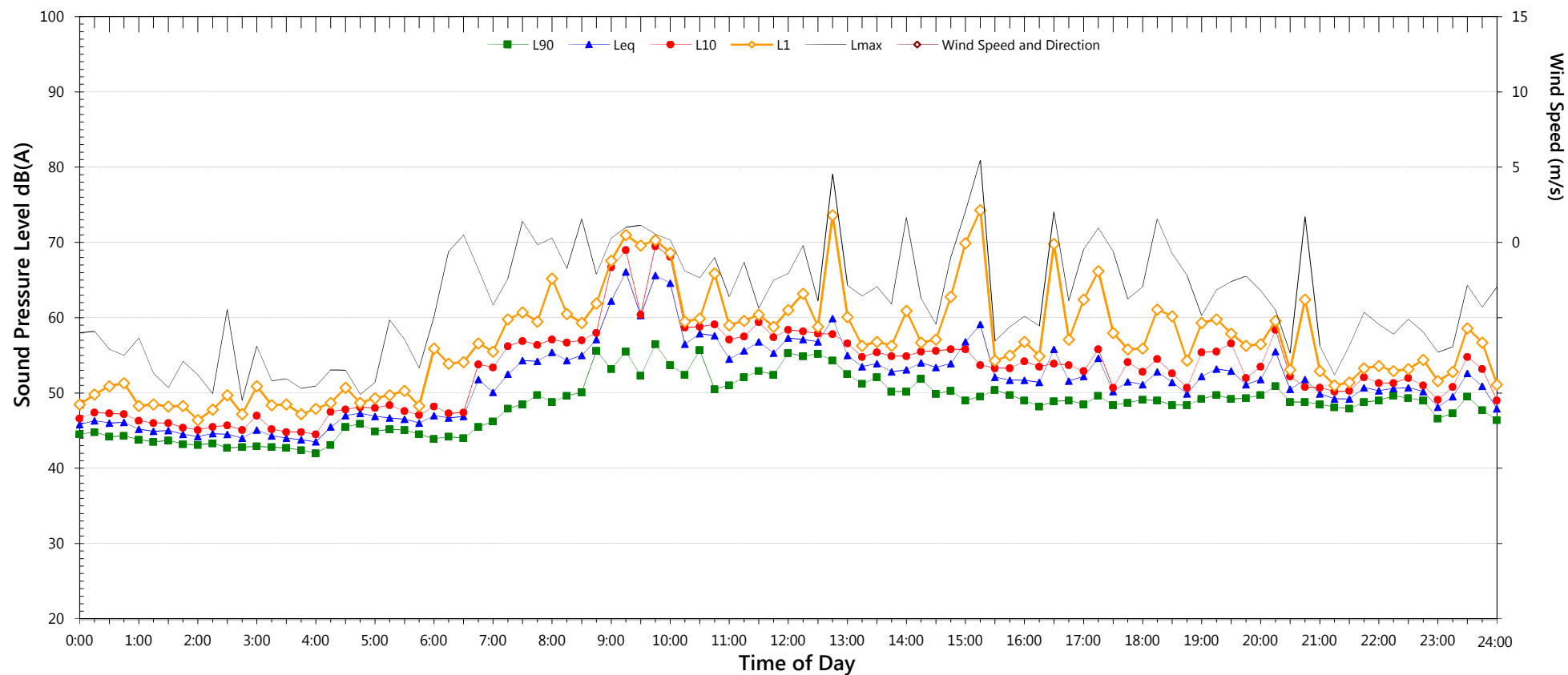
- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- Graphed data measured in free-field; tabulated results facade corrected
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 58.2     | 49.3               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 62.5     | 51.9               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 52.5     | 46.4               |

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Saturday, 11 February 2017



| NSW Industrial Noise Policy (Free Field)     |                  |                      |                      |
|----------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                                   | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4,5</sup> |
| L <sub>90</sub>                              | 48.5             | 48.1                 | 44.0                 |
| LA <sub>eq</sub>                             | 57.8             | 51.7                 | 49.3                 |
| Night Time Maximum Noise Levels (see note 7) |                  |                      |                      |
| L <sub>Max</sub> (Range)                     | 67.2             | to                   | 72.0                 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range)   | 21.2             | to                   | 22.2                 |

Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.

3. "Evening" is the period from 6pm till 10pm

6. Graphed data measured in free-field; tabulated results facade corrected

4. "Night" relates to the remaining periods

7. Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 59.3     | 50.8               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 65.1     | 53.1               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 53.4     | 48.2               |

2. "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days

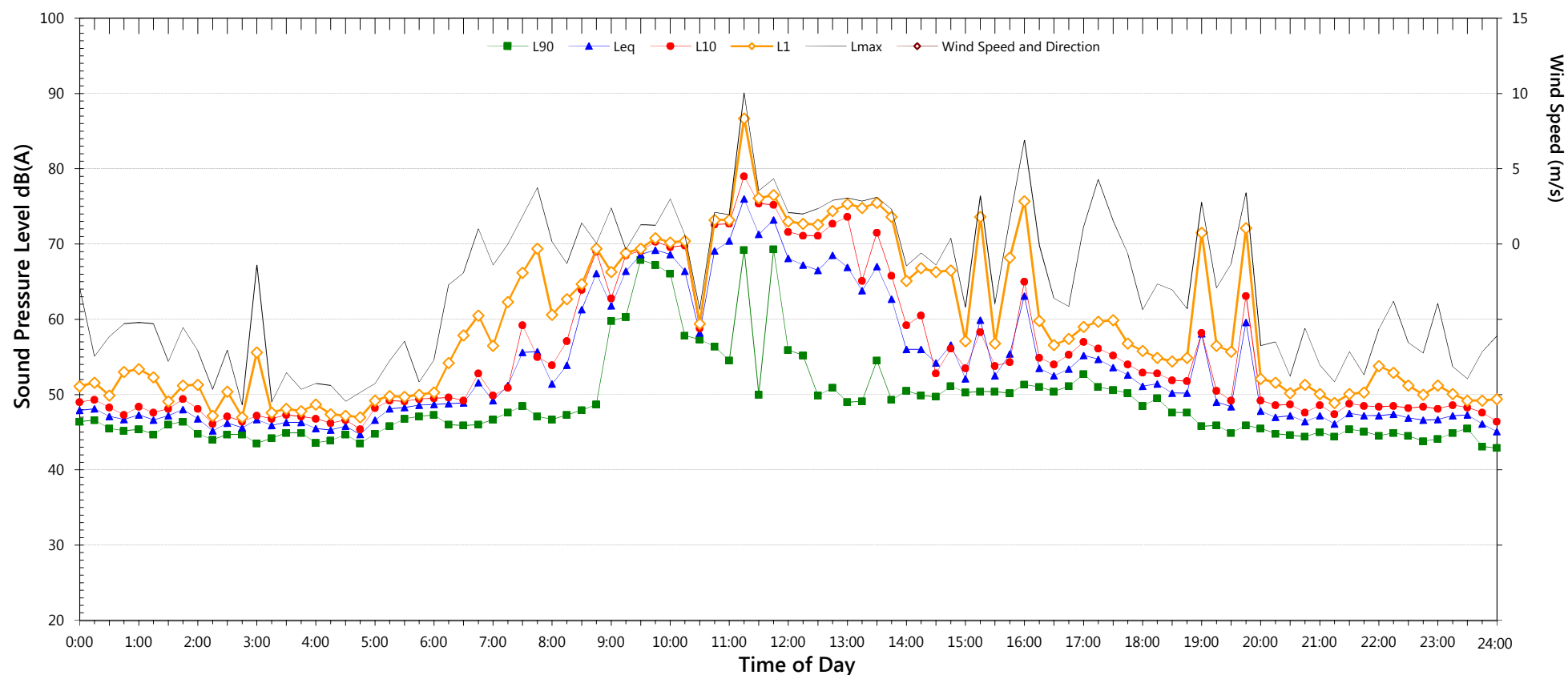
5. "Night" relates to period from 10pm on this graph to morning on the following graph.



# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Sunday, 12 February 2017



| NSW Industrial Noise Policy (Free Field) |                  |                      |                      |
|------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                               | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4,5</sup> |
| L <sub>90</sub>                          | 48.9             | 44.4                 | 42.5                 |
| LA <sub>eq</sub>                         | 66.5             | 52.0                 | 54.4                 |

| Night Time Maximum Noise Levels            |      | (see note 7) |      |
|--------------------------------------------|------|--------------|------|
| L <sub>Max</sub> (Range)                   | 69.4 | to           | 79.8 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range) | 15.5 | to           | 20.2 |

Notes:

- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

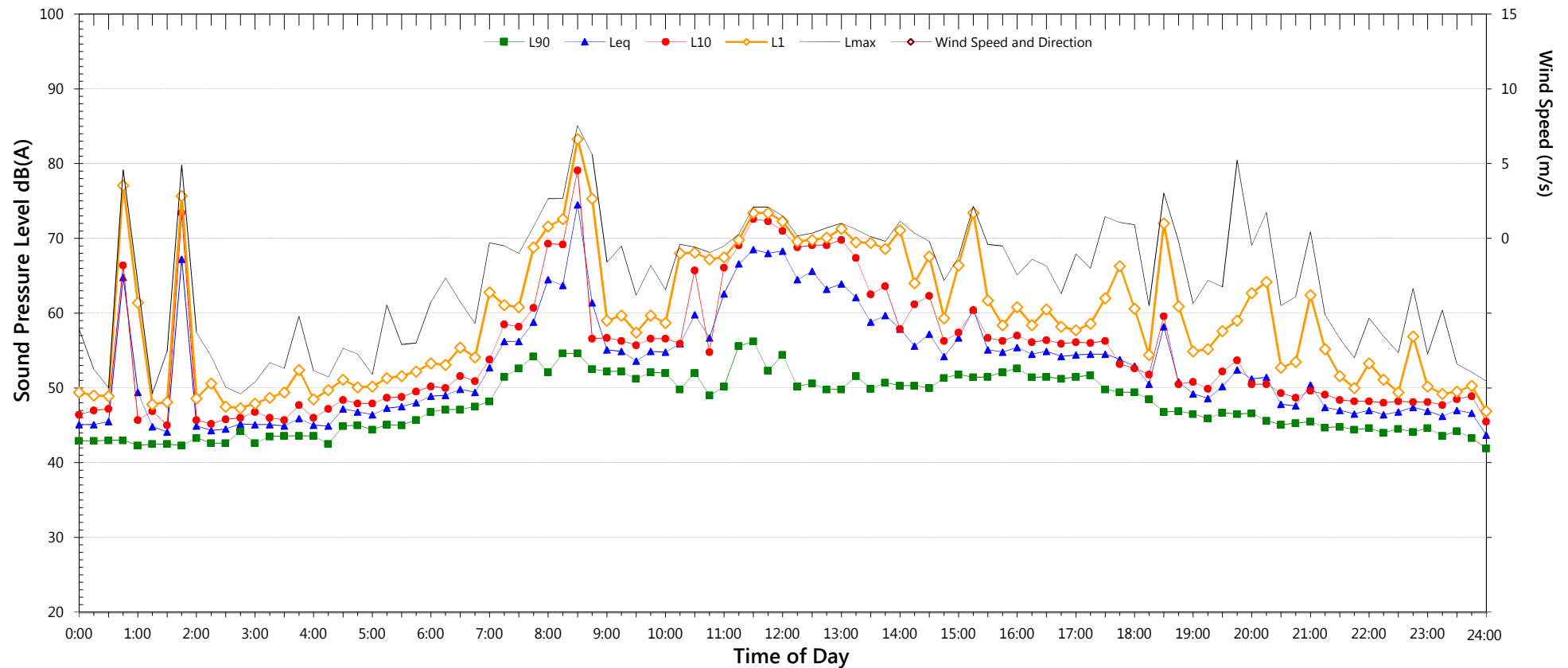
| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 67.3     | 56.9               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 73.8     | 63.8               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 49.5     | 47.3               |

- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Night" relates to period from 10pm on this graph to morning on the following graph.

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Monday, 13 February 2017



| NSW Industrial Noise Policy (Free Field)     |                  |                      |                      |
|----------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                                   | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                              | 49.8             | 44.6                 | 42.2                 |
| L <sub>Aeq</sub>                             | 63.0             | 51.0                 | 46.7                 |
| Night Time Maximum Noise Levels (see note 7) |                  |                      |                      |
| L <sub>Max</sub> (Range)                     | 73.0             | to                   | 73.0                 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range)   | 16.4             | to                   | 23.0                 |

Notes:

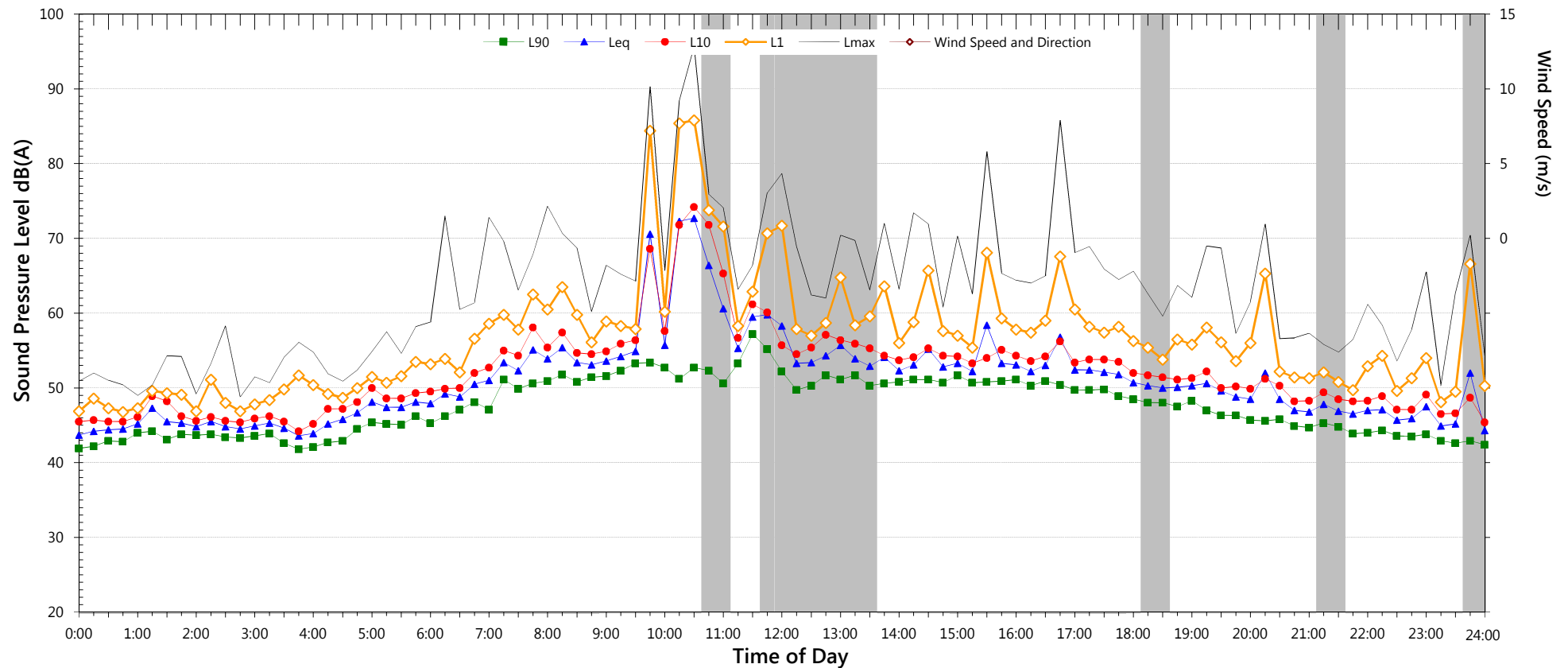
- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Graphed data measured in free-field; tabulated results facade corrected
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 64.2     | 49.2               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 71.0     | 52.5               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 51.0     | 46.9               |

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Tuesday, 14 February 2017



| NSW Industrial Noise Policy (Free Field) |                  |                      |                      |
|------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                               | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                          | -                | -                    | -                    |
| LA <sub>eq</sub>                         | -                | -                    | -                    |

| Night Time Maximum Noise Levels            |      | (see note 7) |      |
|--------------------------------------------|------|--------------|------|
| L <sub>Max</sub> (Range)                   | 65.5 | to           | 73.4 |
| L <sub>Max</sub> - L <sub>eq</sub> (Range) | 15.5 | to           | 23.0 |

Notes:

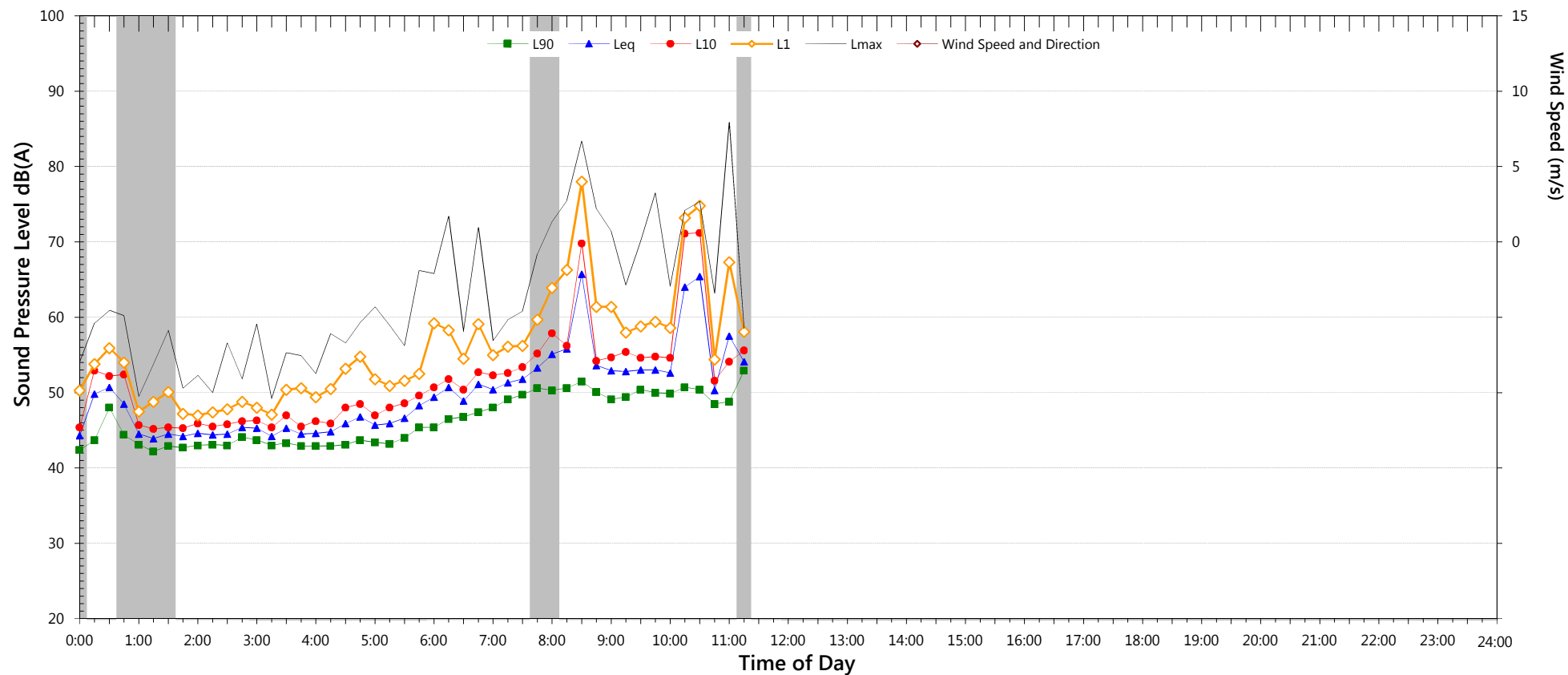
- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Graphed data measured in free-field; tabulated results facade corrected
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 63.4     | 49.7               |
| L <sub>eq</sub> 1hr upper 10 percentile             | 73.3     | 52.9               |
| L <sub>eq</sub> 1hr lower 10 percentile             | 50.4     | 46.9               |

# Unattended Noise Monitoring Results

North of Building 38, Royal North Shore Hospital

Wednesday, 15 February 2017



| NSW Industrial Noise Policy (Free Field)     |                  |                      |                      |
|----------------------------------------------|------------------|----------------------|----------------------|
| Descriptor                                   | Day <sup>2</sup> | Evening <sup>3</sup> | Night <sup>4 5</sup> |
| L <sub>90</sub>                              | -                | -                    | -                    |
| L <sub>Aeq</sub>                             | -                | -                    | -                    |
| Night Time Maximum Noise Levels (see note 7) |                  |                      |                      |
| L <sub>Max</sub> (Range)                     | -                | to                   | -                    |
| L <sub>Max</sub> - L <sub>eq</sub> (Range)   | -                | to                   | -                    |

Notes:

- Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
- "Day" is the period from 8am till 6pm on Sundays and 7am till 6pm on other days
- "Evening" is the period from 6pm till 10pm
- "Night" relates to the remaining periods
- "Night" relates to period from 10pm on this graph to morning on the following graph.
- Graphed data measured in free-field; tabulated results facade corrected
- Night time L<sub>Max</sub> values are shown only where L<sub>Max</sub> > 65dB(A) and where L<sub>Max</sub> - L<sub>eq</sub> ≥ 15dB(A)

| NSW Road Noise Policy (1m from facade) (see note 6) |          |                    |
|-----------------------------------------------------|----------|--------------------|
| Descriptor                                          | Day      | Night <sup>5</sup> |
|                                                     | 7am-10pm | 10pm-7am           |
| L <sub>eq</sub> 15 hr and L <sub>eq</sub> 9 hr      | 61.9     | -                  |
| L <sub>eq</sub> 1hr upper 10 percentile             | 64.7     | -                  |
| L <sub>eq</sub> 1hr lower 10 percentile             | 54.1     | -                  |