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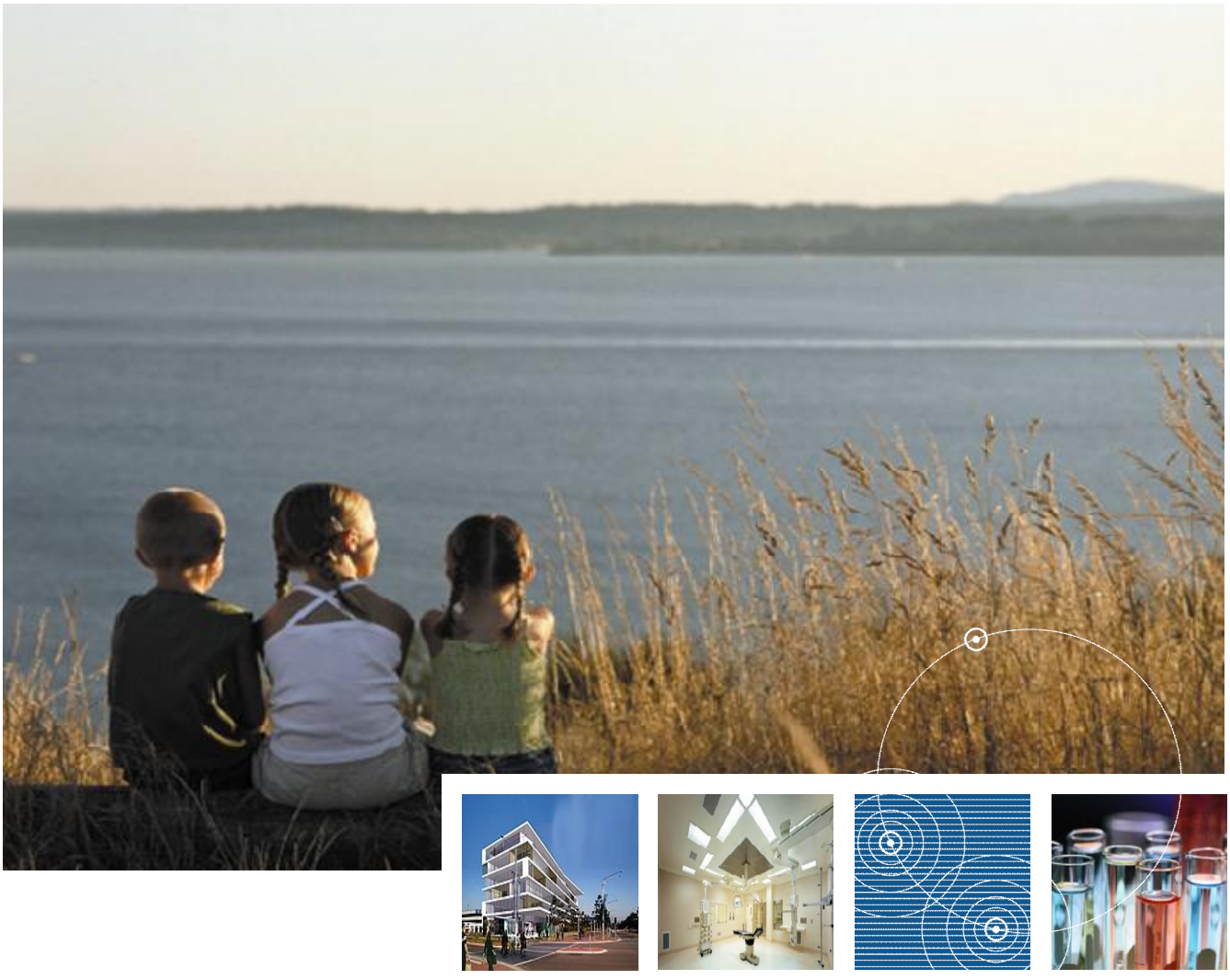

Sydney Olympic Park Private Hospital (Site 9) Rail Noise and Vibration Assessment

Australian Public Trustees Ltd

19 September 2007

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Rail Noise and Vibration Assessment

Prepared for

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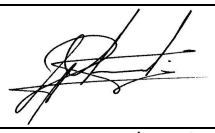
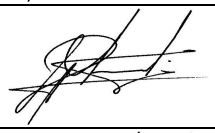
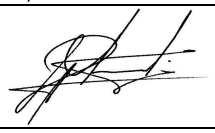
00	18/07/2007	Draft	Patrick Martinez Senior Acoustic Engineer	
01	23/07/2007	Final	Patrick Martinez Senior Acoustic Engineer	
02	19/09/2007	Revised Final Report	Patrick Martinez Senior Acoustic Engineer	

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1.0 Introduction

1.1 Background

Bassett Acoustics was commissioned by PTW Architects on behalf of Australian Public Trustees Ltd to provide an acoustic assessment report in response to the Director-General's Environmental Assessment Requirements (DGR's) for the construction of the Sydney Olympic Park Private Hospital. Section 4.0 of the report provides an acoustic assessment in response to the Sydney Olympic Park Authority queries regarding noise generated at nearby sporting venues and its impact on the proposed private hospital.

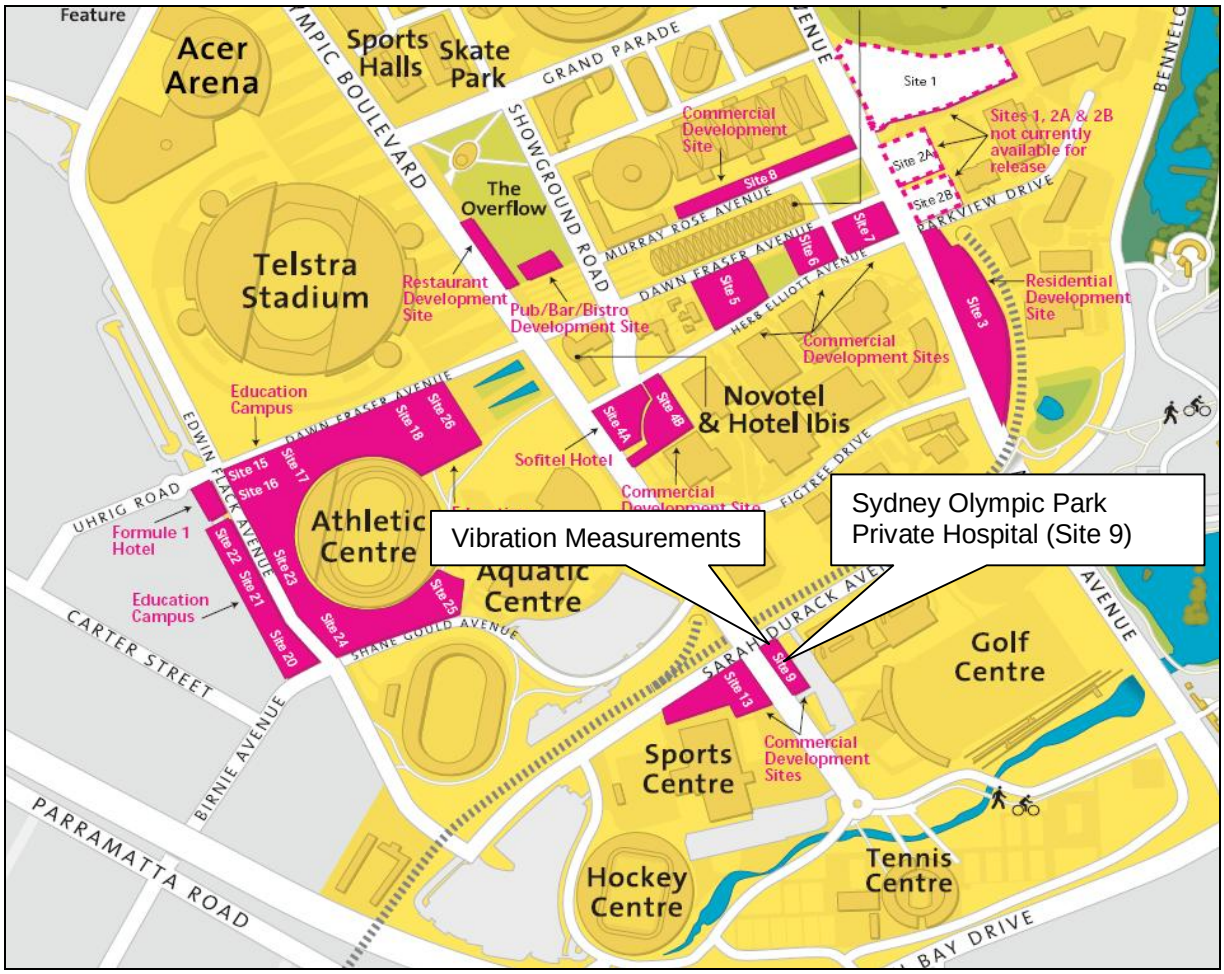
An application for the construction of the proposed Sydney Olympic Private Hospital, including associated on site parking has been submitted to the Department of Planning. The proposed development site is located on the corner of Sarah Durack Avenue and Olympic Boulevard, Sydney Olympic Park.

The acoustic terminology used in this report is explained in Appendix A.

1.2 Site Description

The site of the proposed private hospital is located on the corner of Sarah Durack Avenue and Olympic Boulevard, Sydney Olympic Park, the development site is known as Site 9. The development will comprise of a basement carpark, 6 storey hospital building and associated plant room on the roof level. The site location is shown in Figure 1.1 below. The Sydney Olympic Park rail line is located approximately 30 m to the north of the site. Site 9 is surrounded by commercial and sporting venues.

Figure 1.1 – Site Location Plan



1.3 Development description

Australian Public Trustees Ltd is proposing to construct a private hospital comprising a basement carpark, 6 storey hospital building and associated plant room on the roof level.
Sydney Olympic Park's new private hospital will be a 99-bed facility, incorporating eight operating theatres and 20 consultation rooms and is expected to handle 155,000 patient visits annually.

1.4 Director-General's Environmental Assessment Requirements

The Director-General's Environmental Assessment Requirements (DGR's) for the construction of the Sydney Olympic Park Private Hospital at Site 9 are presented below:

The DGR's, item 11 Acoustics & Noise requires:

- *Noise impacts associated with the future Hospital operation (e.g. noise from ambulance sirens) should be assessed against NSW DEC guidelines, Sydney Olympic Park Noise Management Guidelines 2002 and draft Master Plan 2025 Noise management Guidelines;*
- *The acoustic assessment shall also demonstrate consideration of RailCorp's "Interim Guidelines for Proponents" in addressing rail noise, vibration and electrolysis from the nearby rail corridor.*

Bassett Acoustics has been advised by PTW Architects that the proposed Private Hospital has no emergency department and ambulances visiting the hospital will be for patient transfers only and thus will not require the use of sirens. Therefore, an acoustic assessment of noise associated with the use of ambulance sirens is not required as part of this submission.

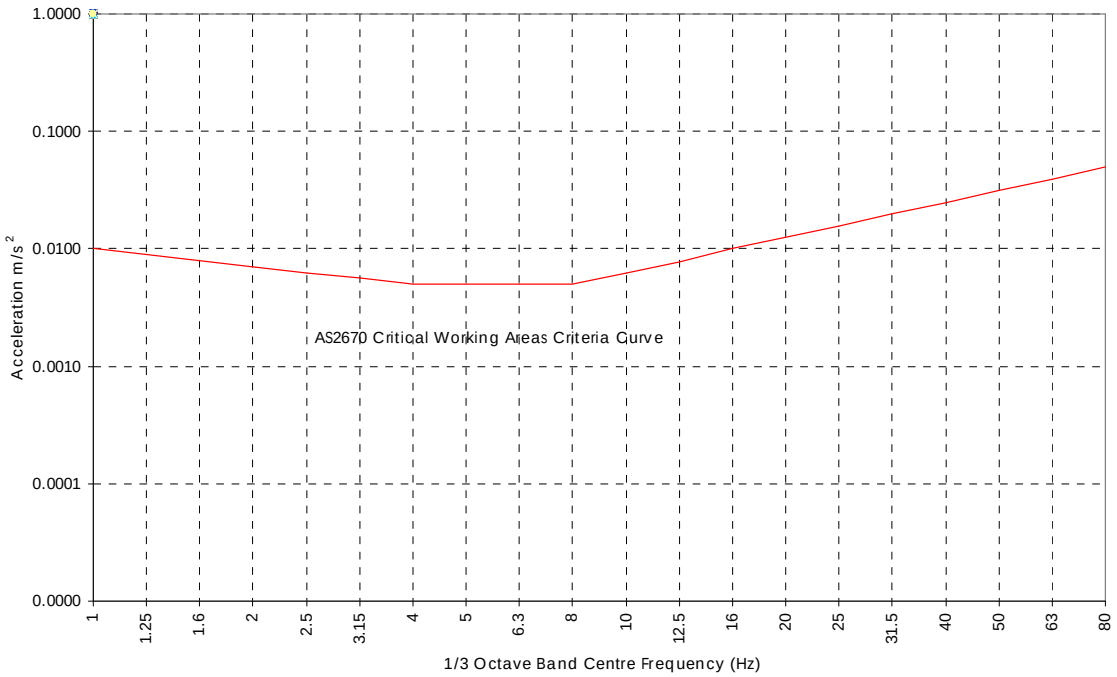
2.0 Vibration criteria

Considering the proximity of the development site to the Sydney Olympic Park rail line, train passbys could potentially give rise to either regenerated noise or perceptible vibration that could adversely affect occupants of the proposed hospital building. Perceptible or tactile vibration refers to vibration that can actually be sensed by touch or felt through the body.
Vibration criteria for railway activities are given by Australian Standard 2670.2:1990 and by the Rail Corporation New South Wales (RailCorp). Vibration levels generated by train passby events are predominantly in the vertical direction. Horizontal vibration levels are insignificant and not an issue, therefore, they have not been measured or assessed in this report.

2.1 Australian Standard 2670.2:1990

Australian Standard 2670.2:1990 "Evaluation of human exposure to whole-body vibration – Part2: Continuous and shock induced vibration in buildings (1-80 Hz)" provides guidance on how to assess the human response to building vibration.
In AS 2670.2:1990 maximum allowable vibration levels are specified in terms of the 'baseline curve'. The baseline curve is shown in Figure 2.1 and it specifies maximum allowable vibration in the vertical axis for critical working areas (e.g. hospital operating theatres, precision laboratories). This reference curve is used as the criteria in this report. Figure 2.1 shows that the human body is most sensitive to vertical vibration in the frequency range 4-8 Hz.

Figure 2.1 – Building vibration z-axis acceleration criteria curves



2.2 Rail Corporation New South Wales criteria

A publication entitled 'Interim Guidelines for Councils – Consideration of rail noise and vibration in the planning process' has recently been produced jointly by the State Rail Authority and the Rail Infrastructure Corporation which have since amalgamated to become the Rail Corporation New South Wales (RailCorp). This document details recommended vibration criteria for developments near rail lines.

The guidelines are concerned with mitigating rail noise and vibration impacts on land that is already zoned to permit residential or other noise-sensitive land uses. Noise sensitive land uses include residential, places of worship, hospitals, nursing homes, educational institutions, passive recreation areas and mixed use developments. The guidelines mainly apply to sites within 60 m of an operational railway line.

2.2.1 Tactile vibration

These guidelines recommend that floor vibration levels in habitable rooms comply with the criteria in British Standard BS 6472:1992 Evaluation of Human Exposure to Vibration in Buildings (1Hz – 80 Hz). This standard is also recommended by the DECC and the Department of Infrastructure Planning and Natural Resources (DIPNR).

2.2.2 Regenerated noise levels

Vibration in a building structure, as well as being felt by the occupant, may also produce audible levels of noise within internal spaces.

Where noise sensitive developments such as hospitals buildings are constructed adjacent to railway tunnels, ground-borne noise may be present without the masking effect of normal airborne railway noise. In such cases, noise sensitive spaces should be designed and constructed to comply with an L_{Amax} ground-borne noise limit of 40 dB(A). Noise levels applicable to offices spaces are typically 5 dB(A) more than for noise sensitive areas. Therefore as this is a hospital development, the L_{Amax} ground-borne noise limit of 40 dB(A) will be used as the criteria in this report.

2.3 British Standard BS 6472:1992 criteria

Disturbance caused by a vibration will depend on its duration, as well as on its magnitude. The rating method detailed in AS2670.2:1990 only differs between continuous and transient events and takes account of magnitude only. The method given in BS 6472:1992 involves the calculation of a Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of bursts of intermittent vibration and of impulsive vibration. Various studies have shown that VDV assessment methods far more accurately assess the level of disturbance than methods which assess the vibration magnitude only. The VDV is the fourth root of the integral of the fourth power of vibration with respect to time. The VDV represents an 'amount' of vibration. In assessing the VDVs, criteria detailed in BS6472:1992 (identical to AS2607.2:1990 criteria) is used, however the base values and multiples are converted into VDVs assuming constant levels over the 16 hour day and 8 hour night. The resulting VDV criteria are shown in Table 2.1.

Table 2.1 – Vibration dose values ($m/s^{1.75}$)

Location	Daytime		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas	0.1	0.2	0.1	0.2

3.0 Vibration measurements

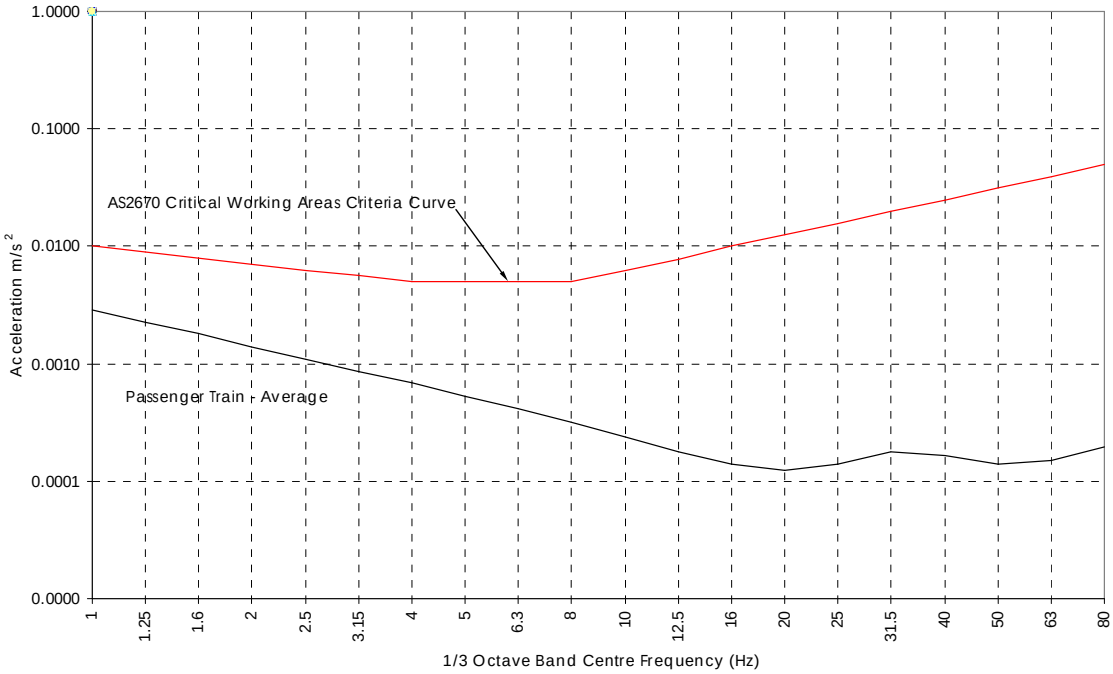
3.1 Methodology

Vibration levels were measured on the most affected site boundary on Site 9 (north-end of Site 9) on Monday 10 and Tuesday 11 July 2007. Ground vibration levels in the vertical direction were measured by attaching the transducer to a metal washer which had been securely glued to an existing building foundation, ensuring good coupling. A SVAN 949 Type 1, Noise and Vibration Analyser and a Dytran Type 3192A accelerometer were used to measure the vibration. The unattended equipment was set to record and store 1 second intervals.
The results were analysed to assess whether the vibration due to trains on the Olympic Park Railway line exceeded the criteria in AS2670.2:1990.

3.2 Vibration levels in vertical direction

The vibration spectra for 30 train events were evaluated against the AS2670.2:1990 criteria and were found to be significantly below the recommended criteria.
Figure 3.1 presents the measured vibration levels and the AS2670.2:1990 criteria across all 1/3 octave frequency bands from 1Hz to 80Hz. The average train vibration level was based on the measured spectrum of 30 individual train movements during the monitoring period.
Note that the assessment and the design of the isolation of vibration sensitive equipment (e.g. MRI and Cat Scan equipment) will be undertaken during the detailed design stage of the project.

Figure 3.1 – Train vibration acceleration levels



3.3 Vibration Dose Value

The corresponding VDV of 30 train movements was measured, the maximum VDV was found to be 1.31 x 10^{-2} m/$s^{1.75}$. This value has been taken to be the VDV for each train movement for the purpose of calculating the total daily VDV.
Since the criteria for the day and night periods are identical, the 16 hour day time period will be used for this assessment as it contains a higher number of train movements. The timetable includes for 3 trains to and from Lidcombe per hour and 4 trains to and from Central each day. However, conservatively it is assumed that trains leave the station every 10 minutes (e.g. during special events). The 16 hour daytime VDV has been calculated to be 0.07 m/$s^{1.75}$ based on 192 train movements (12 per hour) of VDV 1.31x 10^{-2} m/$s^{1.75}$and one minute duration each.
The calculated daily VDV of 0.071 m/$s^{1.75}$ is below the criterion of 0.1 m/$s^{1.75}$ and would be unlikely to give rise to complaints by occupants within the proposed hospital building.

3.4 Regenerated noise

Predicted regenerated noise levels in the private hospital are estimated to be approximately L_{Amax} 27 dB(A) at level 1 of the proposed hospital. Conservatively, regenerated noise levels will decrease by approximately 3 dB per level as you go up in the building. Therefore regenerated noise levels would be unlikely to give rise to complaints by occupants within proposed hospital building.

4.0 Noise intrusion from nearby sporting venues

The following provides an assessment in response to the Sydney Olympic Park Authority queries regarding noise generated at nearby sporting venues and its impact on the proposed private hospital. During the detail design stage of the project, the acoustic requirements for the façade of the building will be confirmed and this assessment will be supplemented by on-site ambient noise monitoring.

4.1 Acoustic design criteria

4.1.1 Recommended ambient noise levels

In a general hospital environment, the ambient noise levels will be largely governed by the level of internal activity in each occupied area. For example, noise from air conditioning plant is likely to be the principal component of ambient noise in quieter ward areas. A generous level of ambient noise is generally preferable in open plan spaces to ensure a good level of acoustic privacy. Background noise levels that are too loud however may lead to communication difficulties, fatigue and sleep disturbance.
Table 1 (Section 2) of Australian / New Zealand Standard 2107:2000 "Acoustics – Recommended design sound levels and reverberation times for building interiors" gives recommended noise levels and reverberation times for different occupancies of various building categories. The levels for the areas relevant to this development are given in Table 1 below, which are based upon Bassett's interpretation of AS2107.

Table 1 Recommended Design Sound Levels

Type of Occupancy/Activity	Recommended Design Sound Level, dB(A)	
	Satisfactory	Maximum
Casualty areas	40	45
Corridors and lobby spaces	40	50
Consulting rooms	40	45
Delivery suites	45	50
Intensive care wards	40	45
Kitchens, sterilizing and service areas	50	55
Laboratories	45	50
Nurses' stations	40	45
Office areas	40	45
Operating theatres	40	45
Sterilizing areas in operating theatres	40	45
Surgeries	40	45
Wards	35	40
Waiting rooms, reception areas	40	50

The recommended noise levels are given in terms of equivalent continuous A-weighted noise levels (L_{Aeq}).

4.2 Sydney Olympic Park - Revised Masterplan

The 'Sydney Olympic Park – Revised Masterplan' (Masterplan) document prepared by Wilkinson Murray (reference: Report No. 99053-MP, Version E, Issued July 2006) has been reviewed in terms of predicted noise levels at the proposed Private Hospital site (Site 9).
The Masterplan document discusses the main types of noise to be expected at the Park, appropriate noise criteria for assessing these noises and noise mitigation measures which may be incorporated into future residential developments. The Masterplan does not specifically address hospitals or other health buildings, however, Table 1 above presents applicable internal noise criteria for health buildings.

Table 2-1 of the Masterplan presents external noise criteria for residential developments, the worst case scenario external noise criterion is equivalent to an internal noise criterion of 35 dB(A) for sleeping areas. According to Table 1 above, the most stringent internal noise criterion is for hospital wards with 35 dB(A) as the satisfactory internal noise level, same as for sleeping areas in a residential development. Given that the acoustic requirements for residential developments in the Masterplan are the same as that for a hospital ward the zones of residential noise suitability identified in Section 3 of the Masterplan document are relevant to hospital wards.

Section 3.3 'Noise Contours & Zones of Residential Suitability' in the Masterplan document has identified Site 9 as a zone where:

- *"Some noise mitigation required. This Zone is where the noise levels exceed the appropriate criterion by up to 10dB (shown in green)."*

4.3 Noise mitigation

Considering that the Masterplan document has categorised Site 9 as a zone where the external noise levels may exceed the appropriate criteria by up to 10dB, noise mitigation measures will need to be included in the design of the building with the objective of satisfying the internal noise criteria identified in Table 1.
Architectural treatment measures (typically involving acoustic treatment of facades) are designed to achieve internal noise levels that would have normally prevailed if the external noise criteria were achieved. It is therefore recommended that the internal amenity of the wards be protected by way of improved glazing and/or the provision of air-conditioning and mechanical ventilation to enable windows to be kept shut to limit noise intrusion during noisy events.
Provision of air-conditioning and mechanical ventilation as a minimum, would enable windows to be shut, resulting in internal noise levels approximately 20 dB(A) lower than the predicted external noise levels.
Based on the predicted external noise levels (up to10dB above the recommended external noise criteria), 4mm float glass will satisfy the internal acoustic requirements for hospital wards.

We note that glazing selection will also be influenced by:

- Safety considerations to full height or operable glazing.
- Energy considerations.
- Plant items that, while meeting emission criteria at noise sensitive receivers, contribute to increased localised levels over the building facade.

The extent of the acoustic treatment, in particular glazing selection, should be further developed during the detail designed stage of the project once the layout of internal spaces is finalised and the external noise levels impinging on the proposed development have been quantified.

5.0 Conclusion

This report presents the results and analysis of a vibro-acoustical study of the proposed Sydney Olympic Park Private Hospital. The report was prepared in response to the Director-General's Environmental Assessment Requirements for the construction of the Sydney Olympic Park Private Hospital. Section 4.0 of the report provides an assessment in response to the Sydney Olympic Park Authority queries regarding noise generated at nearby sporting venues and its impact on the proposed private hospital.

Vibration levels during train passbys have been measured and analysed. The vibration levels in the building due to train movements on the Olympic Park rail line were evaluated and found to be below the AS2670.2:1990 criteria. Similarly the total vibration exposure due to the nearby rail operations and internal regenerated noise levels were also found to be below the recommended criteria as outlined in BS 6472:1992.

The proposed Private Hospital has no emergency department and ambulances visiting the hospital will be for patient transfers only and thus will not require the use of sirens.

Review of the 'Sydney Olympic Park – Revised Masterplan', has categorised the proposed development site (Site 9) as a zone where the external noise levels may exceed the appropriate criteria by up to 10dB, thus, noise mitigation measures will need to be included in the design of the building with the objective of satisfying the internal noise criteria identified in this report. Based on the predicted external noise levels from nearby activities (up to10dB above the recommended external noise criteria), 4mm float glass will satisfy the internal acoustic requirements for hospital wards. The extent of the acoustic treatment, in particular glazing selection, should be further developed during the detail designed stage of the project once the layout of internal spaces is finalised and the external noise levels impinging on the proposed development have been quantified.

Appendix A Glossary of Acoustic Terminology

The following is a brief description of the acoustic terminology used in this report.

Ambient Sound — The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.

Audible Range — The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region of 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.

Character, Acoustic — The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.

Decibel, dB — The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds;

0 dB	The faintest sound we can hear
30 dB	A quiet library or in a quiet location in the country
45 dB	Typical office space. Ambience in the city at night
60 dB	Martin Place at lunch time
70 dB	The sound of a passing car on the street
80 dB	Loud music playing at home
90 dB	The sound of a truck passing on the street
100 dB	The sound of a rock band
115 dB	Limit of sound permitted in industry
120 dB	Deafening

dB(A) — A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. Te 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 noted as dB(A). Practically all noise is measured using an "A" filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.

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.

Loudness — A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on.

L_{max} — The maximum sound pressure level measured over a given period.

L_{min} — The minimum sound pressure level measured over a given period.

L_1 — The sound pressure level that is exceed for 1% of the time for which the given sound is measured.

L_{10} — The sound pressure level that is exceeded for 10% of the time for which the given sound is measured

L_{90} — The sound pressure level that is exceeded for 90% of the time for which the given sound is measured. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).

L_{eq} — The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.