INNER SYDNEY HIGH SCHOOL, SURRY HILLS

ACOUSTIC ASSESSMENT OF OPERATION AND CONSTRUCTION NOISE AND VIBRATION FOR PLANNING APPLICATION

Issued

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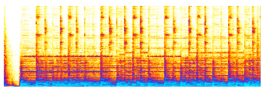

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1 Introduction

The NSW Department of Education (DoE) are preparing a State Significant Development Application (SSD 16_7610) for the development of a new 'Inner Sydney High School' (ISHS) located at the corner of Cleveland and Chalmers Street, Surry Hills (the 'site'), identified as 244 Cleveland Street, Surry Hills NSW 2010.

The Inner Sydney High School is proposed to accommodate up to 1200 students to take enrolment pressure off surrounding high schools exceeding student capacity, and accommodate future population growth within City of Sydney (CoS) Local Government Area (LGA). The high school will contain high quality learning, collaborative learning spaces and associated facilities.

Specifically, this proposal seeks development consent for the following works at the site:

- Internal reconfiguration and refurbishment of the existing heritage listed buildings on the site to create:
    - Collaborative learning hubs with a combination of enclosed and open spaces;
    - Amenities and support areas; and
    - Workplaces and lounge spaces for teachers and administrative staff.
- Construction of a 13 storey plus basement and roof level (approximately 56.5m from Chalmers Street), multi-purpose school building, containing:
    - Collaborative general and specialist learning hubs with a combination of enclosed and open spaces;
    - Library and Resource Hubs;
    - Staff workplaces;
    - Student canteen;
    - Indoor Movement Complex and other indoor recreation and performance spaces;
    - Outdoor learning and recreational areas.
- Associated site landscaping and public domain improvements; and
- Augmentation and construction of ancillary infrastructure and utilities as required.

Acoustic Studio has been commissioned to carry out a noise impact assessment for the proposed redevelopment by the DoE.

This acoustic assessment has been prepared in support of the planning application for the project and addresses the requirements outlined in the Secretary's Environmental Assessment Requirements issued for the project.

The objectives of this assessment are to:

- Identify noise sensitive receivers that will potentially be affected by the operation and construction of the school.
- Carry out noise surveys to determine existing ambient and background noise levels at the nearest noise sensitive receivers that surround the site as well as quantify external noise levels with potential to impact on the site (particularly traffic noise).
- Establish the appropriate noise assessment criteria in accordance with the relevant standards and guidelines. Including:
    - NSW Industrial Noise Policy 2000
    - Interim Construction Noise Guideline 2009
    - Assessing Vibration: A Technical Guideline 2006
- Carry out a quantitative assessment to determine whether the relevant criteria can be achieved based on proposed operations and construction methods. Where applicable, provide recommendations for any necessary acoustic control measures that will need to be incorporated into the development in order to ensure compliance with the assessment criteria.

This report presents the findings of both the operational and construction noise and vibration assessments. It includes measured environmental noise survey data and environmental noise limits based on the measured noise levels in the area. Compliance with these limits will ensure that any noise from the overall development will not impact negatively on the nearest existing receivers and receivers which have been proposed for development. The report also provides recommendations for appropriate vibration level criteria during construction.

1.1 Response to SEARS

The following provides a summary of the SEARS requirements and where the responses to each can be found in this report:

Item	Report Location
4. Environmental Amenity Acoustic impacts	Operational Noise – External Noise Emission • The Use (See Section 6.2 and 8.3) • Traffic Noise Generation (See Section 6.3 and 8.1) • Mechanical Plant (See Section 6.4 and 8.2)
11. Noise and Vibration Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land	Construction Noise and Vibration (See Section 10)

Table 1: Response to SEARS requirements

2 Project Overview

2.1 Background

The population of Sydney is forecast to grow by over one million people in the next 10 years and a significant number will reside in or close to the Sydney CBD in new residential developments in areas such as Green Square, Central to Eveleigh precinct, Barangaroo, Central Square, the Bays Precinct and Ultimo. This growth in inner Sydney suburbs is occurring rapidly, putting significant pressure on public infrastructure, including transport, health services and education.

The DoE has a legislative responsibility to provide teaching spaces to meet demand in all areas across NSW. A new Inner Sydney High School is to be built on Cleveland Street, Surry Hills to meet this demand. Cleveland Street Intensive English High School currently occupies the site. A new facility is being constructed for Cleveland Street Intensive English High School on a site already owned by DoE at Alexandria.

The Cleveland Street school site will be redeveloped to create a new future focused high-rise school with a mix of new and refurbished buildings. The heritage of the site is a major consideration for the design of the new campus. A design excellence competition has been completed with the winning architects, Francis Jones Morehen Thorp (FJMT) continuing to progress the design for the school. The new Inner Sydney High School is expected to open in 2020. The new Inner Sydney High School will offer:

- Facilities that are readily accessible and flexible to meet the demands of an evolving curriculum in line with future-focused learning principles.
- Flexible and well connected teaching and learning spaces that enable a variety of teaching and learning practices.
- Spaces that are engaging and supportive for students and teachers.
- Technology-rich settings with an emphasis on mobility and flexibility.
- A healthy and environmentally sustainable environment.
- Innovative, connected outdoor spaces that enable play and collaborative learning.
- Connected open space, creating a welcoming and accessible school with indoor and outdoor teaching and learning opportunities.

No buildings of heritage significance are proposed to be demolished as part of the redevelopment.

The new teaching spaces will incorporate principles of energy efficiency and ecologically sustainable development (ESD). This includes:

- Passive design principles
- Thermal performance and comfort.
- Natural lighting.
- Water recycling management.

Works are as illustrated in detail in the Architectural Design Statement as prepared by FJMT.

2.2 Description of the proposal

The DoE proposes to develop a high school that will inhabit a heritage site in Surry Hills bounded by Cleveland Street and Chalmers Street.

The proposal includes the fit out and refurbishment of existing buildings plus a new tower building to provide four key building areas including:

- Building 1 (Existing) – Learning spaces, practical activity areas
- Building 2 (Existing) – Administration and staff hub.
- Building 3 (Existing) – Learning spaces, performing arts spaces and practical activity areas
- New Tower
    - Basement / Lower Ground - Gymnasium, movement studio, learning spaces
    - Ground - Café and Covered Outdoor areas
    - Level 1 – Library, Student and Community Hub.
    - Level 2 to 4 –Design and Technology, Visual Arts, Food Technology
    - Level 5 – Rooftop games area (including Basketball Court).
    - Level 6 to 8 – Learning Community and General STEAM
    - Level 9 – Outdoor Terrace
    - Level 10 to 11 – Learning Community and Specialist STEAM
    - Level 12 – Outdoor learning

The existing site and proposal is shown in Figure 1 and Figure 2.

Figure 1: Site Plan With Existing Buildings

Figure 2: Inner Sydney High School – New and Refurbished Buildings

2.3 Operating hours

Inner Sydney High School will generally operate within typical school hours. The operating hours are still to be developed and at this stage the assessment has considered the following indicative hours:

- School hours are from 8:30 am to 4:00 pm on school term weekdays.
- Recess bell times are 10:45 am to 11:00 am.
- Lunch bell times are 12:45 pm to 1:15 pm.
- Cleaning is typically undertaken out of school hours, from 3:00pm to 9:00pm on weekdays.
- Maintenance is carried out during and after school hours, up to 5:00pm.

2.4 Site details

The site is located within an urban environment on the outskirts of Sydney CBD, characterised by high levels of activity throughout the day and medium to high noise levels in the evening and night.

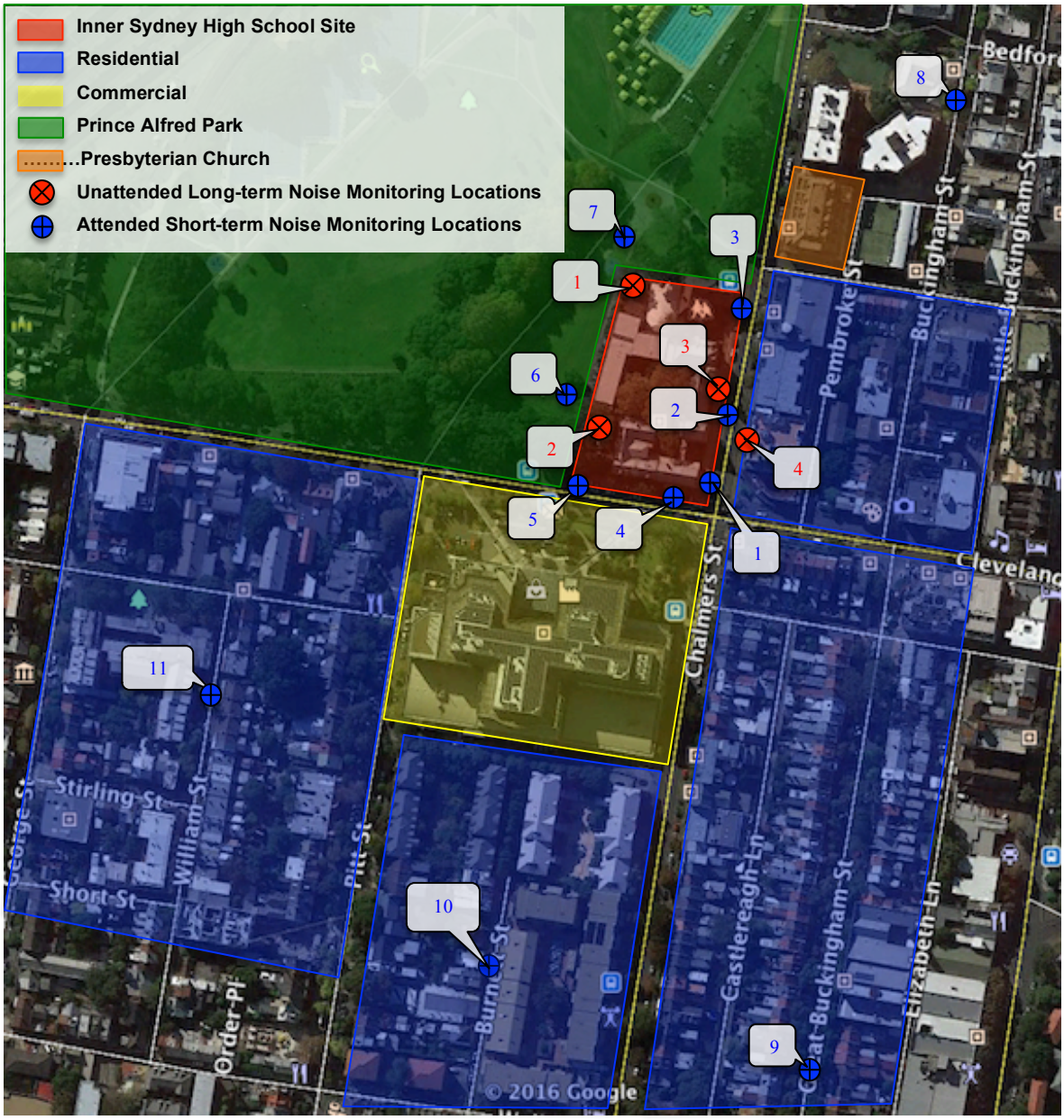


Figure 3: Proposed Inner Sydney High School site in relation to noise-sensitive receivers.

Existing neighbouring buildings and areas that surround the site are as follows:

- Prince Alfred Park and Pool areas to the North and West.
- Presbyterian Church of Australia to the North East.
- Residential buildings to the East and South East.
- Commercial properties across Cleveland Street to the South.

3 Existing Noise Environment

3.1 General survey information

A survey of the existing noise environment around the Cleveland Street, Chalmers Street and Prince Alfred Park site was conducted with two unattended noise monitors used to continuously record the noise levels on the site. Unattended long-term noise monitoring was carried out from Friday 31st March to Tuesday 11th of April 2017 and from Thursday 25th May to Thursday 1st of June 2017 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Unattended long-term noise monitoring was carried out with the following noise loggers:

- Logger 1: Ngara (Serial Number 878079).
    - This logger was used at Location 1 from 5th April to 11th April 2017; and
    - At Location 2 from 31st March to 5th April 2017.
- Logger 2: RTA 02 (Serial Number 038).
    - This logger was used at Location 3 from 31st March to 11th April 2017.
    - At Location 4 from 25th May to 1st June 2017.

The loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the 12-day measurement period. The calibrations of the loggers were checked before and after use and no variations were noted.

Operator attended short-term monitoring was also carried out on Thursday 23rd, Wednesday 29th and Friday 31st of March 2017 and on Wednesday 5th of April 2017, in order to supplement the long-term outdoor data across the site and at key surrounding receivers, plus to obtain spectral noise data for traffic noise at the proposed development site.

Attended short-term measurements were made with two Brüel & Kjær Hand-held Analysers Type 2250 (Serial Numbers 2832406 and 3010373). The calibrations of the analysers were checked before and after the surveys and no variation in levels occurred.

Windshields were used to protect the microphone of all the loggers and analysers. Weather conditions were calm and dry during the attended noise survey.

Anthony Cano and Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys.

The unattended long-term noise monitoring locations and attended short-term noise monitoring locations are shown in Figure 3.

3.2 Unattended Long-term monitoring results

Noise loggers were located at the proposed development site at the following locations:

- Location 1 – At the Northwest corner of the site, in the playground fronting Alfred Park to capture a combination of **ambient and background noise** levels at the site.
- Location 2 – at the Southwest end of the proposed development site to capture existing **traffic noise** along Cleveland Street.
- Location 3 – at the East end of the proposed development site to capture existing **ambient and background noise** levels at the site plus **traffic noise** levels along Chalmers Street.
- Location 4 – at the exposed Chalmers Street elevation of the Level 2 car park at 188 Chalmers Street, being the residential building nearest to the proposed development (on the opposite side of Chalmers Street). This logger location was selected to capture existing **ambient and background noise** levels at the closest affected residential boundary - representing the nearest noise-sensitive receiver to the site.

These positions were chosen as they represented secure places to leave the noise loggers unattended whilst obtaining typical representative traffic plus background and ambient noise levels at the nearest noise sensitive receivers. The unattended long-term noise monitoring locations are shown in Figure 3.

The detailed results of the unattended long-term noise monitoring at the four logger locations are shown graphically in Appendix A.

3.2.1 Traffic Noise

Traffic noise monitoring results are summarised in Table 2 below.

Location	Traffic Noise Levels[1], dB(A)			
	Period		Noisiest 1 Hour Period	
	Day $L_{eq, (15\ hr)}$	Night $L_{eq, (9\ hr)}$	Day $L_{eq, (1\ hr)}$	Night $L_{eq, (1\ hr)}$
Cleveland Street Facade[2]	75	71	78	77
Chalmers Street Facade	72	66	79	72

Table 2: Long-term traffic noise levels measured

3.2.2 Background and Ambient Noise

The logged data shows the background and ambient noise levels representative of the area. The recorded background noise levels have been used to establish limiting criteria for noise emitted from the operation of the new buildings.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

The background sound levels have been established in general accordance with the methodology described in the NSW INP, i.e. the 10^{th} percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment period. These background noise levels are shown in Table 3 below together with the L_{Aeq} ambient noise levels measured for each period.

[1] Includes façade reflections.

[2] Levels are adjusted to represent levels at facades, taking into consideration distance attenuation and shielding to the logger location.

In accordance with the INP, any data likely to be affected by rain, wind or other extraneous noises has been excluded from the calculations.

Location	Background Noise Levels (RBL), dB(A)			Leq Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Position 1 Playground, Facing Alfred Park	51	50	44	59	57	55
Logger Position 2 Cleveland Street	53	53	45	64	64	60
Logger Position 3 Chalmers Street	55	53	43	68	66	62
Logger Position 4 Chalmers Street, Nearest Residential Boundary	56	53	46	69	66	64

Table 3: Long-term background and ambient noise levels

From observations during our site visit, it is noted that both ambient and background noise levels around the proposed development site is generally dominated by traffic noise around the site.

3.3 Short-term monitoring results

Eleven (11) short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location 1** on the footpath in front of the existing Building 1 fronting Chalmers Street
- **Location 2** on the footpath in front of the Existing Building 2 fronting Chalmers Street
- **Location 3** on the footpath in front of the Existing Building 3 fronting Chalmers Street
- **Location 4** on the footpath in front of the Existing Building 1 fronting Cleveland Street
- **Location 5** on the footpath in front of the Existing School Car Park fronting Cleveland Street
- **Location 6** within Alfred Park at the façade of Building 4 with a direct line of site to Cleveland Street
- **Location 7** within Alfred Park at the façade of Building 3 with a direct line of site to Chalmers Street
- **Location 8** on the footpath in front of residential buildings on Buckingham Street
- **Location 9** on the footpath in front of residential buildings on Great Buckingham Street
- **Location 10** on the footpath in front of residential buildings on Burnett Street
- **Location 11** on the footpath in front of residential buildings on William Street

The measured values of the short-term traffic, background and ambient noise monitoring around the existing site are shown in Table 4.

Location	Time	Descriptor	Measured sound level, dB re 20 µPa									
			Overall dB(A)	Octave band centre frequency[1], Hz								
				31.5	63	125	250	500	1k	2k	4k	8k
1	Between 8am and 9am, 23 March 2017	L_{eq}	74	75	84	77	75	71	69	66	60	55
		L_{90}	66	70	69	64	63	61	62	58	50	42
2	Between 9am and 10am, 23 March 2017	L_{eq}	75	77	81	74	75	71	70	66	61	55
		L_{90}	64	64	67	62	60	59	60	56	49	40
3	Between 9am and 10am, 23 March 2017	L_{eq}	79	82	88	77	76	79	71	68	65	67
		L_{90}	63	66	66	61	59	58	59	55	48	39
4	Between 9am and 10am, 23 March 2017	L_{eq}	75	85	84	79	76	70	70	67	63	61
		L_{90}	65	73	72	67	63	60	60	56	52	45
5	Between 9am and 10am, 23 March 2017	L_{eq}	73	78	82	75	69	68	69	66	61	55
		L_{90}	62	72	69	64	58	56	56	54	49	42
6	Between 9am and 10am, 23 March 2017	L_{eq}	60	72	73	65	57	53	54	52	51	48
		L_{90}	53	67	65	57	50	47	48	45	40	31
7	Between 10am and 10:30am, 23 March 2017	L_{eq}	57	68	70	65	59	51	51	48	42	33
		L_{90}	53	63	63	58	51	47	48	44	36	27
8	Between 3pm and 4pm, 5 April 2017	L_{eq}	55	68	67	58	53	51	50	46	43	38
		L_{90}	49	64	59	51	47	46	43	38	31	25
9	Between 3pm and 4pm, 5 April 2017	L_{eq}	47	60	59	50	45	43	43	40	37	29
		L_{90}	43	54	53	46	42	39	38	33	27	20
10	Between 4pm and 5pm, 5 April 2017	L_{eq}	44	55	54	49	43	43	39	35	32	24
		L_{90}	43	52	48	45	41	41	37	31	23	16
11	Between 4pm and 5pm, 5 April 2017	L_{eq}	44	52	50	47	43	39	37	35	37	32
		L_{90}	40	50	47	44	40	37	34	28	22	15

Table 4: Short-term traffic, background and ambient noise levels – Day time survey

4 Key Acoustic Considerations

The following acoustic issues are to be addressed as part of the Noise Impact Assessment for the Inner Sydney High School:

External Noise Intrusion - For each building, the building envelope must limit external noise intrusion levels so that appropriate internal noise levels are achieved within the sensitive spaces. In particular, this applies to traffic noise intrusion from Cleveland and Chalmers Street and the impact on accommodation in each building.

External Noise Emissions - Noise emissions from the proposed development will need to be managed to limit environmental noise impacts on nearby buildings resulting from the operation of the proposed development. In particular, this applies to:

- Building services and plant - The impact of mechanical noise generated by any new mechanical plant and services. The mechanical plant noise levels are to be assessed against the NSW Industrial Noise Policy (INP) 2000.
- Traffic noise generation - The impact of traffic noise on surrounding receivers from changes in traffic flow as a result of the new development.
- Operational noise – associated with noisy activities, particularly noise associated with the use of the rooftop basketball court

Construction Noise and Vibration - The impact of noise and vibration generated during the construction stage of the project on surrounding noise sensitive premises.

The development will contribute noise and vibration to the surrounding environment during the construction stage of the school. Typically, this will result from intermittent noise from construction equipment and plant commonly used on construction sites.

Design noise and vibration limits have been set for the project and construction noise and vibration impacts have been anticipated from standard construction procedures.

The construction noise and vibration limits and expected impacts are reported in Section 9 of this report.

Several residential locations have been considered in the Noise Impact Assessment of the **External Noise Emissions** and **Construction Noise and Vibration**, however the acoustic criteria have been derived using levels affecting the residential receivers across Chalmers Street only, which is the worst affected residential receiver location. Achieving criteria at the Chalmers Street residential receivers also means achieving at all other residential receivers.

5 Relevant Standard and Guidelines

5.1 Guidelines used for the operational acoustic assessment

The following standards and guidelines are considered relevant to the project and have been referenced in developing the project noise criteria:

- City of Sydney (DCP) 2012
- Protection of the Environmental Operations (POEO) Act 1997
- NSW *Industrial Noise Policy* (INP) 2000
- NSW State Environmental Planning Policy (SEPP), Infrastructure 2007
- NSW Department of Planning, *Development Near Busy Roads and Rail Corridors*, 2008
- NSW Department of Education and Communities (DEC) – DG11 Acoustics
- Australian Standard AS 2107:2016
- NSW Environmental Protection Authority (EPA) Road Noise Policy, 2011
- NSW EPA *Noise Guide for Local Government* (NGLG) 2013.

6 Acoustic Design Criteria

6.1 External Noise Intrusion

6.1.1 Traffic Noise

SEPP INFRASTRUCTURE 2007

Clause 102 of SEPP 2007 outlines requirements related to the assessment of noise impact from non-road developments that are adjacent to road corridors with traffic volumes of more than 40,000 vehicles.

Objective criteria for internal noise levels that must be achieved are provided for residential development only.

In the absence of objective criteria for the educational facilities, reference is made to NSW Department of Planning (DoP), *Development Near Busy Roads and Rail Corridors – Interim Guideline* and Australian Standard AS2107, which recommend internal design noise levels within occupied spaces and are detailed below.

NSW DoP, Development Near Busy Roads and Rail Corridors

For airborne noise from road traffic, the NSW DoP Interim Guideline sets an internal noise target of 40 dB(A)[3] for educational institutions.

NSW Department of Education and Communities – Educational Facilities and Standards Guidelines DG11 Acoustics

The NSW DEC DG11 guideline (found at https://efsg.det.nsw.edu.au) provides internal noise levels that should be achieved within educational facilities which are generally consistent with the recommended satisfactory design sound levels form Australian Standard 2107.

The DEC, requires that recommended internal noise levels in DG 11 be achieved in all relevant spaces within the proposed development. Therefore the criteria outlined in DG 11 have been adopted for this project.

[3] Airborne noise is from traffic is calculated as $L_{eq\ 15\ hr}$ Day and $L_{eq\ 9\ hr}$ night.

6.2 External noise emission criteria – The Use

6.2.1 Local Development and Environment Plans

City of Sydney Standard Conditions of Development Consent (CoS-SCDC)

The CoS SCDC states the following general requirements for noise control.

"...

NOISE - GENERAL

a) The emission of noise associated with the use of the premises including the operation of any mechanical plant and equipment shall comply with the following:

i) The $L_{Aeq,\ 15minute}$ noise level emitted from the use must not exceed the project specific noise level for that receiver as determined in accordance with the NSW EPA Industrial Noise Policy. Noise must be measured in accordance with the Industrial Noise Policy and relevant requirements of Australian Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.

ii) Project specific noise levels shall be determined by establishing the existing environmental noise levels, in complete accordance with the assessment $L_{A90,\ 15minute}$ / rating $L_{A90,\ 15minute}$ process to be in accordance with the requirements for noise monitoring listed in the NSW EPA Industrial Noise Policy and relevant requirements of Australian Standard AS1055-1997 Acoustics – Description and measurement of environmental noise.

iii) Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable.

b) An $L_{Aeq,\ 15\ minute}$ noise level emitted from the use must not exceed the $L_{A90,\ 15\ minute}$ noise level by more than 3 dB in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed inside any habitable room of any affected residence or commercial premises provided that;

i) Where the $L_{A90,\ 15\ minute}$ noise level is below the threshold of hearing, Tf at any Octave Band Centre Frequency shall be used instead.

ii) The $L_{Aeq,\ 15\ minute}$ noise level and the $L_{A90,\ 15\ minute}$ noise level shall both be measured with all external doors and windows in the affected residence closed;

iii) The relevant background noise level ($L_{A90,\ 15\ minute}$) is taken to mean the day evening or night rating background noise level determined in complete accordance with the methodology outlined in the NSW EPA Industrial Noise Policy and Australian Standard AS1055-1997 Acoustics – Description and measurement of environmental noise.

iv) Background noise shall be established in the absence of all noise emitted from the use but with the ventilation equipment normally servicing the affected residence operating. Background noise measurements are to be representative of the environmental noise levels at the affected location.

i) Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable. Internal noise measurements are not to be corrected for duration.

The requirements of Item a) for external noise emissions at **external boundaries** are consistent with the relevant criteria established in Table 8.

With respect to Item (b) The NSW INP states that where an internal noise criterion is specified and the potentially affected room has a window open sufficiently to provide adequate ventilation then an external noise level 10 dB above the internal noise criteria shall apply. This methodology assumes that the external background noise level directly influences the internal background noise level, with the level difference between the two being equal to the sound insulation provided by the separating element (such as a window). Therefore, as a worst-case assessment it is assumed that achieving $L_{A90,\ 15\ minute}$ + 3 dB (condition b) externally will also result in achieving $L_{A90,\ 15\ minute}$ + 3 internally.

Based on this the following criteria for noise emissions measured **externally at residential and commercial receivers** are:

Location	Time	Descriptor		Measured sound level, dB re 20 µPa									
				Overall dB(A)	Octave band centre frequency[1], Hz								
					31.5	63	125	250	500	1k	2k	4k	8k
Residential/ Commercial	Day (7am-6pm)	Measured RBL	L_{90}	55	57	61	54	53	51	50	46	41	35
		Corresponding Project Criteria (CoS)[2]	**$L_{EQ} \leq L_{90}$ + 3dB**	58	60	64	57	56	54	53	49	44	38

Note: 1. Octave band data is based on attended measurements at attended measurement Position 2 adjusted to reflect the overall levels for each assessment period established using measured Logger Position 3 data.

2. The internal assessment criteria is based on an external background noise level with the assumption that compliance externally will also indicate compliance internally.

Table 5: CoS SCDC external general noise criteria

Environmental Planning and Assessment Act (EP&A) 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act) regulates the majority of planning approval and environmental impact assessment (EIA) requirements in NSW. Section 111 of the Act requires examination and consideration to the fullest extent possible of all matters affecting or likely to affect the environment by reason of its activities. Acoustic impacts are a common community concern to be addressed in an EIA.

6.2.2 Protection of the Environment Operations Act (POEO) 1997

The Protection of the Environment Operations (POEO) Act 1997 defines "Offensive Noise" as follows:

"...

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

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

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

(b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations. ..."

Further advice on the assessment of "Offensive Noise" is provided in the Noise Guide for Local Government (NGLG), 2010, which provides a checklist (shown in Table 6 below), of items that may be considered.

Offensive noise test: Checklist of considerations

Q1: Is the noise loud in an absolute sense? Is it loud relative to other noise in the area?

This establishes that the noise is likely to be heard by neighbours. Its volume alone may be annoying. An example would be music being played at a very high volume in a residence so it can be heard over very noisy activity outside, such as construction work. The noise may also be loud relative to the background noise. An example would be loud fireworks set off late at night. Noise measurements using a sound level meter would help to determine how loud the noise is relative to the background noise level in the area.

Q2: Does the noise include characteristics that make it particularly irritating?

The presence of tones, impulses or fluctuations in volume can make people more likely to react to the noise. These can be judged subjectively but noise measurements will help to quantify the extent of these characteristics. Examples might be screeching sounds from poorly maintained equipment or a 'beeper' alarm that uses a pulsed sound made up of one or two alternating frequency tones, usually higher pitched, that are louder than the background noise in the area.

Q3: Does the noise occur at times when people expect to enjoy peace and quiet?

People usually expect their surroundings to be quieter during the evening and at night. Talk to the complainants about how the noise affects them to see if it is interfering unreasonably with their comfort at home. Is it regularly disturbing their sleep, making it difficult to have a conversation, study, read or hear the TV? Noise that regularly disturbs sleep is likely to be considered offensive by complainants and this should be taken into account in your assessment.

Q4: Is the noise atypical for the area?

Where noise from an activity that is causing nuisance is new or unusual for an area, people are more likely to react. Look at the typical uses of the area and determine whether the activity is consistent with the local environmental plan. An example might be a rock drill used on a residential construction site.

Q5: Does the noise occur often?

Noise can be more annoying when it occurs frequently. Examples might be a leaf blower used every morning or a band that practises frequently without regard to the impact on neighbours.

Q6: Are a number of people affected by the noise?

Only one person needs to be affected by the noise for it to be deemed offensive. However, talking to other neighbours likely to be exposed to the same noise about how it affects them may assist in deciding what action to take. Some councils have a policy of requiring a minimum number of complaints from different individuals before taking formal action.

Table 6: NGLG Offensive Noise Checklist

6.2.3 Defining environmental noise criteria

The noise definitions and conditions provided by the CoS, LEP and POEO are generally focused around a subjective assessment.

Acoustic Studio recommends determining suitable objective criteria for assessing offensive noise, for noise emissions from mechanical plant, sound systems, students and staff.

Compliance with the criteria described in the sections that follow will ensure that the general noise conditions described in this section will be met.

6.3 External noise emission criteria – Traffic Noise Generation

6.3.1 NSW Road Noise Policy

The NSW Road Noise Policy (RNP) provides criteria for traffic noise from new roads or additional traffic generated on roads from land use development.

When considering land use redevelopment and the impact on sensitive land uses (residential / schools / hospitals / recreational) the guideline states that *" In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB"…* (in relation to existing noise levels).. *"represents a minor impact that is considered barely perceptible to the average person".*

6.4 External noise emission criteria – Mechanical Plant

6.4.1 Local Development and Environment Plans

City of Sydney Standard Conditions of Development Consent (CoS-SCDC)

The CoS SCDC provides specific noise criteria to control noise emissions from a premise related to mechanical plant and equipment and is defined as follows:

"... NOISE - MECHANICAL PLANT AND EQUIPMENT

Noise associated with the use of mechanical plant and equipment must not give rise to any one or more of the following:

(a) Transmission of "offensive noise" as defined in the Protection of the Environment Operations Act 1997 to any affected receiver.

(b) A sound pressure level at the boundary of any affected receiver that exceeds the background (LA90, 15minutes) noise level by more than 5dB. The background noise level must be measured in the absence of noise emitted from the use in accordance with Australian Standard AS1055. ..."

We note that the COS SCDC requirement for noise emissions from mechanical plant is consistent with the NSW INP "Intrusiveness Criteria". Therefore, achieving compliance with the INP project specific criteria outlined in Table 8 will also achieve compliance with the COS SCDC requirements for residential receivers. However, the SCDC requirement is applicable to "any affected receiver" (not limited to residential), therefore the following criteria for receivers other than residential is provided below. This should be considered in conjunction with Table 8.

Receiver Type	Period	Background Noise Level L_{90} dBA	Criteria $L_{eq} = L_{90} + 5$ dBA
Any Receiver	Day (7am-6pm)	55	60

Table 7: CoS SCDC external mechanical plant noise criteria

6.4.2 New South Wales Industrial Noise Policy (INP)

The INP provides the framework and process for deriving noise goals for consents and licences that enable the EPA to regulate industrial premises that are scheduled under the *Protection of the Environment Operations Act 1997*. The EPA INP Application Notes provides additional guidance on elements of the INP, including assessment of changes to existing premises (infrastructure and / or operations).

The INP applies to fixed facilities, commercial premises and individual industrial sources such as heating, ventilating and air conditioning (HVAC) equipment. It is also typically applied for general maintenance noise such as cleaning activities. It provides guidance on the methodology for determining limiting noise criteria designed for external noise emissions typically associated with mechanical plant.

The NSW INP defines environmental industrial noise goals in two ways. The goals apply at the most-affected point on or within the residential boundary and are location-dependent. They also depend on the occupancy: residential, commercial, educational, etc.

The INP considers the following when establishing the criteria:

- The *time of day* that the noise generating development will be in operation, defined by the following:
    - Day (7am to 6pm)
    - Evening (6pm to 10pm)
    - Night (10pm to 7am)
- The existing *Ambient* (L_{eq}) and *Background* noise levels (L_{90}) that surround the site.
- The *type of noise source* and its characteristics. The INP provides modifying factors for noise sources with certain characteristics that may potentially cause greater annoyance than other noise sources of the same level.

The residential ***intrusiveness*** criterion aims to control short duration noise impacts and is based on the existing background noise level, and is defined as:

$L_{Aeq,15\ minute}$ from new noise source ≤ Existing long-term $L_{A90,Day/Evening/Night}$ + 5.

The ***amenity*** criterion aims to maintain noise amenity for a particular land use, including non-residential uses. It defines recommended noise levels, called Acceptable Noise Levels (ANL), for different neighbourhood types. The urban residential ANLs are:

- Day time (7am to 6pm): 60 $dBL_{Aeq\ (11hrs)}$
- Evening (6pm to 10pm): 50 $dBL_{Aeq\ (4hrs)}$
- Night time (10pm to 7am): 45 $dBL_{Aeq\ (9hrs)}$

Modification factors apply to the amenity criterion when existing industrial noise exceeds the acceptable noise levels (refer Table 2.2 and Section 2.2.3 of the NSW INP). No industrial noise corrections are required for this location. A modified ANL may be applied where the industrial noise exceeds the ANL but is inaudible above the traffic noise. This has been applied for the Inner Sydney High School and shown in Appendix B.

The NSW INP applies "penalty" or "correction" factors to account for particular noise characteristics such as tonal, low frequency dominant, or intermittent noise (refer Table 4.1 of the NSW INP). No penalty factors have been applied in this assessment, based on the assumption that mechanical plant will be controlled at source to avoid intermittent, tonal, or low-frequency-dominant noise emissions.

Any non-operational period is excluded from an INP assessment. For the Inner Sydney High School, it is assumed that the mechanical plant may be in operation during the day and evening time periods 7am to 10pm, including for facility maintenance purposes (such as cleaning activities). The night-time hours between 10pm and 7am are excluded from the assessment.

Based on the measured noise levels detailed in Section 3, and in accordance with the methodology outlined in the NSW INP, Table 8 details the corresponding limits of allowable noise emission from mechanical plant and general maintenance activities associated with the development at the nearest receiver boundaries. The derivation of these environmental noise breakout limits according to the NSW INP is detailed in Appendix B.

Receiver Type	Period	INP Criteria			
		Acceptable Noise Level	Amenity $L_{eq\ (period)}$, dBA	Intrusiveness $L_{eq\ (15\text{-}minute)}$, dBA	INP Project Specific[4]
Residential	Day (7am-6pm)	60	58	60	58
	Evening (6pm-10pm)	50	56	58	56
	Night (10pm to 6am)	45	52	48	48
Place of Worship	When in use	50[5]	58	60	58
Passive Recreation Area	When in use	50	58	60	58
Commercial premises	When in use	65	58	60	58
School Classroom	Noisiest 1-hour period When In Use	45[5]	58	60	58

Table 8: INP project specific criteria for external noise emissions from mechanical plant

[4] Project Specific Criteria are based on the more stringent of the Amenity and Intrusiveness Criteria.

[5] The NSW INP specifies an internal ANL of 35 and 40 for school classroms and places of worship respectively. The NSW INP also states that where internal noise levels are specified, external noise 10 dB above internal noise levels can be applied which should achieve an internal noise level where a window is adequately opened to provide natural ventilation.

7 External Noise Intrusion

7.1 Traffic Noise

Noise from Cleveland and Chalmers Streets will be the key traffic noise source affecting the development.

Based on long-term unattended and short-term attended noise data, a summary of traffic noise levels at Cleveland and Chalmers Streets are provided in Table 9.

Location	Traffic Noise Levels[6], dB(A)			
	Period		Noisiest 1 Hour Period	
	Day $L_{eq, (15\ hr)}$	Night $L_{eq, (9\ hr)}$	Day $L_{eq, (1\ hr)}$	Night $L_{eq, (1\ hr)}$
Cleveland Street Facade[7]	75	71	78	77
Chalmers Street	72	66	79	72

Table 9: Day and night traffic noise levels based on attended measurements and logger data

Note: Grey highlights show night period, which is outside school operating hours.

Acoustic Studio has carried out a review of traffic noise impacts with consideration of the following:

- Noise levels are based on measurement data for the worst-case 1-hour noise level
- Internal noise levels for existing buildings and facades are based on measurements carried out within internal spaces on site and are adjusted to consider the long-term noise data from the logger.
- Internal noise levels for new buildings are predicted based on levels incident at the façade of each space, which are based on both attended and unattended measurements. The measurements are adjusted to consider site-specific factors such as distance attenuation (building setback), shielding and building reflections.
- Attenuation provided by the building envelope construction, with the weakest elements being:
    - Existing external glazing.
    - The building envelope construction for the new tower building

[6] Includes façade reflections.

[7] Levels are adjusted to represent levels at facades, taking into consideration distance attenuation and shielding to the logger location.

- Internal noise levels have been considered (or measured in existing buildings) for two scenarios:
    - Windows closed.
    - Windows opened sufficiently to provide cross ventilation, where it is understood that the open area requirements for natural ventilation (5% of floor area) will be provided along the north and eastern facades facing into the school grounds.

From the assessment, Acoustic Studio has identified that achieving internal noise levels in accordance with DG11 will typically require the following:

- Windows to be kept closed where required.
- Windows to be repaired where required, to seal any gaps or broken glass.
- Windows in existing heritage buildings fronting either Cleveland or Chalmers street will need to be upgraded with thick secondary glazing and a large air gap.
- Windows in the new tower building will be designed to control traffic noise intrusion as required.

Final details and extent of treatments to the façade and roof of relevant buildings will be determined with input from Acoustic Studio at the detailed design stage to ensure the requirements of DG 11 are achieved.

7.2 Rail and Light Rail Noise and Vibration

7.2.1 Sydney Metro City and Southwest Rail Network

It is understood that the proposed Sydney Metro City and Southwest Rail tunnel will intersect and pass under Cleveland Street near Renwick Street, approximately 300m from the Inner Sydney High School.

Potential noise and vibration impacts have been considered and we make the following comments.

- There are no airborne noise impacts to receivers above ground surface, from underground rail networks. The determining factor for the building envelope construction will be driven by the control of traffic noise.
- The design of the underground rail network will include vibration control measures to achieve specific vibration limits at the nearest residential receivers along Cleveland Street and Renwick Street. Satisfying these limits will also ensure the vibration limits at the Inner Sydney High School are also achieved.

7.2.2 Sydney CBD and South East Light Rail Network

Additionally, the proposed Sydney CBD and South East Light Rail network will pass through along Devonshire Road, approximately 360m from the Inner Sydney High School.

Potential noise and vibration impacts have been considered and we make the following comments.

- The Inner Sydney High School will be setback from the light rail network by a sufficient distance such that airborne noise impacts are not considered an issue. The determining factor for the building envelope construction will be driven by the control of Traffic noise, which will be louder than noise associated with light rail operations.
- The design of the light rail network will include vibration control measures to achieve specific vibration limits at the nearest residential receivers along Chalmers Street. Satisfying these limits will also ensure the vibration limits at the Inner Sydney High School are also achieved.

8 Operational Noise Impact Assessment (External Noise Emissions)

8.1 Traffic Noise Generation

Acoustic Studio has considered noise associated with additional traffic generation on streets surrounding the Inner Sydney High School campus.

Following a review of the Traffic Impact Assessment prepared by Positive Traffic (*ref: PT16042r01 - Proposed Secondary School 244 Cleveland St Surry Hills_V2.pdf*) we make the following comments:

- We understand that there is an existing carpark, and car parking spaces / provisions for staff will be maintained for the new Inner Sydney High School school and therefore traffic generation from the proposed development is likely to remain similar to existing conditions.
- In addition, the limited availability of parking off site further discourages the use of travel by car, with nearby on-street parking imposed with time restrictions and parking fees.
- It is expected that non-public transport trips to the school (student drop offs) will be equivalent to the current non-public trip movements.
- The net increase in student numbers will result in additional trip generation associated with public transport. Given the close proximity to Central Station (a major transport for the Sydney public transportation network), we understand there is available capacity with current services passing / nearby to the Inner Sydney High School site for additional bus / train patronage to accommodate this additional trip generation.
- Further to the above, all secondary schools provide a range of physical education and sporting options for students, which may require use of buses for transportation to and from venues to ensure diverse opportunities are provided. The existing northbound bus lane on Chalmers Street along the frontage of the school provides the best opportunity to park buses to pick up and drop of students to and from organised sporting events. Occurrence for sport bus pickups will be limited to short time frames and are considered insignificant relevant to the number of current heavy vehicle movements around the site on a daily basis.

Based on the above comments, the additional traffic noise generation is considered negligible (less than 2 dB) as there are no significant changes to traffic flow expected once the Inner Sydney High School is operating.

8.2 Mechanical Plant

Plant associated with the operation of the proposed Inner Sydney High School should be controlled to ensure external noise emissions are not intrusive and do not impact on the amenity of neighbouring receivers with the relevant criteria in Section 6 of this report.

At this stage, final plant selections have not been made; therefore a detailed assessment has not been carried out. Any new items of plant will be reviewed to ensure that noise emissions meet the applicable environmental noise criteria.

In the absence of preliminary plant noise data or final locations, Acoustic Studio makes the following general comments:

- Air conditioning is proposed for the rooms exposed to Chalmers Street and Cleveland Street in buildings 1, 2 and 3, and for all the rooms in the new tower.
- The nearest potentially affected receivers are the residential and commercial buildings adjacent to the east, across Chalmers Street. Achieving criteria for the residential receivers on Chalmers Street, which is the worst affected location, means achieving the criteria at any other residential receiver locations surrounding the site.
- The plant will operate during normal school hours and potentially operate into the evening period, to accommodate extra-curricular school activities, and maintenance and cleaning.
- The most restrictive criterion for the plant operating up to 6pm is 55 dB(A) at the nearest residential receivers. Achieving this criterion will ensure compliance with the relevant criteria at all other receivers.
- Plant will generally be switched off at night (6pm to 7am). If not, the most restrictive night time criterion of 43 dB(A) shall apply at the nearest residential receivers.
- Enclosure, attenuation and / or internally lined ductwork may be required for fans in order to meet both the internal and environmental noise criteria.

During the detailed design stage, Acoustic Studio will provide detailed design advice to the architect and mechanical engineer to ensure that noise emissions from mechanical plant are effectively controlled to meet the relevant criteria at the nearest receiver boundaries.

Noise emissions from general maintenance and cleaning activities may need management controls such as time restrictions particularly for external area maintenance activities, and keeping doors and windows closed during internal maintenance at more sensitive early morning and late evening hours.

General design considerations and controls that may need to be implemented typically include, but are not limited to:

- Strategic selection and location of plant to ensure the cumulative noise contribution at the receiver boundary is achieved, and/or
- Noise control measures to be put in place to minimise noise impacts such as:
  - Noise enclosures as required
  - Noise barriers as required
  - Acoustic louvres as required
  - In-duct attenuation

8.3 Rooftop Basketball Court Use

8.3.1 Assessment methodology

The acoustic assessment has considered the following:

- Use of the rooftop basketball court will typically occur during school hours for extracurricular activities that may occur in the day time period. There is also potential for after-hours use by the school or community and therefore the assessment also considers the evening period (6pm to 10pm).
- Noise levels from the use are considered over a worst case – 15-minute period.
- The assessment considers the worst-case (closest noise sensitive) proposed residential noise receiver development adjacent to the site to the east at a distance of 30m from the closest point of the proposed rooftop basketball court. Compliance at this location will result in compliance at all other locations.
- The assessment considers a free-field source in an open space and the noise being transmitted from the roof to the receiver.
- The assessment considers distance attenuation, shielding and reflections plus directivity.

8.3.2 Source Noise Levels

Basketball Activities Sound

Description	Sound pressure level, dB re 20µPa									
	Overall dB(A)	Octave band centre frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
Free-field noise level from basketball game activities	73	72	75	74	68	67	69	68	63	55

Table 10: Basketball activities source noise level

8.3.3 Noise Emission Predictions

Calculation	Sound pressure level, dB re 20µPa								
	Octave band centre frequency, Hz								
	31.5	63	125	250	500	1k	2k	4k	8k
Free-field noise level from basketball game activities	72	75	74	68	67	69	68	63	55
Distance Attenuation / Directivity	-19	-19	-19	-19	-19	-19	-19	-19	-19
Resulting level at the residential boundary	53	56	55	49	48	50	49	44	36
COS Criteria - External (7am to 6pm)	60	64	57	58	54	53	49	44	38
Complies?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
COS Criteria - External (6pm to 10pm)	58	62	55	56	52	51	47	42	36
Complies?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**No**	**Yes**

Table 11: Noise assessment at nearest residential receivers from worst case basketball activities within the rooftop basketball court

Based on the predictions detailed above, use of the rooftop basketball court during school hours / day period are expected to comply with the relevant criteria.

For the rooftop basketball court use outside school hours / evening period, there will be times where noise levels may exceed the criteria by up to 2 dB in some octave bands (2kHz and 4kHz). This exceedance is considered marginal and therefore typical use is not expected to generate any adverse impact.

8.4 Offensive Noise

From the preliminary assessment and details provided in the previous sections, we make the following comments with respect to offensive noise.

- The primary noise emissions from the proposed building will be mechanical plant and noise associated with the use of the rooftop basketball court.
- Mechanical plant will be selected and noise controls implemented to ensure that the noise emitted is not loud in an absolute sense and not loud relative to the pre-existing ambient and background noise levels that surround the site.
- Noise from mechanical plant is generally broadband, and will be controlled so that there are no characteristics that will make it particularly irritating.
- Noise associated with the operation of the new building will be during normal school hours and on occasion may operate for extended periods when out of school activities are carried out (such as use of the rooftop basketball court out of hours).
- By controlling noise emissions (associated with the operation of the proposed development) in accordance with the relevant criteria, amenity of noise sensitive receivers will be maintained and noise emissions should not be intrusive, therefore it is not expected that people and noise sensitive receivers will be adversely affected by the development.

Based on the comments above, the development is able to satisfy the requirements of the POEO for "Offensive Noise" provided the relevant criteria outlined in Section 6 are achieved.

9 Construction Noise and Vibration Assessment

The following provides a preliminary construction noise and vibration assessment based on an indicative construction description provided by Root Partnerships and will be developed further once a contractor is appointed to confirm methodology and equipment.

9.1 Relevant codes and standards

In preparing this construction noise and vibration assessment, the following legislation, codes and standards have been found to be relevant for the Inner Sydney High School project:

- NSW Department of Environment and Climate Change (DECC) "Interim Construction Noise Guideline", 2009.
- NSW Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline", 2006
- The City of Sydney "Construction Hours / Noise within the Central Business District – Code of Practice", 1992
- Australian Standard "AS 2436 : Guide to Noise Control on Construction, Maintenance & Demolition Sites", 1981
- Australian Standard "AS 1055 : Acoustics – Description and Measurement of Environment Noise", 1997
- Australian Standard "AS 2670.2 : Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)", 1990
- British Standards Institution "BS 6472 – Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)", 1992
- German Institution for Standardisation "DIN 4150.3 : Structural vibration – Effects of vibration on structures", 1999
- Protection of the Environment Operations Act 1997

9.2 Criteria and limits

9.2.1 Airborne noise – Residential Criteria

City of Sydney Construction Hours / Noise within the Central Business District – Code of Practice (CoS-CP)

Table 12 below shows the different time frames and associated noise criteria for nominated affected residential receivers as presented in the CoS-CP as applicable to the Project.

At this stage we understand works will be carried out during standard hours and not during the night time period. Therefore, night-time noise limits / criteria and assessment are not included in this quantitative assessment.

The CoS-CP describes criteria in the form of "average Lmax" (L_{Avmax}), which is equivalent to L_{A10}.

Day	Time Period	Airborne Construction Noise Criteria, dB L_{A10}	
Monday to Friday	00:00 – 07:00	Background + 0 dB	N/A
	07:00 – 08:00	Background + 5 dB	53 + 5 = **58**
	08:00 – 19:00	Background + 5 + 5 dB	55 + 10 = **65**
	19:00 – 23:00	Background + 3 dB	N/A
	23:00 – 24:00	Background + 0 dB	N/A
Saturday	00:00 – 07:00	Background + 0 dB	N/A
	07:00 – 08:00	Background + 5 dB	52 + 5 = **57**
	08:00 – 17:00	Background + 5 + 5 dB	53 + 10 = **63**
	17:00 – 23:00	Background + 3 dB	N/A
	23:00 – 24:00	Background + 0 dB	N/A

Table 12: CoS-CP construction airborne noise criteria for residential receivers

OEH Interim Construction Noise Guideline (OEH ICNG)

The relevant guideline applied for the assessment of construction noise is the DECC NSW, *"Interim Construction Noise Guideline (ICNG), 2009"*. This guideline provides construction noise criteria for Residential, Commercial and Industrial noise receivers as follows.

Section 4 of the ICNG provides recommendations for standard hours of work and suggests construction noise management levels that aim to minimise the likelihood of annoyance caused to noise sensitive receivers. These consider both airborne and ground borne noise level impacts.

Table 13 below outlines the methodology for determining construction noise criteria at nearby residential receivers surrounding the development site based on existing background noise levels.

Time of Day	Management level $L_{Aeq\ (15\ min)}$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL[8] + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours:	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

Table 13: Residential construction noise criteria for airborne noise

[8] The RBL is the overall single figure background level representing each assessment period (day/evening/night) over the whole assessment period. This is the level used for assessment purposes and is further described in the EPA *"NSW Industrial Noise Policy, 2000"*

Based on the requirements detailed in Table 13 above and the measured data of existing conditions at the site (Section 3), the RBL has been calculated over the relevant periods and the corresponding project specific noise criteria levels for residential airborne noise has been determined. These are detailed in Table 14 below.

Location	Period		Rating Background Level RBL, dB(A	Criteria $L_{eq\ (15\ min)}$ dBA	
Residential Receivers	Recommended Standard Hours	Monday to Friday 7am-6pm	55	RBL + 10	65
		Saturday 8am-1pm	53		63
	Outside Recommended Standard Hours	Saturday 7am-8am	52	RBL + 5	57
		Saturday 1pm-6pm	52		57

Table 14: ICNG project specific residential noise criteria for airborne noise

Project Specific Airborne Noise Criteria

The CoS and ICNG criteria have both been considered and the more stringent of the two has been applied for the assessment as shown in Table 15. The time periods listed in Table 15 are based on the CoS time periods for sites which are outside of the city centre.

Day	Period	CoS-CP	ICNG	Project Specific Criteria
Monday to Friday	07:30 – 08:30	53 + 5 = 58	65	58
	08:30 – 17:30	55 + 10 = 65	65	65
Saturday	07:30 – 08:30	52 + 5 = 57	57	57
	08:30 – 13:00	53 + 10 = 63	63	63
	13:00 – 15:30	53 + 10 = 63	57	57

Table 15: Project specific residential noise criteria for airborne noise

9.2.2 Airborne noise – *Other Sensitive Land Uses*

OEH's "Interim Construction Noise Guideline" suggests construction noise management levels for other sensitive land uses surrounding construction sites. They are as follows:

- Offices, retail outlets: $L_{Aeq,15min}$ 70dBA (external)
- Classrooms: $L_{Aeq,15min}$ 45dBA (internal)
- Places of Worship: $L_{Aeq,15min}$ 45dBA (internal)
- Passive recreation areas: $L_{Aeq,15min}$ 60dBA (external)

Where reference is made to an internal noise level, an external noise level 10 dB above the internal noise levels are applied which should achieve the internal noise level where a window is adequately opened to provide natural ventilation. The NSW Industrial Noise Policy supports this methodology.

9.2.3 Ground-borne noise

The ICNG recommends internal ground-borne noise maximum levels at residences affected by nearby construction activities. Ground-borne noise is noise generated by vibration transmitted through the ground into a structure and can be more noticeable than airborne noise for some sensitive receivers. The ground-borne noise levels presented below from the OEH / EPA ICNG are for residential receivers during evening and night-time periods only, as the objective is to protect the amenity and sleep of people when they are at home.

- Evening: $L_{eq,15min}$ 40 dB(A) (internal)
- Night: $L_{eq,15min}$ 35 dB(A) (internal)

The internal noise levels are assessed at the centre of the most affected habitable room.

9.2.4 Plant and Equipment Noise Level Limits

The allowable $L_{A\ avmax}$ noise levels for construction appliances, which are equivalent to L_{A10}, as per City of Sydney CoS-CP are shown in Table16 below.

GROUP A (see Note 2)	GROUP B 90dBA	GROUP C 85dBA	GROUP D 80dBA	GROUP E 75dBA	GROUP F 70Dba
Pile drivers Hydraulic hammers Machine mounted rock breakers Sand blasters Steam cleaners Mole borers	Earthmoving equipment of engine capacity above 200kW NEP Warning sirens* Reversing alarms+ Trucks	Impulsive tools - air, electric or hydraulic Earthmoving equipment of engine capacity between 100kW and 200kW NEP Explosive power tools Impact wrenches Refuse chutes* Scabblers Chain saws Rock drills	Concrete agitators Concrete pumps Concrete saws Cranes (fixed) Cranes (mobile) Earthmoving equipment up to and including engine capacities of 100kW NEP Concrete vibrators Portable hand tools Vibratory compacters	Air compressors above 170 L/s capacity Construction dumpers over 1m^3 capacity Public address system* Internal combustion or electrically driven equipment (unless grouped elsewhere) over 14kW NEP	Air compressors up to 170 L/s capacity Fluid pumps Internal combustion or electrically driven equipment (unless grouped elsewhere) up to 14kW NEP

* To be measured at the site boundary closest to the affected area.
\+ Reversing alarms must be controlled so that noise levels produced do not exceed the background sound level by more than 10dBA.

Table 16: Listed appliances and allowable noise levels relevant to the Project as per CoS-CP

9.2.5 Construction Vibration

There are three key items that should be considered in the assessment of vibration impacts from construction works. These include vibration impacts in terms of:

- Human comfort
- Sensitive equipment and processes (where applicable)
- Structural damage

Relevant criteria for each of these are detailed in the sections that follow.

9.2.6 Human Comfort

The Department of Environment and Conservation (DEC) "Assessing Vibration: A Technical Guideline", (2006) provides suitable criteria that can be applied to the assessment of vibration and human comfort. The guideline makes reference to the British Standard BS 6472: 1992, which shares many similarities to the Australian Standards AS 2670.2: 1990. This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration plus limits for critical areas in hospital buildings, and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time). Vibration in buildings may also occur from internal sources (within a building structure), such as building services and plant. As well as being sensitive to vibration, medical equipment can also be the source of vibration within the building.

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent:

- **Continuous vibration** continues uninterrupted for a defined period (usually throughout daytime and/or night-time). This type of vibration is assessed on the basis of weighted rms acceleration values.
- **Impulsive vibration** is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.
- **Intermittent vibration** can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose values.

The criterion also considers the type of vibration being assessed, namely continuous, impulsive and intermittent vibration. Examples of these vibration types are provided in Table 17.

Continuous	Impulsive	Intermittent
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jackhammers. Where the number of vibration events in an assessment period is three or fewer this would be assessed against impulsive vibration criteria.

Table 17: Examples of vibration types

The relevant criteria for human exposure to continuous and impulsive vibration are detailed in Table 18. Vibration levels are assessed through the consideration of the summation of effects for vibration levels at frequencies from 1 to 80 Hz for all axes.

Human exposure to intermittent vibration is assessed using the Vibration Dose Value (VDV). The VDV accumulates the vibration energy experienced over an extended period (daytime and night-time periods) from intermittent events. Table 19 sets out the acceptable VDV values for intermittent vibration.

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	0.20	0.14	0.40	0.28
	Night time	0.14	0.10	0.28	0.2
Offices, schools, educational institutions and places of worship	Day or night time	0.40	0.28	0.80	0.56
Workshops	Day or night time	0.80	0.58	1.6	1.16
Impulsive vibration					
Critical areas	Day or night time	0.10	0.072	0.20	0.14
Residences	Day time	6.0	4.2	12.0	8.4
	Night time	2.0	1.4	4.0	2.8
Offices, schools, educational institutions and places of worship	Day or night time	13.0	9.2	26.0	18.4
Workshops	Day or night time	13.0	9.2	26.0	18.4

Table 18: Preferred and maximum weighted rms values for continuous and impulsive vibration velocity (mm/s) 1-80 Hz

Location	Daytime		Night-time	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Table 19: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

9.2.7 Sensitive Equipment

Neighbouring vibration receivers with sensitive equipment are likely to require a higher degree of vibration isolation than the values outlined in Table 18 and Table 19.

Vibration Criterion (VC) curves are used to provide the basis for the design and protection of highly vibration sensitive equipment. Table 20 details the VC curves applicable to a range of highly sensitive equipment that should be referred to and considered in conjunction with manufacturer guidelines specific to each type of equipment.

Curve	Max Value 8-80Hz	Detail Size	Equipment Types / Requirements
	Microns / sec, rms	Microns	
VC-A	50	8	Bench Microscopes < 400 x Magnification, optical and other precision balances, coordinate measuring machines and optical comparators
VC-B	25	3	Bench Microscopes > 400 x Magnification, microsurgery and neurosurgery
VC-C	12.5	1	Electron Microscopes < 30,000 x magnification, magnetic resonance imagers and microelectronics manufacturing equipment
VC-D	6	0.3	Electron Microscopes > 30,000 x magnification, mass spectrometers and cell impact equipment
VC-E	3	0.1	Un Isolated laser and optical research systems

Table 20: VC Curves for Highly Sensitive Equipment

Figure 4 shows the relationship between criteria for highly sensitive equipment and human exposure criteria shown in Table 18.

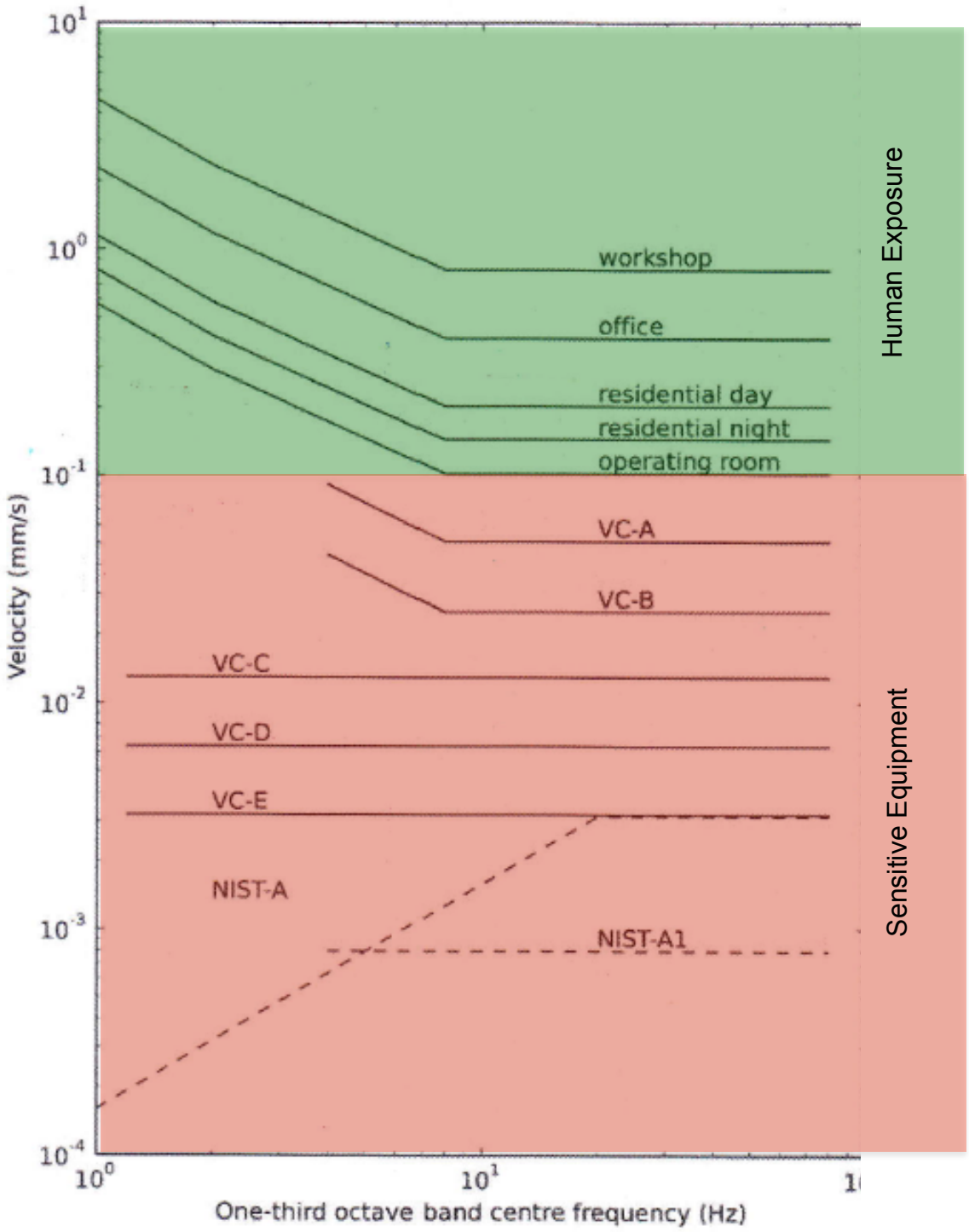


Figure 4: VC Curves - *Source: ANC Guidelines – Measurement and Assessment of Ground-borne Noise & Vibration, Association of Noise Consultants (2012)*

At this stage no structures at or surrounding the site have been identified as having particularly vibration sensitive equipment.

9.2.8 Structural Damage

Criteria to prevent building damage and disruption to equipment and processes are discussed in Appendix C.

Recommended approach to vibration management

The criteria given in Table 18 for Human Comfort shall generally form the limiting vibration criteria for the Project.

It is recommended that a precautionary approach for managing vibration-induced damage be taken for this project, whereby conservative vibration criteria are adopted in the first instance. It would be possible to relax these criteria if required, subject to review of specific buildings by a structural engineer and a regime of vibration monitoring.

The recommended precautionary criteria are:

- 3 mm/s (130 dB re 10^{-6} mm/s) for buildings surrounding the project site identified as "sensitive", which may include heritage. At this stage no structures at or surrounding the site have been identified as particularly sensitive to vibration-induced damage.
- 5 mm/s (134 dB re 10^{-6} mm/s) for residential dwellings.
- 20 mm/s (146 dB re 10^{-6} mm/s) for classrooms, commercial premises.

9.3 Construction noise and vibration assessment

9.3.1 Proposed Hours

Proposed construction hours for the project are as follows:

- 7:30am to 5:30pm Monday to Friday.
- 7:30am to 3:30pm Saturday.

9.3.2 Description of proposed works

The Project Manager has developed a construction program that outlines the key construction activities in each particular location. Based on this, it is anticipated that the key construction activities to occur for each area / stage are as follows:

Stage of Works (Period)	Main Tasks	Typical Plant
Main Works (May 2018 to Jan 2020)	Site Establishment	Skip Trucks / Hammer Drill / Hand Tools / Circular Saw
	Shoring and Piling/Stormwater Diversion/Excavation	Piling Rig / Excavator
	Excavation/Structure	Excavator With Bucket and Hammer / Bobcats / Tip Trucks / Bin Lift trucks / Tower Crane / Hand Tools / Concrete Mixer Truck / Concrete Pump / Concrete Pencil Vibrator
	New Building Structure, Facades & Internal Walls/Existing Building Structure, Plant & Services Rough-In	Tower Crane / Concrete Mixer Truck / Concrete Pump / Concrete Pencil Vibrator / Hand Tools / Hammer Drill / Mobile Crane / Circular Saw / Concrete Mixer / Demo Saw / Grinder
	New Building Facades, Internal Walls, Ceilings & Joinery, Finishes & Fixtures/ Existing Building Works & Services Rough-In	Hammer Drill / Tower Crane/ Mobile Crane / Hand Tools / Circular Saw / Concrete Mixer / Demo Saw / Grinder

Table 21: Proposed Works

9.3.3 Construction noise and vibration sources

The key construction noise sources for the works occurring during the project and the associated equipment noise levels are listed in Table 22 below. These values are based on Acoustic Studio's database plus Australian and International Standards.

Equipment Type	Item	Typical Noise Level $L_{A10,15min}$ SWL
Heavy Vehicles	Tipper Truck	114
	Bin Lift Truck	114
	Hiab Truck	116
	Delivery trucks (semi-trailers, rigid trucks)	108
	Concrete Mixer trucks	112
Site Machinery	Mobile Crane	111
	Bobcat	113
	Excavator (with rock breaker / rock saw)	119
	Excavator (8 Tonne w/bucket)	108
	Concrete Vibrator	104
	Concrete pump	113
Hand Held Tools	Angle Grinder	104
	Drill	94
	Hammer Drill	107
	Jackhammer	113
	Hand Tools (Electric)	102
	Circular saw	115
	Demo Saw	122

Table 22: Anticipated airborne noise levels for construction noise equipment / plant

Potential sources of vibration and ground-borne noise during the construction works include:

- Demolition and excavation plant including rock-breakers and jack hammers.
- Installation of structure
- Grinding, cutting and drilling of existing building structures.

Vibration and ground-borne noise impacts are likely to be highest during the demolition and excavation stages of the project, when equipment such as rock breakers and jackhammers are used.

9.3.4 Sensitive receivers

Nearest sensitive receivers to the Inner Sydney High School site that will be potentially affected by noise and vibration associated with proposed construction are shown in Table 23.

Receiver	Location	Approximate Distance from construction site (closest point)
Residential	Apartments to the East, across Chalmers Street	30m
Place of Worship	Presbyterian Church of Australia to the Northeast, across Chalmers Street	30m
Recreational	Prince Alfred Park and Swimming Pool surrounding site to the North and Northwest	10m
Commercial	Australia Post across Cleveland Street to the South	50m
Residential	Houses to the Southwest, on Williams Street	200m

Table 23: Noise sensitive receivers and approximate distance (closest point) to Project site

9.3.5 Methodology

A preliminary assessment of the likely noise impacts of the proposed works on the most-affected receivers surrounding the site has been carried out.

The assessment has considered the following:

- Typical construction activities considered in the noise impact assessment are as detailed in Table 21.
- Project specific criteria at each sensitive receiver location as outlined in Section 9.2.
- Noise level predictions are calculated using the noise data provided in Table 22.
- Noise level predictions consider for:
  - Distance attenuation
  - Ground and building reflections
- L_{Aeq} noise levels are predicted for the operations of the nearest construction area on the site to each sensitive residential receiver location.
- The predictions consider a range from individual tasks and associated equipment up to the cumulative noise contribution from all key activities and corresponding equipment with plant running simultaneously for each phase and main task.
- The predictions assume continuous operation of equipment / plant over the 15-minute assessment period.
- For the purposes of this assessment, predictions have only been undertaken for worst-case external activities to be carried out at the site. Continuous construction noise associated is expected to comply with stated criteria for nearest residential and educational receivers when these activities occur indoors.

9.3.6 Noise assessment results

The following section presents the results of the preliminary noise assessment carried out for external construction works scheduled for the project.

This construction noise assessment determines the potential noise impact of activities and associated plant and equipment at the most affected receivers.

Tables 24-28 below present the predicted construction noise levels at the nearest affected locations, with comparison against the relevant criteria ICNG Standard Construction Hours.

Location (Criteria) and Construction Activity (Monday to Friday, 7:30am-8:30am)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (58 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (45 dBA)
Main Works					
Shoring and Piling/Stormwater Diversion/Excavation	78 to 83	74 to 79	88 to 93	78 to 83	62 to 67
Excavation/Structure	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Structure, Facades & Internal Walls/Existing Building Structure, Plant & Services Rough-In	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Facades, Internal Walls, Ceilings & Joinery, Finishes & Fixtures/ Existing Building Works & Services Rough-In	65 to 87	60 to 83	74 to 97	65 to 87	48 to 71

Table 24: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Monday to Friday 7:30am to 8:30am criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Construction Activity (Monday to Friday, 8:30am-5:30pm)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (65 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (50 dBA)
Main Works					
Shoring and Piling/Stormwater Diversion/Excavation	78 to 83	74 to 79	88 to 93	78 to 83	62 to 67
Excavation/Structure	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Structure, Facades & Internal Walls/Existing Building Structure, Plant & Services Rough-In	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Facades, Internal Walls, Ceilings & Joinery, Finishes & Fixtures/ Existing Building Works & Services Rough-In	65 to 87	60 to 83	74 to 97	65 to 87	48 to 71

Table 25: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Monday to Friday 8:30am to 5:30pm criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Construction Activity (Saturday, 7:30am-8:30am)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (57 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (45 dBA)
Main Works					
Shoring and Piling/Stormwater Diversion/Excavation	78 to 83	74 to 79	88 to 93	78 to 83	62 to 67
Excavation/Structure	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Structure, Facades & Internal Walls/Existing Building Structure, Plant & Services Rough-In	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Facades, Internal Walls, Ceilings & Joinery, Finishes & Fixtures/ Existing Building Works & Services Rough-In	65 to 87	60 to 83	74 to 97	65 to 87	48 to 71

Table 26: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Saturday 7:30am to 8:30am criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Construction Activity (Saturday, 8:30am-1:00pm)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (63 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (50 dBA)
Main Works					
Shoring and Piling/Stormwater Diversion/Excavation	78 to 83	74 to 79	88 to 93	78 to 83	62 to 67
Excavation/Structure	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Structure, Facades & Internal Walls/Existing Building Structure, Plant & Services Rough-In	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Facades, Internal Walls, Ceilings & Joinery, Finishes & Fixtures/ Existing Building Works & Services Rough-In	65 to 87	60 to 83	74 to 97	65 to 87	48 to 71

Table 27: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Saturday 8:30am to 1:00pm criteria are in red. Predicted levels assume no noise mitigation in place.

Location (Criteria) and Construction Activity (Saturday, 1:00pm-3:30pm)	Predicted equipment noise level, in $dBL_{Aeq,15min}$				
	Residential Chalmers (57 dBA)	Australia Post (70 dBA)	Prince Alfred Park (60 dBA)	Presbyterian Church (55 dBA)	Residential Williams Street (45 dBA)
Main Works					
Shoring and Piling/Stormwater Diversion/Excavation	78 to 83	74 to 79	88 to 93	78 to 83	62 to 67
Excavation/Structure	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Structure, Facades & Internal Walls/Existing Building Structure, Plant & Services Rough-In	65 to 88	60 to 83	74 to 97	65 to 88	48 to 71
New Building Facades, Internal Walls, Ceilings & Joinery, Finishes & Fixtures/ Existing Building Works & Services Rough-In	65 to 87	60 to 83	74 to 97	65 to 87	48 to 71

Table 28: Predicted equipment/plant noise levels at nearest sensitive residential, commercial, recreational and place of worship receiver locations – Levels predicted to exceed the Saturday 1:00pm to 3:30pm criteria are in red. Predicted levels assume no noise mitigation in place.

There will be times / situations when demolition and new-build works are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers

For each of these activities and assuming that, in fact, these activities are found to exceed the noise criteria, then the noise control measures in 9.4.1 shall be considered and implemented wherever reasonable and feasible. In addition, the construction best practices presented in Section 9.4.4 shall be considered to minimise the noise impacts on the neighbourhood.

9.4 Control elements

9.4.1 Noise

As a general rule, prevention should be applied as universal work practice at any time of day, but especially for the occasional construction works to be undertaken at critical times outside normal daytime/weekday periods.

It is noted that the reduction of noise at the source and the control of the transmission path between the construction site and the receiver(s) are the preferred options for noise minimisation. Providing treatments at the affected residences or other sensitive land uses should only be considered as a last resort. Construction noise shall be managed by implementing the strategies listed below:

- Plant and equipment
  - Use quieter methods.
  - Use quieter equipment.
  - Operate plant in a quiet and effective manner.
  - Where appropriate, limit the operating noise of equipment.
  - Maintain equipment regularly.
  - Where appropriate, obtain acoustic test certificates for equipment.
- On site noise management
  - Strategically locate equipment and plant.
  - Avoid the use of reversing alarms or provide for alternative systems.
  - Maximise shielding in the form of existing structures or temporary barriers.
  - Schedule the construction of barriers and structures so they can be used as early as possible.
- Consultation, notification and complaints handling
  - Provide information to neighbours before and during construction.
  - Maintain good communication between the community and Project staff.
  - Have a documented complaints process and keep register of any complaints.
  - Give complaints a fair hearing and provide for a quick response.
  - Implement all feasible and reasonable measures to address the source of complaint.
- Work scheduling
  - Schedule activities to minimise noise impacts.
  - Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
  - Keep truck drivers informed of designated routes, parking locations and delivery hours.

9.4.2 Vibration

At this stage, we anticipate that construction works will result in no adverse vibration impacts at surrounding receivers.

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating to determine whether the existence of significant vibration levels justifies a more detailed investigation.

A more detailed investigation will involve methods of constraining activities generating high vibration levels. A method of monitoring vibration levels will then need to be put in place. Vibration mitigation measures and a review of vibration criteria may then be necessary.

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

- Modifications to construction equipment used.
- Modifications to methods of construction.
- Rescheduling of activities to less sensitive times.

If the measures given above cannot be implemented or have no effect on vibration levels or impact generated, a review of the vibration criteria should be undertaken and the vibration management strategy amended.

9.4.3 Vibration surveys

Since the actual vibration levels experienced will be dependent upon the site characteristics and the specific equipment being used, early vibration level checks should be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

Shortly before the commencement of each activity the background vibration level could be measured and again once the activity has begun. If the survey indicates levels of vibration exceeding those expected, the vibration management strategy for that process could be re-assessed.

9.4.4 Additional noise and vibration control measures

If, during construction, an item of equipment exceeds ether the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with construction best practices presented in Section 9.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver. For example, residential receivers are likely to be more sensitive to noise before 9 am than the commercial receivers.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix E of AS2436.
- Limit the number of trucks on site at the commencement of site activities to the minimum required by the loading facilities on site.
- When loading trucks, adopt best practice noise management strategies to avoid materials being dropped from height into dump trucks.
- Avoid unnecessary idling of trucks and equipment.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc.) not specifically identified in this plan incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all internal and underground works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when noise goals cannot be met due to safety or space constraints.

9.5 Noise and vibration monitoring

9.5.1 Noise monitoring

The Contractor should consider implementing environmental noise monitoring at the locations described below.

- The boundary of the construction site at the closest receiver (Apartment on Chalmers St)

An allowance of 1 day per week, at least, should be dedicated to monitoring of noise and vibration for the first four weeks of construction. Further monitoring should be reviewed after this time or sooner should it be deemed necessary by the Acoustic Consultant and the Project Manager. This should take place mainly at the above locations although other locations and plant and equipment monitoring should take place as and when necessary. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

9.5.2 Vibration monitoring

A vibration monitoring system could be implemented. This system would monitor vibration levels when there is potential for them to change. This could happen in various situations, such as, changes in equipment and activities or changes to work procedures that

might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so that results obtained are readily comparable with results obtained earlier. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

9.5.3 Reporting

The Contractor should prepare a noise monitoring report each month for review by the Project Manager. The reports should summarise and interpret the results of the noise and vibration monitoring carried out during the past month.

9.6 Communication and complaints

The Contractor should establish a communications register for recording incoming complaints. The registration of a particular item will remain open until the complaint has been appropriately dealt with.

In addition the following procedures are an example of the procedures that should be specifically adopted for complaints relating to noise.

Upon receipt of a complaint The Contractor should:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- Establish from the monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity should be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity should then cease.

Any activity which is directed to cease due to excessive noise should not recommence until the Project Manager is satisfied that the noise and vibration limits requirements can be met and has given permission to recommence the activity.

The Site Supervisor should ensure that a report of any incident is provided to the Project Manager.

The Project Manager should provide a report on the incident to the relevant stakeholders.

The Contractor should provide a 24 hour telephone contact number and this number should be prominently displayed on the site.

9.7 Non-compliances

Non-compliance reports can be used as appropriate to deal with failures to meet the construction vibration management and control requirements.

10 Summary and Conclusions

A noise and vibration assessment report has been produced to establish the potential impacts of operational noise plus construction noise and vibration for the proposed Inner Sydney High School development.

The existing noise environment has been established based on long-term and short-term monitoring data.

Appropriate criteria for both noise and vibration have been established based on relevant guidelines and standards.

A summary of the outcomes and recommendations of this noise and vibration assessment are as follows:

- Traffic Noise Intrusion

  Traffic noise intrusion to classrooms and the new Tower have been assessed to ensure that levels will meet applicable criteria for educational buildings. Recommendations for controls have been provided where required to achieve the relevant criteria.

- Operational Noise Impact

  Traffic Noise Generation

  There are no significant changes to traffic flow expected as a result of the proposed Inner Sydney High School operating, therefore changes in traffic noise levels are expected to be negligible.

  Mechanical Plant

  At this stage, final plant selections have not been made; therefore a detailed assessment has not been carried out. Any new items of plant will be reviewed to ensure that noise emissions meet the applicable environmental noise criteria.

  During the detailed design stage, the acoustic consultant shall provide detailed design advice to the architect and mechanical engineer to ensure that noise emissions from mechanical plant are effectively controlled to meet the relevant criteria at the nearest receiver boundaries.

  Rooftop Basketball Court

  Use of the rooftop basketball court during school hours / day period are expected to comply with the relevant criteria.

  For the rooftop basketball court use outside school hours / evening period, there will be times where noise levels may exceed the criteria by up to 2 dB in some

octave bands (2kHz and 4kHz). This exceedance is considered marginal and therefore typical use is not expected to generate any adverse impact.

- Construction Noise

  There will be times / situations when demolition and new-build works are likely to exceed stated criteria, particularly when works occur in the areas closer to sensitive receivers

  If, during construction works, an item of equipment exceeds the stated airborne noise criteria at any sensitive location, the additional noise control measures presented in Section 9.4.4, together with construction best practices presented in Section 9.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Construction Vibration

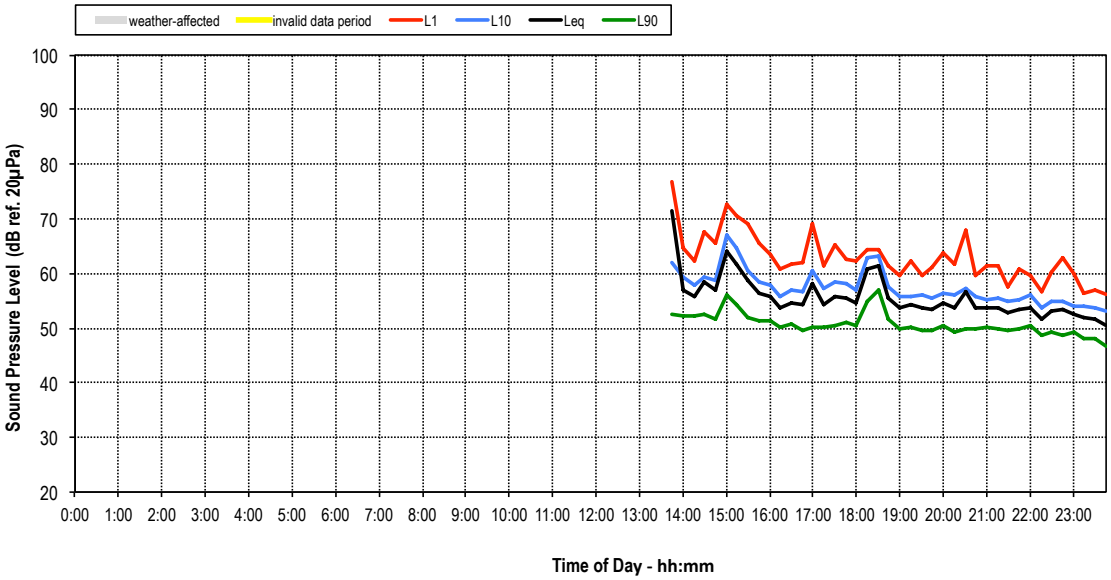
  At this stage, we anticipate that construction works will result in no adverse vibration impacts at surrounding receivers.

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating activity to determine whether the existence of significant vibration levels justifies a more detailed investigation.

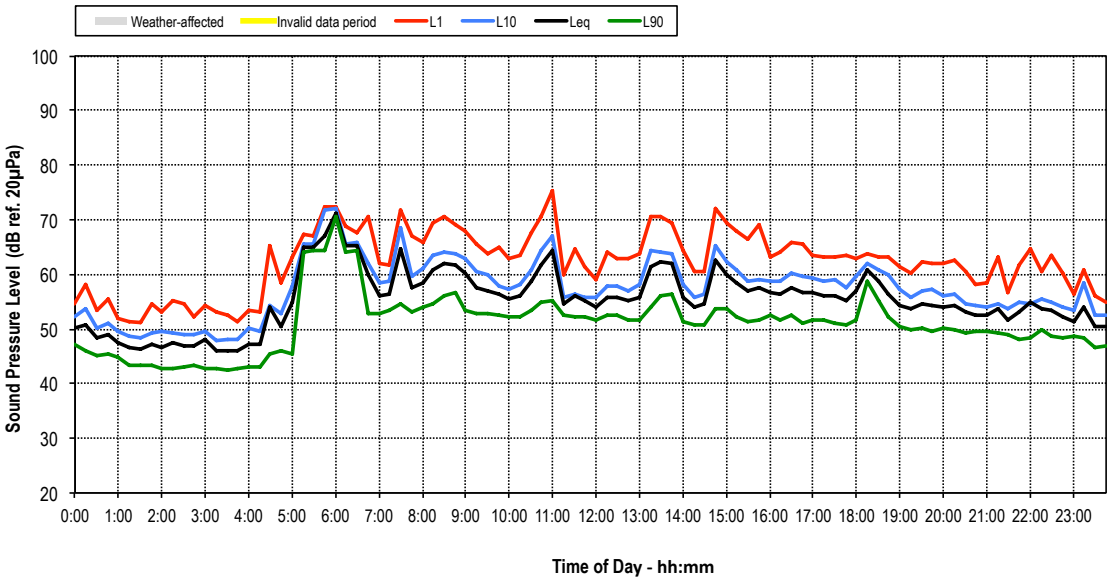
Appendix A : Noise Logger Data

Logger Position 1 – Ambient Noise Logger

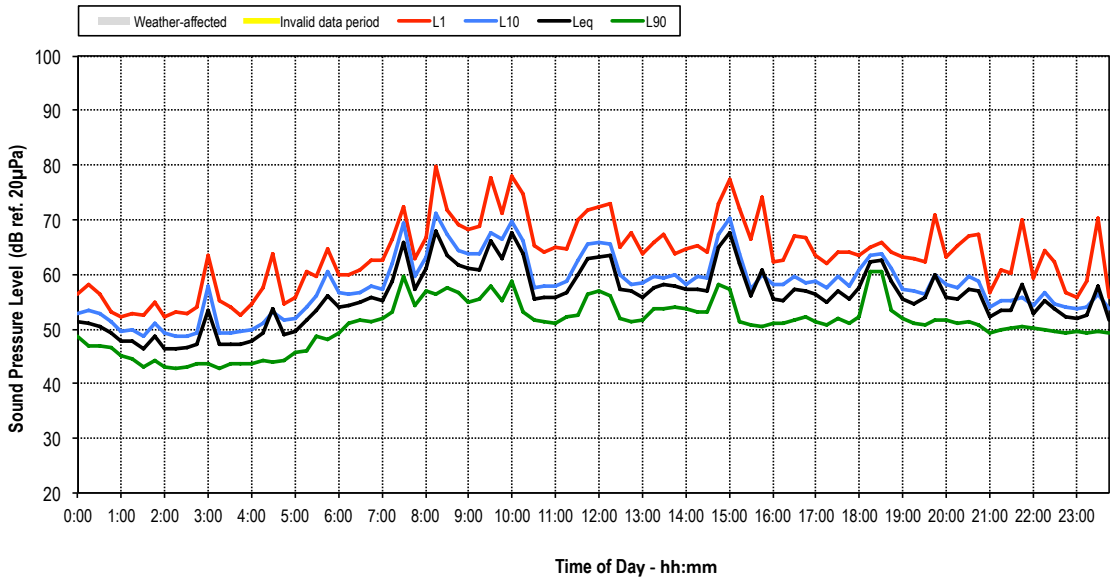
Inner Sydney High School, Playground - Wednesday 05 April 2017



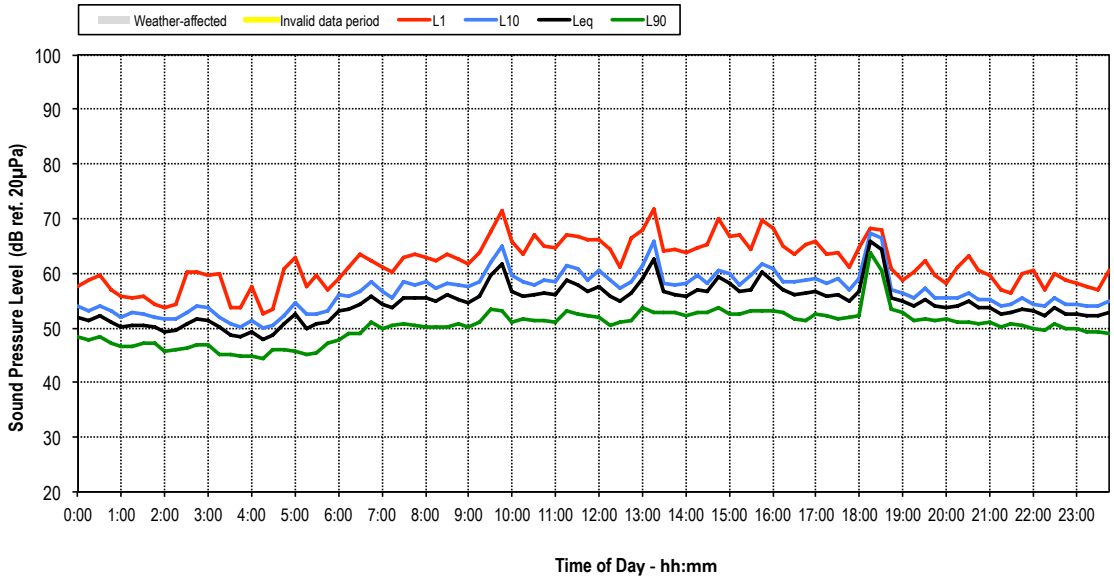
Inner Sydney High School, Playground - Thursday 06 April 2017



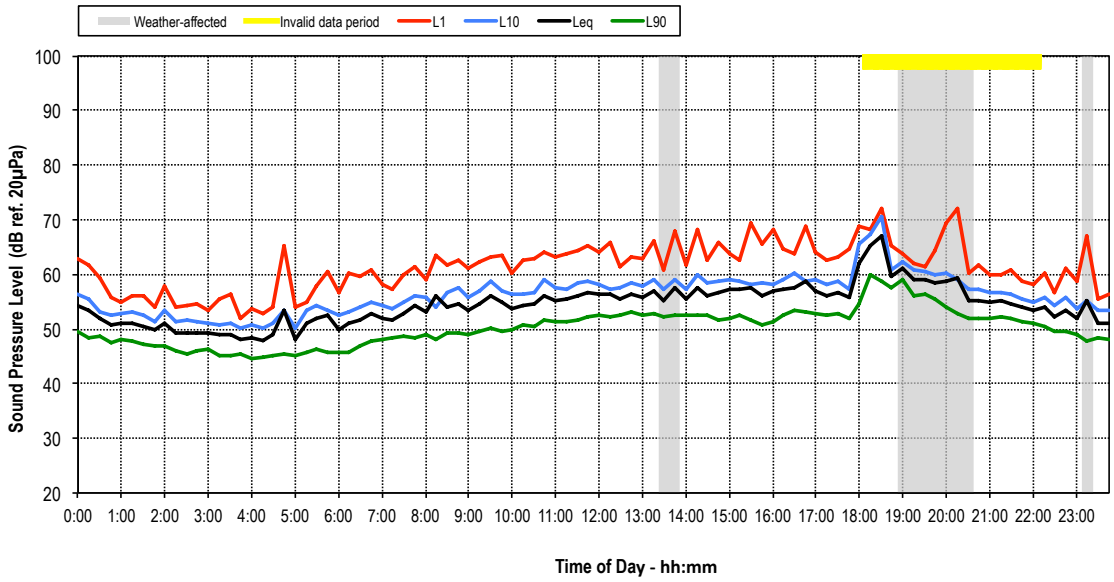
Inner Sydney High School, Playground - Friday 07 April 2017



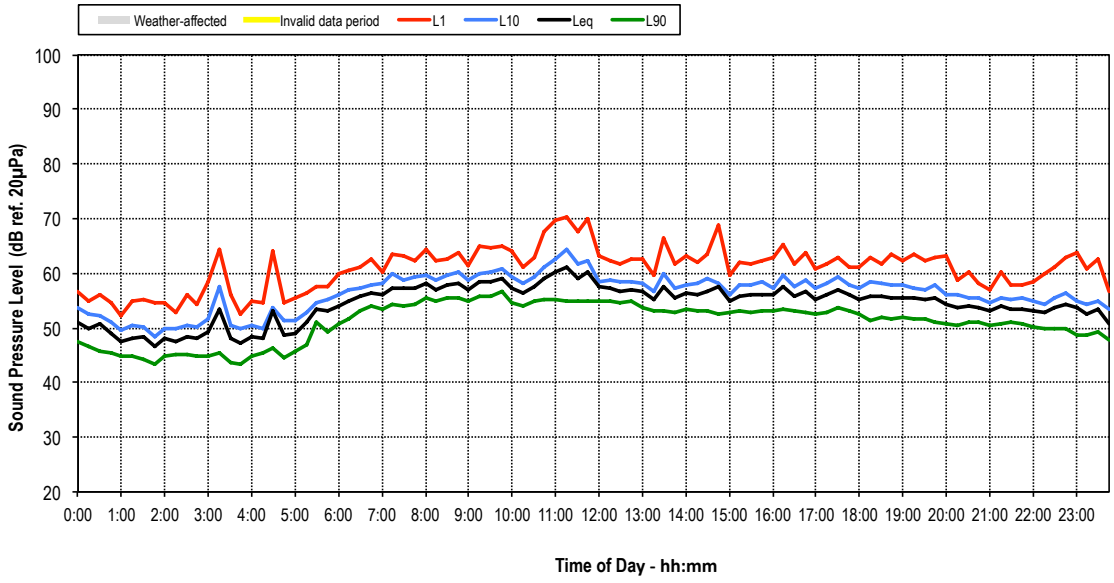
Inner Sydney High School, Playground - Saturday 08 April 2017



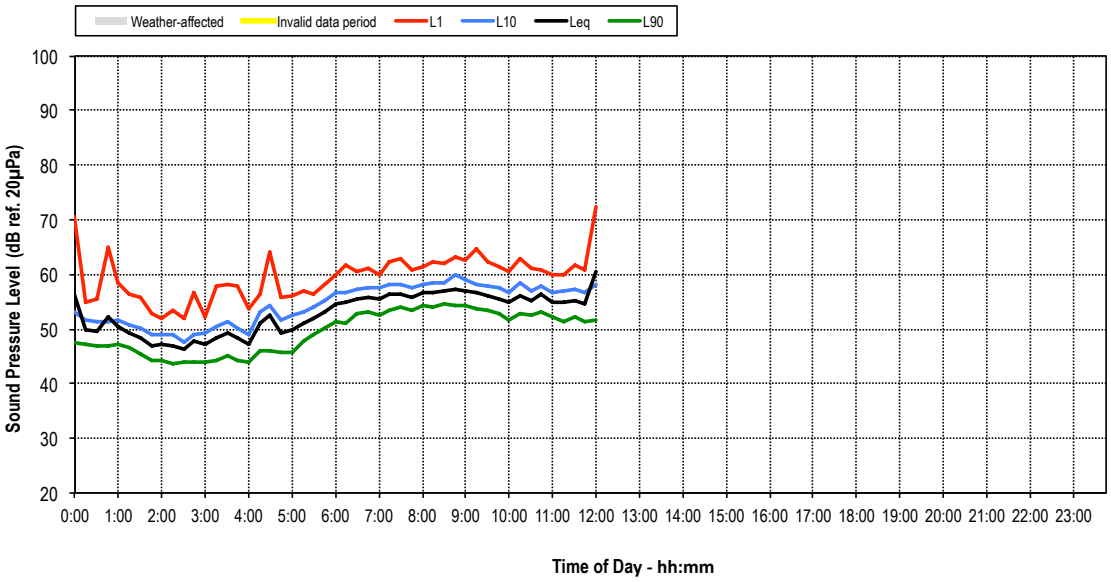
Inner Sydney High School, Playground - Sunday 09 April 2017



Inner Sydney High School, Playground - Monday 10 April 2017

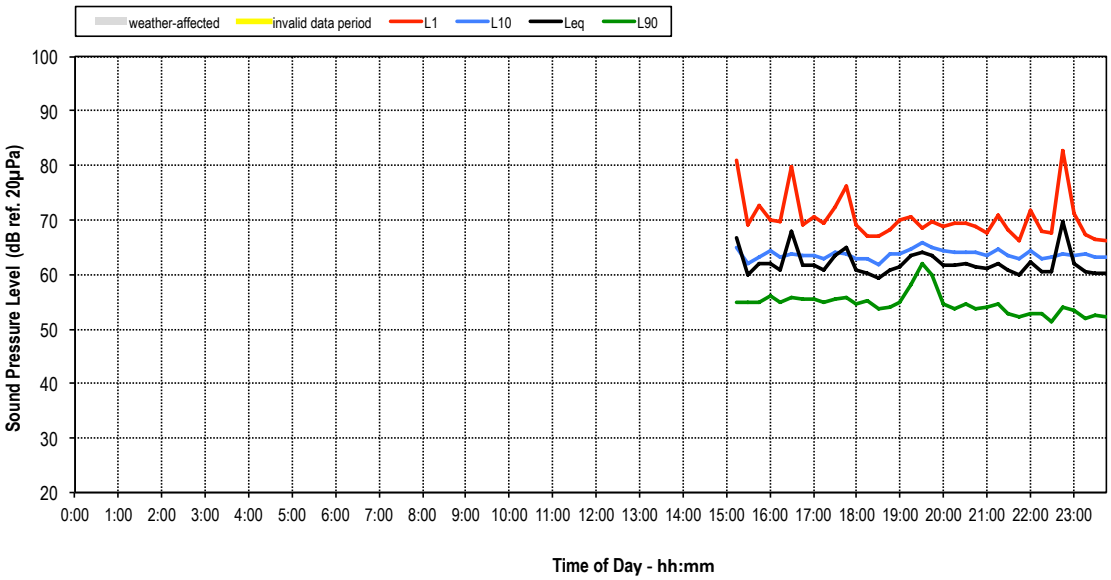


Inner Sydney High School, Playground - Tuesday 11 April 2017

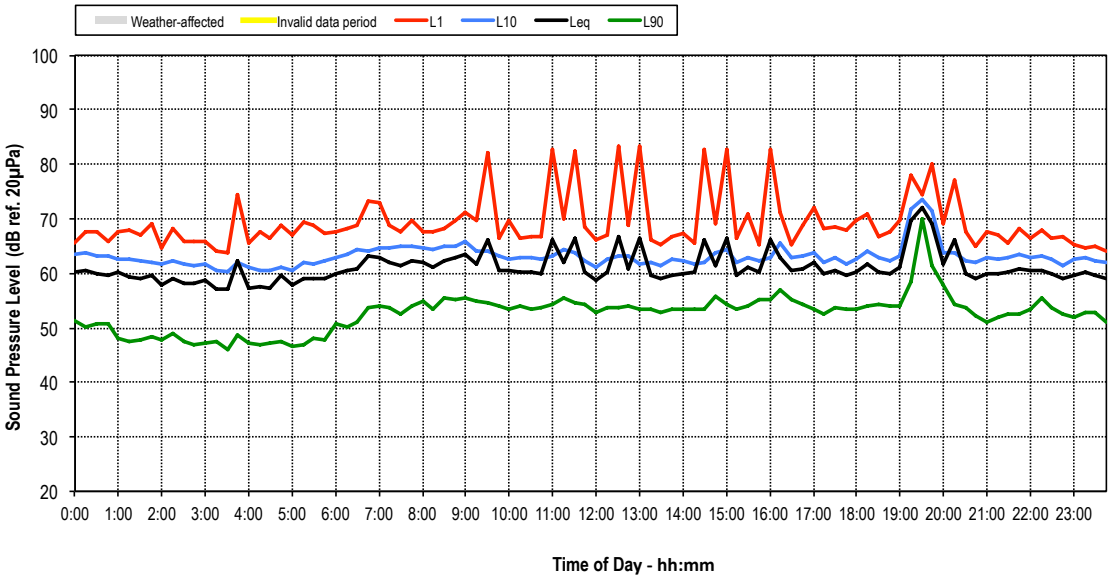


Logger Position 2 – Traffic Noise Logger

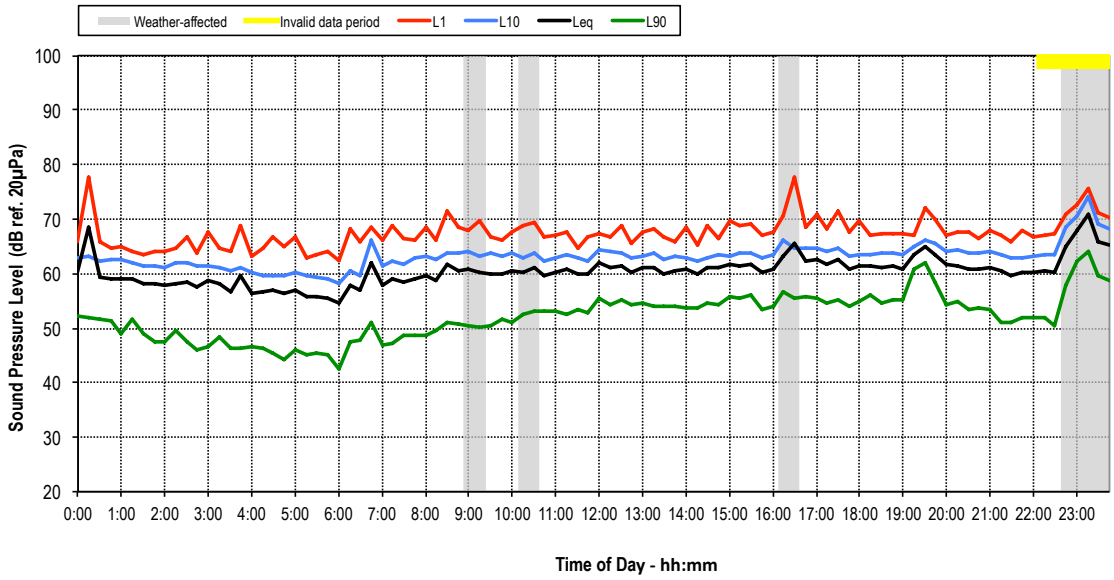
Inner Sydney High School, Cleveland St - Friday 31 March 2017



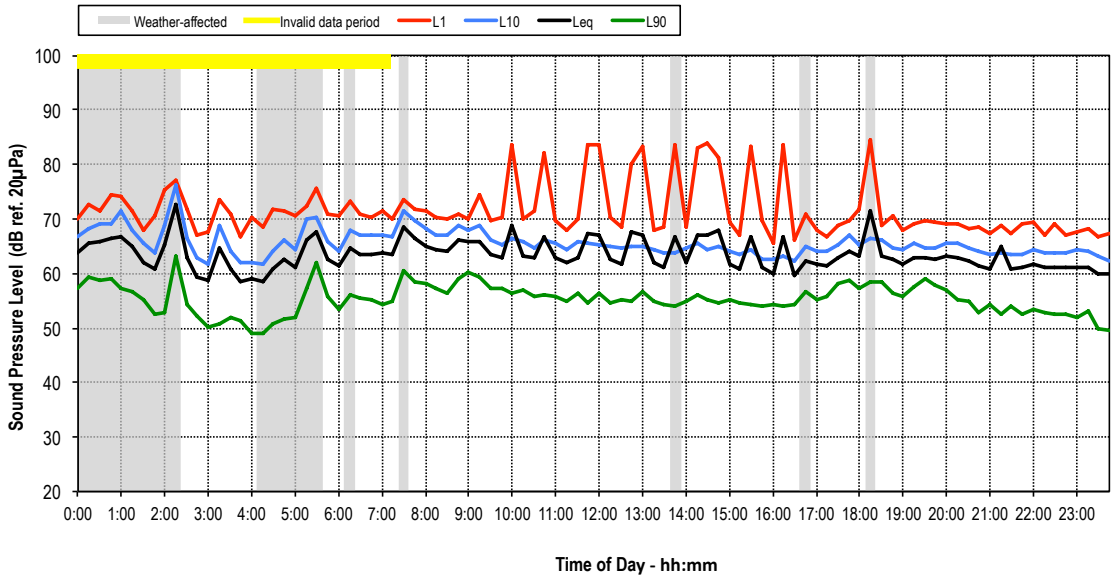
Inner Sydney High School, Cleveland St - Saturday 01 April 2017



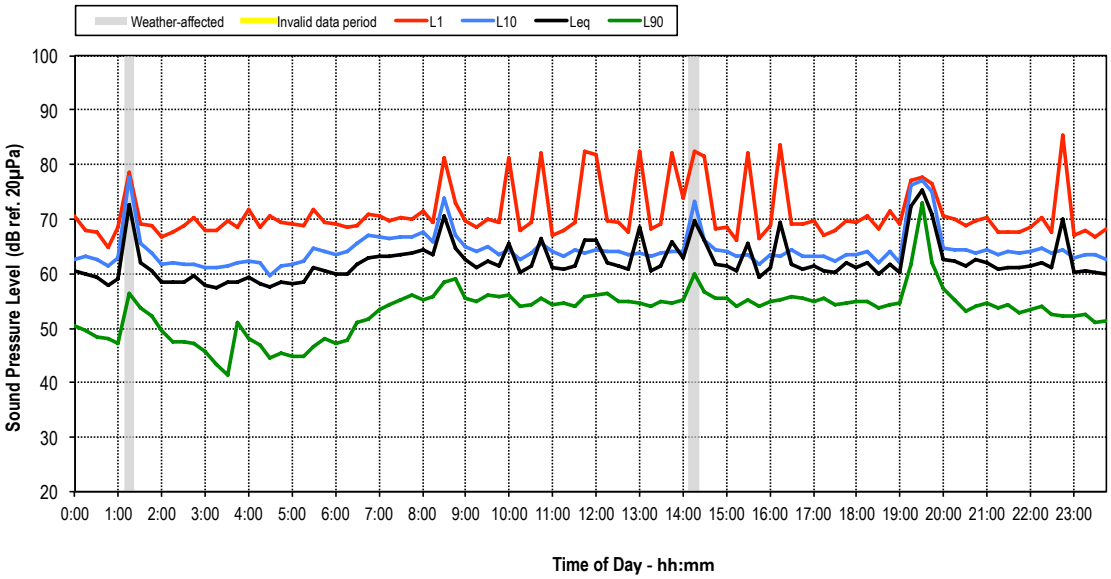
Inner Sydney High School, Cleveland St - Sunday 02 April 2017



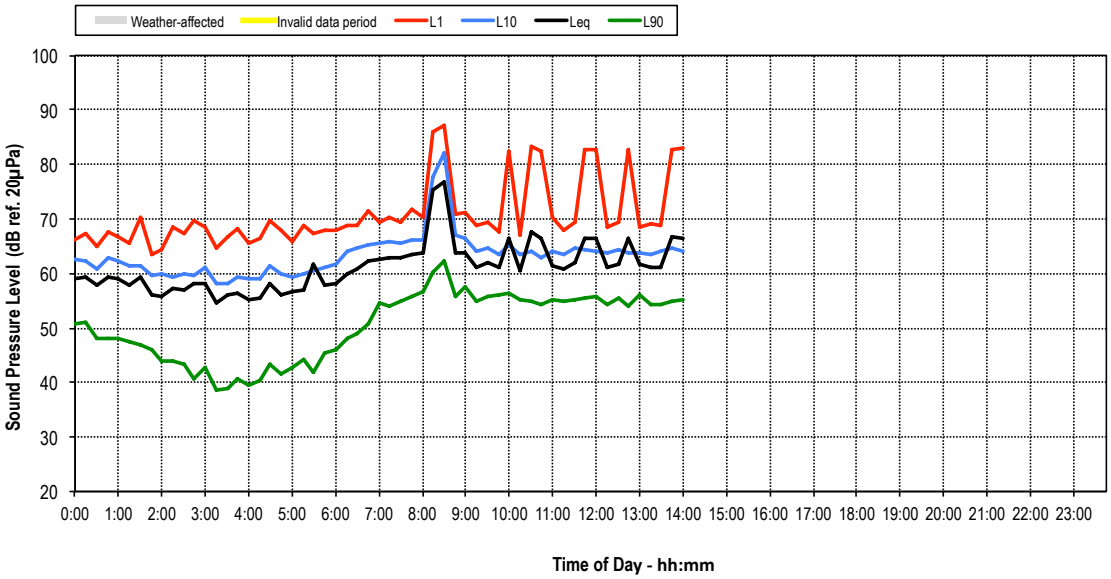
Inner Sydney High School, Cleveland St - Monday 03 April 2017



Inner Sydney High School, Cleveland St - Tuesday 04 April 2017

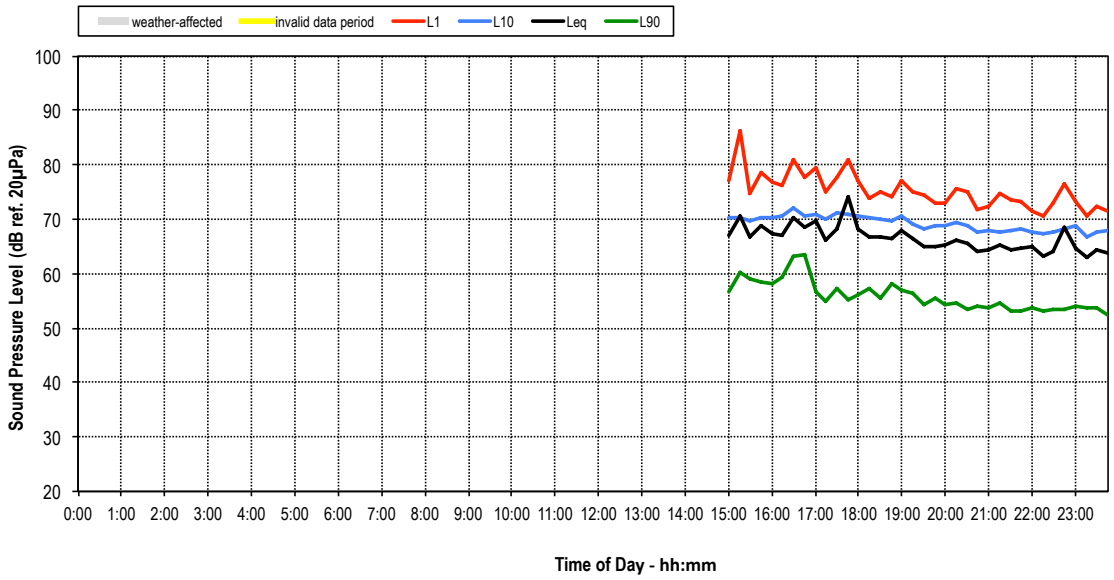


Inner Sydney High School, Cleveland St - Wednesday 05 April 2017

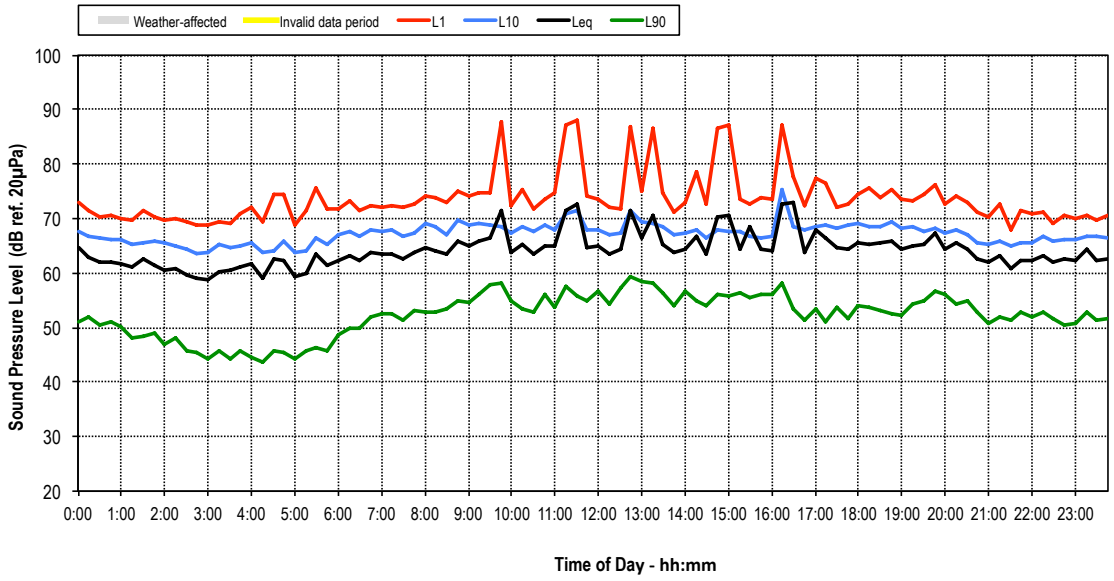


Logger Position 3 – Background and Traffic Noise Logger

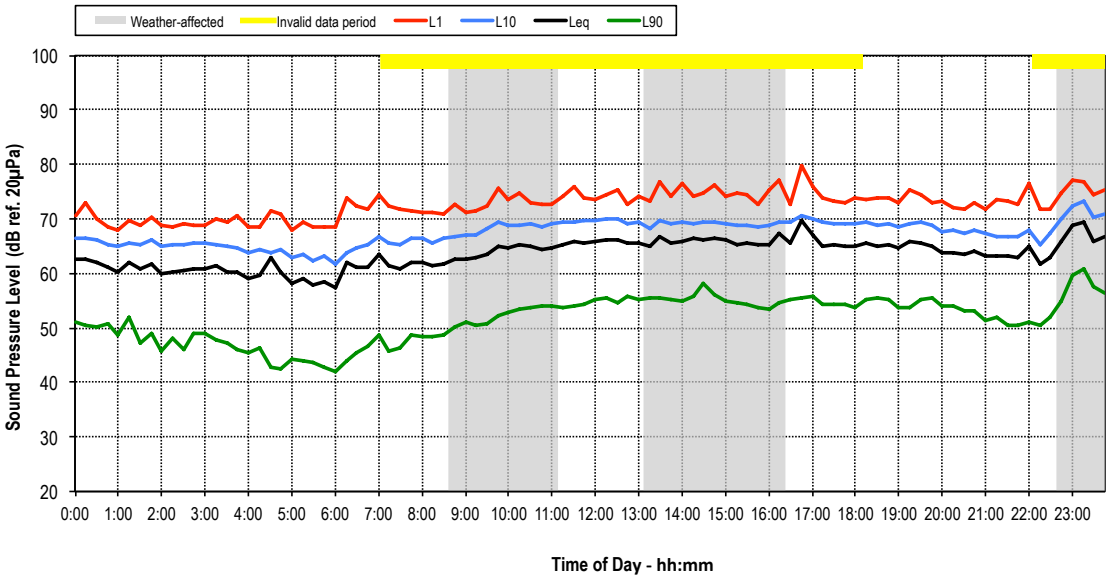
Inner Sydney High School, Chalmers St - Friday 31 March 2017



Inner Sydney High School, Chalmers St - Saturday 01 April 2017



Inner Sydney High School, Chalmers St - Sunday 02 April 2017



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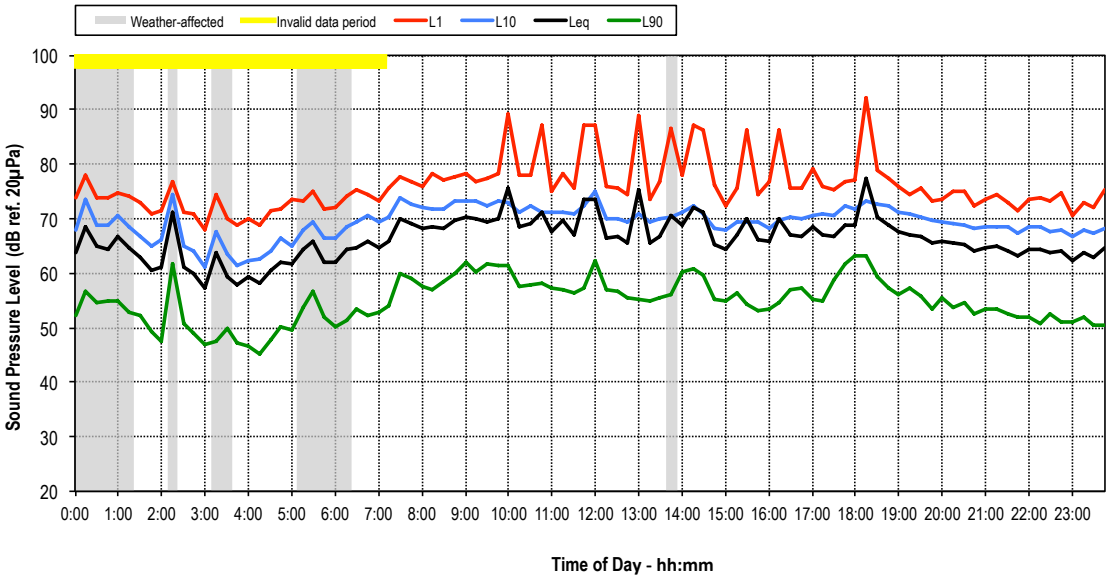

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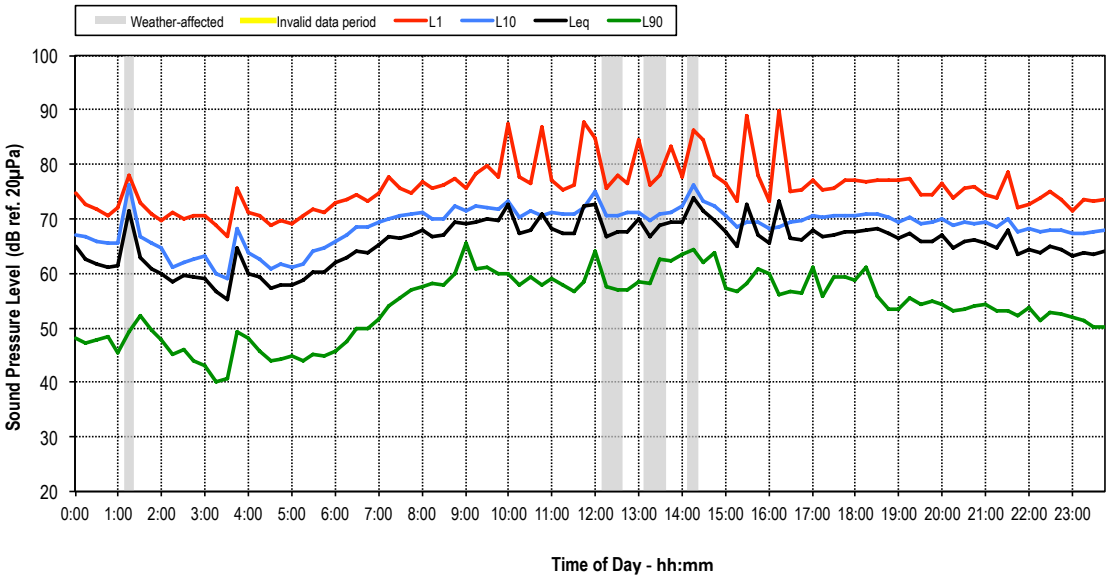

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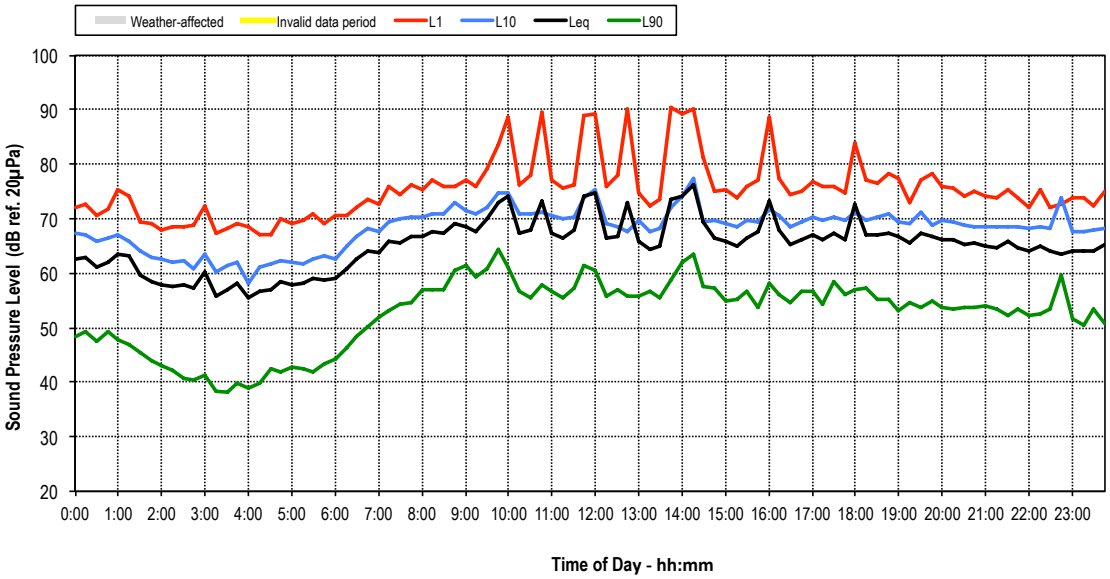
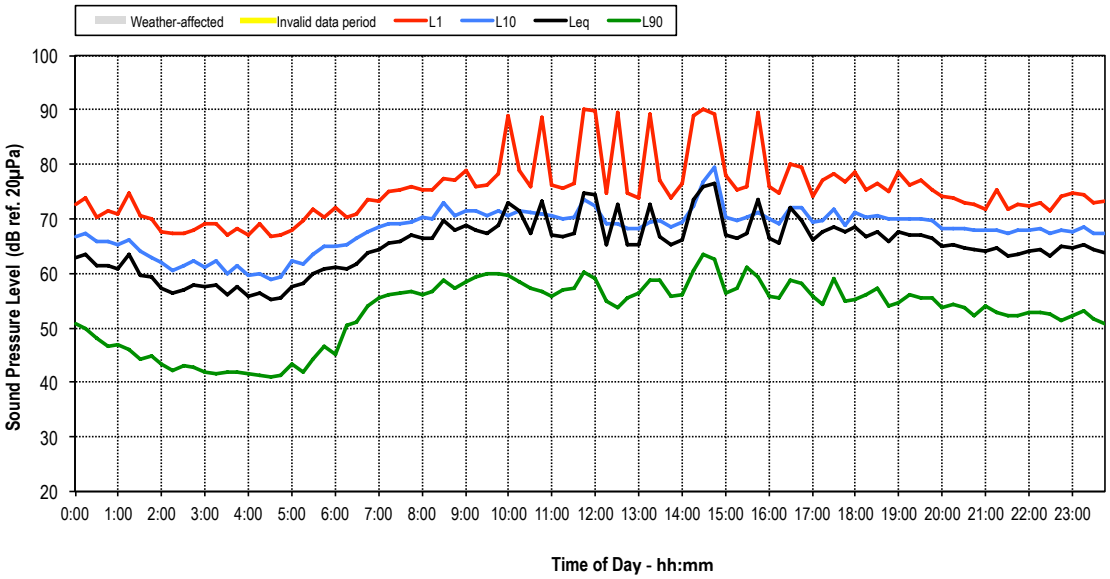
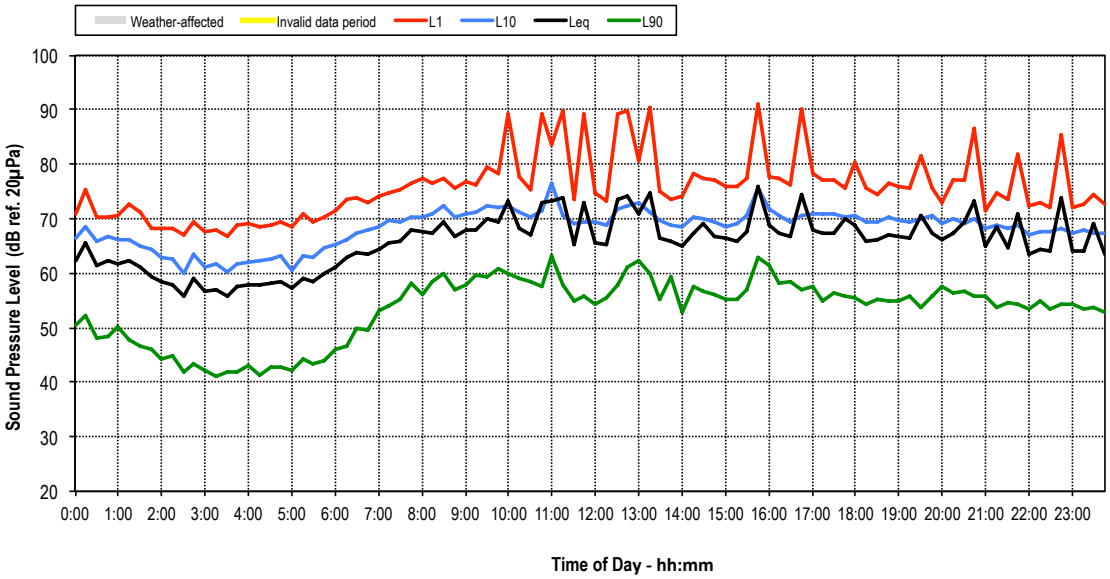


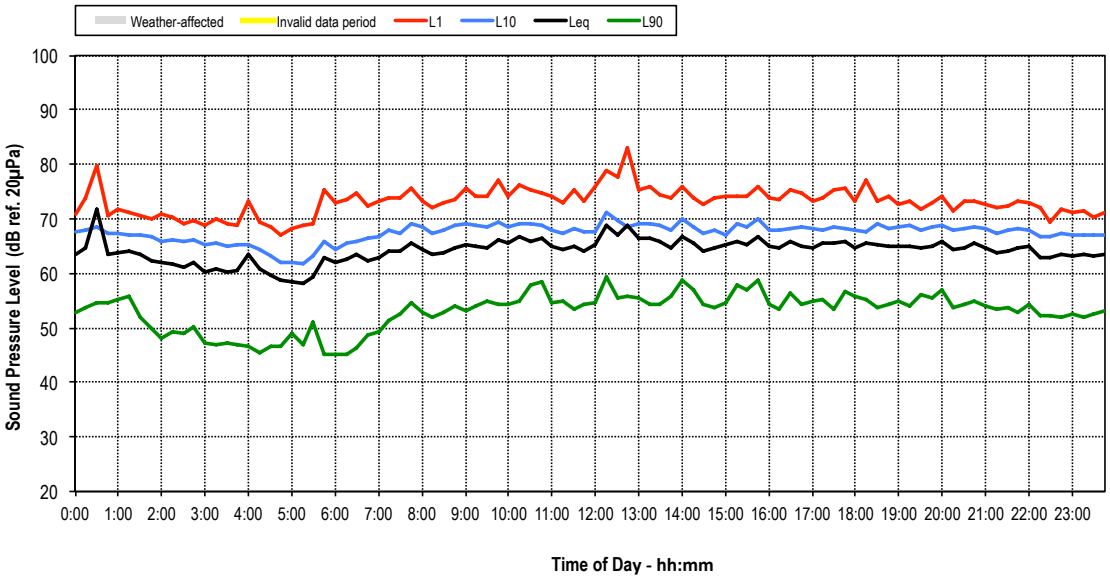
Inner Sydney High School, Chalmers St - Thursday 06 April 2017



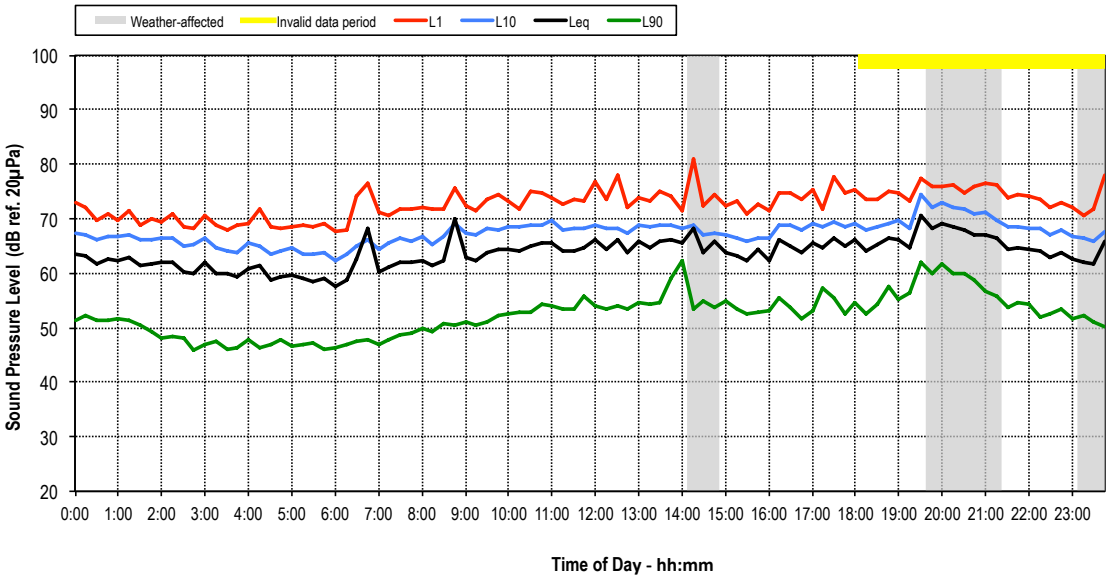
Inner Sydney High School, Chalmers St - Friday 07 April 2017



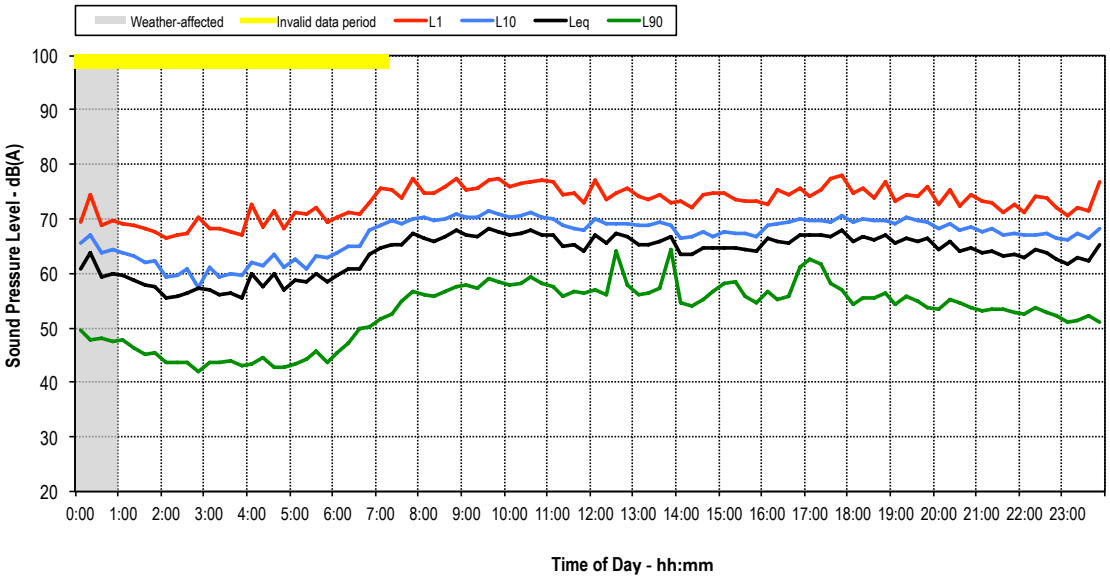
Inner Sydney High School, Chalmers St - Saturday 08 April 2017



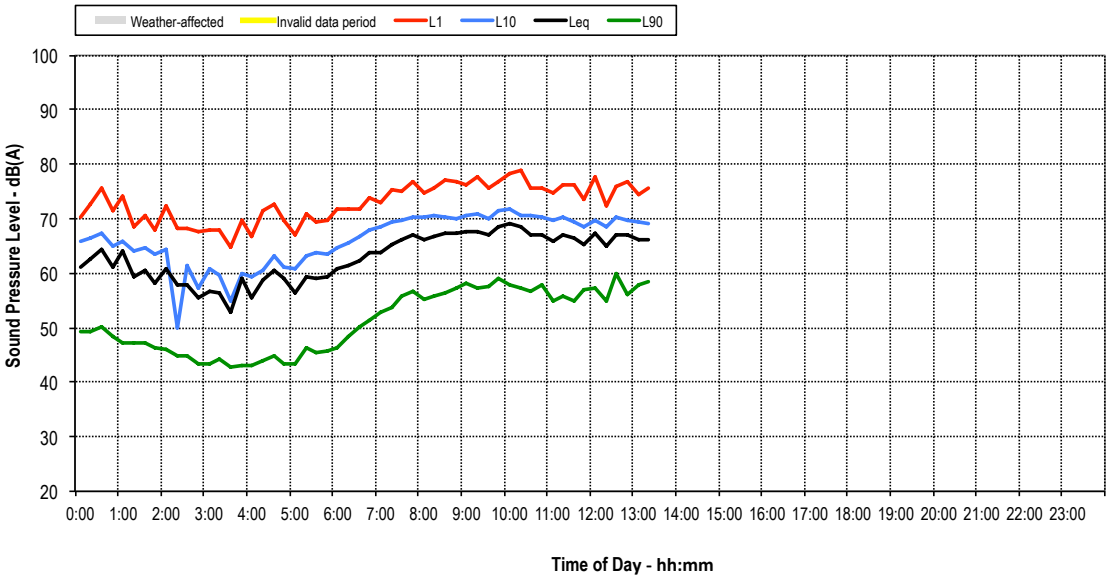
Inner Sydney High School, Chalmers St - Sunday 09 April 2017



Inner Sydney High School, Chalmers St - Monday 10 April 2017

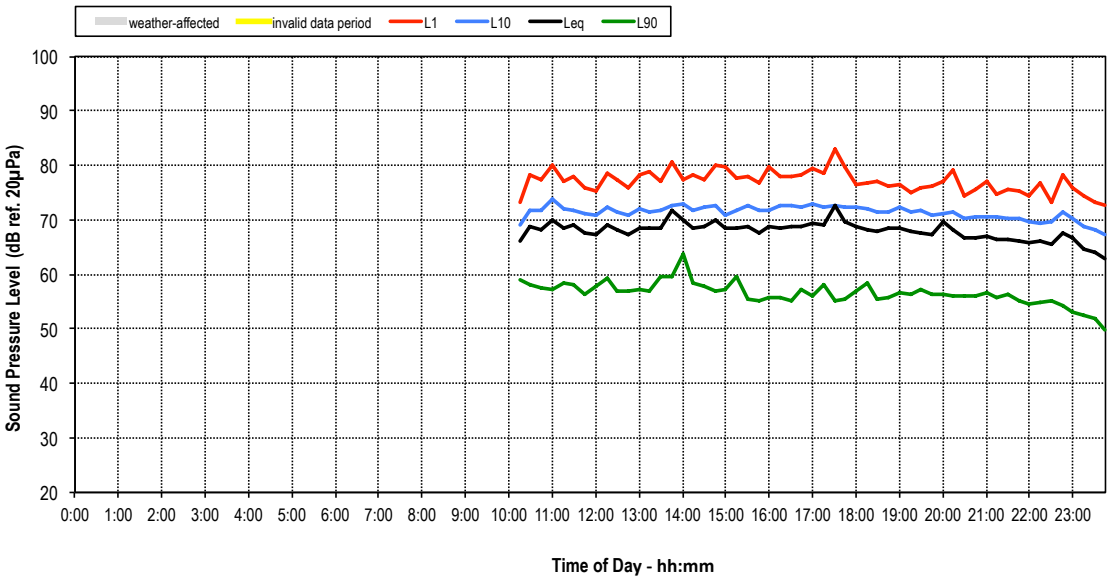


Inner Sydney High School, Chalmers St - Tuesday 11 April 2017

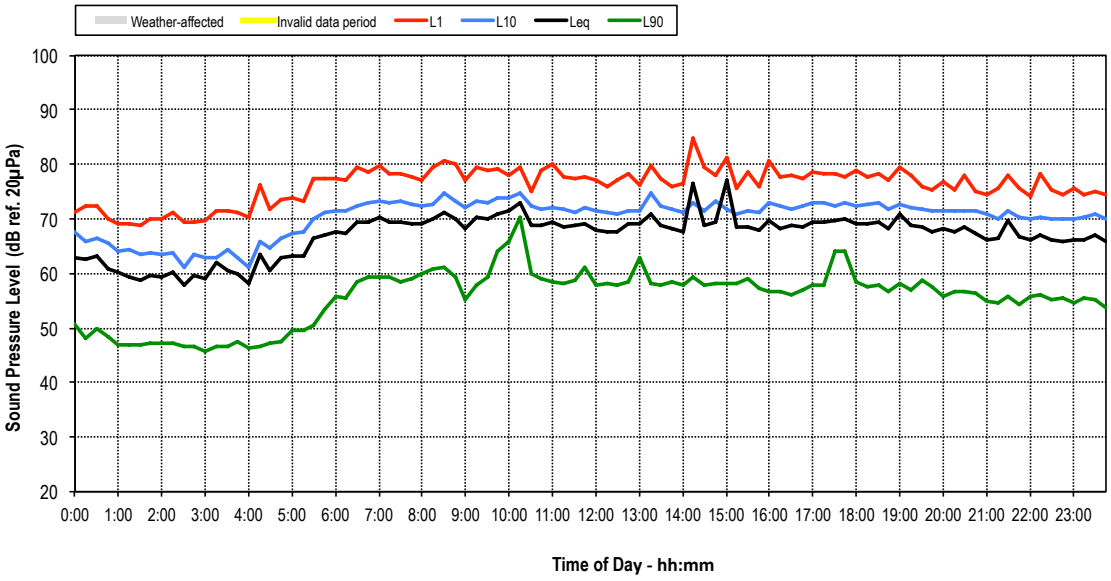


Logger Position 4 – Background Noise Logger

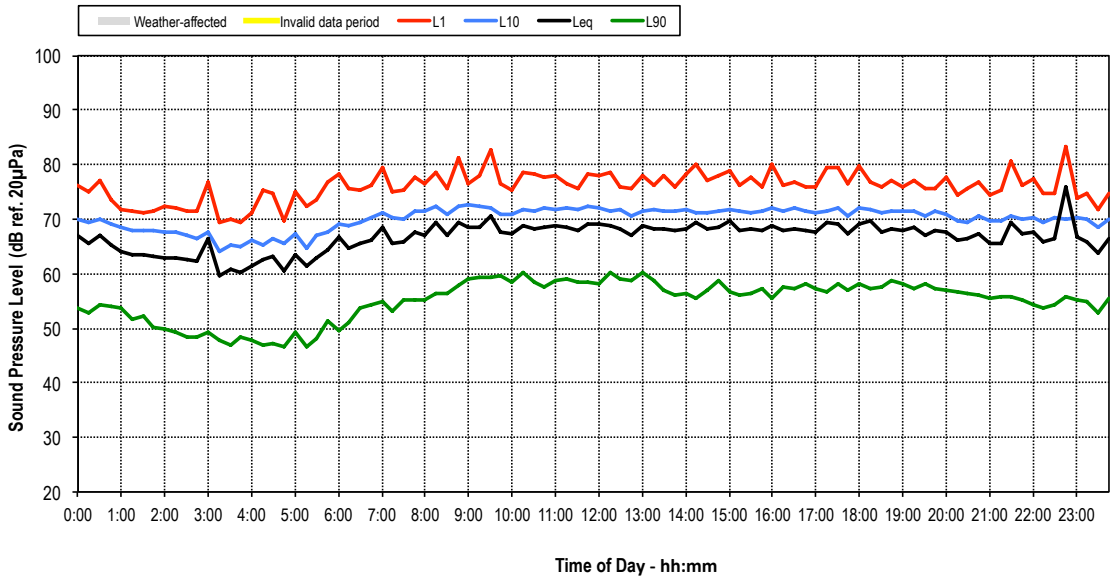
Inner Sydney High School, Residential Chalmers St - Thursday 25 May 2017



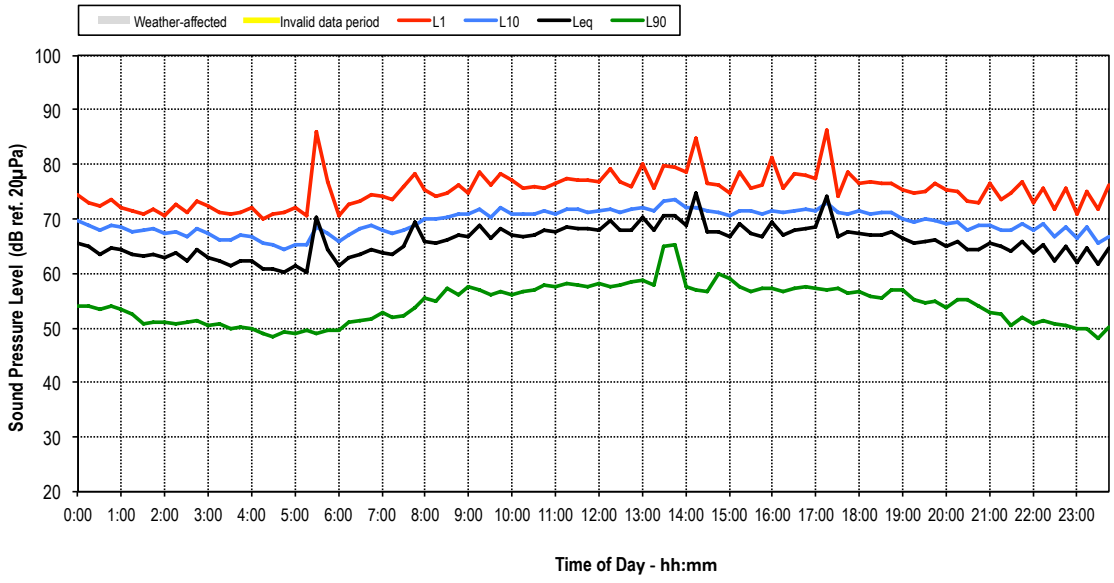
Inner Sydney High School, Residential Chalmers St - Friday 26 May 2017



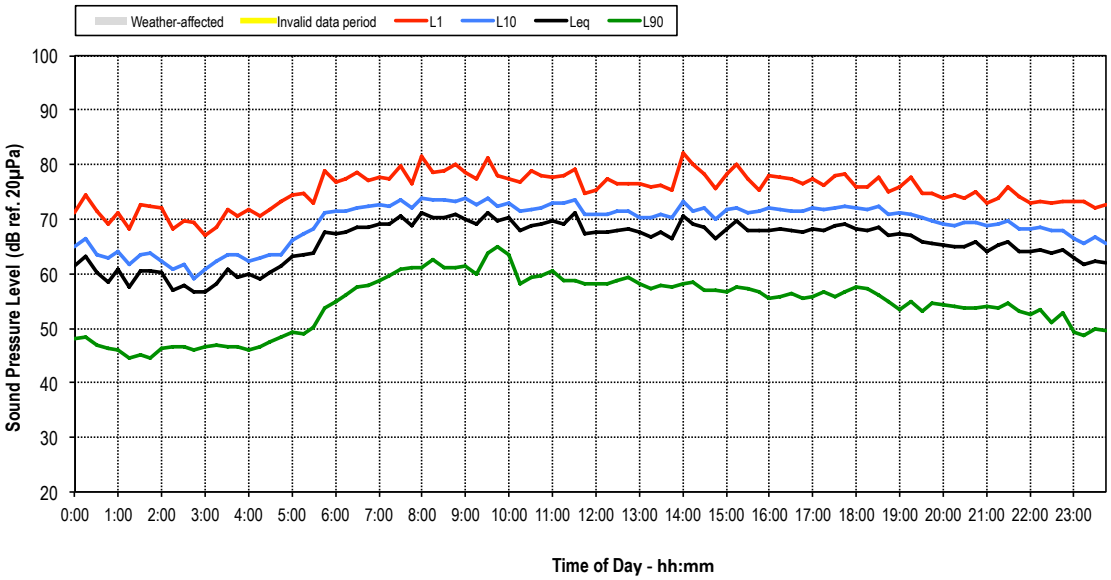
Inner Sydney High School, Residential Chalmers St - Saturday 27 May 2017



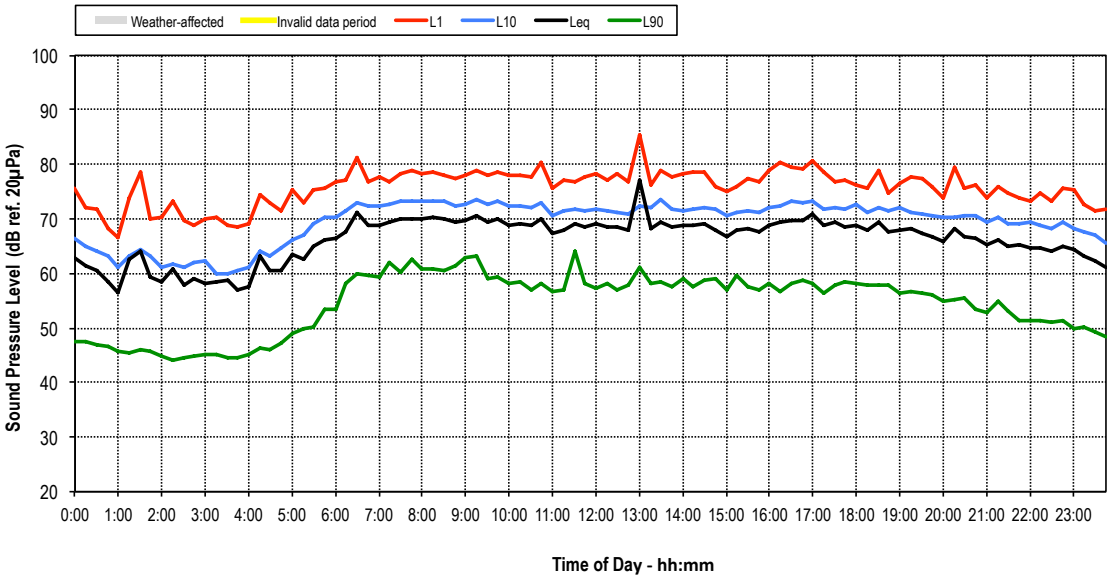
Inner Sydney High School, Residential Chalmers St - Sunday 28 May 2017



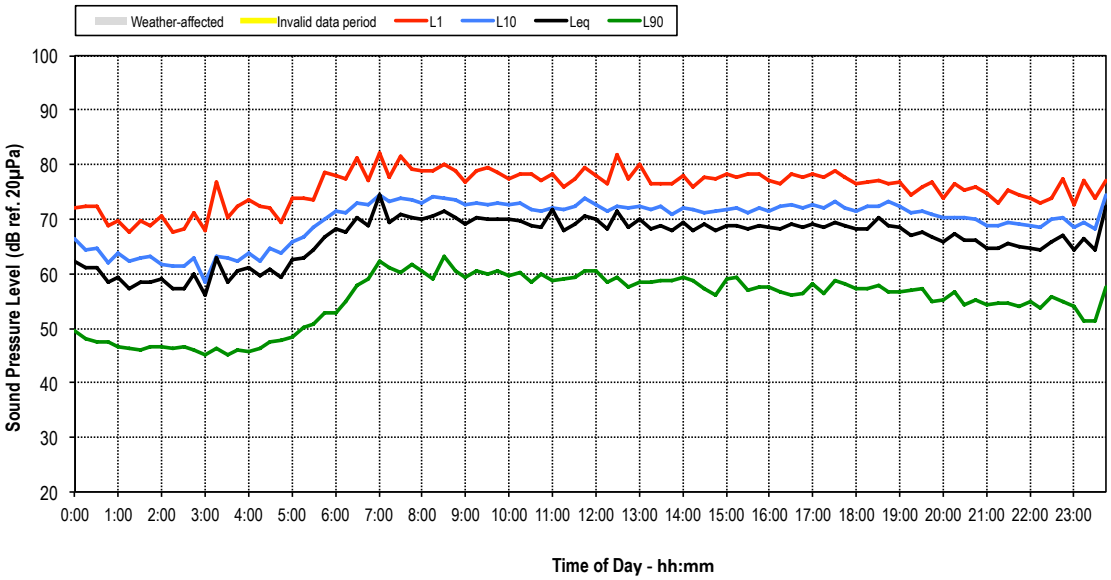
Inner Sydney High School, Residential Chalmers St - Monday 29 May 2017



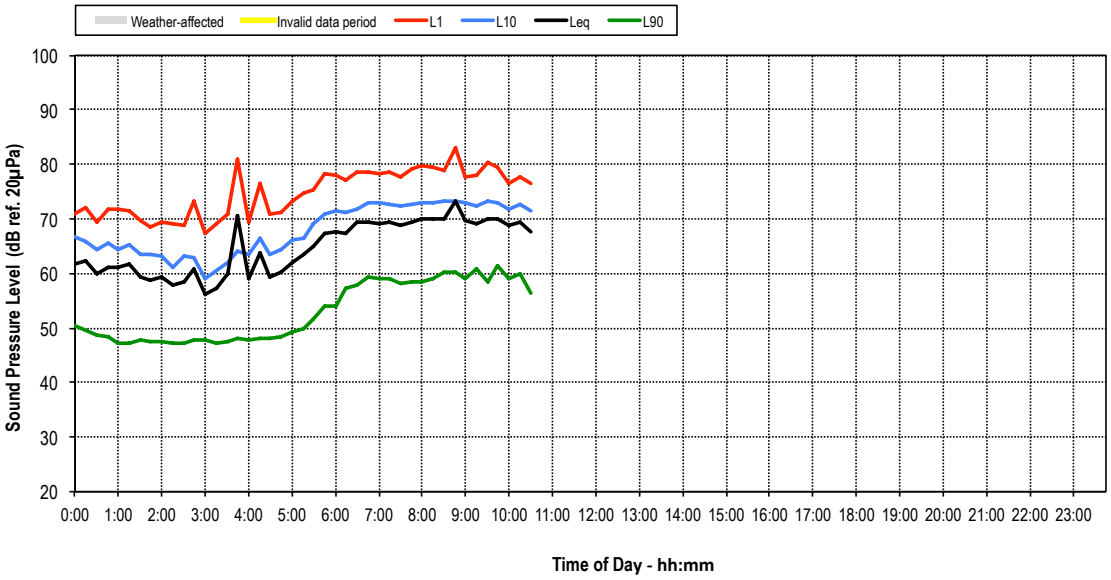
Inner Sydney High School, Residential Chalmers St - Tuesday 30 May 2017



Inner Sydney High School, Residential Chalmers St - Wednesday 31 May 2017



Inner Sydney High School, Residential Chalmers St - Thursday 01 June 2017



Appendix B : Derivation of Environmental Noise Break-out Limits (NSW INP)

The NSW INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. Both are used to derive the project specific noise level.

Assessing intrusiveness

The intrusiveness criterion essentially means that the equivalent continuous noise level of the source should not be more than 5 dB above the measured existing background noise level.

Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise, including plant. The existing noise level from industry (or plant) is measured - if it approaches the criterion value, then the noise levels from new plant need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion.

The cumulative effect of noise from all industrial or plant sources is considered in assessing impact.

Project specific noise level

For any new plant, the more stringent of the intrusive and the amenity criteria sets the project specific noise level.

The derivation of the project specific noise levels is provided below.

B.1 Existing Background and Ambient Noise Levels

The rating background level (RBL) has been determined from $L_{A90,15min}$ measured during the long-term noise survey in accordance with the methodology prescribed in NSW INP.

Three time periods are considered (consistent with the operating times of the plant associated with the development and the time of day classifications in the Policy):

- Day - 7 am to 6 pm
- Evening - 6 pm to 10 pm
- Night - 10 pm to 7 am

From the noise logger data presented in Appendix A, the calculated RBL's and measured ambient noise levels are shown below in Table B1.

Location	L_{90} Background Noise Levels, dB(A)			L_{eq} Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Position 1 Playground Facing Alfred Park	51	50	44	59	57	55
Logger Position 2 Cleveland Street	53	53	45	64	64	60
Logger Position 3 Chalmers Street	55	53	43	68	66	62
Logger Position 4 Chalmers Street, Nearest Residential Boundary	56	53	46	69	66	64

Table B1: Long-term background and ambient noise levels measured around the Inner Sydney High School site

From observations during our site visit, it is noted that both ambient and background noise levels around the proposed development site is generally dominated by traffic noise around the site.

B.2 Determination of intrusiveness criterion

The intrusiveness criterion is defined as:

$$L_{Aeq,15\ minute} \leq \text{rating background level plus 5}$$

The intrusiveness criterion has been determined from the RBL's presented in Table B.1 for each period and from the short-term measurements presented in Section 3. The intrusiveness criterion is established for residential receivers and in this instance is based on Logger Position 3.

- Day Intrusiveness criterion of 55 + 5 = **60 dB(A)**
- Evening Intrusiveness criterion of 53 + 5 = **58 dB(A)**
- Night Intrusiveness criterion of 43 + 5 = **48 dB(A)**

B.3 Determination of amenity criterion

To limit continuing increases in noise levels, the maximum ambient noise levels within an area from industrial noise sources should not normally exceed the acceptable noise levels appropriate for the type of area (e.g. the acceptable noise level in a rural area would be less than that in an urban or industrial area).

Recommended L_{Aeq} noise levels from industrial noise sources within NSW INP

The Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy) are given in Table B2 below.

The nearest residential receivers to the project are considered to be in a Noise Amenity Area characterised by the NSW Industrial Noise Policy as Urban.

Type of Receiver	Period	Recommended $L_{Aeq, period}$ Noise Level (ANL)	
		Acceptable	Recommended Maximum
Residential – Urban (external)	Day	60	65
	Evening	50	55
	Night	45	50
Place of Worship (external)	When in use	50[8]	45
Passive Recreation Area	When in use	50	55
Commercial Premises (external)	When in use	65	70
School Classroom (Internal / External)	Noisiest 1-hr period when in use	35 / 45[9]	40

Table B2: Recommended LAeq noise levels from industrial noise sources at residential and commercial receivers

For the purpose of this assessment, "Acceptable" noise levels as presented in the table above are to be adopted.

[9] The NSW INP specifies an internal ANL of 35 and 40 for school classroms and places of worship respectively. The NSW INP also states that where internal noise levels are specified, external noise 10 dB above internal noise levels can be applied which should achieve an internal noise level where a window is adequately opened to provide natural ventilation.

Existing L_{Aeq} levels

The existing L_{Aeq} levels, determined from the ambient noise level measurements, are as follows:

Type of Receiver	Period	Existing L_{Aeq} Level
Residential – Urban (external)	Day	68
	Evening	66
	Night	62
Commercial / Classroom	When In Use	68[10]

Table B3: Existing LAeq Levels for nearest residential receiver location for project

Amenity criterion

The amenity criterion is determined from the relationship of the existing L_{Aeq} noise level from industrial and traffic sources and the Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy).

This process is summarised below in Table B4.

Receiver	Period	Existing L_{Aeq} Level	ANL	Adjustment to ANL	Amenity Criterion
Residential	Day	68	60	Existing $L_{Aeq, period (traffic)}$ minus 10	58
	Evening	66	50	Existing $L_{Aeq, period (traffic)}$ minus 10	56
	Night	62	45	Existing $L_{Aeq, period (traffic)}$ minus 10	52
Commercial	When in Use	68	65	Existing $L_{Aeq, period (traffic)}$ minus 10	58
Educational	Noisiest 1-hour period When In Use	68	45	Existing $L_{Aeq, period (traffic)}$ minus 10	58

Table B4: Determination of amenity criterion for residential receivers

[10] When considering both day and night

B.4 Project specific noise level

The Project Specific Noise Level is defined as the lower of the intrusiveness and the amenity criteria. On this basis, the Project Specific Noise Levels (PNLs) for new roof plant associated with the site are shown in Table B5 below (PNLs shown shaded in grey).

Type of Receiver	Period	Intrusiveness Criterion	Amenity Criterion
Residential – Urban (external)	Day	60	58
	Evening	58	56
	Night	48	52
Commercial (external)	When in use	-	58
Classroom (Internal)	Noisiest 1-hr period when in use	-	58

Table B5: Determination of project specific noise levels for Inner Sydney High School

Appendix C : Building damage vibration criteria

There is little reliable data on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage. This lack of data is one of the reasons that there is variation between international standards, why the British Standards Institution (BSI) did not provide guidance before 1992 and why there are still no International Organisation for Standardisation (ISO) guidance limits.

There are however several standards that can be referred to.

German Standard

The relevant German standard is DIN 4150: Part 3: 19862. This standard gives guidelines for short-term and steady state structural vibration. For short-term vibration in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
	less than 10Hz	10 to 50 Hz	50 to 100 Hz	Frequency mixture
Commercial, Industrial or Similar	20	20 to 40	40 to 50	40
Dwellings or Similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

Table C1: Guideline Values of Vibration Velocity, vi, for Evaluating the Effects of Short-term Vibration

The guidelines state that:

Experience to date has shown that, provided the values given in Table D2 are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of table D2 are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary.

Swiss Standard

The relevant Swiss standard is SN 640 312:1978. For steady state vibration, form machines, traffic and construction in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s	
	Foundation	
	10 to 30Hz	30 to 60Hz
Commercial, Industrial including retaining walls	12	12 to 18
Foundation walls and floors in concrete or masonry. Retaining walls and ashlar construction	8	8 to 12
Foundations and basement floors concrete, with wooden beams on upper floors. Brick walls.	5	5 to 8
Particularly sensitive	3	3 to 5

Table C2: Guideline Values of Vibration Velocity, vi, for Evaluating the Effects of Steady State Vibration

British Standard

The relevant standard is BS7385: Part 2: 1993[11]. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

The Standard proposes the following limits on the foundations of the building:

Structural type	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15Hz increasing to 50mm/s @ 40Hz and above

Table C3: Transient Vibration Guide Values for Cosmetic Damage

The standard states in Annex A, that … *the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance.* It is recommended that buildings of

[11] British Standards 7385:1993 Part 2 "*Evaluation and Measurement for vibration in Buildings. Guide to damage levels from ground-borne vibration*"

importance be considered on a case-by-case basis with detailed engineering analysis being carried out if necessary.

Annex B of the Standard gives a breakdown of data that should be recorded. Included in this are details of the building structure, such as general condition of the structure, list of defects, photographs, details of all major extensions, repairs and renovations. A crack exposure report should be prepared both pre and post exposure, both internally and externally.

Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2 - 1993[12], which, in Appendix J, recommends maximum peak particle velocities, measured at the ground surface due to blasting. The lower recommended peak particle velocity is 10 mm/s. The standard states however, that structures that may be particularly susceptible to ground-borne vibration should be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

[12] AS 2187.2 - 1993 Explosives - Storage, transport and use. Part 2: Use of explosives