Appendix D

ARUP's Updated Noise and Vibration Impact Assessment

NSW Health Infrastructure

Forensic Pathology & Coroners Court

Noise and Vibration Impact Assessment

Issue 2 | 11 July 2016

Job number

Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Level 10 201 Kent Street
PO Box 76 Millers Point
Sydney 2000
Australia
www.arup.com

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		Name	Daniel Jimenez	Cameron Hough	Nick Boulter
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Contents

Appendices

1 Introduction

Arup has been commissioned by NSW Health Infrastructure to conduct an acoustic assessment of construction and operation noise and vibration impacts associated with the new Forensic Pathology and Coroners Court (FPCC) building works within the NSW Forensic & Analytical Science Service site boundary.

This Noise and Vibration Impact Assessment:

- describes the proposed works
- documents the likely construction and operational noise impacts of the proposal on the noise sensitive receivers
- details protective measures to be implemented.

This assessment is presented in line with the Standard Secretary's Environmental Assessment Requirements (SEARs).

2 Applicable Policies and Guidelines

The purpose of the Noise and Vibration Impact Assessment is to control noise from the construction activities carried out on site to the nearby noise sensitive receivers in the surrounding area in accordance with the following codes, standards and guidance:

Australian Standard. (2010). *AS2436:2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites.*

British Standards. (2014). *BS5228-1:2009 + A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Part 1: Noise.*

British Standards. (June 2008). *BS 6472-1:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings (Part 1: Vibration Sources Other Than Blasting).*

British Standards. (November 1993). *BS7385-2:1993 Evaluation and Measurement for Vibration in Buildings (Part 2: Guide to Damage Levels From Groundborne Vibration).*

Department for Environment Food and Rural Affairs. (2005). *Update of Noise Database for Prediction of Noise on Construction and Open Sites.*

German Standard. (February 1999). *DIN 4150-3 Structural Vibration - Effects of Vibration on Structures.*

NSW Department of Environment, Climate Change and Water. (July 2009). *Interim Construction Noise Guideline.*

NSW Environment Protection Authority. (February 2006). *Assessing Vibration: A Technical Guideline.*

3 Scope

This noise and vibration impact assessment is applicable to all construction works related to the Forensic Pathology and Coroners Court project, for which NSW Health infrastructure and their nominated contractors and associated sub-contractors are responsible.

4 Definitions

4.1 Decibel

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

4.2 dB(A)

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

4.3 L_{Aeq} – Equivalent Continuous Sound Level

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level. The equivalent continuous sound level can also have the A – weighting applied (see dB(A)) in which case it is denoted L_{Aeq} .

4.4 Statistical Noise Levels

4.4.1 $L_{A10(T)}$

Refers to the Sound Pressure Level, measured in dB(A), exceeded for 10 percent of the stated measurement period.

For the purpose of assessment of compliance with this plan the duration interval (T) shall be 15 minutes. L_{A10} is deemed to be equivalent to $L_{A\ AV.\ MAX}$

4.4.2 $L_{A90(T)}$

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

For the purpose of assessment of compliance with this plan the duration interval (T) shall be 15 minutes.

4.5 Assessment Background Level (ABL)

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

4.6 Rating Background Level (RBL)

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

5 Noise Sensitive Receivers

The proposed new NSW Forensic Pathology service and Coroner's Court building is to be located in Lidcombe NSW, adjacent to the current NSW Forensic & Analytical Science Service (FASS), Office of Environment and Heritage (OEH) and Environmental Protection Authority (EPA) buildings. Figure 1 shows the proposed site location.

Figure 1: FPCC location, site context and noise monitoring locations map.

The nearest noise sensitive receivers identified are:

- Residential receivers north of the proposal site.
- Commercial receivers (offices and laboratories) used by the NSW Forensic Analytical Science Services (FASS), the NSW Office of Environment and Heritage (OEH) and the NSW Environment Protection Authority (EPA) located east of the proposal site.
- An active recreation area west of the site (Carnarvon Gold Club)

The noise logger locations were selected based on safety and security concerns. The location of noise monitoring location 1 (see above) is acoustically equivalent to the environment at the side of the eastern edge of golf course land. Similarly, noise

monitoring location 2 is at a location acoustically equivalent to the residential property to the north of the site, being the same distance from the main noise source (Main Avenue). Both locations were secure behind the site fence but with a clear view of the main noise sources.

Eucalyptus Street to the East is effectively screened by several of the existing buildings on site and much further away. Achieving acceptable noise at the nearest residential in Palm Circuit would ensure that acceptable noise levels are also achieved at Eucalyptus Street.

6 Environmental Noise Survey

A summary of measured unattended broadband noise levels is provided in Table 1. Results are presented under Day, Evening and Night time periods as defined in the NSW Industrial Noise Policy. Details of the unattended noise survey methodology, equipment and results are provided in Appendix A.

Long term noise measurements were checked and validated against short-term attended measurements.

Table 1: Summary of measured noise indices

Location	Time Period	Rating Background Level (RBL) – dB(A)	$L_{Aeq\ (period)}$, dB
Location 1 – West of site	Day (7:00 – 18:00)	50	61
	Evening (18:00 – 22:00)	49	60
	Night (22:00 – 7:00)	44	59
Location 2 – North of site	Day (7:00 – 18:00)	47	57
	Evening (18:00 – 22:00)	46	56
	Night (22:00 – 7:00)	43	54

7 Construction Noise and Vibration

7.1 Hours of Work

Noise and vibration limitations are put in place to protect the amenity of the noise and vibration sensitive receivers. The relevant NSW Interim Construction Noise Guideline recommended standard hours for construction work related to the FPCC development are shown in Table 2.

Table 2: Recommended standard hours for construction work

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

All commercially available construction methods/tools/procedures to minimise the noise and vibration impact on the tenancy are recommended to be used by the contractor to ensure the construction noise and vibration criteria is met. Noise and vibration management strategies for construction works are outlined in Section 7.4 for reference. Note that mitigation measures presented in Section 7.4 are not deemed an exhaustive list and the contractor will be required to update the strategies in accordance with the construction activities requirements.

7.2 Criteria

7.2.1 Construction Noise

Construction noise is likely to cause annoyance to noise sensitive receivers in the vicinity of a construction site. The NSW Interim Construction Noise Guideline (ICNG) (NSW Department of Environment, Climate Change and Water, July 2009) provides guidance on construction management requirements based on management level criteria to determine the construction noise mitigation measures and control the noise amenity at residences, other sensitive land uses and, commercial and industrial premises.

7.2.1.1 Residences

The ICNG establishes a "Noise affected" and a "Highly noise affected" criteria to determine the noise management requirements necessary to minimise the construction noise impact upon noise sensitive receivers. Table 3 summarizes the construction noise criteria.

Table 3: Construction noise criteria for residential receivers

Period	Management level criteria[1] $L_{Aeq, (15\ min)}$	Management requirements
Recommended standard hours: Monday to Friday (7am to 6pm) Saturday (8am to 1pm)	Noise affected RBL + 10 dB	- Apply all feasible and reasonable work practices to meet the affected level - Inform all potentially impacted residents of the nature of the works to be carried out, the expected noise levels, duration and contact details
	Highly noise affected 75 dB(A)	- The relevant authority may require respite periods by restricting the hours that very noisy activities can occur
Outside recommended standard hours	Noise affected RBL + 5 dB	- The relevant authority may request strong justification to carry out works outside of standard hours - Apply all feasible and reasonable work practices to meet the affected level - Negotiate with the community if the criteria is not met

[1] Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level

7.2.1.2 Other Sensitive Land Uses

The ICNG recommends determining suitable noise levels on a project-by-project basis where other noise sensitive receivers other than residential receivers may be affected by construction noise.

Table 4: Recommended construction noise limits for non-residential sensitive receivers

Sensitive Land Use	Management level, $L_{Aeq,15min}$ (applies when properties are being used)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion) e.g. Carnarvon Golf Club, west of the site	External noise level 65 dB(A)

7.2.1.3 Commercial Premises

The ICNG also gives recommended management measures for commercial (e.g. offices, retail outlets) and industrial premises:

- Commercial premises (e.g. offices and laboratories at the existing FASS, OEH and EPA buildings)
  - External $L_{Aeq,15minute}$ 70 dB(A)

7.2.2 Construction Vibration

7.2.2.1 Human comfort and amenity

The NSW EPA's Assessing Vibration: A Technical Guideline (NSW Environment Protection Authority, February 2006) provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472 (British Standards, June 2008).

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event.

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

The recommended vibration limits for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration in Table 5 and Table 6 respectively.

Table 5: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s²) 1-80 Hz

Location	Assessment Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Residences	Daytime 0700-2200	0.010	0.0071	0.020	0.014
	Night-time 2200-0700	0.007	0.005	0.014	0.010
Impulsive Vibration					
Residences	Daytime 0700-2200	0.30	0.21	0.60	0.42
	Night-time 2200-0700	0.10	0.071	0.20	0.14

Table 6: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime 0700-2200		Night-time 2200-0700	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26

7.2.2.2 Building damage

There are no Australian standards regarding structural damage of buildings from groundborne vibration. It is common practice in Australia to base building damage thresholds on guidance from British and German standards.

With regards to the potential for vibration to cause structural damage to buildings, BS7385: Part 2: 1993 (British Standards, November 1993) 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. Part 2 of the Standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk. BS7385.2 is commonly used in Australia to set damage thresholds for typical buildings.

Limits on the foundations of the building as proposed in the Standard are listed in Table 7.

Table 7: Transient vibration guide values for cosmetic damage

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

DIN 4150: Part 3: 1999 (German Standard, February 1999) also gives guidelines for short-term and steady state structural vibration for varying types of structure. The limits for short-term vibration in buildings of varying sensitivity are given in Table 8.

Table 8: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Short-term Vibration

	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
Structural type	1 Hz to 10 Hz	10 to 50 Hz	50 to 100 Hz	Frequency mixture
Dwellings or Similar	5	5 to 15	15 to 20	15

The guidelines state that:

> *"Experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding the values in table [17] does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary."*

The most stringent limit recommended in the German Standard is 3 mm/s. This criterion is applicable to particularly sensitive constructions such as heritage structures or dilapidated structures and is considered too stringent for typical buildings.

For the purposes of this CNVMP, the thresholds from BS 7385.2 shall be adopted when assessing the potential for building damage from construction activities.

7.2.2.3 Laboratory Equipment Operation

Vibration sensitive equipment such as optical microscopes is likely to be affected when high intensity construction activities are carried out on site. It is not clear at the time of submission of this document which specific activities are carried out at the FASS laboratories (and hence the vibration sensitivity of the labs). As an interim approach, Vibration Curve B (VC-B) has been adopted as an indicative impact threshold as per IEST-RP-CC012.1, "*Consideration in Clean Room Design*".

7.3 Construction Noise and Vibration Assessment

7.3.1 Source Noise Levels

Indicative construction activity noise source levels have been assumed for the proposed construction works, based on previous construction noise assessments for building projects conducted by Arup and on the likely construction methodology.

The following major construction activities have been modelled:

- Demolition
- Excavation
- Sheet piling
- Construction

For each activity, typical construction equipment used for that activity has been combined into an overall source sound power level for the activity, accounting for the likely usage patterns of items of equipment over a typical 15-minute period (which is the assessment time frame for construction noise levels).

Sound levels for items of construction plant have been derived from the databases in BS5228-1 (British Standards, 2014) and subsequent updates (Department for Environment Food and Rural Affairs, 2005), and AS2436 (Australian Standard, 2010).

Items of plant that have particularly-annoying characteristics (e.g. impulsive or tonal noise characteristics, such as piling or drilling equipment) has had a +5 dB adjustment penalty applied to account for these characteristics, as required by the NSW ICNG.

Table 9 summarises the construction source levels and the major items of construction equipment modelled for each major construction activity:

Table 9: Activity Sound Power Level derived from the construction equipment typically used in each construction activity

Activity	Construction Equipment	Activity Sound Power Level, dB re 1pW
Demolition	Angle grinder Jackhammer Dump truck	$L_{eq,adj,15min}$ 122 dB(A)
Excavation	Tracked excavator Circular saw Dozer Dump Truck Crane tower Concrete pump Cement mixer	$L_{eq,adj,15min}$ 117 dB(A)
Sheet piling	Bored piling rig	$L_{eq,adj,15min}$ 117 dB(A)
Construction	Circular saw Dozer Dump truck Crane tower Concrete pump Cement mixer Core drill	$L_{eq,adj,15min}$ 120 dB(A)

7.3.2 Methods of Construction

It should be noted that the construction contractor would refine construction methods to minimise the construction noise impact upon the noise sensitive receivers adjacent to the proposal area, and be required to prepare a detailed construction noise and vibration management plan as part of the construction process.

7.3.3 Predicted Construction Noise Levels

Construction noise levels have been predicted for the sources derived in Section 7.3.1. The noise sources corresponding to each work activity were assessed in close vicinity of the noise sensitive receivers identified in Figure 1.

For each of these noise sources, Table 10 presents a summary showing the highest predicted noise level at each category of noise-sensitive receiver (Residential receivers

north of the FPCC site, offices and laboratories in the existing FASS, OEH and EPA buildings), and presents the ICNG construction screening criteria for comparison.

Highlighted cells indicate an exceedance of the limiting criteria.

Table 10: Construction Noise Screening Calculations, dB re 20 µPa

Activity	Receiver	Predicted Construction Noise Level dB $L_{Aeq,adj,15min}$	Noise Limits, dB(A)		
			Day	Evening	Night
Demolition	Residential	80	57	51	48
	Golf club	76	65	-	-
	Laboratories	79	70	-	-
Excavation	Residential	75	57	51	48
	Golf club	71	65	-	-
	Laboratories	74	70	-	-
Sheet piling	Residential	69	57	51	48
	Golf club	66	65	-	-
	Laboratories	69	70	-	-
Construction	Residential	69	57	51	48
	Golf club	74	65	-	-
	Laboratories	77	70	-	-

7.3.4 Predicted Construction Noise Levels with Mitigation

Indicative noise mitigation for different noise mitigation measures have been obtained from the guidance of AS2436 and BS5228.1, as summarised below in Table 11

Table 11: Indicative Noise Reduction Provided by Noise Mitigation Measures

Construction Equipment	Noise Mitigation Measure	Indicative Noise Reduction	Source
Generators Cement mixers Hand-held tools Drilling rigs	Acoustic Screening	5 dB(A)	Table C3 AS2436:2010

Construction Equipment	Noise Mitigation Measure	Indicative Noise Reduction	Source
Excavators/loaders Dozer Trucks Bored piling rig Crane tower	Residential-grade silencer	10 dB(A)	Table C2 AS2436:2010

The predicted construction noise levels at the noise sensitive receivers are summarised in Table 12.

Table 12: Mitigated Construction Noise Screening Calculations, dB re 20 µPa

Activity	Receiver	Predicted Construction Noise Level dB $L_{Aeq,adj,15min}$	Noise Limits, dB(A)		
			Day	Evening	Night
Demolition	Residential	74	57	51	48
	Golf club	71	65	-	-
	Laboratories	74	70	-	-
Excavation	Residential	67	57	51	48
	Golf club	64	65	-	-
	Laboratories	67	70	-	-
Sheet piling	Residential	59	57	51	48
	Golf club	56	65	-	-
	Laboratories	59	70	-	-
Construction	Residential	59	57	51	48
	Golf club	68	65	-	-
	Laboratories	71	70	-	-

Even with "feasible and reasonable" mitigation levels in place, the Noise Affected Level is predicted to be exceeded at residential receivers (for all activities) and at all receivers (for demolition and construction).

Provided that construction works occur during standard hours, no additional mitigation measures are required to be considered under the ICNG.

However, if Out of Hours Work (OOHW) is required as part of the FPCC construction works, construction noise levels would be more than 5 dB(A) above the Noise Affected Level for OOHW at residential receivers.

This would trigger additional administrative measures to be determined in consultation with the affected community and the consent authority, e.g. provision of respite periods.

7.4 Construction Noise Management

Until the contractor is appointed and he has determined the construction methods and programme it is not possible to undertake detailed predictions of the noise levels that will be generated.

However, it will be made a specific requirement of the Contractor's scope that they deal effectively with construction noise and vibration by planning, mitigation and consultation and implement all "feasible and reasonable" work practices to minimise noise. They will be required to comply with the requirements of the appropriate codes – particularly the Auburn City Council Construction Policy and Interim Construction Noise Guideline for NSW.

This will include:

- Appointing a named member of the site staff who will act as the Responsible Person with respect to noise and vibration
- Ensuring that the Responsible Person keeps the local community advised on expected activities.
- Ensuring that the Responsible Person checks the conditions of the powered equipment used on site daily to ensure plant is properly maintained and that noise is kept as low as practicable.
- Ensuring that the Responsible Person controls the working hours on site to ensure that work is only done during the acceptable periods as defined in the Interim Construction Noise Guideline for NSW (7am to 6pm on weekdays and 8am to 1pm on Saturdays. No work on Sundays) unless prior approval from the consent authority is arranged.
- Ensuring that noise levels are kept as low as is reasonably practicable and providing appropriate and safe noise mitigation methods following the guidance in AS2436-1981: Guide to noise control on construction, maintenance and demolition sites.
- Maintaining appropriate records of complaints.

7.4.1 Universal Work Practices

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Ensure site managers periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use
- Ensure all doors/hatches are shut

7.4.2 Demolition

- Demolition works are to be conducted during standard construction hours only (i.e. no works on Sunday or Saturday after 1:00 pm)
- Regularly inspect and maintain plant to avoid increased noise levels from rattling hatches, loose fittings etc
- Check hatches/enclosures regularly to ensure that seals are in good working order and doors close properly against seals.
- Use non-"beeper" reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise-sensing alarms.
- Avoid dropping materials from height.
- Provide resilient damping material on bin trucks to minimise impact noise from materials loaded on truck
- Avoid metal-to-metal contact on equipment wherever possible
- Conduct work behind temporary hoardings/screens wherever possible. Site hoardings shall be located as close to the noise source as possible, and will be as high as feasible considering the structural support of the hoarding. Site hoardings may not be effective at screening noise to upper floors of residential receivers, but can be an effective noise mitigation measure for receivers located on lower floors.
- Keep blade of saws sharp; use a damped blade wherever possible
- Fit mufflers/silencers to pneumatic tools (e.g. breakers)
- Use residential-grade mufflers on plant
- Use dampened bits on impulsive tools such as jackhammers to avoid "ringing" noise.

If mitigated noise levels from demolition are predicted or measured to exceed 75 dBA $L_{Aeq,15minute}$, provide respite periods (e.g. breaks of 1-2 hours) during the day when demolition does not occur.

7.4.3 Excavation

- Excavation works are to be conducted during standard construction hours only (i.e. no works on Saturday after 1:00 pm)
- Use residential-grade mufflers on major items of plant
- Regularly inspect and maintain plant to avoid increased noise levels from rattling hatches, loose fittings etc
- Check hatches/enclosures regularly to ensure that seals are in good working order and doors close properly against seals.
- Use non-"beeper" reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise-sensing alarms.
- Avoid dropping materials from height.
- Provide resilient damping material on bin trucks to minimise impact noise from materials loaded on truck
- Avoid metal-to-metal contact on equipment wherever possible
- Conduct work behind temporary hoardings/screens wherever possible. Site hoardings shall be located as close to the noise source as possible, and will be as high as feasible considering the structural support of the hoarding. Site hoardings may not be effective at screening noise to upper floors of residential receivers, but can be an effective noise mitigation measure for receivers located on lower floors.
- If mitigated noise levels from excavation are predicted or measured to exceed 75 dBA $L_{Aeq,15minute}$, provide respite periods (e.g. breaks of 1-2 hours) during the day when excavation does not occur.

7.4.4 Construction

- Construction is to occur during standard construction hours only (i.e. no works on Saturday after 1:00 pm)
- Use residential-grade mufflers on major items of plant
- Regularly inspect and maintain plant to avoid increased noise levels from rattling hatches, loose fittings etc
- Check hatches/enclosures regularly to ensure that seals are in good working order and doors close properly against seals.
- Use non-"beeper" reversing/movement alarms such as broadband (non-tonal) alarms or ambient noise-sensing alarms.
- Avoid dropping materials from height.
- Provide resilient damping material on bin trucks to minimise impact noise from materials loaded on truck
- Avoid metal-to-metal contact on equipment wherever possible
- Conduct work behind temporary hoardings/screens wherever possible. Site hoardings shall be located as close to the noise source as possible, and will be as high as feasible considering the structural support of the hoarding. Site hoardings may not be effective

at screening noise to upper floors of residential receivers, but can be an effective noise mitigation measure for receivers located on lower floors.

- If mitigated noise levels from installation are predicted or measured to exceed 75 dBA $L_{Aeq,15minute}$, provide respite periods (e.g. breaks of 1-2 hours) during the day when Installation works do not occur.

7.4.5 Deliveries

- Keep truck drivers informed of designated vehicle routes, parking locations and acceptable delivery hours for the site.
- Avoid deliveries at night/evenings
- No idling of delivery trucks
- Receive/unload all deliveries behind a site hoarding/temporary acoustic screen, wherever possible

7.4.6 Stockpiling

- Stockpile materials behind a site hoarding/temporary acoustic screen
- Use residential-grade mufflers on major items of plant

7.4.7 Landscaping

- Use residential-grade mufflers on major items of plant

7.4.8 Work Outside of Standard Working Hours

Work outside standard hours will only be conducted in the following circumstances:

- Works required to prevent any threat to pedestrian safety or a threat of environmental harm if work was to occur during standard construction hours (e.g. emergency works, incomplete works that need to continue out-of-hours in order to maintain safe passage, works requiring closure of Main Avenue entrance).
  In these situations the person who becomes aware of the situation will notify the Site Foreman (SF) or Project Engineer (PE) who will in turn notify the General Foreman (GF) or Project Manager (PM) who will be responsible for recording the details of the additional working hours. Attended monitoring of noise levels by the Acoustic Consultant (AC) may be required at the discretion of the PM. Clear and concise notification of the community will occur as discussed further in 7.4.10.
- The delivery of plant, equipment and materials which is required outside Standard Working Hours as requested by police or other authorities for safety reasons and with clear and concise notification to the community as agreed by the Site Environmental Representative
- All “feasible and reasonable” noise mitigation measures discussed in this chapter (Section 7) must be implemented for out-of-hours’ work.

If the resulting mitigated noise levels for the activity exceed the Highly Noise Affected Level, and works cannot be conducted during standard construction hours, the works may

still occur subject to the consent authority's approval, however affected residents must be informed of the likely time, duration and extent of the noise impacts.

7.4.9 Noise Monitoring

Attended environmental noise monitoring will take place at the discretion of the PM at locations determined prior to the beginning of the construction works.

The locations for noise monitoring shall be representative of the worst affected locations in order to effectively address community concerns in regards to noise.

Additional attended noise monitoring at other locations and plant and equipment monitoring on-site will take place as and when necessary.

The GF will issue a detailed construction programme as required. An acoustic consultant will review the programme and arrange monitoring to coincide with potentially noisy activities.

7.4.9.1 Reporting

Reports covering the attended monitoring described in section 7.4.9 above will be prepared after each monitoring session by the Acoustic Consultant for review by the GF. The reports will summarise and interpret the results of each session of noise monitoring. Noise monitoring reports will be prepared within 1 week of completed monitoring and issued in a format suitable for presentation to the consent authority.

7.4.10 Community Notification

Community notification via letter box drops must occur at least five (5) days in advance of any planned out-of-hours work. Notification will occur regardless of whether the planned work is expected to cause adverse noise impacts to residents.

The notification will:

- Provide a clear and concise description of the planned works
- Provide details of the timing and expected duration of the works
- Provide details of the timing and expected duration of "loud" activities
- Inform residents of the noise mitigation measures being implemented for the proposed works, and that all "feasible and reasonable" measures have been implemented to reduce noise impacts.
- Provide a readily accessible contact point (eg mobile phone number and name, 24-hour toll-free information line)

Letter box drops will also be used to manage noise sensitive receiver expectations by notifying residents that increased noise levels may be experienced by upper-floor receivers due to these receivers overlooking the site.

8 Operational Noise Assessment

8.1 Criteria

Environmental noise emissions from the development are to be assessed under two main policies from the EPA. These are outlined in further detail below and give different requirements. Ultimately the most onerous of these will apply.

8.1.1 Environmental Protection Authority – Industrial Noise Policy

Assessment and control of industrial noise is provided by the NSW Environmental Protection Authority (EPA) in the Industrial Noise Policy (INP). The INP provides guidelines which apply to mechanical services plant installed at FPCC, and is appropriate for assessment of noise impacts from developments that have the potential to increase existing noise levels.

An INP assessment comprises two components for two main purposes:

- Control of intrusive noise impacts for residents
- Maintaining noise level amenity for particular land uses for residences and other land uses.

For FPCC, both are of concern to ensure that criteria are met for nearby noise sensitive residential receivers. These are addressed below:

8.1.1.1 Intrusive Criteria

For assessing intrusiveness, the existing ambient noise level needs to be measured. The intrusiveness criterion requires that the equivalent continuous noise level (L_{Aeq}) of new industrial noise sources should not be more than 5 dB above the measured Rated Background Level (RBL), over any 15 minute period.

8.1.1.2 Amenity Criteria

In addition to the intrusive criteria, the INP also makes provision for maintaining noise level amenity for particular area types. The cumulative effect of noise from existing and proposed industrial noise sources needs to be considered in assessing this impact. The existing noise level from industry is measured. If it approaches a predefined value based on area type, then noise levels from new industrial noise sources need to be designed so that the cumulative effect does not produce total noise levels that exceed the criterion.

In order to determine criteria for noise emissions from FPCC, an environmental noise survey has been conducted in the vicinity of the proposed development site. A summary of the results is presented in Section 0 and details are given in Appendix A.

8.1.1.3 INP Summary

A summary of the INP is provided for the residential receivers north of the FPCC site across Main Avenue in Table 13. The criteria is based on the results of the closest surveyed location presented in Table 1. The final column below (the Project Specific Criterion) is the one to be used for the development, which is the lowest between the Intrusiveness and the Amenity Criterion.

Table 13: INP noise criteria for new industrial plant at residential receivers

Location	Time Period[1]	Intrusiveness Criterion $dBL_{Aeq,15min}$	Amenity Criterion $dBL_{Aeq,period}$	Project Specific Criterion
Residential receivers north of FPCC site	Day	52	**47**	47 $dBL_{Aeq, period}$
	Evening	51	**46**	46 $dBL_{Aeq, period}$
	Night	48	**44**	44 $dBL_{Aeq, period}$

[1] Time periods are defined by the NSW INP as Day (0700h-1800h), Evening (1800h-2200h) and Night (2200h-0700h).

8.2 Mechanical Services Noise Impact Assessment

The assessment of the mechanical services noise impact is based on preliminary selection of major mechanical plant equipment (i.e. air-handling units, cooling towers, chillers) and schematic design mechanical drawings.

8.2.1 Plant Noise Data

The following sound power data have been used to model noise radiation from the plant to the nearest noise sensitive receivers.

Table 14: Sound Power Data for AHU Plant used in noise modelling

Plant Item	Sound Power Level (dB re 10^{-12}W) Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
AHU.01.01	75	73	84	86	88	83	84	79
AHU.01.2	75	74	84	85	84	80	80	73
AHU.01.3	78	87	86	88	87	82	76	75
AHU.01.4	76	76	85	89	91	86	88	86
AHU.01.5	75	73	84	85	87	82	83	77
AHU.01.6	78	87	86	88	87	82	76	75
AHU.01.7,8,9 X 3	77	75	86	79	81	79	75	71
AHU.01.10	74	82	83	82	82	79	77	72

Plant Item	Sound Power Level (dB re 10^{-12}W) Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
AHU.01.11,12,13	80	70	83	82	84	82	79	74
AHU.01.14	80	86	90	86	87	84	81	79
AHU.01.15	73	79	83	85	86	83	78	76
AHU.01.16	75	74	84	87	89	84	85	82
AHU.01.17	81	87	90	86	87	84	81	79
AHU.01.18	80	81	90	83	83	81	73	67
AHU.01.19	74	70	80	77	80	79	75	72

Table 15: Sound Power Data for Chiller Plant used in noise modelling

Plant Item	Sound Power Level (dB re 10^{-12}W) Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
CH-01	92	92	92	92	91	88	85	80
CH-02	96	96	96	96	95	92	89	84
CH-03	96	96	96	96	95	92	89	84

Table 16: Sound Power Data for Cooling Towers used in noise modelling

	Sound Power Level (dB re 10^{-12}W) Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
CT-01	104	104	101	98	92	88	84	77
CT-02	104	104	101	98	92	88	84	77
CT-03	104	104	101	98	92	88	84	77

8.2.2 Noise Predictions

The noise predictions have assessed noise from each item of plant to atmosphere via the direct connections to the intake/ discharge louvres. Plantroom noise levels have also been assessed to enable checks to be made on plant noise transfer from the plantrooms to atmosphere.

The calculations have followed accepted acoustic principles, taking allowance for noise propagation using the methodology given in ISO 9613.2, and the tendency for large openings to ‘beam’ sound (known as directivity).

For the AHUs, allowances have been made for the attenuation of noise by the casings of the units and through the coils and filters on the intake.

The calculations have looked at various noise control techniques for each individual item of plant as well as the total noise from *all* items of plant. The calculations have included a 5dB factor of safety to account of the uncertainty at this time with regards to the final plant selections.

8.2.3 Results

Predicted noise levels from mechanical plant at the most affected noise sensitive residential receiver are summarised in Table 17.

Table 17: Predicted Noise Levels from FPCC plantroom

Receiver	Predicted Level	Time Period	Criteria	Meets Criteria?
Residential receivers north of FPCC site	44 dB	Day	47 dB	✓
		Evening	46 dB	✓
		Night	44 dB	✓

* Marginal exceedance of less than 2 dB

These screening calculations indicate that typical mechanical equipment associated with the FPCC building is likely to comply with the project noise criteria at nearby receivers; however compliance will be subject to the individual items of plant selected, and the cumulative impact from all items of plant must be considered as part of ongoing design.

As ongoing design of the FPCC building continues, plant selection will be refined, sited and (if necessary) fitted with noise mitigation measures such as attenuators, acoustic louvres or acoustic screening so that the noise criteria in Table 13 are not exceeded.

8.3 Sleep Disturbance

Operation of the new FPCC building is predicted not to cause any significant sleep disturbance impacts for the residential noise sensitive receivers located north of the proposal site due to the invariable nature of the noise sources (i.e. the noise sources are not expected to generate sudden or intermittent noise bursts). Sleep disturbance impacts will therefore not be discussed any further in this report but equipment selections will be kept under review in case new plant or activities are proposed that could potentially lead to sleep disturbance issues.

9 Safety

Personnel involved in operations will be issued with ear plugs or ear defenders, which must be used whenever noise levels interfere with normal speech when individuals are standing at a distance of 1m from each other, or when the eight-hour equivalent continuous A-weighted sound pressure level, $L_{Aeq,8hr}$ measured with a properly calibrated sound level meter exceeds 85 dB.

Signs shall be erected and made visible at the entry to all areas where noise levels will exceed 85 dB(A).

Appendix A

Environmental Noise Survey

A1 Methodology

A1.1 Unattended Long Term Noise Measurements

Unattended noise monitoring equipment was used to gain an understanding of typical noise levels at the subject site. Noise monitoring devices were installed on 9 December to 17 December 2015 at two locations shown in Figure 1.

Long-term noise measurements were made in 15-minute intervals, using 'fast' time constant. Broadband and octave band L_{Aeq}, L_{A10} and L_{A90} measurements were made. This equipment measured continuous noise data for 8 days.

Meteorological conditions were monitored during the survey period. No measured data was removed as there was no influence of any adverse weather conditions or extraneous noise events.

A1.2 Attended Short Term Noise Measurements

Attended noise measurements were undertaken on Wednesday 9 December 2015 and Thursday 17 December 2015 to validate unattended noise measurements. Broadband and octave band L_{Aeq}, L_{A10} and L_{A90} measurements were made.

A2 Measurement Locations

Figure 1 shows a map of the area, annotated with the locations of the two noise loggers. Logger locations were chosen as representative of the current conditions at the project site, within site security and access constraints.

Additional work in the following stages of design will be required to determine noise criteria appropriate to future developments in close proximity to future developments around the FPCC site.

A3 Equipment

Equipment used to measure the baseline noise levels is detailed in Table 18. All equipment was checked for calibration before and after measurements with no significant drift in calibration being recorded. All equipment held a current NATA calibration certificate at the time of the survey.

Table 18: Noise Survey Equipment

Equipment manufacturer and type	Description of Equipment	Serial No.
ARL Ngara – Type 1	Sound logging meter	878060
ARL Ngara – Type 1	Sound logging meter	87807f
Brüel and Kjær 2270	Type 1 sound level meter	2754328
Brüel and Kjær 4231	Sound level meter calibrator	2445716

A4 Long Term Unattended Noise Logging Results

A4.1 Summary

A summary of measured unattended broadband noise levels is provided in Table 19.Results are presented as the Rating Background Level (RBL) determined for the Day, Evening and Night time periods using the "tenth percentile" method as defined in the NSW Industrial Noise Policy.

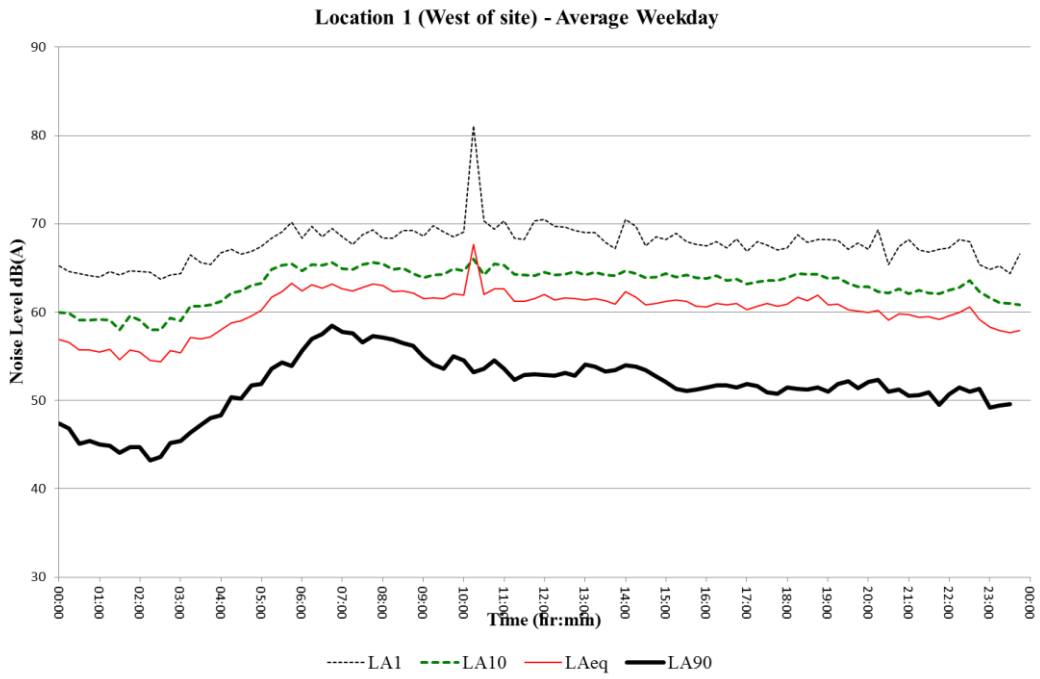
Long term noise measurements were checked and validated against short-term attended measurements.

Table 19: Summary of measured noise indices

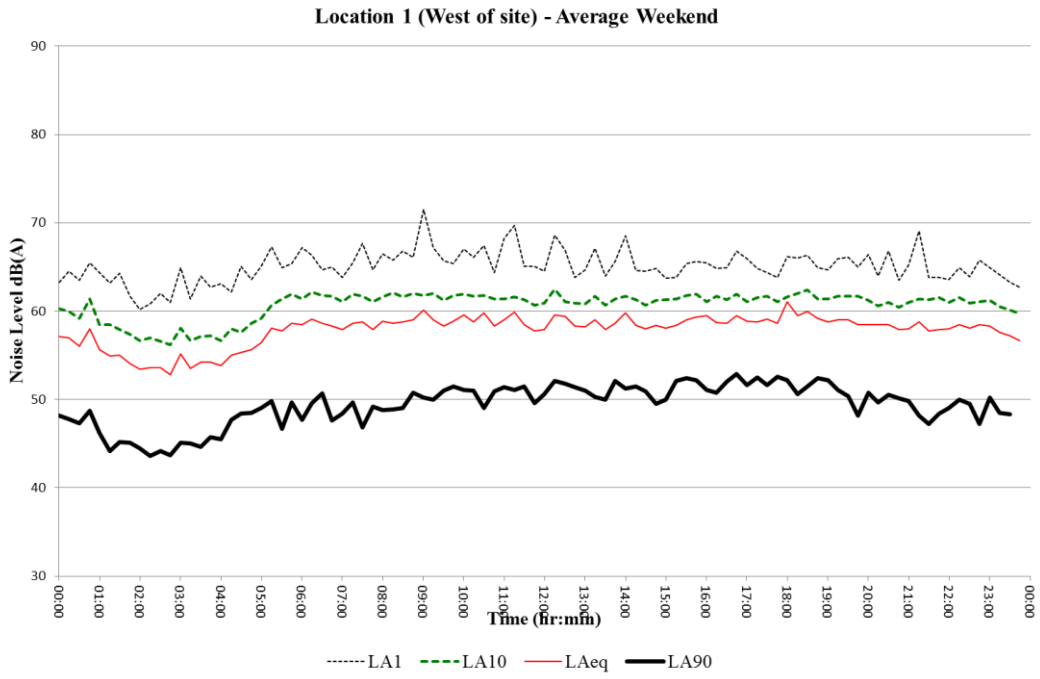
Location	Time Period	Rating Background Level (RBL) – dB(A)	$L_{Aeq\ (period)}$, dB
Location 1 – West of site	Day (7:00 – 18:00)	50	61
	Evening (18:00 – 22:00)	49	60
	Night (22:00 – 7:00)	44	59
Location 2 – North of site	Day (7:00 – 18:00)	47	57
	Evening (18:00 – 22:00)	46	56
	Night (22:00 – 7:00)	43	54

A4.2 Location 1 – West of site

A4.2.1 Average Weekday

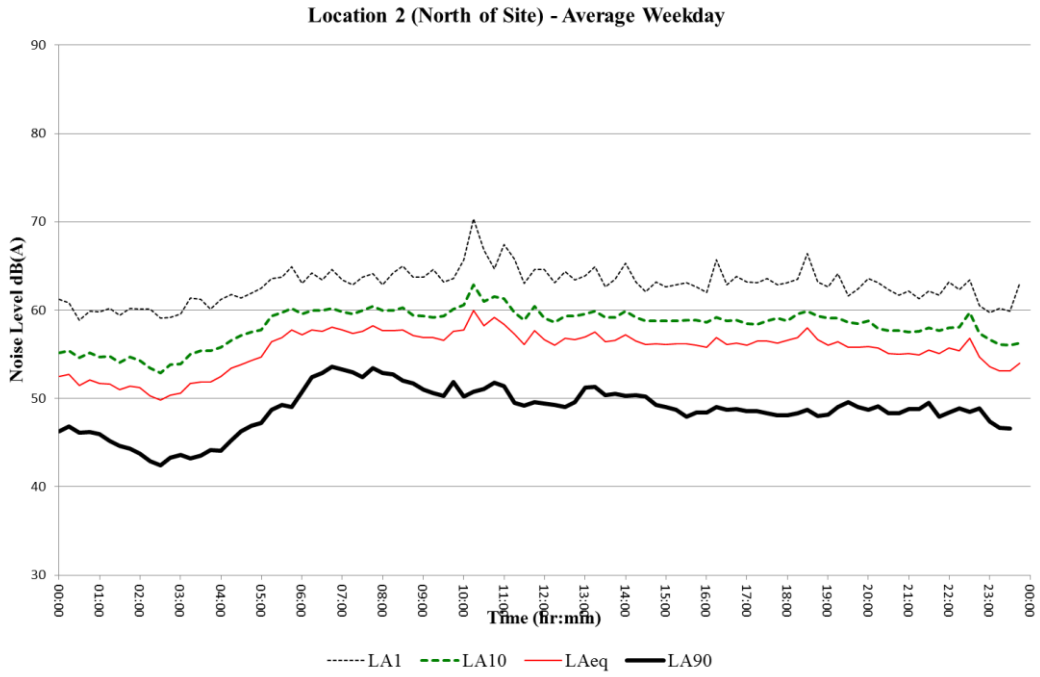


A4.2.2 Average Weekend



A4.3 Location 2 – North of site

A4.3.1 Average Weekday



A4.3.2 Average Weekend