# APPENDIX F

## Noise and Vibration Impact Assessment

energy2U
Alliance

16 September 2010

# North Sydney Zone Substation Redevelopment
# Noise and Vibration Assessment

# QUALITY INFORMATION

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The Energy2U Alliance brings partners EnergyAustralia, Leighton Contractors Pty Ltd, AECOM Australia Pty Ltd and PowerServe Pty Ltd together to undertake works for EnergyAustralia's Overflow Infrastructure Project.

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# 1 INTRODUCTION

## 1.1 Background

This project is being delivered by the Energy2U Alliance (energy2u) which brings together partners from EnergyAustralia, Leighton Contractors Pty Limited, AECOM Pty Limited and PowerServe Australia Pty Limited to undertake works for EnergyAustralia.

energy2u has prepared this Environmental Noise and Vibration Assessment to assess the construction and operational noise and vibration impacts associated with the redevelopment of the zone substation in North Sydney.

This report was initially prepared to support a Review of Environmental Factors (REF) prepared under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The REF was approved on 16th February 2010 and preparatory site work commenced on the site of the proposed substation on 23rd February 2010. Work that has been completed to date includes the clearing and excavation of the proposed site for the new substation.

During preparation of the REF, consultation was conducted with the community, relevant stakeholders and government authorities and feedback was received from interested parties. A neighbouring land owner on Walker Street subsequently commenced Land and Environment Court proceedings based on an allegation that EnergyAustralia inadequately complied with Section 111 of the EP&A Act and had not considered the environmental impact associated with the substation redevelopment to the fullest extent possible.

Accordingly, it was determined that Project Approval should be sought from the Minister for Planning under Part 3A of the EP&A Act and construction work on site ceased on 21st May 2010. The Part 3A Assessment would allow the regional benefits and significance of the project to be more appropriately weighted and a more rigorous assessment of the potential impacts.

The noise and vibration assessment has been revised to support an Environmental Assessment (EA) that has been prepared in accordance with Part 3A of the EP&A Act.

The project involves the construction, operation and maintenance of a new North Sydney zone substation and the decommissioning and demolition of the existing North Sydney zone substation. The key activities associated with the project include:

- Construction of a brick-clad substation building (to RL 94);
- Installation of an 11 kV switchboard;
- Installation of three 50 Mega Volt Amp (MVA) 132/11 kV low noise transformers that would be oil cooled;
- Installation of 1600 Amp 132 kV gas insulated switchgear (GIS);
- Installation of control and protection panels;
- Installation of auxiliary equipment for the transformers and substation;
- Installation of a cable vault and conduits in Ward Street and conduits in Harnett Street;
- Commissioning of the substation;
- Temporary interconnection works between the existing and the new substations; and
- Decommissioning and demolition the existing North Sydney (Berry Street) zone substation.

Construction of the cable vault would be undertaken over a period of approximately six months at night and during the weekend to minimise traffic impacts.

## 1.2 Purpose of this report

This report:

- Identifies sensitive receivers likely to be affected by construction and operational noise and vibration during both the construction and operation of the proposed substation and decommissioning and demolition of the existing substation, including both existing and approved but not yet constructed developments;
- Presents baseline conditions based on monitoring results and the levels and character of noise generated by noise sources associated with the redevelopment;
- Recommends environmental criteria for operational noise emissions from the mechanical plant and transformers to the closest residential (including approved but not yet constructed developments) and commercial premises that would be affected;
- Presents modelling assumptions;
- Recommends mitigation measures that might be used to control operational environmental noise emissions to the appropriate criteria;
- Establishes noise management levels by which construction noise and vibration impacts at sensitive locations be evaluated;
- Calculates noise and vibration levels likely to be associated with the construction works, and evaluates the extent of resulting impacts; and
- Recommends appropriate mitigation measures and performance requirements to be considered further during construction planning in order to protect community values and sensitive locations from construction noise and vibration in accordance with relevant standards and/or guidelines.

Ambient noise levels were continuously monitored for a period of five days between Friday 3 July 2009 and 9 July 2009 at the rear of 136 Walker Street, North Sydney.

The measurements were used to establish the construction noise management levels and operational environmental noise emission criteria in accordance with procedures recommended by the Department of Environment, Climate Change and Water (DECCW) and relevant standards.

Recommendations have been presented, incorporating a reasonable and feasible approach to mitigation measures that might be considered, to minimise construction noise intrusion at sensitive receivers. Recommendations have also been made to ensure that operational environmental noise emissions would be controlled.

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

The acoustic assessment outlined in this report considers the following documents as stated in the Director General's Requirements (DGRs) for the project dated 14 July 2010:

- Operational noise – *NSW Industrial Noise Policy* (NSW Environment Protection Authority, 2000);
- Traffic Noise – *Environmental Criteria for Road Traffic Noise* (NSW Environment Protection Authority, 1999);
- Site establishment and construction noise – *Interim Construction noise Guideline* (NSW Department of the Environment and Climate Change, 2009); and
- Vibration – *Assessing Vibration: A Technical Guideline* (NSW Department of the Environment and Climate Change, 2006) and *British Standard BS7385-Part 2:1993 Evaluation and Measurement for Vibration in Buildings*.

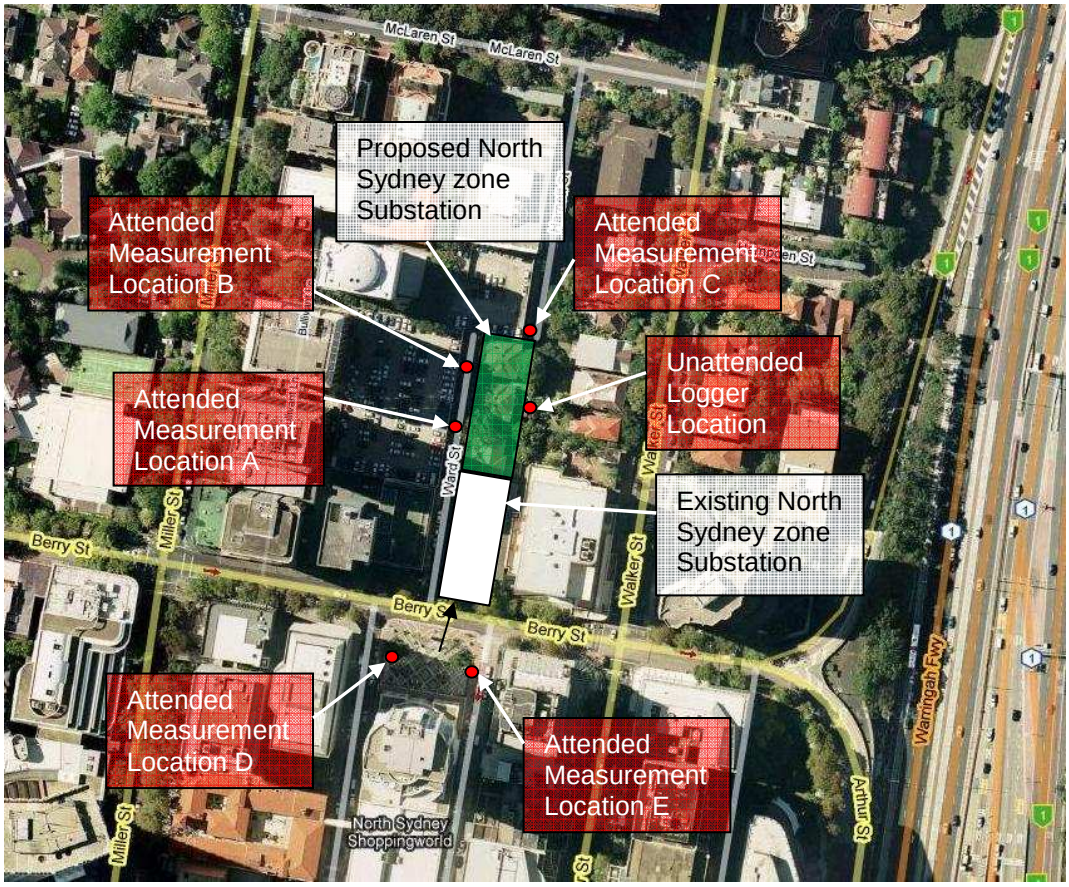
## 1.3 Site location and nearby sensitive receivers

The redevelopment site is located in North Sydney and comprises the existing substation at 70-74 Berry Street and the site of the proposed substation at 3-11 Ward Street as shown in Figure 1. There are residences and a restaurant located to the rear of the People Telecom Building (along Walker Street to the east of the proposed substation) at a distance of approximately 10-15 m away. Other residences are located approximately 40 m away, in high rise apartments in Berry Street. There is a commercial building that adjoins the site on the corner of Berry and Walker Streets. Within this building there is a restaurant on the north west corner of the building, adjacent to the site.

There is a proposed 22 storey mixed use (commercial and residential) development to be located to the east of the site at 136-140 Walker Street. This proposal received development approval from North Sydney Council in October 2008.

Less sensitive receptors around the proposed redevelopment include office spaces and a three storey open carpark to the west and north.

**Figure 1 - Location plan showing locations of both attended and unattended monitoring prior to construction**



## 1.4 Construction description and methodology

The proposed new North Sydney substation would comprise of a building with a footprint of approximately 1200 $m^2$. The height of the building would be approximately 25 m above Ward Street and 29 m above Harnett Street. The basement of the building has already been excavated (as part of a separate approval) approximately 9 m below Ward Street and 4 m below Harnett Street.

The proposed redevelopment works would include the following:

- Construction of a building containing 3 fully enclosed bays to each separately house one transformer (50MVA 132/11kV). These bays are naturally ventilated by means of large air intake openings and vent shafts on the western side;
- Installation of 3 auxiliary transformers in separate bays;
- Space provisions for 6 capacitor banks;
- Installation of switchgear in enclosed switchrooms;
- Installation of a cable vault at the corner of Ward and Berry Street; and
- Decommissioning and demolition of existing substation.

The following schedule of equipment is to be used for the construction of the substation, installation of the cable vault on the corner of Berry and Ward Streets, and demolition of existing substation:

**Substation building**

- Tower crane;
- Mobile crane;
- Man and material (M & M) hoist;
- Scaffolding;
- Jackhammers;
- Mulcher / chipper;
- Elevated work platforms (EWP);
- Traffic control vehicles and equipment;
- Trucks;
- Concrete saws;
- Concrete trucks and pumps;
- Equipment delivery vehicles, including low loaders; and
- High voltage testing equipment.

**Cable vault and trenches**

- Excavators;
- Rock saws;
- Rock breaker;
- Mobile crane;
- Jackhammers;
- Cable trucks;
- Traffic control vehicles and equipment;
- Saw cutting machine with vacuum and transport utility;
- Backhoe;
- Trucks;
- Concrete saws;
- Cable winch;
- Concrete trucks and pumps;
- Whacker rammers;
- Truck mounted augers; and
- Equipment delivery vehicles, including low loaders.

# 2 AMBIENT NOISE MONITORING

Both attended and unattended measurements were taken in order to qualify and quantify the noise sources in the area around the proposed substation and the surrounds. A noise logger alone is unable to qualify noise in the area; hence attended measurements were taken.

## 2.1 Unattended ambient noise levels

An Infobyte iM3 Noise Monitor was placed at the rear of 136 Walker Street and was used to continuously measure ambient noise levels at the location shown in Figure 1. The logger was set for sample periods of 15 minutes and continuously logged between Friday 3 July 2009 and Wednesday 9 July 2009. The noise logger was deployed at the selected location in order to approximate the general ambient noise levels in the area in the absence of the noise source to be assessed (i.e. the proposed redevelopment of the substation including the existing substation). The noise logger was calibrated before and after the measurements and no significant drift in calibration was observed.

A noise logger measures the noise levels over the sample period and then determines $L_{A1}$, $L_{A10}$, $L_{A90}$, $L_{Amax}$ and $L_{Aeq}$ levels of the noise environment. The background noise level is defined by the NSW Industrial Noise Policy (INP) as "the underlying level of noise present in ambient noise when all unusual extraneous noise is removed". It can include sounds that are normal features of a location and may include birds, traffic, insects etc. The background noise level is represented by the $L_{A90,15\ min}$ descriptor. The noise levels measured adjacent to the proposed site was analysed to determine a single assessment background level (ABL) for each day, evening and night period, in accordance with the INP.

The ABL is established by determining the lowest tenth-percentile level of the $L_{A90}$ noise data acquired over each period of interest. Table 2-1 presents the individual ABL's for each day's assessment periods. The background noise level or Rating Background Level (RBL) representing the day, evening and night-time assessment periods is based on the median of individual ABLs determined over the entire monitoring duration. Table 2-1 also presents the existing $L_{Aeq}$ ambient noise level, for each day, evening and night period, in accordance with the INP. An overall representative $L_{Aeq}$ noise level is determined by logarithmically averaging each assessment period for the entire monitoring duration. Graphical representations of the logged noise levels are included in Appendix B.

**Table 2-1 - Existing ambient noise levels adjacent to the proposed North Sydney substation**

| Date | $L_{A90}$ Background Noise Levels, dB(A) | | | $L_{Aeq}$ Ambient Noise Levels, dB(A) | | |
|---|---|---|---|---|---|---|
| | Day | Evening | Night | Day | Evening | Night |
| Friday 3 July, 2009 | - | 52 | 46 | - | 55 | 51 |
| Saturday 4 July, 2009 | 52 | 51 | 46 | 55 | 53 | 51 |
| Sunday 5 July, 2009 | 51 | 49 | 44 | 54 | 53 | 50 |
| Monday 6 July, 2009 | 56 | 50 | 45 | 59 | 54 | 51 |
| Tuesday 7 July, 2009 | 57 | 52 | 46 | 60 | 51 | 52 |
| **RBL** | **54** | **51** | **46** | **-** | **-** | **-** |
| **Log Average** | **-** | **-** | **-** | **57** | **55** | **51** |

Notes:

- Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays
- RBL - Rating Background Noise Level (RBL) is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the background level $L_{A90}$. The RBL is based on the median of the individual daily background noise levels during each assessment period over the entire monitoring period.
- The $L_{Aeq}$ level is the equivalent continuous sound level and has the same sound energy over the sample period as the actual noise environment with fluctuating sound levels. The overall representative $L_{Aeq}$ noise level is determined by logarithmically averaging each assessment period for the entire monitoring period.

## 2.2 Attended ambient noise measurements

Attended noise measurements were conducted at Locations A, B and C (as shown in Figure 1) on Tuesday 14 July 2009 and at Locations D and E on Tuesday 10 August 2010. The purpose of these measurements was to qualify and quantify the noise environment in the vicinity of the proposed redevelopment and to confirm that the location of the unattended noise measurements was not affected by noise emanating from the existing substation. Table 2-2 presents a summary of these measurements.

**Table 2-2 - Measured noise levels on Tuesday 14 July 2009 and 10 August 2010**

| Location / Time / Date | Comments | Noise Levels | |
|---|---|---|---|
| | | Descriptor | dB(A) |
| A / 2:08am / 14 Jul 2009 | 28 m from the end of Ward Street (towards Berry Street):<br>- Mechanical plant and equipment serving nearby buildings located behind Wilson carpark clearly audible (approx 45 dB(A);<br>- Traffic and trucks along Berry Street and distant clearly audible;<br>- No tonal characteristics audible; and<br>- No noise from existing substation audible.<br>Plant ramped up to 48 dB(A) and aborted measurements at approx 10min in duration. | $L_{A90}$<br>$L_{Aeq}$ | 46<br>48 |
| B / 2:20am / 14 Jul 2009 | At entrance to Wilson carpark with Wilson carpark shielding plant and equipment from building behind:<br>- Dominated by distant traffic;<br>- Mechanical plant and equipment serving nearby buildings located behind Wilson carpark could barely be heard at times being approximately 44 dB(A);<br>- No tonal characteristics audible; and<br>- No noise from existing substation audible<br>Garbage truck idling on Berry Street and measurements aborted at approximately 10 min in duration. | $L_{A90}$<br>$L_{Aeq}$ | 45<br>50 |
| C / 2:36am / 14 Jul 2009 | At the end of Harnett Street adjacent to proposed site (North):<br>- Mechanical plant and equipment serving People Telecom building clearly audible at 42 – 44 dB(A);<br>- Distant traffic clearly audible; and<br>- No noise from existing substation audible. | $L_{A90}$<br>$L_{Aeq}$ | 44<br>47 |
| D / 3:45 am / 10 Aug 2010 | In front of residential building across road from Ward Street (west side closest to Denison Street):<br>- Dominated by hum of mechanical plant and equipment serving nearby buildings on Denison Street;<br>- Distant traffic audible;<br>- Limited amount of traffic along Berry Street; and<br>- No noise from existing substation audible. | $L_{A90}$<br>$L_{Aeq}$ | 51<br>59 |
| E / 4:00 am / 10 Aug 2010 | In front of residential building across road from Ward Street (east side closest to Little Spring Street):<br>- Dominated by hum of mechanical plant and equipment serving building on Little Spring Street;<br>- Distant traffic audible;<br>- Limited amount of traffic along Berry Street; and<br>- No noise from existing substation audible. | $L_{A90}$<br>$L_{Aeq}$ | 51<br>55 |

# 3 OPERATIONAL NOISE AND VIBRATION CRITERIA

## 3.1 Protection the Environment Operations Act 1997 – Section 139

The main acoustic requirement of Protection of the Environment Operations Act 1997 (POEO Act) is to ensure that "a noise is not offensive". The definition for an offensive noise is included below.

***offensive noise*** *is:*

*(d) 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*

*(e) 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.*

To determine if a noise source is offensive, a primary consideration is to determine if the noise source is intrusive. The DECCW provides guidelines for external noise emissions from developments in its INP. The INP recommends a method which can be used to ascertain the intrusiveness of noise emissions.

DECCW states that the relationship between the statutory definition of offensive noise and intrusive noise is that intrusive noise can represent offensive noise, but whether this is always true can depend on the source of the noise, noise characteristics and cumulative noise levels. Therefore to avoid the emission of an offensive noise, noise emissions should not be intrusive as defined by the DECCW in the following manner:

*"A noise source is generally considered to be intrusive if noise from the source, when measured over a 15 minute period, exceeds the background noise by more than 5 dB(A).*

## 3.2 Environmental noise emission criteria

### *3.2.1 General considerations – use of the redevelopment*

The criteria for noise emission are set by the guidelines in the INP. Of significance to substation noise is that penalties of up to 5dB(A) may be applied where the subject noise emission is tonal or with significant low frequency content at the receiver. This is applied when the level of a one-third octave band exceeds the level of each adjacent band by:

- 5 dB(A) or more if the frequency band containing the tone is above 400 Hz
- 8 dB(A) or more if the frequency band containing the tone is below 400 Hz and above 160 Hz inclusive; and
- 15 dB(A) or more if the frequency band containing the tone is below 160 Hz.

The INP's objectives are to preserve the amenity of the environment and to protect against noise intrusion. The amenity of the environment is protected by assessing the absolute noise levels against acceptable levels for a particular land use. Noise intrusion is prevented by restricting the level by which a noise source may intrude above the prevailing background noise levels. In most cases either the intrusive criterion or the amenity criterion is more stringent and sets the allowable noise levels for a new development.

In order to satisfy the above requirements at noise-sensitive receptors such as residences, amenity and intrusive noise criteria are recommended for daytime (7 am to 6 pm), evening (6 pm to 10 pm) and night-time assessment periods (10 pm to 7 am).

### 3.2.2 *Intrusive noise criteria*

The DECCW states in its INP that:

> *"The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the $L_{Aeq}$ descriptor), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB"*

The intrusive criteria are established from the ambient $L_{A90}$ background noise level (in the absence of the noise source to be assessed) at the nearest sensitive receivers (refer to $L_{A90}$ in Table 2-1). This ambient background noise level is termed the RBL. The intrusive noise criteria is then determined by adding 5dB(A) to the RBL level.

The intrusive noise criteria for existing and proposed sensitive receivers directly adjacent (east) to the proposed substation site i.e. existing residences and approved mixed use development are detailed in Table 3-1 based on the background noise measurements recorded at the adjacent property as shown in Figure 1.

**Table 3-1 - Intrusive noise criteria, $L_{Aeq}$ - dB(A)[1]**

| Daytime (7am to 6pm) | Evening (6pm to 10pm) | Night (10pm to 7am) |
|---|---|---|
| $L_{Aeq}$, dB(A) | | |
| 59 | 56 | 51 |

[1] RBL in Table 2-1 plus 5 dB(A).

### 3.2.3 *Amenity noise criteria*

The INP states, that to limit the continuing increase in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 3-2. The amenity assessment is based upon the noise criteria specific to land use and associated activities, and is expressed in $L_{Aeq}$ over the specified time periods: day, evening and night. The amenity criteria are set out in full in Table 2.1 of the INP (refer to Table 3-3 for an excerpt). Under the INP guidelines, the existing residential receivers and proposed mixed use development adjacent to the proposed North Sydney substation would be classified as "urban".

The "urban" amenity noise goals during the day, evening and night-time periods for residential receivers and commercial premises are reproduced in Table 3-2.

**Table 3-2 - INP recommended $L_{Aeq}$ noise levels from industrial noise sources (excerpt)**

| Type of Receiver | Indicative Noise Amenity Area | Time of Day | Acceptable $L_{Aeq}$ noise level, dB(A) | Recommended Maximum, $L_{Aeq, period}$, dB(A) |
|---|---|---|---|---|
| Residence (for existing and proposed receptors) | Urban | Day | 60 | 65 |
| | | Evening | 50 | 55 |
| | | Night | 45 | 50 |
| Commercial premises | All | When in use | 65 | 70 |

Due to the close proximity of the residential premises and the less stringent commercial premises noise criteria, complying with the residential criteria would also mean compliance with the commercial criteria.

**Table 3-3 - INP modification to acceptable noise level (ANL)* to account for existing level of industrial noise (excerpt)**

| Total existing $L_{Aeq}$ noise level from industrial noise sources, dB(A) | Indicative Noise Amenity Area |
|---|---|
| ≥ Acceptable noise level plus 2 | If existing noise level is *likely* to decrease in future: acceptable noise level minus 10<br>If existing level is *unlikely* to decrease in future: existing level minus 10 |
| Acceptable noise level minus 3 | Acceptable noise level minus 3 |

* *ANL = recommended acceptable $L_{Aeq}$ noise level for the specific receiver, area and time of day from Table 2.1.* (of the INP)

Table 2-1, Table 3-2 and Table 3-3 are used to determine the project specific amenity criteria which are presented in Table 3-4 below.

Table 3-4 schedules the amenity noise limits for the proposed redevelopment site. Noise emission from the site should not exceed these levels at the façade of any residential property.

**Table 3-4 - Amenity noise criteria, $L_{Aeq, period}$ - dB(A)**

| Daytime (7am to 6pm) | Evening (6pm to 10pm) | Night (10pm to 7am) |
|---|---|---|
| $L_{Aeq}$, dB(A) | | |
| 57[1] | 45[2] | 41[3] |

[1] Daytime: existing $L_{Aeq}$ is 57 dB(A), which is acceptable level minus 3, i.e. amenity criteria (Table 3-3) is (60-3=) 57 dB(A)..

[2] Evening: existing $L_{Aeq}$ is 55 dB(A), which is acceptable level plus 5, i.e. amenity criteria (Table 3-3) is (55-10=) 45 dB(A).

[3] Night-time: existing $L_{Aeq}$ is 51 dB(A), which is acceptable level plus 6, i.e. amenity criteria (Table 3-3) is (51-10=) 41 dB(A).

### *3.2.4 Project specific noise criteria*

The Project Specific Noise Levels (PSNL) for the various assessment periods, at the nearby residences are shown with shading in Table 3-6. For relatively constant noise emissions during the various assessment periods, the PSNL becomes the lower of either the intrusiveness or amenity criterion. This approach represents a conservative assumption.

Note that if the measured noise levels (in particular transformers) at the receiver are tonal they would be subject to a 5 dB(A) penalty.

**Table 3-5 - Noise limits, $L_{Aeq, period}$ - dB(A)**

| Daytime (7am to 6pm) | Evening (6pm to 10pm) | Night (10pm to 7am) |
|---|---|---|
| $L_{Aeq, period}$, dB(A) | | |
| 57 | 45 | 41 |

**Table 3-6 – Summary of environmental noise emission criteria**

| Period | RBL, $L_{A90}$ | Intrusive Criterion (=RBL+5) $L_{Aeq, 15min}$, dB(A) | Ambient $L_{Aeq, period}$, dB(A) | Amenity Criterion $L_{Aeq, period}$[1], dB(A) |
|---|---|---|---|---|
| Daytime (7am to 6pm) | 54 | 59 | 57 | 57 |
| Evening (6pm to 10pm) | 51 | 56 | 55 | 45 |
| Night (10pm to 7am) | 46 | 51 | 51 | 41 |

[1] Where the amenity criteria is satisfied over the worst case 15 minute period during each assessment period, the criteria would be satisfied over the entire assessment period.

As the noise emissions from the proposed substation would be dominated by relatively constant noise sources such as transformers and fans, the $L_{Aeq, period}$ has been assumed to be equal to the assessed $L_{Aeq, 15 min}$ for the worst case operational scenario. This represents a conservative assumption.

Further to this, AECOM understands that it is likely that the place of occupancy most affected by noise emission would be the proposed mixed use development (with a total of 46 residential apartments) located at 136 - 140 Walker Street.

## 3.3 Sleep disturbance

The application notes for the INP recommend that sleep disturbance is assessed based on the emergence of the $L_{A1 (1 minute)}$ noise level over the corresponding $L_{A90 (15 minute)}$ noise level.

The following screening criterion for sleep disturbance is recommended for the assessment of sleep disturbance:

$$L_{A1 (1 minute)} < L_{A90 (15 minute)} + 15 \text{ dB(A)}$$

The night-time noise emissions from the substation would generally be associated with relatively constant activities. Therefore no significant peak noise events would be expected.

## 3.4 Vibration criteria

Unlike the criteria applicable to noise emissions, vibration criteria are the same for both the construction and operational phases of this project. The DECCW '*Assessing Vibration: a technical guideline*', (DECC, 2006) and *British Standard BS7385-Part 2:1993 Evaluation and Measurement for Vibration in Buildings* have been designed to be used in evaluating and assessing the effects on amenity of vibration emissions from industry, transportation and machinery. These guidelines are used in assessments of vibration impacts caused by the construction and operation of new developments.

DECCW document "*Interim Construction Noise Guideline*" (ICNG) is employed to set guideline values for ground-borne noise.

Vibration criteria are set primarily according to whether the particular activities of interest are continuous in nature or intermittent, whether they occur during the daytime or night-time and the type of receiver to be assessed e.g. commercial or residential.

The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed, i.e. human disturbance or discomfort;
- Those in which the integrity of the building or the structure itself may be prejudiced; and
- Those where the building contents may be affected.

Therefore, vibration levels at sensitive receiver locations must be controlled so as to prevent discomfort and regenerated noise, tactile vibration and in some extreme cases, structural damage.

Refer to Section 4.2 for the relevant tactile vibration and regenerated noise criteria related to the construction and operation of the proposed North Sydney substation and associated cable vault on Berry Street, and the decommissioning and demolition of the existing substation.

Operationally, vibration isolation design has been completed and compliance would be achieved with the criteria outlined in Section 4.2 of this report.

# 4 CONSTRUCTION NOISE AND VIBRATION CRITERIA

## 4.1 Construction noise criteria

### *4.1.1 Construction noise management levels*

In July 2009 the DECCW published its *Interim Construction Noise Guidelines (ICNG)* for use in construction noise assessment. This document supersedes its previous publication the *Environmental Noise Control Manual (ENCM)* and is used here as the basis for establishing construction noise criteria.

The DECCW states in Section 5.1:

> *"The relevant consent or determining authority may require that a noise management plan be prepared as part of an environmental management plan."*

Noise management levels are to be set for the standard working hours, and are to be complied with where reasonably practicable. Work that is proposed outside of standard working hours, as defined in the *ICNG*, generally requires strong justification.

The ICNG states that the noise and vibration construction management plan should detail the "best practice" construction methods to be used, presenting a reasonable and feasible approach. The plan should identify the extent of the residential area affected and assess the impact on residents. The plan should detail any community relation programs that are planned e.g. prior notification for particularly noisy activities, letter box drop regarding out of hours construction work to be undertaken and a 24 hour contact phone number for residents to call should they have any complaints or questions.

The ICNG defines what is considered to be feasible and reasonable as follows:

> *Feasible*
>
> *A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements.*
>
> *Reasonable*
>
> *Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.*

The ICNG recommends that a quantitative assessment is carried out for all *'major construction projects that are typically subject to the EIA process'*.

Predicted noise levels at nearby noise sensitive receivers (residential, commercial and industrial premises) are compared to the levels provided in Section 4 of the ICNG. Where an exceedance of the criteria is predicted, the ICNG advises that the proponent should apply all feasible and reasonable work practices to minimise the noise impact.

Section 4 of the ICNG also classifies noise criteria into the following categories:

- Airborne noise;
- Ground-borne noise;
- Sleep disturbance at residences;
- Blasting and vibration; and
- Predicting noise levels – quantitative assessment.

### 4.1.2 *Airborne noise*

Noise Management Levels (NML's) for residential receivers are set using the information in Table 4-1.

**Table 4-1 – Noise at residences using quantitative assessment**

| Time of day | Management Level $L_{Aeq, (15min)}$ [1] | How to apply |
|---|---|---|
| **Recommended standard hours:**<br>Monday to Friday 7 am to 6 pm<br>Saturday 8 am to 1 pm<br>No work on Sundays or public holidays | Noise affected<br>RBL + 10 dB | The noise affected level represents the point above which there may be some community reaction to noise.<br>• Where the predicted or measured LAeq, (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.<br>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<br>75 dB(A) | The highly noise affected level represents the point above which there may be strong community reaction to noise.<br>• 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:<br>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<br>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<br>RBL + 5 dB | • A strong justification would typically be required for works outside the recommended standard hours.<br>• The proponent should apply all feasible and reasonable work practices to meet the noise affected level.<br>• 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.<br>For guidance on negotiating agreements see section 7.2.2 (ICNG). |

[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. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

The ICNG states:

> *Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories. The external noise levels should be assessed at the most-affected occupied point of the premises:*
>
> - *industrial premises: external $L_{Aeq}$ (15 min) 75 dB(A)*
> - *offices, retail outlets: external $L_{Aeq}$ (15 min) 70 dB(A)*
> - *other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.*
>
> *Examples of other noise-sensitive businesses are theatres and child care centres. The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels (Standards Australia 2000).*

The Noise Management Levels applicable to the proposed excavation, construction and demolition works have been calculated based on the RBL's detailed in Section 2 and Table 4-1, and are scheduled in Table 4-2 below.

**Table 4-2 – Construction noise management levels applicable to the proposed North Sydney substation redevelopment**

| Date | Noise Management Levels, $L_{Aeq}$, dB(A) | |
|---|---|---|
| | Day (standard hours) | Night (out of hours) |
| RBL (from Table 2-1) | 54 | 46 |
| **Residential, $L_{Aeq, (15min)}$ (adjacent to the proposed substation)** | **64**[1] | **51**[2] |
| **Office, $L_{Aeq}$** | **70** | **N/A** |
| **Café / Restaurant** | **55 (Internal),** refer to AS/NZS:2107:2000[3] | **N/A** |

[1] RBL + 10 dB(A) (Table 4-1) – standard hours.
[2] RBL + 5 dB(A) (Table 4-1) – outside standard hours.
[3] Noise measurements inside the adjacent restaurant were measured to be 55 dB(A) when unoccupied (on 11 March 2010). This noise level was dominated by background music, It must be noted that typical noise levels in similar restaurants, when occupied by patrons, have previously been measured to be between 65 and 70 dB(A).

### *4.1.3 Sleep disturbance at residences*

The ICNG recommends that a quantitative assessment be carried out where construction works are planned over more than two consecutive nights. Factors that may be important in assessing the extent of impact on sleep include how often high noise events occur at night, the predicted maximum noise levels at night, whether there are times when there is a clear change in the noise environment and the degree of maximum noise levels above the background noise level at night.

There are no specific sleep disturbance criteria outlined in the ICNG but it refers to the *NSW Environmental Criteria for Road Traffic Noise (EPA 1999) (ECRTN)* for guidance. The following summary of the identified ECRTN sleep arousal issues gives recommendations for noise criteria to control maximum internal noise levels. The intent of a sleep arousal criterion is to ensure that the amenity of sleeping areas is protected and sleep arousal, beyond reasonable limits is avoided.

The following characteristics of a noise signal are identified as being strongly related to sleep disturbance:

- The peak level of the noise events, described by either $L_{A1, (1minute)}$ or $L_{Amax}$;
- The emergence of noise events above the general ambient noise level, described by measures such as ($L_{Amax} – L_{Aeq}$) or ($L_{Amax} – L_{A90}$);

- The number of such noise events occurring during the sleeping period;

A comparison of the existing research on sleep arousal results in the following conclusions:

- Appropriate screening criteria are determined to be an $L_{A1, (1\ minute)}$ level 15dB(A) above the RBL for the night-time period;
- Maximum internal noise levels below 55 dB(A) are unlikely to cause awakening reactions (this is equivalent to an external noise level of 65 dB(A) allowing for a 10 dB(A) noise reduction for windows open for natural ventilation);
- One or two noise events per night, with maximum internal noise levels of 70 dB(A), are not likely to significantly affect health and well being.

Based on the above discussion, it is recommended that maximum internal noise levels in a sleeping area are assessed against the following sleep arousal criteria:

- One or two noise events per night are permitted to exceed 55 dB(A) internally by up to 15 dB(A);
- The remaining construction noise events in the night period (10 pm to 7 am) should not exceed 55 dB(A) $L_{Amax}$ internally.

### *4.1.4 Predicting noise levels – quantitative assessment*

In order to accurately undertake this assessment, the following parameters were clearly identified:

- All noise sources of the proposed construction works;
- Location and height of noise sources;
- Type of noise;
- Proposed movement alarms on all moving equipment;
- Proposed alternative work methods or proposed mitigation methods;
- Equipment or plant noise levels;
- All stages of the construction works;
- Proposed hours of construction;
- Other concurrent construction activities occurring in the vicinity;
- Duration of noise sources; and
- Noise sources during decommissioning and demolition of the existing substation.

## 4.2 Construction vibration criteria

### *4.2.1 Ground-borne noise*

Vibration generated by compacting enters buildings via the ground. This causes the floors, walls and ceilings to vibrate and to radiate noise. This noise is commonly referred to as structure or ground-borne noise or regenerated noise. Ground-borne noise is low frequency and if audible is perceived as a ‘rumble’.

In general, ground-borne noise level values are relevant only where they are higher than the airborne noise from the construction activities. Regenerated noise levels would be masked by air-borne noise associated with the construction activities.

The ground-borne noise goals as outlined in the DECCW document “Interim Construction Noise Guideline” (ICNG) are listed in Table 4-3. The ground-borne noise levels are applicable during the evening and night-time periods only, as the objectives are to protect the amenity and sleep of people when they are at home. The ground-borne noise goals are only applicable when ground-borne noise levels are higher than airborne noise levels.

**Table 4-3 – Ground-borne noise goals**

| Time | Ground-borne noise goals |
|---|---|
| **Evening (6 pm to 10 pm)** | 40 dB(A) $L_{Amax, slow}$ |
| **Night-time (10 pm to 7 am)** | 35 dB(A) $L_{Amax, slow}$ |

Ground-borne noise levels may also be subject to community consultation and mitigation would depend on the extent of impacts and also the scale and duration of works.

### 4.2.2 Vibration – Human comfort

In general the human response to vibration is found to be a complex phenomenon. There are wide variations in vibration tolerance of humans and accordingly acceptance goals for human comfort are hard to define and quantify. Acceptable values of human exposure to vibration are primarily dependent on the activity taking place in the occupied space (e.g. workshop, office, or residence) and the character of vibration (e.g. continuous or intermittent). In addition, specific values are dependent upon social and cultural factors, psychological attitudes, expected interference with privacy, and ultimately the individual's perceptibility.

Any construction vibration assessment for work which does not include blasting is to include human comfort for construction in accordance with the guideline *Assessing Vibration: A Technical Guideline (DECC 2006)* which refers to *BS 6472:1992 'Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80Hz)'*. BS 6472:1992 has been recently superseded by BS 6472:2008, however, DECCW has advised that the 1993 standard should be used rather than the newer 2008 standard.

#### *Assessing Vibration: A Technical Guideline (DECCW 2006)*

The abovementioned guideline for vibration assists in protecting people from significant levels of vibration above preferred and maximum values felt inside buildings. The guideline, however, does not address vibration induced damage to structures or building contents, or structure-borne noise effects.

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

- Continuous vibration: machinery, steady road traffic, continuous construction activity such as tunnel boring;
- Impulsive vibration: 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 ; and
- Intermittent vibration: Trains, nearby intermittent construction activity, impact pile driving, jack hammers.

When applying the criteria, it is important to note that vibration may enter the body along different orthogonal axes, i.e. x-axis (back to chest), y-axis (right side to left side), or z-axis (foot to head). The three axes are referenced to the relevant position of the human body. Thus, vibration measured in the horizontal plane should be compared with x- and y-axes criteria if the concern is for people in an upright positions, or with the y- and z- axes criteria if the concern is for people in a lateral position (e.g. asleep at night). Where the orientation of the occupant is unknown or could vary, then the most conservative approach should be adopted.

#### *Human comfort continuous vibration criteria*

Structural vibration in buildings can be detected by the occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon the use of the building and the time of day.

Preferred and maximum allowable magnitudes for continuous exposure to building vibration with respect to human response are shown in Table 4-4 below.

**Table 4-4 - Human comfort vibration limits for continuous vibration**

| Type of space occupancy | Time of day | Preferred and maximum weighted rms values for continuous vibration acceleration | | | |
|---|---|---|---|---|---|
| | | Preferred vibration RMS velocity, mm/s | | Maximum vibration RMS velocity, mm/s | |
| | | z-axis | x- and y-axis | z-axis | x- and y-axis |
| Residential | Day | 0.01 | 0.0071 | 0.020 | 0.014 |
| | Night | 0.007 | 0.005 | 0.014 | 0.010 |
| Offices, schools | Day/Night | 0.020 | 0.014 | 0.040 | 0.028 |

From DECCW "Assessing vibration: A technical guideline"

*Human comfort intermittent vibration criteria*

Disturbance caused by vibration would depend on its duration as well as its magnitude. This method involves the calculation of a Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of bursts of intermittent vibration.

The VDV is the fourth root of the integral of the fourth power of vibration with respect to time. The VDV represents an 'amount' of vibration dose which accumulates over an assessment period. The VDV criteria recommended in BS6472:1992 are shown in Table 4-5.

**Table 4-5 - Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$)**

| Time period | Low probability of adverse comment, m/s$^{1.75}$) |
|---|---|
| Residential Buildings Day (16 hr) | 0.2 - 0.4 |
| Residential Building Night (8hr) | 0.13 - 0.26 |
| Offices / Café | 0.4 - 0.8 |

Daytime is 7.00 am to 10.00 pm; Night-time is 10.00 pm to 7.00 am.

In the absence of a criterion for Café, the office criteria is to be adopted.

### *4.2.3 Vibration – Structural damage*

Ground vibration criteria are defined in terms of levels of vibration emission from the works that would avoid the risk of damage to buildings and other structures.

Most commonly specified 'safe' structural vibration levels are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels that have the potential to cause damage to the main structure. Examples of threshold or cosmetic cracking include minor non-structural effects such as superficial cracking in cement render or plaster. Structural damage criteria are presented in *British Standard BS7385-Part 2:1993 'Evaluation and Measurement for Vibration in Buildings'*.

This standard provides recommended maximum levels of vibration that reduce the likelihood of cosmetic damage caused by vibration. Table 4-6 indicates the vibration limits presented in BS7385 to ensure cosmetic damage does not occur.

**Table 4-6 - Structural damage vibration limits (PPV)**

| Type of building | Peak component particle velocity in frequency range of predominant pulse | |
|---|---|---|
| | 4 Hz to 15 Hz | 15 Hz and above |
| 1. Reinforced or framed structures Industrial and heavy commercial buildings | 50 mm/s at 4 Hz and above | |
| 2. Dwellings and buildings of similar design and/or use | 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz | 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above |

The above guide values may need to be reduced by up to 50% if the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply. On this basis, the maximum allowable peak particle velocities are set to 7.5 mm/s for the proposed works.

## 4.3 Construction road traffic noise criteria

DECCW's Environmental Criteria for Road Traffic Noise (ECRTN) has been used to assess the noise arising from traffic generated by the proposed development. The ECRTN guidelines are applicable for traffic movements generated during the construction phase of the project.

### *4.3.1 Road traffic access to site*

The main road providing access to the proposed development is Ward Street via Berry Street during the construction of the cable vault and demolition of the existing substation and Harnett Street via McLaren Street during the construction of the substation.

The following classifications of roads are relevant:

- McLaren Street would be classified as an existing collector road;
- Berry Street would be classified as an existing arterial road; and
- Ward and Harnett Streets would be classified as local roads.

Table 4-7 presents the road traffic noise criteria from the DECCW for land use developments with a potential to create additional traffic on existing freeways/ arterial roads. The external noise criteria are applied 1 m from the external facade of the affected building.

**Table 4-7 – Road traffic noise criteria**

| Period | | |
|---|---|---|
| **Existing arterial roads** | | |
| Day (7:00 am – 10:00 pm) | $L_{Aeq\ (15hr)}$ | 60 dB(A) |
| Night (10:00 pm – 7:00 am) | $L_{Aeq\ (9hr)}$ | 55 dB(A) |
| **Existing collector roads** | | |
| Day (7:00 am – 10:00 pm) | $L_{Aeq\ (15hr)}$ | 60 dB(A) |
| Night (10:00 pm – 7:00 am) | $L_{Aeq\ (9hr)}$ | 55 dB(A) |
| **Local roads** | | |
| Day (7:00 am – 10:00 pm) | $L_{Aeq\ (15hr)}$ | 55 dB(A) |
| Night (10:00 pm – 7:00 am) | $L_{Aeq\ (9hr)}$ | 50 dB(A) |

It must be noted that the noise impact on Ward Street is non-existent as there are no sensitive residential receivers located there.

Note that where the criteria have already been exceeded the DECCW recommends that:

> *"Where feasible and reasonable, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access roads; regulating times of use; using clustering; using quiet vehicles; and using barriers and acoustic treatments.*
>
> *In all cases traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB."*

# 5 OPERATIONAL NOISE ASSESSMENT AND RECOMMENDATIONS

## 5.1 Noise sources

Once the proposed substation is operational, noise significant equipment would comprise mechanical plant and transformers. The sound power levels for this plant are presented in Table 5-1 and Table 5-2.

**Table 5-1 – Mechanical plant sound power levels**

| Plant Description | Octave band noise levels, dB | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | dB(A) | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| Exhaust fan: EAF-R-1 | 73 | 66 | 67 | 70 | 71 | 67 | 64 | 62 |
| Exhaust fan: EAF-R-2 | 93 | 89 | 85 | 90 | 88 | 90 | 85 | 81 |
| Exhaust fan: EAF-R-3 | 86 | 86 | 79 | 82 | 79 | 82 | 80 | 78 |
| Exhaust fan: EAF-R-4 | 86 | 83 | 79 | 85 | 83 | 82 | 79 | 70 |
| Exhaust fan: EAF-R-5 | 83 | 80 | 78 | 77 | 75 | 78 | 78 | 73 |
| Exhaust fan: EAF-R-6 | 77 | 68 | 71 | 75 | 71 | 71 | 69 | 64 |
| Exhaust fan: EAF-R-7 | 83 | 80 | 78 | 77 | 75 | 78 | 78 | 73 |
| Outside air fan: OAF-B-1 | 75 | 68 | 71 | 75 | 71 | 71 | 69 | 64 |
| Supply air fan: SAF-2A-1 | 93 | 89 | 85 | 90 | 88 | 90 | 85 | 81 |

**Table 5-2 – Transformer sound power levels**

| Description | ⅓ Octave band noise levels, dB | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | dB(A) | 50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1.25k | 1.6k | 2k | 2.5k | 3.15k | 4k | 5k |
| Transformer sound power levels | **91** | 69 | 80 | 79 | 94 | 95 | 80 | 101 | 82 | 83 | 81 | 75 | 76 | 71 | 69 | 63 | 61 | 57 | 52 | 44 | 35 | 26 |
| Tonal characters | | | +11 | | +15 | | | -15 | +21 | -19 | | | | | | | | | | | | |

It is noted, noise from transformers, in particular the tone generated at 200Hz, may be a cause of nuisance when noise levels are close to the tonality limits in the general considerations presented in Section 3.2.1, therefore a 5 dB(A) tonality penalty has been applied.

## 5.2 Operational recommendations

### *5.2.1 Mechanical services recommendations*

The following schedules in Table 5-3 and

Table 5-4 present the recommended treatment for each piece of mechanical plant and equipment at the North Sydney substation redevelopment with the sound power levels presented in Section 5.1. Table 5-3 presents a schedule of silencers corresponding to each of the fans scheduled in Table 5-1. These silencers in conjunction with the duct treatment in

Table 5-4 are required to meet the established internal and external noise criteria presented Section 3.

**Table 5-3 – Fan silencer schedule**

| Fan designation | Silencer description | Insertion loss, dB | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k |
| SAF-2A-1 | NAP CS-1D (inlet) | 4 | 6 | 12 | 21 | 20 | 15 | 14 |
| EAF-R-2 | NAP CS-2D (inlet) | 8 | 12 | 20 | 31 | 33 | 30 | 23 |
| | NAP CS-2D (inlet) | 8 | 12 | 20 | 31 | 33 | 30 | 23 |
| EAF-R-3 | NAP CS-2D (outlet) | 8 | 12 | 20 | 31 | 33 | 30 | 23 |
| EAF-R-4 | NAP CS-1D (outlet) | 4 | 6 | 12 | 21 | 20 | 15 | 14 |
| EAF-R-7 | NAP CSP-2D (inlet) | 4 | 8 | 13 | 18 | 23 | 18 | 13 |

**Table 5-4 – Fan duct treatment**

| Fan designation | Direction of airflow | Description of treatment |
|---|---|---|
| OAF-B-1 | Inlet and outlet | Unlined ductwork as per mechanical drawing 207401 dated 10 February 2010 |
| SAF-2A-1 | Inlet (noise to outside) | Silencer as per schedule Table 5-3 and 1 m of 50 mm thick internally insulated ductwork |
| | Outlet (noise to substation) | 6 m + 2 lined mitre bends internally lined with 50 mm thick insulation |
| EAF-R-1 | Inlet (noise to toilets) | 2 m internally lined with 50 mm thick insulation |
| | Outlet (noise to substation) | - |
| EAF-R-2 | Outlet (noise to outside) | Silencer as per schedule Table 5-3 and 1 m of 50 mm thick internally insulated ductwork |
| | Inlet (noise to substation) | Silencer as per schedule Table 5-3, 4 m + 2 mitre bends of 50 mm thick internally insulated ductwork |
| EAF-R-3 | Outlet (noise to outside) | Silencer as per schedule Table 5-3 and 1 m of 50 mm thick internally insulated ductwork |
| | Inlet (noise to substation) | 17 m + 2 lined mitre bends internally lined with 25 mm thick insulation |
| EAF-R-4 | Outlet (noise to outside) | Silencer as per schedule Table 5-3 and 1 m + 1 mitre bend of 50 mm thick internally insulated ductwork |
| | Inlet (noise to substation) | 17 m + 2 mitre lined bends internally lined with 25 mm thick insulation |
| EAF-R-5 | Outlet (noise to outside) | 2 m + 1 lined mitre bend internally lined with 25 mm thick insulation |
| | Inlet (noise to substation) | 6 m + 3 lined mitre bends internally lined with 50 mm thick insulation |
| EAF-R-6 | Outlet (noise to outside) | 1 m + 1 lined mitre bend internally lined with 50 mm thick insulation |
| | Inlet (noise to substation) | 3 m + 1 lined mitre bend internally lined with 50 mm thick insulation |
| EAF-R-7 | Outlet (noise to outside) | 2 m + 1 lined mitre bend internally lined with 50 mm thick insulation |
| | Inlet (noise to substation) | Silencer as per schedule Table 5-3 |

5.2.2 The recommendations presented in Table 5-3 and Table 5-4 have been incorporated into the design of the substation.

### 5.2.3 Transformer enclosure

***Internal walls***

Walls in all three transformer bays are to be constructed with Boral Acousticell (or equivalent) as shown in the attached markup in Appendix C. Boral Acousticell (or equivalent) are to have an absorption coefficient as scheduled in Table 5-5 below.

**Table 5-5 - Acoustic Block absorption coefficients – α**

| Description | Octave band absorption coefficients, α | | | | | | |
|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k |
| Boral Acousticell (or equivalent) | 0.2 | 0.7 | 0.95 | 0.45 | 0.27 | 0.25 | 0.22 |

***Ventilation stacks***

Ventilation stacks of all 3 transformer bays would be lined with 50 mm thick glasswool acoustic insulation (minimum density 32 kg/m$^3$) covering 100% of the internal shaft wall surface areas (as shown in Appendix C). The insulation should typically be installed with a facing of perforated compressed fibrous cement facing with a minimum of 30% open area with perforations being no greater than 10 mm in diameter.

### 5.2.4 Other noise sources

Other potentially noisy equipment has been reviewed and would comply with the criteria outlined in Section 3. Noise from the lift for instance would be contained within the lift shaft which would be constructed with concrete.

## 5.3 Operational traffic noise

Once complete the North Sydney substation would have a negligible amount of traffic travelling to and from the site, hence the absolute noise impact would be close to zero decibel increase.

## 5.4 Environmental noise emission assessment

Operational noise emissions from the proposed substation have been assessed and recommendations presented in Section 5.2 of this report.

Estimated noise emission from the proposed substation at the nearest affected properties (which would be those existing and proposed including the proposed development at 136-140 Walker Street to the immediate east) would be 36 dB(A) at the boundary. As there would be a tonality penalty of 5 dB (due to the tonal nature of the proposed transformers) imposed on the redevelopment, the equivalent noise level would be 41 dB(A) at peak load times.

The predicted noise levels would comply with the governing night-time criterion (41 dB(A)) defined in Section 3 (Table 3-6) during peak loads and expected to be lower at night when the transformers are not running at 100% capacity.

As compliance would be achieved at the closest sensitive receiver, it should be noted that compliance would also be achieved at other existing and proposed residential properties in the immediate vicinity, including existing premises along Walker Street and an approved 8 storey mixed use development proposed for 144-150 Walker Street.

### *5.4.1 Adjacent developments (including proposed 136-140 Walker Street)*

Upon completion of the proposed substation and the proposed building at 136-140 Walker Street a void would be created, extending to the roof of the proposed substation and approximately level 9 of the residential building at 136-140 Walker Street.

Noise generated by residents whilst occupying balconies of 136-140 Walker Street may reflect off the proposed substation facade. Speech privacy calculations have been completed assuming that residents speak with “normal conversational” voices, the background noise level at 136-140 Walker Street is 46 dB(A) or higher and receivers on balconies are separated by at least 3 m vertically or 6 m horizontally. The calculations indicate that “acceptable” speech privacy would result, conversations from one balcony would be occasionally heard and understood at an adjacent balcony, however the conversations would generally be non-intrusive. It should be noted that the presence of the proposed substation facade does not have a significant impact on the privacy level achieved, rather the controlling factor is the distance between receivers.

From the calculations, it is reasonable to assume that the acoustic amenity of the proposed residential apartment building would not be adversely affected by the construction of the proposed substation. It should also be noted that during the daytime and evening periods, the background noise level is likely to be higher than 46 dB(A) therefore, the resulting speech privacy would be higher than detailed above.

Noise emission from the substation site has been addressed by means of engineering noise control to meet established site specific noise criteria outlined in this report.

# 6 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT AND RECOMMENDATIONS

## 6.1 Construction equipment noise levels

Noise levels of various pieces of demolition, excavation and construction equipment were obtained from previous measurements and the following documents:

- *AS 2436-1981 'Guide to Noise Control on Construction, Maintenance and Demolition Sites'*;
- *BS 5228: Part 1:1984 'Noise control on construction and open sites – Part 1 Code of practice of basic information and procedures for noise control'*; and
- *'Update of noise database for prediction of noise on construction and open sites'* by Department for Environment Food and Rural Affairs, 2005; and
- *'Update of noise database for prediction of noise on construction and open sites'* by Department for Environment Food and Rural Affairs, 2006.

The noise levels used in calculations are shown in Table 6-1.

**Table 6-1 - Indicative sound power levels for construction equipment likely to be used for the North Sydney substation redevelopment**

| Equipment | Typical 'On time' in a 15 minute period (%) | Maximum noise level $L_{A,eq}$ at 7m under load, dB(A) | Estimated sound power level ($L_{A,W}$), dB(A) |
|---|---|---|---|
| 30T Excavator Bucket | 100% | 85 | 110 |
| Jackhammer | 100% | 90 | 115 |
| Bulldozer | 100% | 85 | 110 |
| Rock Breaker / Hydraulic | 100% | 95 | 120 |
| Mobile crane | 10% | 85 | 110 |
| Stone Saw | 100% | 91 | 116 |
| Rotary and Percussive rock drill (127mm diameter) | 100% | 80 | 105 |
| Excavator Mounted Hydraulic Rock Hammer | 100% | 94 | 119 |
| Truck & Trailer | 10% | 84 | 109 |
| 25T Concrete Mixer | 100% | 84 | 109 |
| Concrete pump | 100% | 82 | 107 |

As discussed previously, the cable vault would be constructed during the night (Sunday to Friday) and during the day on weekends.

## 6.2 Construction noise assessment and recommendations

### *6.2.1 Construction equipment noise assessment*

Preliminary calculations have been undertaken for the proposed equipment to be used during the construction of the proposed substation and demolition of the existing substation. This has enabled a determination to be made regarding the indicative extent of mitigation required. Table 6-2 and Table 6-3 schedule estimated construction noise levels for different types of equipment to be used at the nearest affected sensitive receivers.

The noise levels provided below are for each individual piece of equipment being used in isolation of other equipment. Typical construction scenarios where plant and equipment are used in parallel (i.e. resulting in cumulative noise) has been considered and an increase is likely to be negligible (i.e. 1 dB(A) or less).

**Table 6-2 - Estimated construction and demolition noise levels at residences (proposed North Sydney substation site) – daytime only**

| Plant and equipment in operation | $L_{Aeq}$ Noise Level – dB(A) | | |
|---|---|---|---|
| | No noise controls, dB(A) | Exceedance of the Noise Management Levels (NML's), dB(A)* Day (7am to 6pm) | NML's, dB(A) |
| **Sensitive receivers adjacent to proposed substation (i.e. 136-140 Walker Street)** | | | |
| **Construction and demolition** | | | Day (standard hours): 64 (Table 4-2) |
| Crane | 69 | 2 | |
| Truck and trailer | 68 | 1 | |
| 25T concrete mixer | 78 | 11 | |
| Concrete pump | 76 | 9 | |
| Jackhammer | 84 | 17 | |

* These exceedances have taken into account some shielding and distance attenuation.

Noise during construction as shown in Table 6-2 (which would be during the day) would likely exceed the criteria by 1 to 17dB(A) during the day. These exceedances would be managed with a Construction Noise and Vibration Management Plan (CNVMP) to be prepared by the construction contractor. Typical mitigation measures are outlined in section 6.2.3.

Table 6-3 presents estimated construction noise levels for construction of the cable vault on Berry Street. A CNVMP would be prepared before the construction of the cable vault commences.

**Table 6-3 - Estimated construction noise levels at residences (cable vault on Berry Street) – night-time only**

| Plant and equipment in operation | $L_{Aeq}$ Noise level, dB(A) | | |
|---|---|---|---|
| | No noise controls, dB(A) | Night time exceedance of the Noise Management Levels (NML's), dB(A)* | NML's, dB(A) |
| **Residences along Berry Street** | | | |
| Jackhammer | 75 | 24 | Night (out of hours): 51 (Table 4-2) |
| Bulldozer | 70 | 19 | |
| Rock breaker / Hydraulic | 80 | 29 | |
| Crane | 70 | 19 | |
| Stone saw | 76 | 25 | |
| Rotary and percussive rock drill (127mm) | 65 | 14 | |
| Excavator mounted hydraulic rock hammer | 79 | 28 | |
| Truck and trailer | 69 | 18 | |
| 25T Concrete mixer | 69 | 18 | |
| Concrete pump | 67 | 16 | |

* These exceedances have not taken into account any shielding as there would be direct line of sight to the residences across Berry Street.

**Table 6-4 - Estimated construction noise levels at café and offices - daytime only**

| Plant and equipment in operation | $L_{Aeq}$ oise level, dB(A) | | | | |
|---|---|---|---|---|---|
| | No noise controls, dB(A) | Exceedance of the Noise Management Levels (NML's), dB(A)[1] | | NML's, dB(A) | |
| | | Restaurant | Office | Restaurant | Office |
| **Café and Offices adjacent to North Sydney Substation** | | | | **When in use** | |
| Jackhammer | 84 | 19 | 14 | External: 65[3] dB(A) | External: 70 dB(A) |
| Crane | 69 | 4 | - | | |
| Truck and trailer[2] | 68 | 3 | - | | |
| 25T Concrete Mixer[2] | 78 | 13 | 8 | | |
| Concrete pump[2] | 76 | 11 | 6 | | |

[1] These exceedances have taken into account some shielding and distance attenuation.
[2] See Section 6.2.2 for increases due to increases in volumes.
[3] The DECCW's ICNG recommends that a conservative difference between external and internal noise levels is 10 dB with windows open (for adequate natural ventilation) – for the purposes of a quantitative assessment

It is expected that there would be noise exceedances during construction that would be in the range of 14 to 29 dB(A) at the residences (across from where the cable vault would be constructed) and 3 to 19 dB(A) at the adjacent offices and restaurant.

### *6.2.2 Construction traffic noise*

***Cable vault construction (corner of Berry and Ward Streets) – night-time only***

As presented in the *"Traffic management plan – stage 2 North Sydney zone substation cable vault at the intersection of Ward and Berry Streets revision 1 dated 15 July 2010"* it is expected that up to 10 trucks would visit the site during each night shift. This would equate to a maximum of 1 truck per hour which would equate to an $L_{Aeq, 9hour}$ of approximately 50 dB(A), therefore complying with the ECRTN criteria presented in Section 4.3 at night on a local road.

***Zone substation construction (including demolition of existing substation) – daytime only***

As presented in the *"Traffic management plan North Sydney zone substation revision 4 dated 27 July 2010"* it is expected that around 10 trucks would be visiting the site during the day which equates to less than one truck per hour. During concrete pours, 25 trucks per day would be visiting the site to make deliveries which is an increase to less than 2 trucks per hour. This would equate to a maximum of 2 trucks per hour which would equate to an $L_{Aeq, 15hour}$ of approximately 53 dB(A), therefore complying with the ECRTN criteria presented in Section 4.3 during the daytime on a local road.

### *6.2.3 Noise and vibration management and mitigation strategies*

The Interim Construction Noise Guideline (ICNG) accepts the fact that large scale construction often results in excessive noise, albeit on a temporary basis, and where physical mitigation options are limited, stresses the importance of community engagement in a frank and upfront manner.

The ICNG recommends that the contractor demonstrate best practicable means of controlling noise and include noise mitigation measures in the construction management plan to minimise the noise impact at sensitive receivers. This may include the work practices described below.

A CNVMP would be prepared as part of the CEMP for the construction of the proposed substation, cable vault and cable trenches. A Demolition Management Plan (DMP) would be prepared and would include measures to manage noise impacts during the demolition of the existing substation. The CNVMP and DMP would include reasonable and feasible methods for reducing the impact of noise on the surrounding sensitive receivers. They would also include appropriate complaints registration and handling procedures. Mitigation measures that would form part of these plans are discussed below.

Where an exceedance of criteria is predicted, the ICNG advises that the proponent should apply all reasonable and feasible work practices to minimise the noise impact.

The following measures would be implemented to minimise noise impacts during construction:

- Portable barriers and hoardings would be considered where reasonable and feasible. The use of semi-permanent barriers during the construction of the cable vault would not be feasible as the road needs to be reopened to daytime traffic after each shift, requiring all equipment to be completely removed from the work location each morning;
- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers;
- Avoiding the coincidence of noisy plant and equipment working simultaneously close together and adjacent to sensitive receivers would be avoided, where practicable;
- Where possible, equipment with directional noise emissions would be orientated away from sensitive receivers;
- Locate noisy plant away from potentially noise affected neighbours or behind barriers, such as sheds or walls;
- Loading and unloading would be carried out away from sensitive receivers, where practicable;
- The selection of site access points would take into account the proximity of noise sensitive receivers;
- Maintenance work on construction plants with the potential to generate noise impacts would be carried out away from noise sensitive receivers and confined to standard daytime construction hours, where possible;
- Minimising consecutive works in the same locality, where practicable;
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment;
- Turn off plant that is not being used;
- Examine, and implement where feasible and reasonable, alternative work practices which generate less noise – for example, use electric equipment instead of diesel or petrol powered equipment;
- Examine, and implement where feasible and reasonable, the use of silenced equipment and noise shielding around stationary plant (such as generators), subject to manufacturers' design requirements;
- Ensure plant is regularly maintained, and repair or replace equipment that becomes noisy;
- Arrange the work site to minimise the use of movement alarms on vehicles and mobile plant;
- Where practicable, reversing beepers on trucks would be replaced with low pitch tonal beepers (quackers) after 10 pm;
- Alternative construction methodologies would be considered where noise levels exceed the noise management levels. If no reasonable and feasible options can be found, community consultation measures would be undertaken. It should be noted that alternative construction methods to rock breaking, such as the use of rock splitting (or penetrating cone fracture) have been already considered. However, these methods are likely to impact on (reduce) the integrity of the highly sensitive existing high voltage cables and optic fibre which must remain in operation during the construction of the cable vault. As a result, these methods have been deemed unfeasible.
- Mobile plant such as excavators and other diesel operated machinery would be fitted with silencing equipment, where practicable, if works are planned out of standard operating hours;
- Low noise machinery would be selected where practicable (e.g. electric instead of internal combustion, vibratory piling instead of impact);
- Plant and equipment would be operated and maintained in an efficient and proper manner;

- Dropping materials from a height, either into or out of trucks, trays or bins would be avoided;
- Vehicle speeds would be restricted on, or near, the work site;
- Intermittently used machinery would be shut down or throttled down when not in operation;
- Rowdy behaviour would be avoided on work sites, such as shouting, radios and inappropriate vehicle use;
- Plant or machinery would not be 'warmed up' before the nominated working hours;
- All construction vehicles would enter and leave the site in accordance with site entry controls;
- Noise monitoring at selected receivers would be considered to investigate complaints regarding noise impacts. Contractors and workforce would be informed of noise sensitive neighbours;
- Noisy activities would be conducted in as short a time period as possible with minimum delays;
- Construction works for the proposed substation would generally be undertaken during the following standard operating hours: Monday to Friday from 7am to 6pm and Saturday from 8am to 4pm. No work would occur on Sundays or Public Holidays. Works may be undertaken outside of standard operating hours if the both of the following criteria are satisfied:
  - The works cannot be undertaken during standard operating hours e.g. RTA requirements for road works within Berry and Ward Streets; and
  - Any potentially affected residents are given prior notice of work times and reasons.

  For works that are planned out of standard operating hours, the noisiest works, such as rockbreaking, would be scheduled so they are completed before 10 pm, where practicable;
- Construction works for the proposed cable vault and cable excavations would generally be undertaken during the following hours:
  - Sunday – Wednesday 8:00pm to 5:00am
  - Thursday 8:30pm to 5:00am
  - Friday 8:30pm to 7:00am
  - Saturday 8:00am to 5:00pm
  - Sunday 8:00am to 5:00pm

  Night work would only be carried out a maximum of 5 nights per week, with works carried out during the daytime on Saturday and Sunday. Two nights of respite (Friday, Saturday or Sunday nights) would be implemented each week.
- Work for the cable vault and substation building would generally not be carried out simultaneously (as the vault would be constructed at night and on weekends, whereas the building work would generally be carried out during daytime hours). The cable vault construction period would run parallel with the construction period for the substation building. However, as excavation for the substation building has been completed, the noise generated by the construction of the substation building with construction plant such as cranes, trucks and power tools, will have different, less annoying characteristics than percussive noise from rock hammering. In addition as the construction of the substation building progresses further acoustic shielding would be provided to receivers on Berry Street.

  It should be noted that whilst it is unlikely that noisy activities would be able to be restricted to certain times of the day, continuous work would enable the works to be completed quicker, minimising the length of time residents are subjected to construction noise.

*Respite periods*

- The proposal involves activities which could generate noise levels above $L_{Aeq}$ 75 dB(A) or activities likely to generate noise with intermittent, impulsive, tonal or low-frequency characteristics which have the potential to affect the amenity of adjacent noise receivers. In the case that high impact noise activities or activities likely to generate noise with intermittent, impulsive, tonal or low-frequency characteristics are required, respite periods would be implemented.

*Community notification*

- Potentially noise affected neighbours would be contacted at the earliest possible time before any site work begins. Affected properties would be suitably notified in relation to hours of works and anticipated duration of noisy activities. This notification would include approaching in person and letterbox drops.
- For residential properties where noise levels from the construction works are likely to exceed the noise management levels, it is recommended that letterbox drops as a minimum be considered. Letter box drops should occur a minimum of 7 days ahead of proposed construction works.
- An information display may also be erected in the foyer of 77-81 Berry Street and other information posted in prominent locations in the building;
- Register all community and stakeholder enquiries and complaints in a community and stakeholder database and address as required. The community relations hotline number would be provided to the community and stakeholders who would potentially be directly impacted by construction at least 48 hours prior to commencement of construction activities. A complaints procedure would be detailed in order to address any complaints;
- Inform potentially noise affected neighbours about the nature of the construction stages and the duration of noisier activities – for example, excavation and rock-breaking;
- Describe any noise controls, such as walls to be built first that would reduce noise, temporary noise walls, or use of silenced equipment;
- Provide contact details on a site board at the front of the site, and maintain a complaints register suited to the scale of works; and
- Provide a copy of the noise management plan, if available, to potentially noise affected neighbours.

*Noise and vibration complaints*

- Any noise or vibration complaints would be addressed in a timely manner, in accordance with the Incidents and Complaints Management Procedure.

## 6.3 Construction vibration assessment and recommendations

### *6.3.1 Construction vibration assessment*

The levels of vibration generated on-site by the works should be within the limits acceptable to the relevant guidelines outlined in this report at all times, wherever possible. As far as is reasonably practicable, measures should be taken to minimise the generation of vibrations within the site. The Contractor should use the best available technology and the best practicable means to prevent or mitigate the effects of vibration from the works.

Vibration propagation is very site specific however some indicative minimum buffer distances between vibration equipment and receivers used to avoid human discomfort during the day-time are listed below in Table 6-5. It is recommended that attended vibration measurements are conducted when the works commence to confirm safe distances for the equipment to be used.

**Table 6-5 - Buffer distance requirement**

| Criterion | | | Equipment and estimated safe distances | | | | |
|---|---|---|---|---|---|---|---|
| | | | Rotary cutter | Light rockbr. (300 kg) | Medium rockbr. (900 kg) | Heavy rockbr. (1600 kg) | Handheld Jack-hammer |
| Regenerated noise (residential only) | Day | | No criterion | | | | |
| | Evening | | 12 m | 35 m | 50 m | 60 m | 20 m |
| | Night | | 20 m | 50 m | 60 m | 70 m | 30 m |
| Tactile | Day | Continuous / | 5 m | 25 m | 35 m | 55 m | 10 m |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| vibration | | Residential | | | | | |
| | | Continuous / Commercial | 2 m | 10 m | 20 m | 40 m | 5 m |
| | Day | Impulsive / Residential | < 1 m | 1 m | 5 m | 20 m | < 1m |
| | | Impulsive / Commercial | < 1 m | < 1 m | 5 m | 15 m | < 1 m |
| | Night | Continuous / Residential | 10 m | 35 m | 45 m | 60 m | 20 m |
| | | Continuous / Commercial | n/a | | | | |
| | Night | Impulsive / Residential | < 1 m | 5 m | 10 m | 30 m | < 1m |
| | | Impulsive / Commercial | n/a | | | | |
| Cosmetic damage | | | < 1 m | 2 m | 7 m | 22 m | < 1m |

It can be seen from Table 6-6 that the minimum required buffer distances (as scheduled in Table 6-5) would not be possible for works close to the café/restaurant, the offices as well as residential and proposed commercial receivers at Walker Street. Engineering methods as well as management methods would be required to control tactile vibration and (in case evening and night works are proposed) regenerated noise at these receivers.

It is considered unlikely that the residential receivers on the southern side of Berry Street would be adversely affected by ground-borne noise and vibration.

**Table 6-6 - Distances between sensitive receiver properties and the construction works**

| Location | Approximate worst case distance from construction works, metres |
|---|---|
| Café / Restaurant | 3 |
| Offices | 5 |
| Residences (Walker Street) | 15 |
| Residences (Berry Street) | 40 (at cable vault) |

The CNVMP would include a vibration monitoring program, a complaint management strategy, reasonable and feasible vibration mitigation measures.

### *6.3.2 Construction vibration management and mitigation strategies*

Vibration impacts would be most likely to occur during the excavation of the cable vault and trenches. Continuous rockbreaking close to affected receivers may raise complaints and would require management measures prior to commencement of excavation. The vibration dose values and regenerated noise levels experienced at affected receivers would be controlled by:

- Source controls
  - Use of less noise and vibration intensive equipment (e.g. sawing of trenches prior to rockbreaking, rotary cutting and reducing the size of the rockbreaker); and
  - Negotiating (as per Section 7.2.2 of the ICNG) respite periods and adhering to these predetermined periods.
- Management methods
  - Community consultation;
  - Complaint response;
  - Site layout;
  - Avoiding work during sensitive time periods (e.g. night work);
  - Noise and vibration logging and attended measurements; and
  - Training.
- Path controls

- Noise enclosures; and
- Avoid vibration intensive works in a concentrated area and try to work over a large area in order to reduce maximum vibration dose values, i.e. changing the location of excavation such as working opposite corners/edges.

General mitigation measures to reduce potential vibration impacts associated with the proposed substation redevelopment would include:

- All construction vehicles entering and leaving the site in accordance with site entry controls;
- Condition surveys at affected receivers (residential receivers in Walker Street and the restaurant at 76 Berry Street); and
- Continuously monitoring of the ground vibration levels at selected receivers for the entire duration of the excavation/construction works.

Any damage to buildings or structures attributable to vibration from construction activities would be rectified within a reasonable period, at no cost to the property owners.

# 7 CONCLUSION

This report presents an assessment of the operational and construction noise and vibration likely to be generated as a result of the proposed North Sydney substation redevelopment.

The environmental noise emission criteria for the redevelopment have been established and are based upon accepted guidelines and standards described in Section 3 and the measured ambient noise levels at the site.

Construction noise and vibration management levels have been established and are based on the DECCW requirements and measured ambient noise levels at the site.

Construction noise and vibration along with operational environmental noise emission to noise and vibration sensitive receivers such as nearby residential and commercial receivers have been assessed. The predicted impacts would be some noise exceedances during construction of the new substation and demolition of the existing substation (during the day) of between 1 and 17 dB(A) at nearby residences and 3 to 19 dB(A) at the restaurant and offices. Exceedances during the construction of the cable vault site (at night) are estimated to be between 14 and 29 dB(A) at the nearest residences.

It is proposed that a CNVMP be prepared by the excavation / construction / demolition contractor(s) that includes reasonable and feasible methods in reducing the impact of noise. These may include but not limited to: the strategic location of barriers, enclosures, selection of quieter equipment, community consultation and/or letter drops.

Estimated operational noise emission from the proposed substation at the nearest affected properties (which would be those existing and proposed including the proposed development at 136-140 Walker Street to the immediate east) would be 36 dB(A) at the boundary. As there would be a tonality penalty of 5 dB (due to the tonal nature of the proposed transformers) imposed on the redevelopment, the equivalent noise level would be 41 dB(A) at peak load times. This level is within the project specific noise limits outlined in Section 3 of this report.

This assessment has concluded that construction and operational noise and vibration impacts associated with the proposed substation construction and existing substation demolition can generally be managed by noise and vibration engineering control and management techniques.

# APPENDIX A - GLOSSARY OF ACOUSTIC TERMINOLOGY

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

| | |
|---|---|
| *Sound power level* | The total sound emitted by a source |
| *Sound pressure level* | The amount of sound at a specified point |
| *Decibel [dB]* | The measurement unit of sound |
| *A Weighted decibels [dB(A])* | The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A). |
| *Decibel scale* | The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows: |

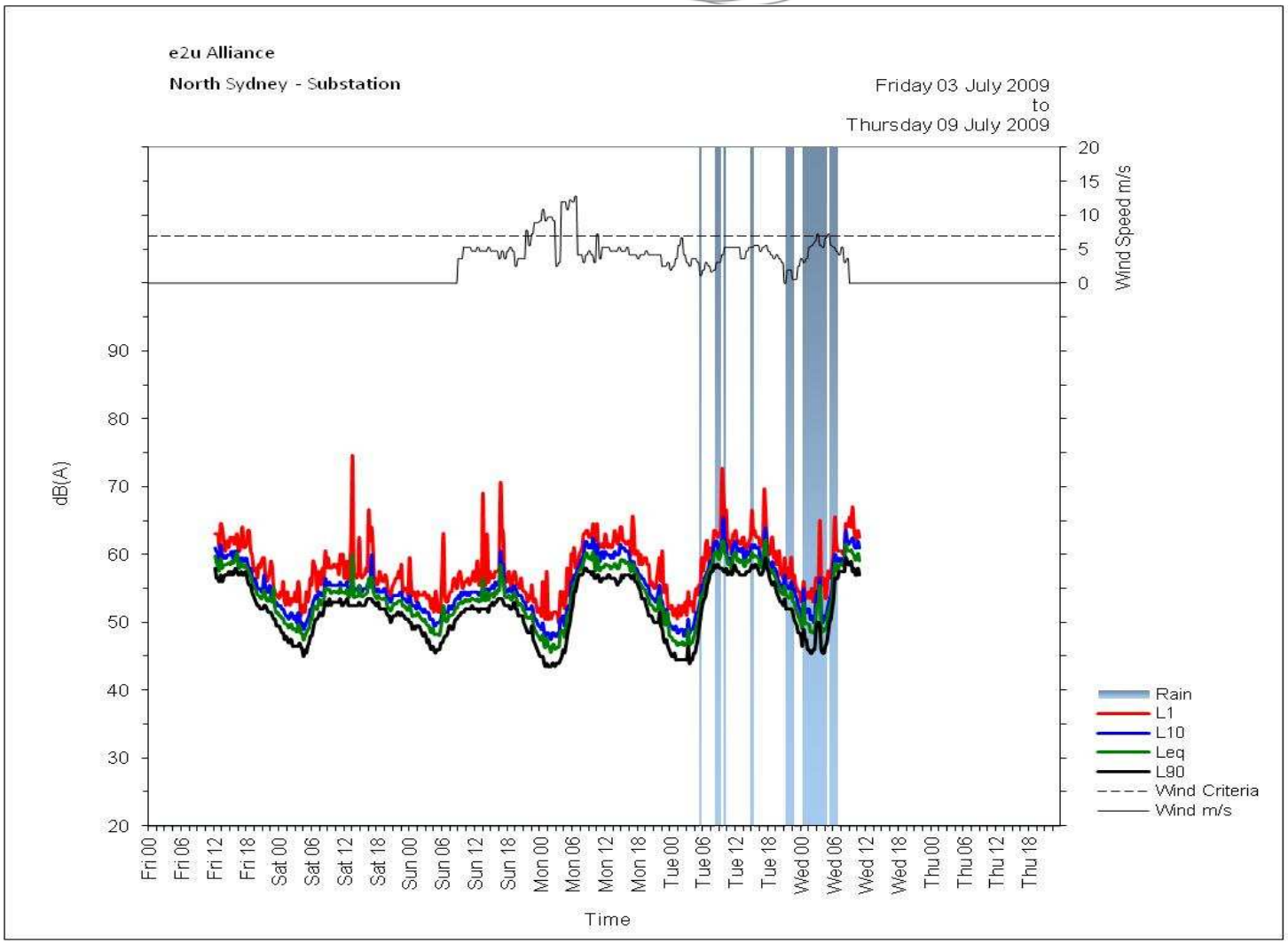
| | |
|---|---|
| 0dB(A) | Threshold of human hearing |
| 30dB(A) | A quiet country park |
| 40dB(A) | Whisper in a library |
| 50dB(A) | Open office space |
| 70dB(A) | Inside a car on a freeway |
| 80dB(A) | Outboard motor |
| 90dB(A) | Heavy truck pass-by |
| 100dB(A) | Jackhammer/Subway train |
| 110 dB(A) | Rock Concert |
| 115dB(A) | Limit of sound permitted in industry |
| 120dB(A) | 747 take off at 250 metres |

| | |
|---|---|
| *Frequency [f]* | The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound. |
| *Equivalent continuous sound level [Leq]* | The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy. |
| *Lmax* | The maximum sound pressure level measured over the measurement period |
| *Lmin* | The minimum sound pressure level measured over the measurement period |
| $L_{10}$ | The sound pressure level exceeded for 10% of the measurement period. For 10% of the measurement period it was louder than the $L_{10}$. |
| $L_{90}$ | The sound pressure level exceeded for 90% of the measurement period. For 90% of the measurement period it was louder than the $L_{90}$. |
| *Ambient noise* | The all-encompassing noise at a point composed of sound from all sources near and far. |

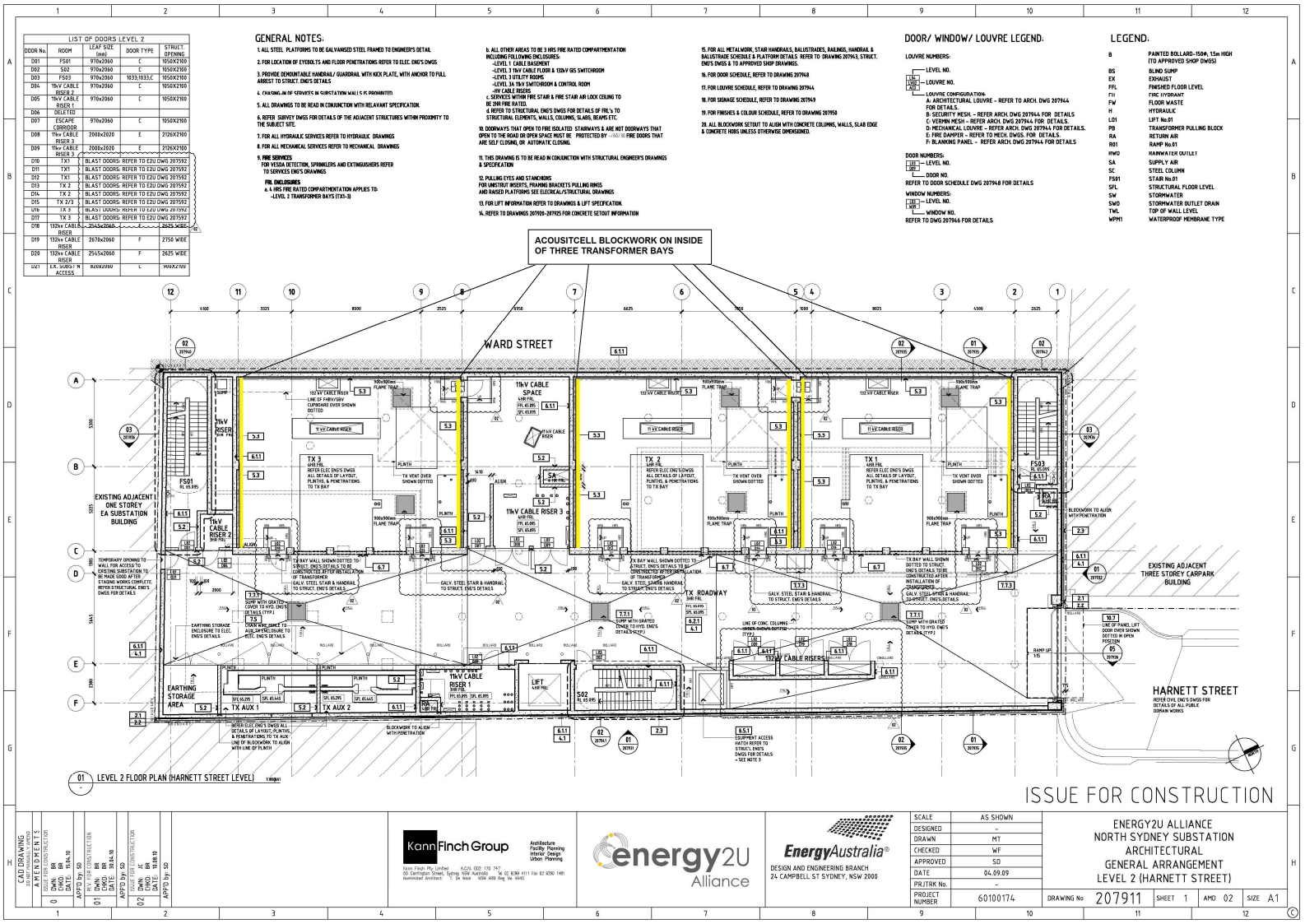
| | |
|---|---|
| *Background noise* | The underlying level of noise present in the ambient noise when extraneous noise (such as transient traffic and dogs barking) is removed. The $L_{90}$ sound pressure level is used to quantify background noise. |
| *Traffic noise* | The total noise resulting from road traffic. The $L_{eq}$ sound pressure level is used to quantify traffic noise. |
| *Day* | The period from 0700 to 1800 h Monday to Saturday and 0800 to 1800 h Sundays and Public Holidays. |
| *Evening* | The period from 1800 to 2200 h Monday to Sunday and Public Holidays. |
| *Night* | The period from 2200 to 0700 h Monday to Saturday and 2200 to 0800 h Sundays and Public Holidays. |
| *Assessment background level [ABL]* | The overall background level for each day, evening and night period for each day of the noise monitoring. |
| *Rating background level [RBL]* | The overall background level for each day, evening and night period for the entire length of noise monitoring. |

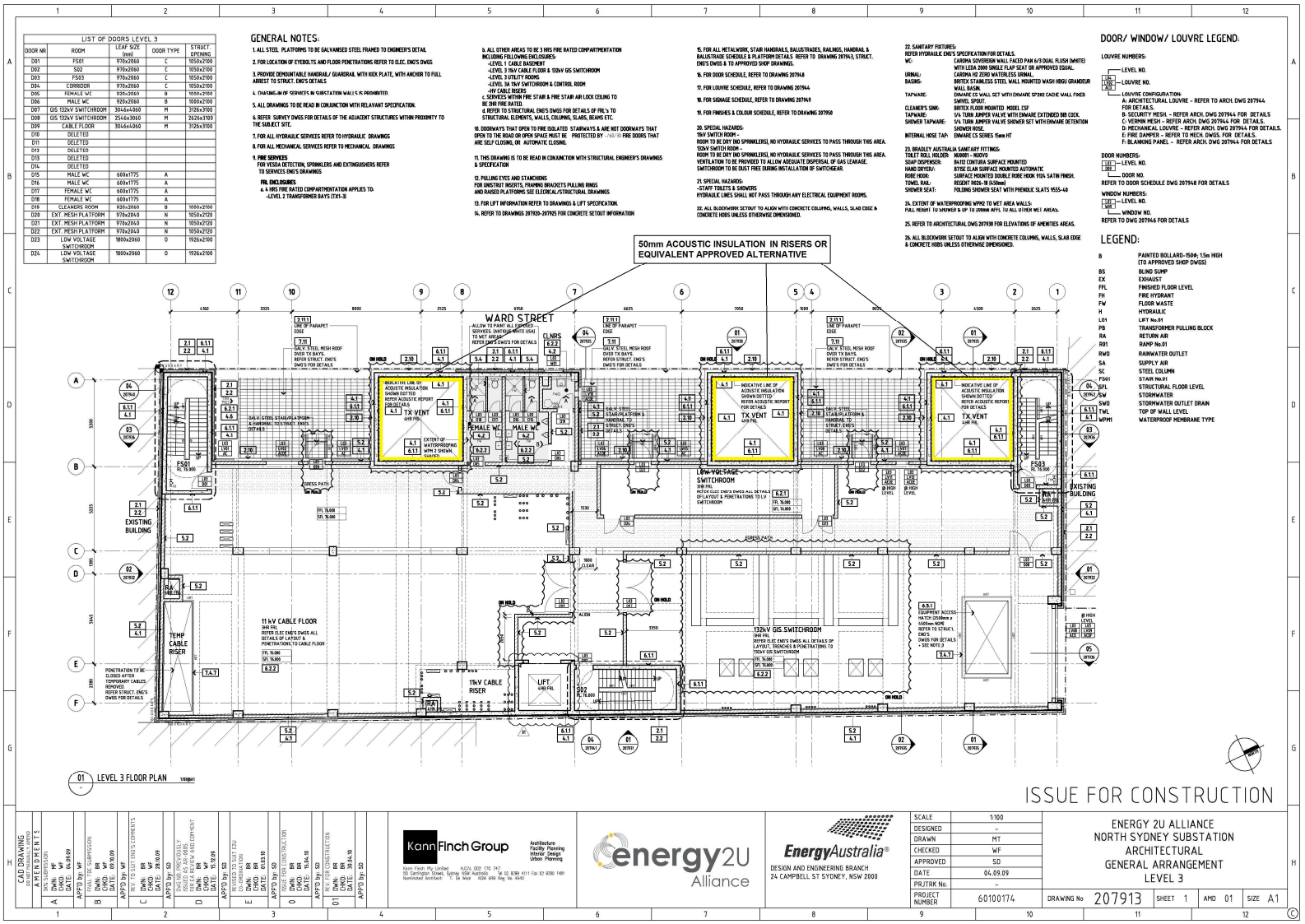
*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 *"Acoustics – Glossary of terms and related symbols"*, the DECCW's NSW Industrial Noise Policy and the DECCW's Environmental Criteria for Road Traffic Noise.

# APPENDIX B - Graphical Ambient Noise Monitoring Results



# APPENDIX C - ARCHITECTURAL MARKUPS


LIST OF DOORS LEVEL 2
GENERAL NOTES:
DOOR/ WINDOW/ LOUVRE LEGEND:
LEGEND:
ACOUSITCELL BLOCKWORK ON INSIDE OF THREE TRANSFORMER BAYS
WARD STREET
11kV CABLE SPACE
TX 3
TX 2
TX 1
TX ROADWAY
11kV CABLE RISER 3
11kV CABLE RISER 2
11kV CABLE RISER 1
11kV RISER
TX AUX 1
TX AUX 2
LIFT
FS01
FS03
S02
EXISTING ADJACENT ONE STOREY EA SUBSTATION BUILDING
EXISTING ADJACENT THREE STOREY CARPARK BUILDING
EARTHING STORAGE AREA
HARNETT STREET
01 LEVEL 2 FLOOR PLAN (HARNETT STREET LEVEL)
ISSUE FOR CONSTRUCTION
Kann Finch Group
energy2U Alliance
EnergyAustralia
DESIGN AND ENGINEERING BRANCH
24 CAMPBELL ST SYDNEY, NSW 2000
ENERGY2U ALLIANCE
NORTH SYDNEY SUBSTATION
ARCHITECTURAL
GENERAL ARRANGEMENT
LEVEL 2 (HARNETT STREET)
SCALE AS SHOWN
DESIGNED -
DRAWN MT
CHECKED WF
APPROVED SD
DATE 04.09.09
PROJTRK No. -
PROJECT NUMBER 60100174
DRAWING No. 207911
SHEET 1
AMD 02
SIZE A1


LIST OF DOORS LEVEL 3
GENERAL NOTES:
50mm ACOUSTIC INSULATION IN RISERS OR EQUIVALENT APPROVED ALTERNATIVE
WARD STREET
11 kV CABLE FLOOR
11kV CABLE RISER
132kV GIS SWITCHROOM
LOW VOLTAGE SWITCHROOM
TX VENT
LIFT
EXISTING BUILDING
DOOR/ WINDOW/ LOUVRE LEGEND:
LEGEND:
01 LEVEL 3 FLOOR PLAN
ISSUE FOR CONSTRUCTION
Kann Finch Group
energy2U Alliance
EnergyAustralia
ENERGY 2U ALLIANCE
NORTH SYDNEY SUBSTATION
ARCHITECTURAL
GENERAL ARRANGEMENT
LEVEL 3
DRAWING No 207913