HEGGIES

REPORT 10-6560-R3

Revision 0

Belmore Park Zone Substation and Commercial Development

Environmental Assessment

Noise and Vibration

PREPARED FOR

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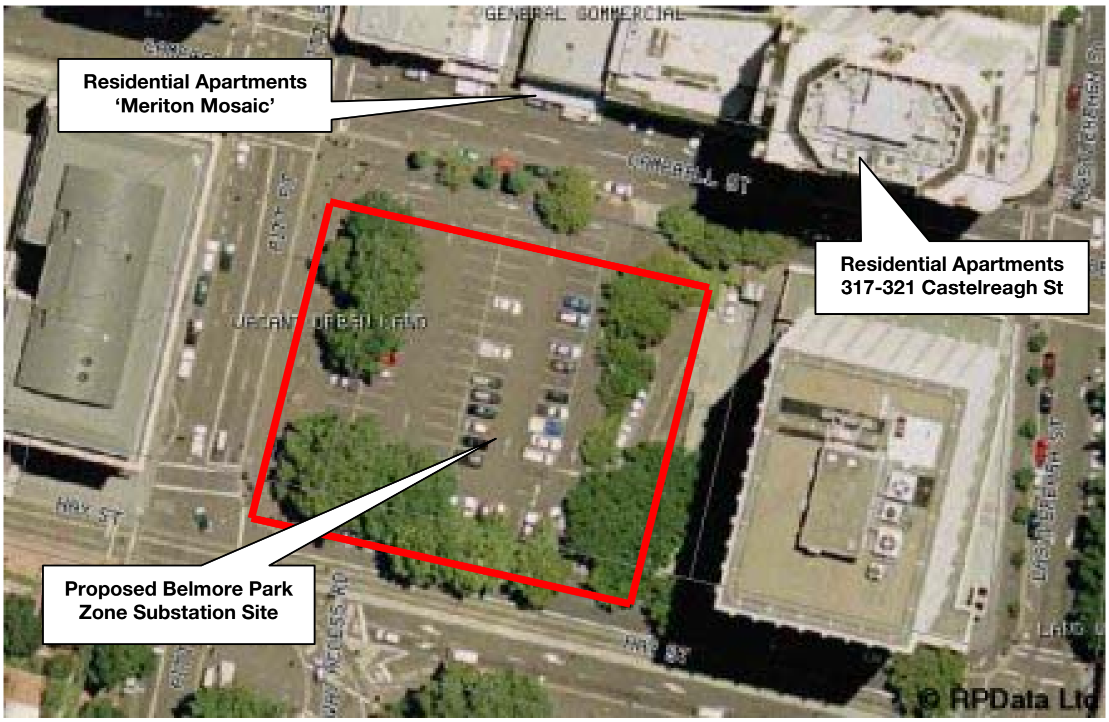
1 INTRODUCTION

The Belmore Park Zone Substation is part of the Sydney CityGrid project, proposed in order for EnergyAustralia to meet their license conditions to maintain a reliable supply of electricity to the Sydney CBD by the replacement and upgrade of distribution infrastructure.

It is proposed to construct an integrated development comprising a Zone Substation and a Commercial Office Building. The development would be located between Pitt Street, Campbell Street and Hay Street, as shown in **Figure 1**.

Figure 1 Aerial View of the Proposed Substation Site and Surrounding Area



Heggies Pty Ltd (Heggies) has been engaged by Plancom Consulting Pty Limited (PlanCom), on behalf of *EnergyAustralia,* to prepare a Noise and Vibration Assessment for the construction phase and operational phase of the Belmore Park Zone Substation Project.

A Preliminary Environmental Assessment for the Sydney CityGrid project has been submitted to the Department of Planning, in which noise and vibration was identified as a "*key aspect"* that would "*require detailed consideration as part of the environmental assessment of the project"*.

The Director-General's noise and vibration requirements for the environmental assessment states:

> *"the Environmental Assessment must include an assessment of the noise and vibration impacts during the construction and operation of the project, in accordance with relevant NSW Government and DECC policies and guidance current at the time of the assessment."*

The purpose of this document is to address the objectives set out above and forms part of a Environmental Assessment Report in support of the Belmore Park Zone Substation element of the Sydney CityGrid project.

An ambient noise survey was conducted to determine design criteria, and computer noise modelling based on equipment sound power levels, was used to estimate the noise emissions.

Specific acoustic terminology is used in this report. An explanation of common acoustic terms is provided in **Appendix A**.

2 PROJECT SUMMARY

2.1 Project Description

It is proposed to construct an integrated development in a 13 storey building comprising a Zone Substation and an A grade 5 green star Commercial Office Building of approximately 21,000 m^2 nett lettable area with ground floor retail and office lobby entry and four basement levels with a loading level and approximately 62 car spaces.

2.2 Proposed Construction Activities

- Site establishment.
- Excavation for footings.
- Construction of new substation and commercial building, noting project will be staged with the substation component constructed first, followed by the integrated commercial component.

2.2.1 Noise Generating Activities

Based on information provided by Plancom, **Table 1** shows the noisy activities envisaged and indicative construction sequence.

Table 1 Noisy Activities and Indicative Construction Sequence

Construction Activity	Typical Equipment	Approximate Timing
Establishment of Belmore Park Site and Bulk Excavation	Power tools, concrete saws, rock hammers, bulldozer, excavator, concrete agitator and pump, delivery vehicles, crane	Aug 2009 - May 2010
Construction of 8 level substation	Crane, scaffolding, concrete pumps, concrete vibrators, concrete delivery trucks, placement of steel reinforcement, scabbling, air compressor, jack hammers, concrete / bitumen saw cutting	Jun 2010 - Aug 2013

Notes 1. A commercial development is proposed be integrated into the substation building in the future.

It should be noted that a commercial development is proposed to be integrated with the substation building in a staged approach, whereby the commercial building will be constructed potentially 5-10 years after completion of the substation building. It is considered that the noisiest activities associated with the bulk excavation and construction of the commercial building will be similar to those presented in Table 1 above.

This preliminary information has been used in the report to identify the noisiest activities, determine the likely sound pressure levels (airborne noise) at the nearest noise-sensitive receivers and determine the likelihood of compliance/non-compliance with relevant criteria. It is noted that construction activities will have a duration of greater than 26 weeks.

This is of significance (particularly for the "stationary" work sites) when deriving and establishing demolition and construction noise criteria (refer to **Section 4.2**).

2.3 Operational Noise Sources

The integrated development will comprise the following significant noise sources:

Substation Component

- Zone substation component located on the eastern side of the building comprising 5 transformers and associated cooling fans. The transformers will be located at ground level with ventilation via open louvres to the east and also to the north and south via the transformer roadway (Campbell and Hay Streets respectively). Cooling fans and radiators for the transformers will be adjacent to the transformers on the ground level.
- Substation basement ventilation system comprising a supply air fan in a fan room via louvres to Hay Street and exhaust fan in a fan room with louvres to Campbell Street.

Commercial Building Component

- Level 14 plant equipment associated with the commercial component including chillers, air handling units and an emergency diesel generator.
- Basement carpark ventilation

2.4 Identification of Noise and Vibration-Sensitive Receivers

The nearest noise and vibration-sensitive receivers to the proposed Belmore Park Project are identified in **Table 2**.

Table 2 Receivers near Belmore Park Works

Receiver Type	Receiver Address
Residential	420 Pitt Street/36 Campbell Street - Strata Units
	414 Pitt Street - Strata Units
	317-321 Castlereagh Street - Strata Units
Hotel/Tavern	428 Pitt Street - Chamberlain Hotel
	431 Pitt Street
Commercial	323 Castlereagh Street
	441 Pitt Street

Note: This table is not exhaustive; it gives an indication of the potentially most affected receivers near to the proposed works, as identified during a site inspection. Other nearby receivers in Campbell Street, Pitt Street and other nearby streets should also be considered as being "potentially affected" by airborne noise, regenerated noise and vibration due to the proposed works.

3 DIRECTOR-GENERAL'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS (DGRS)

Heggies has been provided with the Director-General's (Environmental Assessment) Requirements (DGRs) for the proposed CityGrid project (of which the Belmore Park Substation is a part) which, for the Noise and Vibration aspects, read as follows:

> *The Environmental Assessment must include an assessment of the noise and vibration impacts during both the construction and operation of the project, in accordance with relevant NSW Government and DECC policies and guidance current at the time of the assessment.*

3.1 Input from Agencies

The DGRs have been expanded upon by input provided by Agencies, including the Department of Environment and Climate Change's (DECC's) input on Noise and Vibration, which reads as follows:

The EA should include an assessment of all feasible and reasonable noise and vibration mitigation measures.

The assessment of construction/operational noise and vibration should:

1. *Identify the source, nature and scope of noise and vibration impacts both during the construction and operational phases.*
2. *Identify the project duration, normal construction hours and parts of the project likely to involve significant periods of works outside of normal construction hours, especially any evening and night-time work.*
3. *Assess, quantify and report on predicted night-time noise impacts using both L_{A10} (15 minute) and LA1 (1minute) noise descriptors.*
4. *Assess, quantify and report predicted vibration impacts against acceptable values of human exposure to vibration set out in Tables 2.2 and 2.4 to the Environmental Noise Management Assessing Vibration: technical Guideline (sic).*
5. *Identify the location of all proposed work compounds likely to involve 'out of hours' construction work and construction activities, including bulk material storage compounds and site access gates and assess, quantify and report upon the predicted noise impacts on surrounding noise sensitive receivers, particularly in respect of: material and equipment deliveries and waste and spoil removal or transfer.*
6. *Identify feasible and reasonable noise and vibration mitigation measures for construction and operation including: alternative equipment or construction measures, timing of construction activities; and consideration of respite periods / curfew times for works involving high noise or vibration impacts.*
7. *Outline a complaints monitoring and handling system active during the construction phase of the project.*
8. *The EA should consider current and future land uses of the land in the vicinity of the project of the project with respect to noise and amenity impact, particularly on sensitive receivers.*

In some cases, the *DGRs* and *Input from Agencies* provide reference to documents that contain specific numerical criteria that must be used to assess noise and vibration impacts, such as in Point 4, above.

In many cases however, the DGRs provide a broad methodology for assessing noise and vibration impacts and do not provide a comprehensive checklist of criteria or guidelines that must be used in the EA, instead requiring an assessment *in accordance with relevant NSW Government and DECC policies and guidance current at the time of the assessment*.

Therefore, in the following sections, Heggies has collated and presented the criteria and guidelines that will be used in the assessment of noise and vibration impacts during the construction and operational phases of the Belmore Park Project.

4 NOISE AND VIBRATION GUIDELINES AND CRITERIA

4.1 Operational Noise Criteria

DECC's Industrial Noise Policy (INP) provides guidelines for the assessment of noise impacts associated with industrial activities. It aims to balance the need for industrial activity with the desire for quiet within the community. The criteria selected are designed to protect at least 90 per cent of the population living in the vicinity of the industrial noise sources for at least 90 per cent of the time.

The INP's objectives are:

- to establish noise criteria that would protect the community from excessive noise;
- to preserve the amenity for specific land uses;
- to use the criteria for deriving project specific land uses; and
- to promote uniform methods to estimate and measure noise impacts, including a procedure for evaluating meteorological effects.

Implementation is achieved by ensuring:

- that noise from any single source does not intrude greatly above the prevailing background noise level. This is known as the intrusive noise criterion; and
- that the background noise level does not exceed the level appropriate for the particular locality and land use. This is known as the amenity criterion.

In order to satisfy the above two requirements, an Intrusive and an Amenity noise criterion is recommended of which the lower of the two applies.

4.1.1 Intrusiveness Criterion

In setting an "Intrusive" noise goal, an estimate of the ambient (background) L_{A90} noise level, termed the Rating Background Level (RBL), needs to be established at the nearest sensitive receivers in the absence of the intruding source. An "RBL plus 5 dBA" criterion is then applied to the 15-minute L_{Aeq} noise emissions of the noise source in question at the receivers of interest (normally at their property boundary).

4.1.2 Amenity Criterion

The "Amenity" noise goal seeks to place a limit on noise emissions according to how the existing industrial/commercial-related noise levels relate to recommended noise levels for the type of area involved, ie rural, suburban, urban, etc.

The resulting amenity criterion placed upon noise emissions of a new facility then depends upon whether existing industrial/commercial-related $L_{Aeq(period)}$ noise levels are lower or higher than the recommended amenity level.

In areas where existing industrial/commercial-related noise levels are already high, the amenity noise goal acts to limit new industrial noise emissions so that the cumulative impact of all industrial/commercial noise emissions does not increase.

Conversely, in areas where there is no existing industrial/commercial noise, the amenity noise goal would be set at a level which allows new industrial/commercial noise emissions up to recommended amenity noise levels for the area.

The DECC provides recommended acceptable noise levels for residents located in “Rural”, “Suburban”, “Urban” and “Urban/Industrial” areas. Consistent with the INP, residences surrounding the subject substation would be considered Urban. The recommended acceptable noise levels are shown in **Table 3**.

Table 3 Amenity Criteria - Recommended L_{Aeq} Noise Levels from Industrial Noise Sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level	
			Acceptable	Recommended Maximum
Residence	Rural	Day	50 dBA	55 dBA
		Evening	45 dBA	50 dBA
		Night	40 dBA	45 dBA
	Suburban	Day	55 dBA	60 dBA
		Evening	45 dBA	50 dBA
		Night	40 dBA	45 dBA
	Urban	Day	60 dBA	65 dBA
		Evening	50 dBA	55 dBA
		Night	45 dBA	50 dBA
	Urban/Industrial Interface - for existing situations only	Day	65 dBA	70 dBA
		Evening	55 dBA	60 dBA
		Night	50 dBA	55 dBA

Notes: For Monday to Saturday, Daytime 0700 hours- 1800 hours; Evening 1800 hours - 2200 hours; Night-time 2200 hours - 0700 hours.

On Sundays and Public Holidays, Daytime 0800 hours - 1800 hours; Evening 1800 hours - 2200 hours; Night-time 2200 hours - 0800 hours.

The L_{Aeq} index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.

For “Urban” areas the daytime, evening and night-time period recommended acceptable noise level are **60 dBA**, **50 dBA** and **45 dBA** respectively.

4.1.3 Modifying Factors

In addition, the modifying factors are to be applied if the noise source is low frequency, tonal or intermittent in nature. The modifying factors recommended in the INP for tonal/low frequency noise are presented in **Table 4**.

Table 4 DECC Modifying Factor Corrections

Factor	When to apply	Correction [1]
Tonal Noise	Level of one-third octave band exceeds the level on both sides by: **-5 dB** or more if the centre frequency of the band containing the tone is above 400 Hz **-8 dB** or more if the centre frequency of the band containing the tone is above 160 to 400 Hz inclusive **-15 dB** or more if the centre frequency of the band containing the tone is below 160 Hz	5 dB [2]
Low frequency noise	Measure/assess C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more	5 dB [2]

Note 1: Corrections to be added to the measured or predicted levels

Note 2: Where a source emits tonal and low frequency noise, only one 5 dB correction is to be applied if the tone is in the low frequency range.

Noise from transformers is identified as being tonal/low frequency, resulting in a 5 dBA correction required to be added to the measured or predicted noise levels.

4.1.4 Mechanical Plant to Footpaths

The DECCs INP provides amenity criteria for active recreation areas (e.g. school playground, golf course). An acceptable L_{Aeq} noise level of 55 dBA is recommended by the INP and this has been adopted for pedestrian areas adjacent to the building.

4.1.5 Emergency Diesel Generator

The DECC's Environment Noise Control Manual (ENCM) contains a Noise Control Guideline for emergency diesel generators, and for night-time specifies that:

> *"From 10pm to 7am the L_{A10} noise level should not exceed the L_{A90} Background by more than 5 dBA at the residential boundary, and in any event should not exceed 45 dBA at the boundary."*

4.2 Construction Noise Assessment Criteria

A former incarnation of the DECC, being the Environmental Protection Agency (EPA), published guidelines in its *Environmental Noise Control Manual* (Chapter 171-1) for the control of construction noise.

In summary, the DECC's preferred approach to the control of construction noise involves the following:

- Noise Level Restrictions.
- Time Restrictions.
- Silencing.

4.2.1 Noise Level Restrictions

The *Environmental Noise Control Manual* (ENCM) recommends that the $L_{A10\ (15minute)}$ (average maximum construction noise levels assessed over a 15-minute period) arising from a construction site and measured within the curtilage of an occupied noise-sensitive premises (ie at the boundary or within 30 m of the noise-sensitive premises, whichever is the lesser) should not exceed the levels indicated in **Table 5**.

Table 5 Recommended DECC Noise Criteria for Construction Works

Period of Noise Exposure	$L_{A10(15minute)}$ Construction Noise Goal
Cumulative noise exposure period not exceeding 4 weeks	$L_{A90\ (15minute)}$ plus 20 dBA
Cumulative noise exposure period of between 4 weeks and 26 weeks	$L_{A90\ (15minute)}$ plus 10 dBA
Cumulative noise exposure period longer than 26 weeks	$L_{A90\ (15minute)}$ plus 5 dBA

4.2.2 Time Restrictions

Monday to Friday	0700 hours to 1800 hours
Saturday	0700 hours to 1300 hours if inaudible at residential premises; otherwise, 0800 hours to 1300 hours

No work on Sundays or Public Holidays.

Should any construction works be undertaken outside these hours, a separate assessment of their impacts will be carried out once the nature and extent of those works is known.

4.2.3 Silencing

All practical measures should be used to silence construction equipment, particularly in instances where extended hours of operation are required.

4.2.4 City of Sydney Code of Practice

The general approach of the Code is to set Noise Limits based on a margin above the background noise level. This margin, in turn, varies throughout the day and night depending upon the day of the week and the hour of the day, and ranges from 0 dBA to 10 dBA. The categories of working hours and associated noise limits from the Code are as shown in **Table 6**

Table 6 Categories of Working Hours and Noise Criteria

Day	Time Zone (Hours)	Category	Noise Criteria (which must not be exceeded)
Monday to Friday	07.00 - 08.00	1	Background + 5 dBA
	08.00 - 19.00	1	Background + 5 dBA + 5 dBA to be determined on a site basis[1]
	19.00 - 2200	2	Background + 3 dBA
	22.00 - 07.00	4	Background + 0 dBA
Saturday	07.00 - 08.00	1	Background + 5 dBA
	08.00 - 19.00	1	Background + 5 dBA, + 5 dBA to be determined on a site basis[1]
	19.00 - 2200		Background + 3 dBA
	22.00 - 07.00		Background + 0 dBA
Sunday	0700 - 1700	3	Background + 3 dBA
	17.00 - 07.00	4	Background + 0 dBA

Note 1: The second +5 dBA allowance is discretionary on behalf of Council and its granting depends upon the sensitivity of the potentially affected buildings.
Note 2: All noise levels to be $L_{A\ av\ max\ (15minute)}$ measured at the nearest Nominated Occupancy.
Note 3: The permissible noise level is to be complied with during each 15 minutes period during the relevant Category of hours.

4.3 Vibration Assessment Criteria

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

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed (**Human Comfort**).
- Those in which the integrity of the building or the structure itself may be prejudiced (**Structural Damage**).

Point 4 in the *Input from Agencies* requires an assessment of vibration in accordance with the DECC's, *Assessing Vibration: A Technical Guideline,* (August 2006) specifically Table 2.2 and 2.4.

These tables (and indeed the whole document) in the DECC's *Technical Guideline* only take **Human Comfort** into account. They provide acceptable values for continuous and impulsive vibration in terms of vibration acceleration (m/s^2) in the frequency range 1 Hz to 80 Hz as well as acceptable values for intermittent vibration in terms of Vibration Dose Value (VDV) ($m/s^{1.75}$).

The means by which the criteria set out in the DECC's *Technical Guideline* are measured and assessed (acceleration and dose) are not straightforward and, in the case of acceleration particularly, would impose an onerous burden upon the project if assessment was required to be undertaken in this manner, with no additional benefit to the community. It is far more straightforward to assess vibration in terms of Peak Particle Velocity (PPV).

On past, similar projects, Heggies has determined equivalent vibration criteria consistent with the values in the DECC's *Technical Guideline,* but expressed in terms of PPV. The *Technical Guideline* is based upon some of the references set out below (BS 6472).

4.4 Human Comfort Vibration Criteria

4.4.1 General

Humans are far more sensitive to vibration than is commonly realised. They can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2-1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in **Table 7**.

Table 7 Peak Vibration Levels and Human Perception of Motion

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

Table 7 suggests that people will just be able to feel floor vibration at levels of about 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

4.4.2 Human Comfort Criteria for Continuous Vibration

The DECC's *Technical Guideline* is based upon British Standard 6472-1992 "*Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*". This standard, nominates criteria for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "low probability of adverse comment" from occupants.

In relation to an equivalent Australian Standard, whilst BS 6472 and AS 2670 contain the same criteria for human exposure to continuous vibration, BS 6472 also includes detailed guidance on the use of vibration dose values (VDVs) which allow an assessment of the severity of impulsive and intermittent vibration to be carried out. This analysis and assessment procedure is most relevant to the character of the vibration generated during construction works.

The daytime floor vibration (peak velocity) levels recommended in BS 6472 are presented in **Table 8**.

Table 8 Vibration Levels with "Low Probability of Adverse Comment" (1 Hz to 80 Hz)

Location	Peak Floor Vibration (X, Y Horizontal)	Peak Floor Vibration (Z Vertical)
Residential buildings	0.8 mm/s to 1.6 mm/s	0.3 mm/s to 0.6 mm/s
Offices	1.6 mm/s	0.6 mm/s
Workshops	3.2 mm/s	1.2 mm/s

Situations exist where motion magnitudes above the dose levels given in BS 6472 can be acceptable, particularly for temporary disturbances and infrequent events of short-term duration. An example is a construction or excavation project.

When short-term works such as piling, demolition or compaction give rise to impulsive vibrations, it should be borne in mind that undue restriction on vibration levels can significantly prolong these operations and result in greater annoyance.

In certain circumstances, the use of higher magnitudes of acceptability may be considered, eg for projects having social worth or broader community benefits or in view of the economic or practical feasibility of reducing vibration to the recommended levels. In such cases, best management practices should be employed to reduce noise levels as far as practical.

4.5 Vibration Damage Criteria - Surface Structures

4.5.1 Australian Standard AS 2187: Part 2-2006

In terms of the most recent relevant vibration damage objectives, Australian Standard AS 2187: Part 2-2006 "*Explosives - Storage and Use - Part 2: Use of Explosives*" recommends the frequency dependant guideline values and assessment methods given in BS 7385 Part 2-1993 "*Evaluation and Measurement for Vibration in Buildings Part*" as they are "*applicable to Australian conditions*".

The British Standard sets guideline values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 9** and graphically in **Figure 2**.

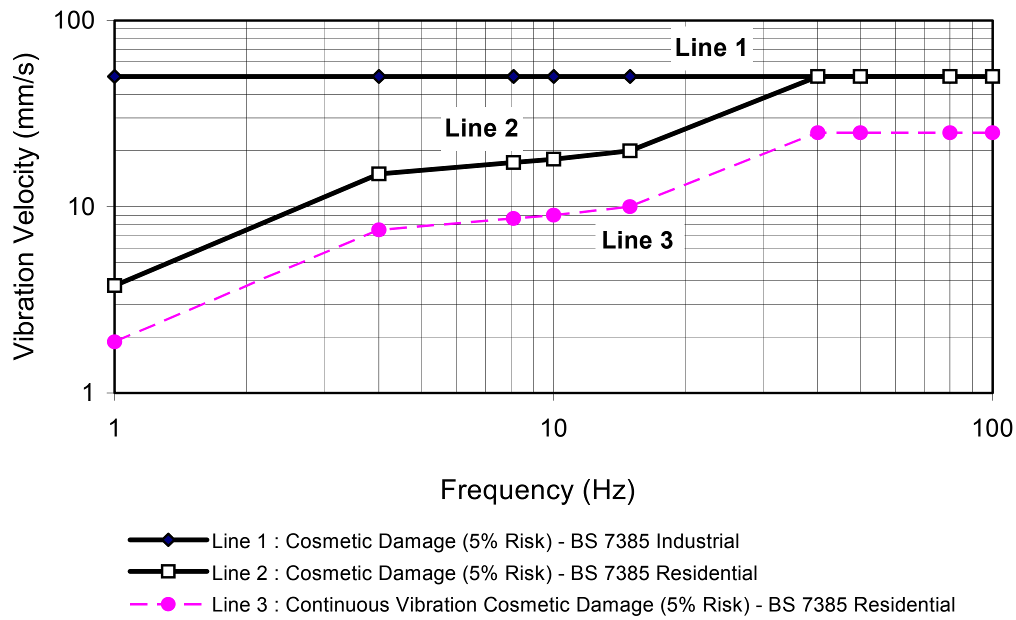
Table 9 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	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	Unreinforced or light framed structures Residential or light commercial type buildings	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 Standard states that the guide values in **Table 9** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 9** may need to be reduced by up to 50%.

Figure 2 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 9** and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the Standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 9** should not be reduced for fatigue considerations.

It is noteworthy that extra to the guide values nominated in **Table 9**, the Standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

4.6 Construction and Operational Traffic Noise Assessment Criteria

For traffic operating on public roads to and from the subject site the DECC's "*Environmental Criteria for Road Traffic Noise"* 1999 (ECRTN) are appropriate for assessing road traffic noise. The DECC's recommended criteria for the three most common road categories are set out in **Table 10**.

Table 10 DECC Road Traffic Noise Criteria

Development	Day (0700 hours to 2200 hours)	Night (2200 hours to 0700 hours)
7. Land use development with potential to create additional traffic on FREEWAYS/ARTERIAL roads	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA
8. Land use development with potential to create additional traffic on COLLECTOR roads	$L_{Aeq(1hour)}$ 60 dBA	$L_{Aeq(1hour)}$ 55 dBA
13. Land use development with potential to create additional traffic on LOCAL roads	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA

Where the L_{Aeq} traffic noise levels already exceed the above targets, a 2 dBA increase in the overall traffic noise levels is normally regarded as an alternative target (having investigated the application of all feasible and reasonable noise mitigation) in order to maintain the general acoustic amenity of the area.

It is likely that on the roads immediately adjacent to the various work sites, the community will associate truck movements with the project. Once the trucks move further from each of the sites, the truck noise may be perceived as part of the general road traffic.

5 AMBIENT NOISE SURVEY

An ambient noise survey was conducted at a location indicative of the nearest residences to the site, being the apartments to the north of the site. The purpose of the survey was to establish the existing ambient noise levels for the determination of design goals for noise emanating from the proposed substation.

5.1 Unattended Noise Survey

Unattended environmental noise monitoring was conducted at on the balcony of Apartment 202 on Level 20 of the Meriton Mosaic development (overlooking and with direct line of site to the Belmore Park work site).

The equipment used was an Acoustic Research Laboratories (ARL) Environmental Noise Logger Type EL-316 (Serial Number 16-207-045) fitted with a microphone windshield. Calibration of the logger was checked prior to and following measurements. Drift in calibration did not exceed ±0.5 dBA. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Noise Monitoring Results

The processed results of the ambient noise survey are presented graphically in **Figure 3** and tabulated in **Table 11** and **Table 12** (noise levels are rounded to the nearest 1 dBA and the median values for each of the 15-minute periods are shown).

The statistical descriptors shown on the graph are:

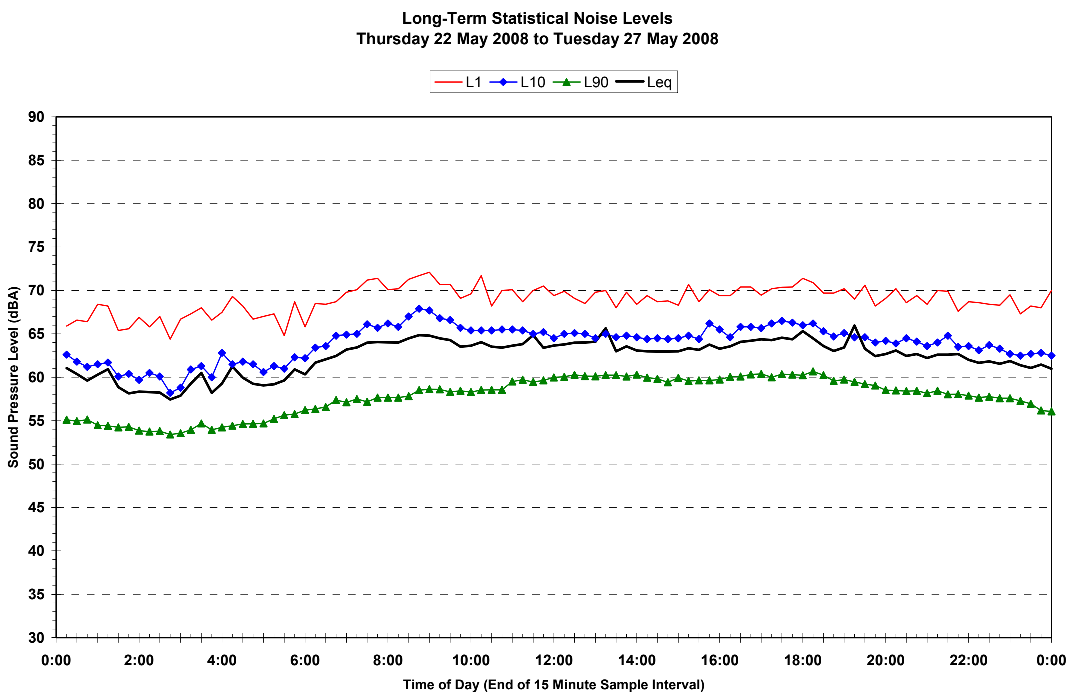
L_{A90} The L_{A90} is the level of noise exceeded for 90% of the sample time (15 minutes).The L_{A90} noise level is described as the average minimum background sound level or simply the background level.

LA10 The LA10 is the noise level exceeded for 10% of the sample time (15-minute) and is typically described as the average maximum noise level.

LA1 The LA1 is the noise level exceeded for 1% of the sample time (15-minute) and representative of the highest noise level events (eg passing heavy vehicles, aircraft etc).

LAeq The LAeq is the energy-average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Figure 3 Long-Term Statistical Noise Levels Receivers near Belmore Park Work Site



Data Processing to Derive Construction and Operational Noise Goals

The results of the noise monitoring have been processed in accordance with the procedures and time periods contained in the DECC's *Industrial Noise Policy*, 2000 (INP).

The RBL is the single figure noise level based on ambient noise measurements, for each day, evening and night-time period, representative of the typical minimum background sound level for that period, used for assessment purposes at the nearest potentially affected residence. By definition the RBL is obtained by calculating the median values of day/evening/night Assessment Background Levels (ABL's) of each day of the ambient noise survey. The ABL is the single figure background noise level representing each assessment period (day, evening and night) for each day of the survey. The ABL is determined by calculating the lower 10 percentile level of all LA90(15minute) samples for each assessment period.

The RBL for the defined daytime, evening and night-time periods has been established and is presented in **Table 11**.

Table 11 Meriton Mosaic Apartment - Measured Ambient Noise Levels

Location	Measurement Descriptor	Measured Noise Level - dBA re 20 µPa			
		Daytime 0700 hours - 1300 hours[1]	Daytime 0700 hours - 1800 hours	Evening 1800 hours - 2200 hours	Night-time 2200 hours - 0700 hours
Receivers near to Belmore Park	L_{Aeq}[2]	64	64	63	60
	RBL (Background)	61	61	59	54

Note 1: Shown for completeness, used to assess construction noise emissions for Saturday works.

Note 2: The L_{Aeq} is essentially the average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Data Processing to Derive Construction Traffic Noise Criteria

In order to assess the noise from construction traffic activity associated with the Belmore Park site, the logged data was processed in order to establish the existing road traffic noise levels at nearby receivers during defined time periods. These time periods are defined in the DECC's *Environmental Criteria for Road Traffic Noise* (ECRTN). The results are presented in **Table 12**.

Table 12 Measured Ambient Noise Levels Corresponding to Defined ECRTN Periods - dBA re 20 µPa

Logging Location	Period			
	Daytime		Night-time	
	$L_{Aeq(15hour)}$	$L_{Aeq(1hour\ day)}$	$L_{Aeq(9hour)}$	$L_{Aeq(1hour\ night)}$
Receivers near to Belmore Park	64	65	60	62

Irrespective of the ECRTN road classification for the streets surrounding the Belmore Park site, the existing road traffic noise levels at receivers near to the Belmore Park site already exceed the ECRTN criteria set out in **Section 4.6**.

6 SITE SPECIFIC CONSTRUCTION AND OPERATIONAL NOISE GOALS

The results of the ambient noise survey conducted at the Meriton Apartments, and presented in **Table 11** of **Section 5**, have been used to determine site specific construction and operational noise goals.

In accordance with the DGRs, which reference NSW Government and DECC policies, the construction noise goals have been set with reference to the DECC's ENCM guidelines.

It is noted the City of Sydney Code of Practice noise criteria is generally consistent with the ENCM with the daytime (0700 hours - 1900 hours) default goal of Background + 5 dBA. For the evening and night-time periods the City of Sydney Code of Practice is generally more stringent by 3 dBA and 5 dBA respectively when compared to the ENCM.

6.1 Construction Noise Goals

On this basis, the "normal construction hours" airborne noise goals (at the nearest residential receiver) for construction activity at the Belmore Park work sites are as follows:

- Daytime 0700 hours - 1800 hours **L_{A10} 66 dBA**
- Saturday Daytime 0700 hours - 1800 hours **L_{A10} 66 dBA**

Should extended work hours be permitted beyond the “normal construction hours” presented in **Section 0**, the following noise goals apply:

- Evening 1800 hours - 2200 hours **L_{A10} 64 dBA**
- Night-time 2200 hours - 0700 hours **L_{A10} 59 dBA**

In order to minimise the risk of sleep disturbance during night-time construction activities (should they be permitted), the DECC’s ENCM recommends that the $L_{A1(1minute)}$ noise level outside a bedroom window should not exceed the L_{A90} background noise level by more that 15 dBA. The $L_{A1(1minute)}$ noise level may conservatively be estimated by the typical maximum level (L_{Amax}) noise emission.

The L_{Amax} sleep disturbance noise goal for residential receivers near to Belmore Park, based on the background night-time noise levels is indicated in **Table 11** is:

- Night-time 2200 hours - 0700 hours **L_{AMax} 69 dBA**

6.1.1 Construction Noise Goals for Retail and Commercial Receivers

For retail and commercial buildings, it is generally accepted that receivers are 5 dBA to 10 dBA less sensitive to noise emissions than residential receivers.

For this assessment, a conservative allowance of 5 dBA has been applied. As such, for all retail and commercial receivers near to the each of the work sites that are affected by construction activities with a duration of 26 weeks or greater, a background + 10 dBA construction noise goal applies.

- For the Belmore Park work site, where the daytime residential construction noise goal is L_{A10} 66 dBA, a construction noise goal of **L_{A10} 71 dBA** would apply for commercial receivers nearby.

6.2 Operational Noise Goals

6.2.1 Residential Receivers

Intrusive Noise Goals

Based on the ambient noise levels at the Meriton Apartments, and the intrusive noise criterion of RBL + 5 dBA at night, the intrusive noise goals are 59 dBA at night, 64 dBA during the evening and 66 dBA during the day.

Amenity Noise Goals

Given the existing ambient noise levels exceed the recommended acceptable noise levels presented in **Table 3**, in accordance with the INP, noise levels from new developments are required to be 10 dBA below the existing noise levels. Accordingly, the amenity noise goals become **50 dBA** at night, **53 dBA** during the evening and **54 dBA** during the day.

The more stringent amenity criteria therefore determine the site specific operational noise goals. Note however that the amenity criteria apply over the whole daytime, evening and night-time periods whilst the intrusive criteria applies over any 15 minute period.

6.2.2 Commercial Receivers

The INP provides amenity criteria for land uses other than residential and as shown in **Table 3**, for commercial premises the acceptable L_{Aeq} noise levels is 65 dBA. Given the existing ambient noise levels are 1 dBA, 2 dBA and 5 dBA below the recommended acceptable noise level for daytime evening and night-time respectively, in accordance with the INP noise levels from new developments are required to be up to 6 dBA below the existing noise levels.

Accordingly, the amenity noise goal for commercial receivers becomes **59 dBA**.

6.2.3 Emergency Diesel Generator

In accordance with the DECC's Noise Control Guideline for emergency diesel generators, as presented in **Section 4.1.5**, the design goal is **45 dBA** at the residential boundary.

6.3 Construction and Operational Related Road Traffic Noise

As presented in **Table 12** existing noise levels exceed the ECRTN criteria. Therefore, noise emission from construction-related traffic should be controlled so as not to cause an increase of more than 2 dBA at receivers near to each work site. This would require that the L_{Aeq} noise contribution from the CityGrid construction-related traffic activity is at least 2 dBA below existing L_{Aeq} traffic noise levels.

7 OPERATIONAL NOISE EMISSIONS AND ASSESSMENT

7.1 Zone Substation Component

The substation component of the development is located on the eastern side of the building comprising five transformers and associated cooling fans. The substation component will be constructed first and may stand alone for a period of up to 5-10 years before the commercial component of the development is constructed.

7.1.1 Modelling Procedures

The Belmore Park Zone substation computer model was prepared using the SoundPLAN Industrial Module (V6.4), a commercial software system developed by Braunstein and Berndt GmbH in Germany. The software allows the use of various internationally recognised noise prediction algorithms. The CONCAWE method, developed in The Netherlands for the assessment of large industrial plants was used for this model.

The computer model predicts the internal reverberant noise levels within the building, as well as the propagation of noise from external façade elements including louvres, to the receptors. The noise model includes source noise emissions, acoustic shielding from transformer enclosures/blast walls, acoustic shielding from site buildings and other features and the location and height of the potentially most affected and/or representative noise-sensitive receptors.

7.1.2 Noise Modelling Parameters

The Belmore Park Zone substation will be equipped with its ultimate capacity of five 50MVA 132/11kV transformers, located on the ground floor with associated cooling radiators and fans located adjacent to the transformers.

The environmental noise modelling used the following parameters for the transformers, fans and their respective enclosures. The sound power levels used are as advised by Energy Australia for the project. The building layout, internal walls and external louvres used in the model are based on the drawings provided to Heggies on 16 March 2009 with the transformer layout presented in **Appendix B**.

- The guaranteed transformer sound power level for natural cooling with no pumps no fans (oil natural air natural (ONAN) cooling) is 72dBA, measured at 105% excitation with no load. The transformer effective noise source height is 2 m. In addition, the transformers were modelled with a third octave spectrum based on a previously measured 50 MVA transformer. The spectrum was normalised to an overall A-weighted sound power level of 72 dBA.
- The guaranteed transformer sound power level for forced cooling ie with pumps and fans operating (oil directed air fan (ODAF) cooling) is 83dBA measured at 105% excitation with no load. The effective noise source height is 0.5 m. In addition, the transformers were modelled with a third octave spectrum based on that of an axial fan. The spectrum was normalised to an overall A-weighted sound power level of 83 dBA.
- A “worst case” scenario of one transformer on no load (ONAN operation), four transformers on load (ODAF operation), inclusive of radiator fans operational during the night-time has been modelled.
- Acoustic Cell Blockwork, in accordance with the Kann Finch Group specification ZN 8700, has been used on the two internal walls facing the five transformers (to the north and south of each transformer) within the building.

7.1.3 Predicted Noise Levels - Transformers and Cooling Radiators

The calculated L_{Aeq} noise levels at the nearest residential boundaries are presented in **Table 13**. The results include a 5 dBA penalty for tonality, in accordance with the INP guidelines.

Table 13 Computed Noise Levels without Mitigation

Receivers/ Addresses	Floor Level[1]	Criteria (INP Amenity)			Received Noise Level – dBA[2]
		Day	Evening	Night	4 Transformers operating ODAF and 1 Transformer ONAN
Meriton Mosaic 36 Campbell Street	Floor 3	54	53	50	44
317-321 Castlereagh Street	Floor 11	54	53	50	46
428 Pitt Street	Floor 2	59	59	59	44
431 Pitt Street	Floor 3	59	59	59	37
441 Pitt Street	Floor 2	59	59	59	34
323 Castlereagh Street	Floor 4	59	59	59	50

Note 1: Noise levels were predicted at all receiver levels, with the floor shown where the highest levels were predicted.

Note 2: No tonal penalty is applied as the received noise level is dominated by the fans in ODAF mode.

Discussion

The predicted results presented in **Table 13** show compliance for the worst case scenario (4 transformers operating ODAF and 1 transformer operating ONAN) at all receiver locations.

Note, the predicted noise levels do not include any contribution from the basement ventilation, L14 Plant Room or carpark ventilation. Therefore, as the predicted noise levels are 4 dBA or more below the design goal, in order to ensure that the combined transformers plus fan plus basement ventilation Level,14 Plant Room and carpark ventilation does not exceed the 50 dBA night-time criterion, the contribution from the basement ventilation, Level 14 Plant Room and carpark ventilation will be required to be at least 3 dBA below the design goal.

Given the basement ventilation forms part of the zone substation, this source has a nominated design target 6 dBA below the design goal, with the combined L14 Plant room and carpark ventilation also a nominated design target 6 dBA below the design goal.

7.1.4 Predicted Noise Levels - Basement Ventilation

As nominated above in **Section 7.1.3** in order to ensure compliance with the criteria, the contribution by the mechanical plant should be set at nominally 6 dBA below the design criteria. To achieve noise level of 44 dBA (ie 6 dBA below the night-time criterion) at the critical 317 Castlereagh Street receiver, the total radiated SWL is required to be 80 dBA (re 10^{-12} dBW) for the ground floor basement ventilation louvres.

The basement ventilation supply fan and exhaust fan louvres will be located on the Hay Street and Campbell Street facades respectively. Heggies has been provided with preliminary substation louvre layout locations and advised that centrifugal fans will be used in associated plant rooms with a nominal free field sound pressure level of 65 dBA at 3 m for each fan. This sound pressure level equates to a sound power level of 86 dBA, which exceeds the nominal 80 dBA required. Consideration will therefore be required for the use of quieter fans, or the inclusion of attenuators.

Furthermore, in relation to footpath noise, the exhaust vents are located approximately 16 m above pedestrians on Campbell Street and a sound power level of 80 dBA will comply with the 55 dBA target.

7.2 Commercial Building Level 14 Plant Component and Basement Ventilation

The building plantroom is proposed to be located on Level 14 and will indicatively comprise four Air Handling Units (AHU), three chillers, fans, pumps and boilers etc. Whilst preliminary information is available on the functional layout, equipment types and details will be developed during the detailed design phase of the project.

At the nearest residential receivers to the north, the combined plantroom and substation noise level (from the Level 14 Plant Room, carpark fans and the ground level transformer room, transformer radiators and basement ventilation is required to be less than 54 dBA during the daytime, 53 dBA during the evening and 50 dBA during the night-time in order to comply with the INP derived design criteria, as specified in **Section 6.2**.

As nominated above in **Section 7.1.3** in order to ensure compliance with the criteria, the contribution by the mechanical plant should be set at nominally 6 dBA below the design criteria. This will ensure that the combined noise from the Level 14 Plant Room, carpark ventilation and the ground level transformer room and basement ventilation will comply.

Selection of the mechanical plant items (and hence their associated sound power levels) Plant Room louvres and other details will occur during the detailed design, hence assessment and mitigation is beyond the scope of this report.

The noise model was used to provide preliminary information on the maximum radiated A-weighted SWL for the plantroom and ground level carpark louvres, by placing sources mid-way along the northern building facades at these two levels. To achieve noise level of 44 dBA (ie 6 dBA below the night-time criterion) at the critical 317 Castlereagh Street receiver, the total radiated SWL is required to be to be 81 dBA (re 10^{-12} dBW) for the plant room and 80 dBA (re 10^{-12} dBW) for the ground floor basement ventilation louvres.

7.3 Commercial Building Emergency Generators

The emergency generator is proposed to be located on the Level 14 of the building. The capacity is estimated to be 1,500 kVA and details will be refined during the detailed design phase of the project.

The nearest receiver is the Meriton Mosaic apartment building, with the design criterion in accordance with **Section 6.2.3** set at 45 dBA.

Given that the details of the diesel generator are yet to be refined, the maximum radiated sound power level (SWL) has been determined to enable compliance with the criterion based on the DECC guidelines. The maximum radiated A-weighted SWL for the generator is specified to be 82 dBA (re 10^{-12} dBW).

8 OPERATIONAL AND CONSTRUCTION NOISE TRAFFIC ASSESSMENT

Heggies has been advised that the following vehicle movements are expected during the construction and operational phases of the project:

- During construction, anticipated maximum truck movements are 20 spoil truck and 2 delivery truck movements per day. These figures apply to both the substation and commercial development components of the Project, which will be constructed separately.
- During operation, a maximum of 48 vehicle movements per hour, which relates to the use of the basement carpark associated with the commercial development. Vehicle movements associated with the substation building would be minor and limited to regular maintenance inspections and activities.

Based on the very low (in the context of existing road traffic noise) volume of truck movements during construction and vehicle movements during operation presented , the project will not result in traffic noise increases that exceed 2 dBA at the receivers near to the Belmore Park work site. It is predicted that, at most, construction/operation related traffic activity will result in noise increases of less than 1 dBA.

9 OPERATIONAL VIBRATION

9.1 Operational Vibration Substation

The five transformers are located at the building ground level, on the same elevated (with respect to the building foundation excavation) concrete slab at the adjacent office space in the building.

The following control measures are recommended to minimise for vibration transmitted into the elevated supporting concrete structure:

- Double neoprene pad isolators shall be formed by two layers (nominally 6 mm to 8 mm) ribbed or waffled neoprene, separated by a stainless steel or aluminium plate. The layers shall be permanently adhered together.

- The pads shall be 40 to 50 durometer. The pads shall be sized so that they are loaded within the manufacturer's range.
- A steel top plate equal to the size of the pad shall be provided in order to transfer the weight of the supported structure to the pads.

9.2 Operational Vibration Commercial Building

Vibration from the operation of the plant room equipment and emergency generators etc has the potential to impact on the occupied areas within the building. The detailed design of the building and the mechanical plant will need to consider the potential vibration impacts and control measures.

10 CONSTRUCTION NOISE AND VIBRATION ASSESSMENT

10.1 Noise Assessment

10.1.1 Equipment Sound Power Levels

In order to undertake an assessment of construction noise, it is necessary to establish a benchmark Sound Power Level (LA10 and LAmax) for each plant item *likely* to be used on site. Based on numerous measurements undertaken on NSW projects of similar scale to the Belmore Park project, Heggies has determined representative limiting Sound Power Levels for typically-used plant items, as presented in **Table 14**.

These Sound Power Levels have been determined by measuring existing plant in good working order in use in NSW and as such are considered readily achievable on future projects. The sound pressure level at 7 m has been presented in order to allow a direct comparison of audit results on site with the requirements of this Environmental Assessment.

Table 14 Limiting Construction Equipment Sound Power and Pressure Levels at 7 m

Plant Item	Sound Power - dBA		Sound Pressure - dBA	
	LAmax	LA10	LAmax	LA10
Concrete Saw	118	115	93	90
Excavator Hammer	122	116	97	91
Rockbreaker	124	118	99	93
Jackhammer	113	107	88	82
Excavator (~3 tonne)	90	87	65	62
Excavator (~6 tonne)	95	92	70	67
Excavator (~10 tonne)	100	97	75	72
Excavator (~20 tonne)	105	102	80	77
Excavator (~30 tonne)	110	107	85	82
Excavator (~40 tonne)	115	112	90	87
Excavator, over 40 t	118	113	93	88
Skidsteer Loaders (~1/2 tonne)	107	104	82	79
Skidsteer Loaders (~1 tonne)	110	107	85	82
Dozer (equiv. CAT D8)	118	113	93	88
Dozer (equiv. CAT D9)	120	115	95	90
Dozer (equiv. CAT D10)	121	116	96	91
Backhoe/FE Loader	111	107	86	82

Plant Item	Sound Power - dBA		Sound Pressure - dBA	
	LAmax	LA10	LAmax	LA10
Scraper	110	105	85	80
Tractors, tracked (50-100 kW)	117	113	92	88
Grader	110	105	85	80
Tracked Loader (0 to 50 kW)	116	111	91	86
Tracked Loader (200 to 300 kW)	122	117	97	92
Dump Truck (~ 15 tonne)	108	103	83	78
Dump Truck (20 t)	107	102	82	77
Dump Truck (25 t, 120 kW)	114	109	89	84
Concrete Truck	112	107	87	82
Concrete mixer truck, (24 t)	116	111	91	86
Concrete Pump	109	107	84	82
Concrete Vibrator	105	103	80	78
Concrete vibrator, hand held	103	101	78	76
Bored Piling Rig	110	104	85	79
Vibratory Roller (~10 tonne)	114	111	89	86
Vibratory Pile Driver	121	115	96	90
Compressor (~ 600 CFM)	100	100	75	75
Compressor (~1500 CFM)	105	105	80	80
Compressor Standard	111	111	86	86
Compressor Super silenced	95	95	70	70
Generator	104	103	79	78
Lighting Tower	80	80	55	55
Flood Lights	90	90	65	65
Cherry Picker	102	99	77	74
Mobile Crane	110	105	85	80
Crane, truck mounted (20 t to 60 t)	109	104	84	79
Hammer drill	112	109	87	84
Grinder	106	103	81	78
Chipping hammer/chisel	119	116	94	91
Impact wrench (12mm cap)	97	94	72	69
Electric Drill	91	88	66	63
Rattle Gun, hand held	105	102	80	77

10.1.2 Construction Noise Impacts

The nearest residential receiver has been identified as the Meriton Mosaic apartments overlooking Belmore Park and located approximately 40 m from the nearest (northern) boundary of the site.

Based on the Sound Power Levels presented in **Table 14**, a construction noise assessment has been undertaken for the residential receivers in the Meriton Mosaic building overlooking the Belmore Park site. The nearest receivers with direct line of site to Belmore Park are approximately 40 m from the nearest boundary of the proposed work site.

These results are indicative of the operation of some of the noisier plant items working in isolation at the northern boundary of the site, representative of early ground level works when establishing the site.

Table 15 Belmore Park Construction Noise Assessment Results - dBA

Plant Item	Sound Pressure, 40 m	
	LAmax[1]	LA10[2]
Concrete Saw	**77**	**74**
Excavator Hammer	**81**	**75**
Rock-breaker	**83**	**77**
Jackhammer	**72**	66
Excavator (~3 tonne)	49	46
Excavator (~6 tonne)	54	51
Excavator (~10 tonne)	59	56
Excavator (~20 tonne)	64	61
Excavator (~30 tonne)	69	66
Excavator (~40 tonne)	**74**	**71**
Excavator, over 40 t	**77**	**72**
Skidsteer Loaders (~1/2 tonne)	66	63
Skidsteer Loaders (~1 tonne)	69	66
Dozer (equiv. CAT D8)	**77**	**72**
Dozer (equiv. CAT D9)	**79**	**74**
Dozer (equiv. CAT D10)	**80**	**75**
Backhoe/FE Loader	**70**	66
Scraper	69	64
Tractors, tracked (50-100 kW)	**76**	**72**
Grader	69	64
Tracked Loader (0 to 50 kW)	**75**	**70**
Tracked Loader (200 to 300 kW)	**81**	**76**
Dump Truck (~ 15 tonne)	67	62
Dump Truck (20 t)	66	61
Dump Truck (25 t, 120 kW)	**73**	**68**
Concrete Truck	**71**	66
Concrete mixer truck, (24 t)	**75**	**70**
Concrete Pump	68	66
Concrete Vibrator	64	62
Concrete vibrator, hand held	62	60
Bored Piling Rig	69	63
Vibratory Roller (~10 tonne)	**73**	**70**
Vibratory Pile Driver	**80**	**74**
Compressor (~ 600 CFM)	59	59
Compressor (~1500 CFM)	64	64
Compressor Standard	**70**	70
Compressor Super silenced	54	54

Plant Item	Sound Pressure, 40 m	
	LAmax[1]	**LA10[2]**
Generator	63	62
Lighting Tower	39	39
Flood Lights	49	49
Cherry Picker	61	58
Mobile Crane	69	64
Crane, truck mounted (20 t to 60 t)	68	63
Hammer drill	**71**	**68**
Grinder	65	62
Chipping hammer/chisel	**78**	**75**
Impact wrench (12mm cap)	56	53
Electric Drill	50	47
Rattle Gun, hand held	64	61

Note 1: L_{AMAX} noise levels predicted to exceed the Belmore Park Sleep Disturbance criterion of 69 dBA are shown in **Bold**

Note 2: L_{A10} noise levels predicted to exceed the Belmore Park Daytime noise criterion of 66 dBA are shown in **Bold**

A review of reveals that approximately 50% of the typical plant items modelled would exceed either the night-time sleep disturbance or the daytime noise criteria. This is not atypical for construction activity in populated urban areas.

Due to the possible exceedances identified, it will be necessary to implement all feasible and reasonable construction noise mitigation measures, including erecting hoardings along site boundaries and selecting the smallest and quietest practicable plant items for each task, whilst maintaining efficiency of operation. These measures will apply equally to the substation and commercial building components of the project, which will be constructed separately in a staged approach potentially up to 5-10 years apart.

10.2 Construction Vibration

10.2.1 Vibration-Intensive Plant

Safe working distances for typical items of "above-ground" vibration-intensive plant are listed in **Table 16**.

These distances are indicative only and can vary depending upon the particular item of plant and geotechnical conditions. For the purpose of this study, a "safe distance" would correspond to the distance at which the maximum vibration level generated by the operation of a subject plant item is predicted not to exceed 2 mm/s.

Table 16 Safe Working Distances for Vibration Intensive Plant Items

Item	Rating	Safe Working Distance	Comments
Rockbreaker	Light (eg Krupp HM 170)	5 m	Based on a 5 mm/s criterion
	Medium (eg Krupp HM 580)	10 m	Based on a 5 mm/s criterion
	Heavy (eg Krupp HM 960)	30 m	Based on a 5 mm/s criterion
Vibratory Hammer (Piling)	12 t Down force	15 m minimum	Based on a 5 mm/s criterion
Hand held jack hammer	-	1 m (nominal)	Avoid contact with structure

Note: The safe working distances apply to structural damage of typical buildings and typical geotechnical conditions. They do not address heritage structures or human comfort considerations. Vibration monitoring is recommended to confirm the safe working distances at specific sites.

Vibration monitoring is recommended for site-specific activities and in situations where there is any doubt regarding the suitability of the plant or where there is believed to be a risk of exceeding the applicable vibration criteria.

Such site validation would allow mitigation options to be established for any work causing excessive vibration, ensuring that disruptions to building tenants are minimised. Such measures could include minimum buffer distances for certain plant items, preferred hours for particular activities or alternate work methods. A programme of vibration monitoring is further discussed in **Section 11.4**.

10.2.2 Effects on Railway Infrastructure

The existing Eastern Suburbs Railway (ESR) passes in close proximity to the Belmore Park Substation and Commercial Development. The ESR is approximately 20 m away from the substation building and approximately 11 m away from the commercial building.

Depending on the precise construction techniques adopted, vibration monitoring may be required in the ESR tunnels whilst construction work proceeds. The need for vibration monitoring in the tunnels would be the subject of further discussions with RailCorp. Similarly, depending on vibration levels expected at the site, additional excavation methods such as saw cutting of limited areas, operation of lower capacity hammers and the like could be adopted to further minimise vibration affects on the tunnel.

11 CONSTRUCTION NOISE AND VIBRATION MANAGEMENT

11.1 Identifying and Managing Future Noise and Vibration Issues

If additional activities or plant are found to be necessary that will result in noise or vibration emissions significantly exceeding those assumed for this assessment (eg impact pile driving), these should be assessed by a qualified noise and vibration expert on a case-by-case basis and appropriate mitigation measures should be implemented.

11.2 Summary of Mitigation Measures

A summary of the noise and vibration mitigation measures that should be implemented for the subject works is listed in **Table 17**.

11.3 Effects of Rail Operations on Proposed Development

Further to Section 10.2.2, it is noted that the operation of the existing ESR rail tunnels may have the potential to impact on the substation and commercial developments. Whilst these impacts are expected to be negligible, the detailed design of both buildings will need to take into consideration the potential acoustic and vibration impacts from the ESR and other sources, and to incorporate mitigation measures, as required.

Table 17 Noise and Vibration Mitigation Measures

Item	Description
Site layout	Where possible, plant will be located and orientated to direct noise away from sensitive receivers.
Construction Hours	Works will be carried out within standard Construction Hours, except as permitted by Conditions of Consent.
Out of Hours works	The noisiest construction activities should take place before 2200 hours, wherever feasible, and endeavour to undertake as much preparation work as feasible in the day-time hours.
Deliveries	Deliveries will be carried out within standard Construction Hours, except as permitted by Conditions of Consent.
Quietest Suitable Equipment	Plant and equipment will be selected to minimise noise emission, as far-as possible, whilst maintaining efficiency of function. Residential-grade silencers will be fitted and all noise control equipment and will be maintained in good order.
Rock Hammering	Works will be carried out within specified Rockbreaking Hours.
Piling	Works must be completed using non-percussive piles. If percussive piles are proposed to be used, approval of the Environmental Management Representative or Director General of the Department of Planning must be obtained following consultation with the DECC.
Reversing Alarms	Non-tonal reversing beepers must be fitted and used on all construction vehicles and mobile plant used for any out of hours work. Mobile plant and trucks operating on site for a significant portion of the project will have reversing alarm noise emissions minimised as far-as possible, recognising the need to maintain occupational safety.
Fixed Plant	Fixed plant will be provided with noise controls to comply with the NSW INP.
PA System	To be used within standard Construction Hours, except in emergency situations.
Noise Barriers - General	Where they are effective and reasonable, solid hoardings and/or site sheds will be erected on work site boundaries and/or around critical work areas on the sites.
Noise Monitoring	Noise monitoring will be carried out to determine compliance with airborne construction noise goals in response to complaints and to conduct plant noise audits.
Vibration Buffer Zones	General safe working distances for rockbreaking and vibratory compaction are described in **Table 16**. Where required, monitoring will be carried out to confirm these buffer zones at locations where buildings are closest.
Vibration Monitoring	Vibration monitoring will be carried out where vibration intensive activities (eg rockbreaking or vibratory compaction) are required to be carried out within the established buffer zones or where there is considered to be a risk that levels may exceed the relevant structural damage criteria.
Truck Noise (off site)	All trucks regularly used for the project (eg spoil trucks) will have mufflers and any other noise control equipment in good working order. Trucking routes will use main roads where feasible.
Educational Facility and Religious Institution Consultation	Affected pre-schools, schools, universities and any other affected educational and religious institutions must be consulted in relation to noise mitigation measures. Noise-intensive construction works in the vicinity of affected educational buildings are not to be timetabled during examination periods, unless other arrangements acceptable to the affected institutions are made at no cost to affected institutions.
Community Liaison	A programme of community liaison and complaint response will be implemented including letter-box drops of proposed noisy activities, progress reports, etc.
Training	Site induction training will include a noise awareness component.

11.4 Noise and Vibration Monitoring

11.4.1 Noise Monitoring

Appropriate noise levels for the relevant classes of construction equipment (with noise control equipment maintained in good condition) have been identified in **Table 14**. Plant and equipment will be checked for compliance with these L_{Amax} noise limits using an audit approach.

Timing of the audits will be as scheduled in **Table 18**. Plant operating on site will be measured under the maximum noise conditions normally occurring. Any equipment significantly exceeding the appropriate noise levels should not be permitted to continue operation on site until noise control measures have been upgraded.

Table 18 Noise Monitoring Recommendations

Monitoring	Schedule	Locations	Procedures and Instrumentation
Attended Monitoring	During relevant periods of construction. Random, but at intervals not exceeding 30 actual days worked by EA.	Alternate between the following locations or others as may be identified as affected from time to time. Receivers near Belmore Park work site.	Attended measurements to quantify and qualify construction noise emissions using a calibrated sound level meter capable of measuring L_{A90}, L_{Aeq}, L_{A10} and L_{A1} statistical noise levels in 15 minute intervals. Minimum of four 15 minute samples per survey. Extraneous noise may be excluded from the measurements. Sources contributing to the noise levels are to be noted.
Plant Noise Audits	Random, but at intervals not exceeding 60 actual days worked by EA.	On site, typically at 7 m from the item of plant in the direction of dominant noise emission. Closer to the source if other sources prevent measurement at this distance.	Attended measurements using a calibrated sound level meter capable of measuring L_{Aeq}, L_{A10} and L_{A1} statistical noise levels. Select the items of plant which appear to be the most dominant sources of noise. Measure noise emissions under conditions of maximum noise normally occurring for that source. For most noise sources, a one minute sample will be satisfactory, although sampling may be extended up to 15 minutes for sources varying greatly over time. Compare the results with levels presented in **Table 14**. Equipment significantly exceeding the appropriate noise levels should not be permitted to continue operation on site until noise control measures have been inspected and upgraded.

It is intended that the above monitoring will be conducted for the assessment and examination of potential reasonable and feasible offsite noise and/or vibration mitigation measures.

11.4.2 Vibration Monitoring and Buffer Distance Tests

Vibration monitoring should be carried out in accordance with the recommendations in **Table 19**.

Table 19 Vibration Monitoring Recommendations

Monitoring	Schedule	Locations	Procedures and Instrumentation
Routine Monitoring	TBC	TBC	TBC
Buffer Distance Tests	At the commencement of work with potentially vibration inducing equipment.	At base of potentially affected structure for structural damage issues.	Attended and/or unattended measurements using a calibrated instrument capable of measuring peak particle velocity vibration in 3 axes.
		On the affected floor for human comfort issues.	Attended and/or unattended measurements using a calibrated instrument capable of measuring RMS velocity, or acceleration in 1/3 octave bands.
Response to Complaints	As required.	At base of potentially affected structure for structural damage issues.	Attended and/or unattended measurements using a calibrated instrument capable of measuring peak particle velocity vibration in 3 axes.
		On the affected floor for human comfort issues.	Attended and/or unattended measurements using a calibrated instrument capable of measuring RMS velocity, or acceleration in 1/3 octave bands.

11.5 Non-Compliance and Corrective Action

Where the noise and/or vibration monitoring identifies non-compliance with the relevant criteria, the contractor will plan and carry out corrective action in consultation with an appropriately qualified acoustical consultant familiar in the assessment and management of construction noise and vibration.

The corrective action may involve supplementary monitoring in order to identify the source of the non-conformance and/or may involve modification of the construction techniques or programme in order to avoid any recurrence or minimise its adverse effects.

11.6 Complaint Handling

The contractor will adopt the following protocol for handling complaints. This protocol is intended to ensure that the issues are addressed and that appropriate corrective action is identified and implemented as necessary:

- It is proposed that a 24-hour, 7days/week toll-free telephone construction response line would be in place for community enquiries and complaints regarding construction activities.
- All complaints will be forwarded to the Community Relations Manager for investigation.
- Records will be kept regarding the source and nature of the complaint.
- The complaint will be investigated in order to determine whether noise and/or vibration have occurred unnecessarily.
- If unnecessary noise and/or vibration have been caused, corrective action will be planned and implemented.
- Complaints will receive a verbal response within 2 hours during construction hours and 24 hours outside of construction hours.
- Complainants will be informed that their complaints are being addressed and (if appropriate) that corrective action is being taken.

- Follow-up investigations will be carried out where necessary in order to confirm the effectiveness of the corrective action.
- Complainants will be informed of the successful implementation of the corrective action that has been taken to mitigate the adverse effects.
- Details of complaints and corrective action will be reported at the end of each day to *EnergyAustralia* and a letter dispatched within 7 calendar days to the complainant.

11.7 Reporting

All monitoring should be reported and incorporated into the contractor's monthly and six-monthly reports to *EnergyAustralia*. These reports will include the following:

- Monitoring locations.
- Tabulation of noise measurement results together with notes identifying the principal noise sources.
- Tabulated vibration monitoring results together with notes describing any vibration intensive activities (if applicable).
- Summary of measurements exceeding the criteria levels and descriptions of the plant or operations causing these exceedances (if applicable).
- Details of corrective action applicable to criteria exceedances (if applicable) and confirmation of its successful implementation. Where corrective action has not yet been implemented, it may be shown as pending and the status of its implementation shall be carried forward to following reports.

The results of supplementary monitoring will be reported in full if this monitoring is carried out in response to complaints or exceedances. When supplementary monitoring is carried out to refine techniques, full reporting is not required. The monthly reports should also include the number and nature of any noise and/or vibration complaints.

11.8 Community Consultation and Liaison

Community consultation should be undertaken by the contractor and *EnergyAustralia* and should include:

- Prior to works commencing and during works, liaising with stakeholders expected to be impacted by construction noise and vibration levels which may exceed the objectives set out in this and future Noise and Vibration Environmental Assessments for the project.
- Advising the community of work to be undertaken.
- Notifying the Local Authority of works detailing proposed work, duration, location and hours, in case of complaints.
- Notifying residents of any works 7 to 14 days prior to the commencement of works.
- Recording, reporting and managing any complaints.

12 CONCLUSION

Heggies Pty Ltd (Heggies) has been engaged by Plancom Consulting Pty Limited (PlanCom), on behalf of EnergyAustralia, to prepare an Noise and Vibration Assessment for the construction and operational phases of the Belmore Park Zone Substation element of the Sydney CityGrid Project. The project is proposed by Energy Australia to cater for future energy demand, and to ensure timely replacement of infrastructure, for the supply of electricity to the Sydney CBD.

This study forms part of the Environmental Assessment Report in support of the Belmore Park Zone Substation Project and its results and findings are summarised in the following points:

- The project includes a integrated development comprising a Zone Substation and a Commercial office building.
- The assessment is to follow the Director-General's noise and vibration requirements for the Environmental Assessment which states: *"the Environmental Assessment must include an assessment of the noise and vibration impacts during the construction and operation of the project, in accordance with relevant NSW Government and DECC policies and guidance current at the time of the assessment."*
- An ambient noise survey has been conducted and accordingly, operational and construction noise goals have been set in accordance with DECC policies and guidelines.
- Noise levels for the operation of the substation, basement ventilation system, and the Level 14 plant equipment have been predicted at the nearest residences. The substation component is predicted to comply with the design goals. For compliance of the combined substation, basement ventilation system and Level 14 plant equipment indicative control measures are discussed.
- To minimise vibration from the transformers, isolation techniques have been recommended.
- Construction noise calculations indicate exceedances of the nominated design goals and it will be necessary to implement all feasible and reasonable construction noise mitigation measures. Construction noise and vibration management techniques including noise mitigation, noise and vibration monitoring, non-compliance and complaints handling and reporting and have been discussed.

13 SUMMARY OF SUBSTATION OPERATIONAL NOISE CONTROL MEASURES AND EQUIPMENT SOUND POWER LEVELS

The recommended noise control measures and equipment sound power levels as used and specified in the assessment are summarised as follows:

- The guaranteed transformer sound power level for natural cooling with no pumps no fans (ONAN cooling) is 72dBA, measured at 105% excitation with no load.
- The guaranteed transformer sound power level for forced cooling ie with pumps and fans operating (ODAF cooling) is 83dBA measured at 105% excitation with no load.
- Acoustic Cell Blockwork, in accordance with the Kann Finch Group specification ZN 8700, is to be used on the two internal walls facing the five transformers.
- The maximum radiated SWL is required to be to be 80 dBA (re 10^{-12} dBW) for the ground floor basement ventilation louvres.

ACOUSTIC TERMINOLOGY

1 Sound Level or Noise Level

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2E-5 Pa.

2 “A” Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an “A-weighting” filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120 110	Heavy rock concert Grinding on steel	Extremely noisy
100 90	Loud car horn at 3 m Construction site with pneumatic hammering	Very noisy
80 70	Kerbside of busy street Loud radio or television	Loud
60 50	Department store General Office	Moderate to quie
40 30	Inside private office Inside bedroom	Quiet to very quie
20	Jnoccupied recording studi	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as “linear”, and the units are expressed as dB(lin) or dB.

3 Sound Power Level

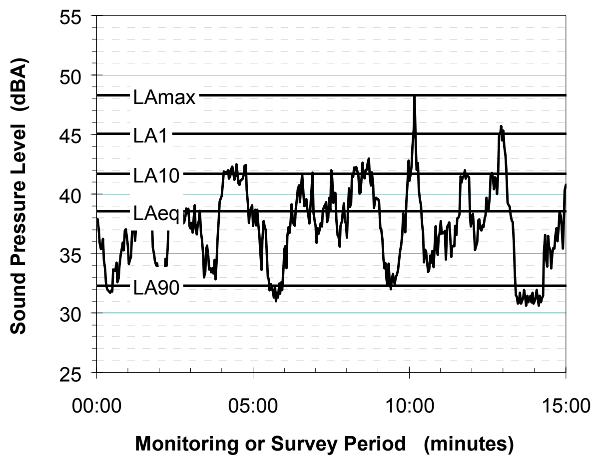
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 1E-12 W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

- L_{A1} The noise level exceeded for 1% of the 15 minute interval.
- L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.
- L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.
- L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the “repeatable minimum” LA90 noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or “average” levels representative of the other descriptors (LAeq, LA10, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than “broad band” noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

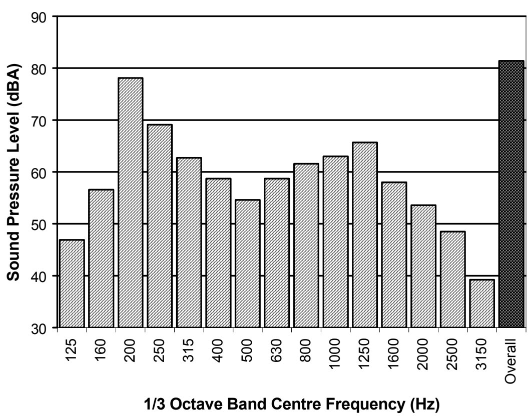
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of "peak" velocity or "rms" velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as "peak particle velocity", or PPV. The latter incorporates "root mean squared" averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (*aligned* toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (1E-6 mm/s). Care is required in this regard, as other reference levels are used by some organizations.

9 Human Perception of Vibration

People are able to "feel" vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

10 Overpressure

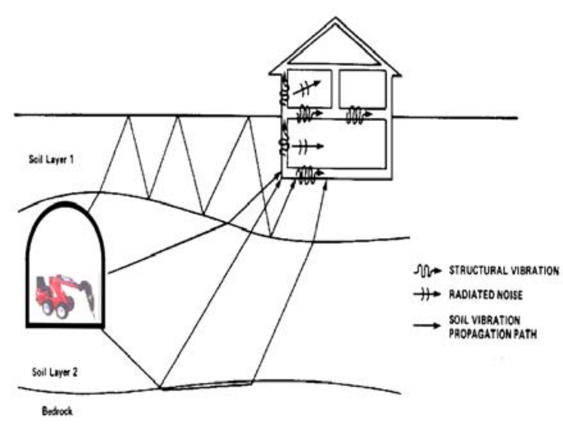
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Regenerated Noise

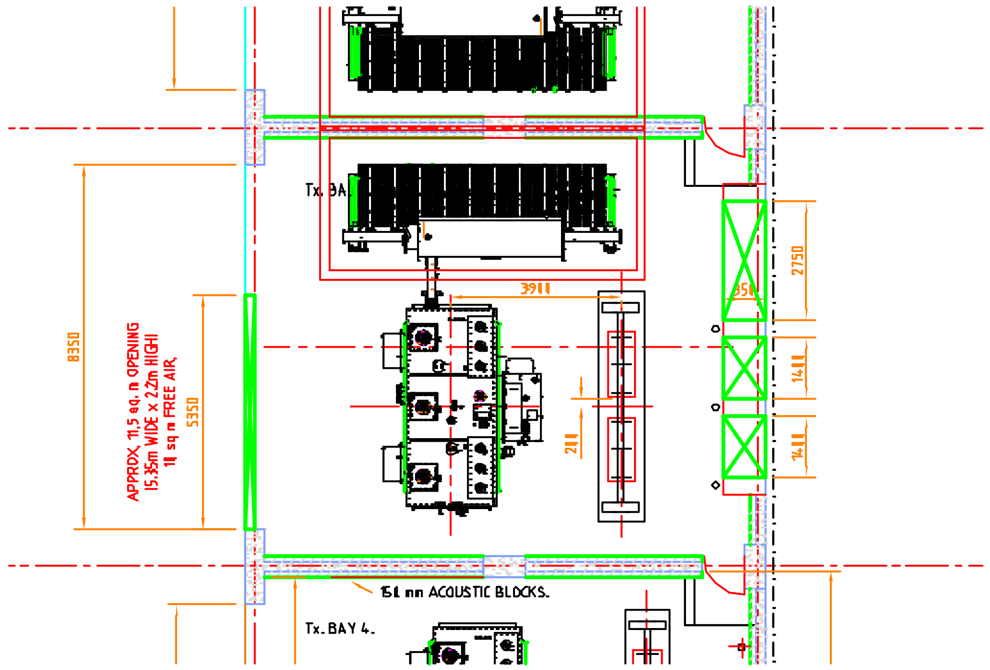
Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed "regenerated noise", "structure-borne noise", or sometimes "ground-borne noise". Regenerated noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

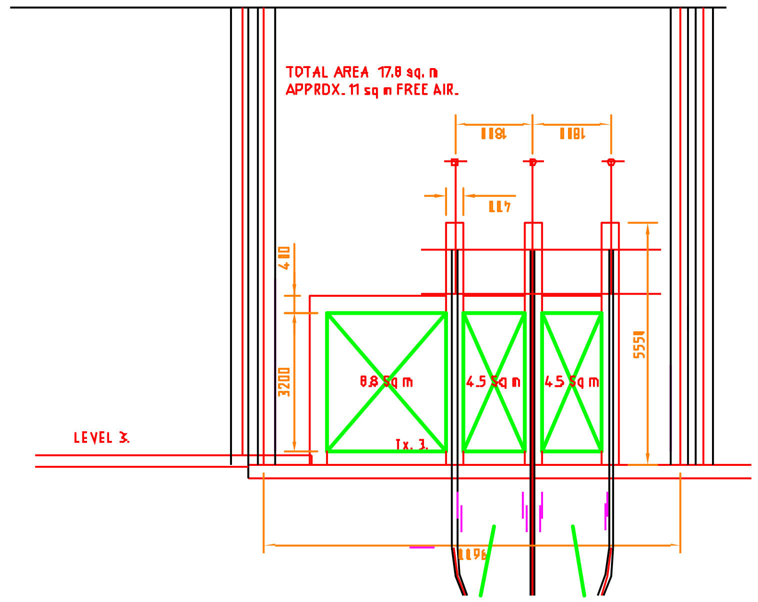
Typical sources of regenerated noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

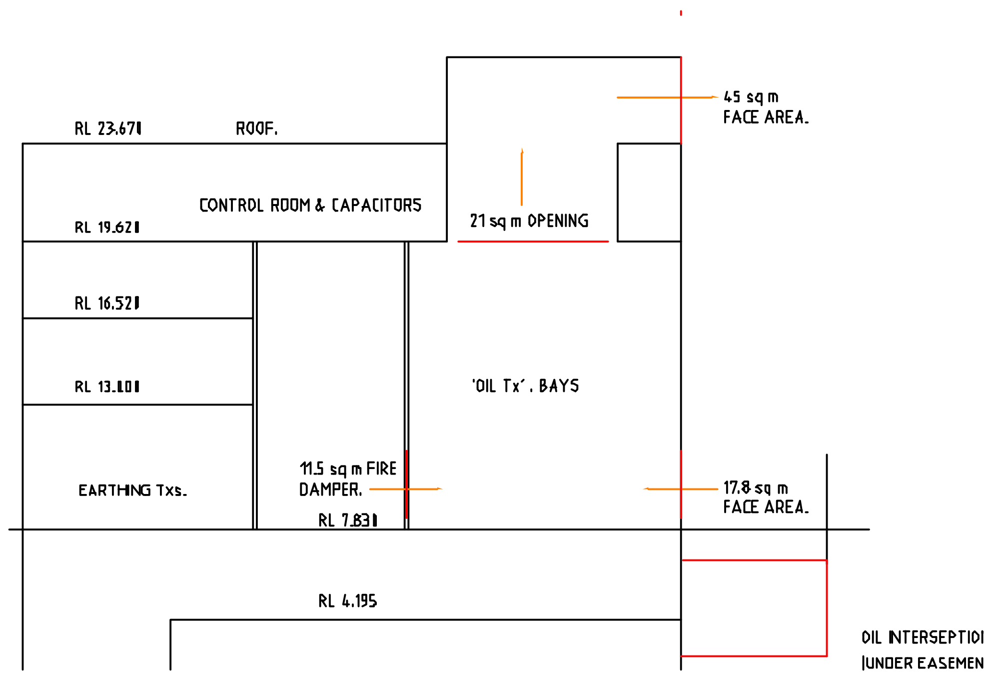
The following figure presents the various paths by which vibration and regenerated noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term "regenerated noise" is also used to describe other types of noise that are emitted from the primary source as a different form of energy. One example would be a fan with a silencer, where the fan is the energy source and primary noise source. The silencer may effectively reduce the fan noise, but some additional noise may be created by the aerodynamic effect of the silencer in the airstream. This "secondary" noise may be referred to as regenerated noise.







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