Appendix D

Noise and vibration

HEGGIES

REPORT 10-6560-R1

Revision 0

Sydney CityGrid Project
Environmental Assessment
Noise and Vibration

PREPARED FOR

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POTTS POINT NSW 2011

27 NOVEMBER 2008

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Sydney CityGrid Project
Environmental Assessment
Noise and Vibration

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10-6560-R1	Revision 0	27 November 2008	Matthew Verth	John Sleeman	John Sleeman

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1 INTRODUCTION

Heggies Pty Ltd (Heggies) has been engaged by Plancom Consulting Pty Limited (PlanCom), on behalf of *EnergyAustralia* to prepare a Noise and Vibration Assessment, including a statement of commitments, for the construction phase and operational phase of the Sydney CityGrid 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 Draft Environmental Assessment Report in support of the Sydney CityGrid project.

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

The Sydney CityGrid project is proposed in order for *EnergyAustralia* to meet their license conditions, to cater for future electricity demand, and to maintain a reliable supply of electricity to Sydney CBD by ensuring timely replacement of electricity supply and distribution infrastructure which is due for retirement..

The project comprises several components which are as follows:

1. **Extension to the existing City South Cable Tunnel** from Wade Place to Riley Street, Surry Hills (approximately 150 m);
2. **Stub Tunnel Connection from the existing City South Cable Tunnel** (nominally 20 m below Campbell Street) to the proposed Belmore Park Zone Substation;
3. **Belmore Park Zone Substation**, encompassing commercial/retail development (at the corner of Pitt, Hay and Campbell Streets);
4. **City East Cable Tunnel** (approximately 3.2 km) from Riley Street, Surry Hills, to Erskine Street, in the northern end of the CBD, inclusive of potential ventilation shaft and services mid-way along the alignment;
5. **City East Zone Substation**, potentially encompassing commercial/retail development (at a site yet to be determined);
6. **New Sub-transmission Switching Station (STSS) at Riley Street**, Surry Hills, and potentially a tunnel services control and access to the City East Cable Tunnel (alternatively, the control and access would be located at a mid-way point along the tunnel alignment); and
7. Potential refurbishment or replacement of the existing **Dalley Street Zone Substation** or building at a nearby site.

A site plan showing proposed work locations and tunnelling alignment options are presented in **Figure 1**. Work sites are numerically identified according to the list presented above.

2.2 Proposed Construction Activities

The construction works being undertaken as part of the proposed CityGrid Project are likely to include:

2.2.1 Extension to the Existing City South Cable Tunnel (CSCT)

- Site preparation.
- Excavation of Little Albion Street.
- Interface to Wade Place Substation.
- Tunnelling by roadheader.
- Spoil removal.
- Resurfacing of excavated site in Little Albion Street.

2.2.2 Stub Tunnel Connection from the Existing City South Cable Tunnel

- Site preparation and establishment of Belmore Park Site.
- Excavation of Belmore Park site adjacent to Campbell Street.
- Tunnelling by roadheader.
- Spoil removal for Stub Tunnel only.

2.2.3 Belmore Park Zone Substation

- Site establishment.
- Excavation for footings.
- Construction of new substation and commercial building.

2.2.4 City East Cable Tunnel (CECT)

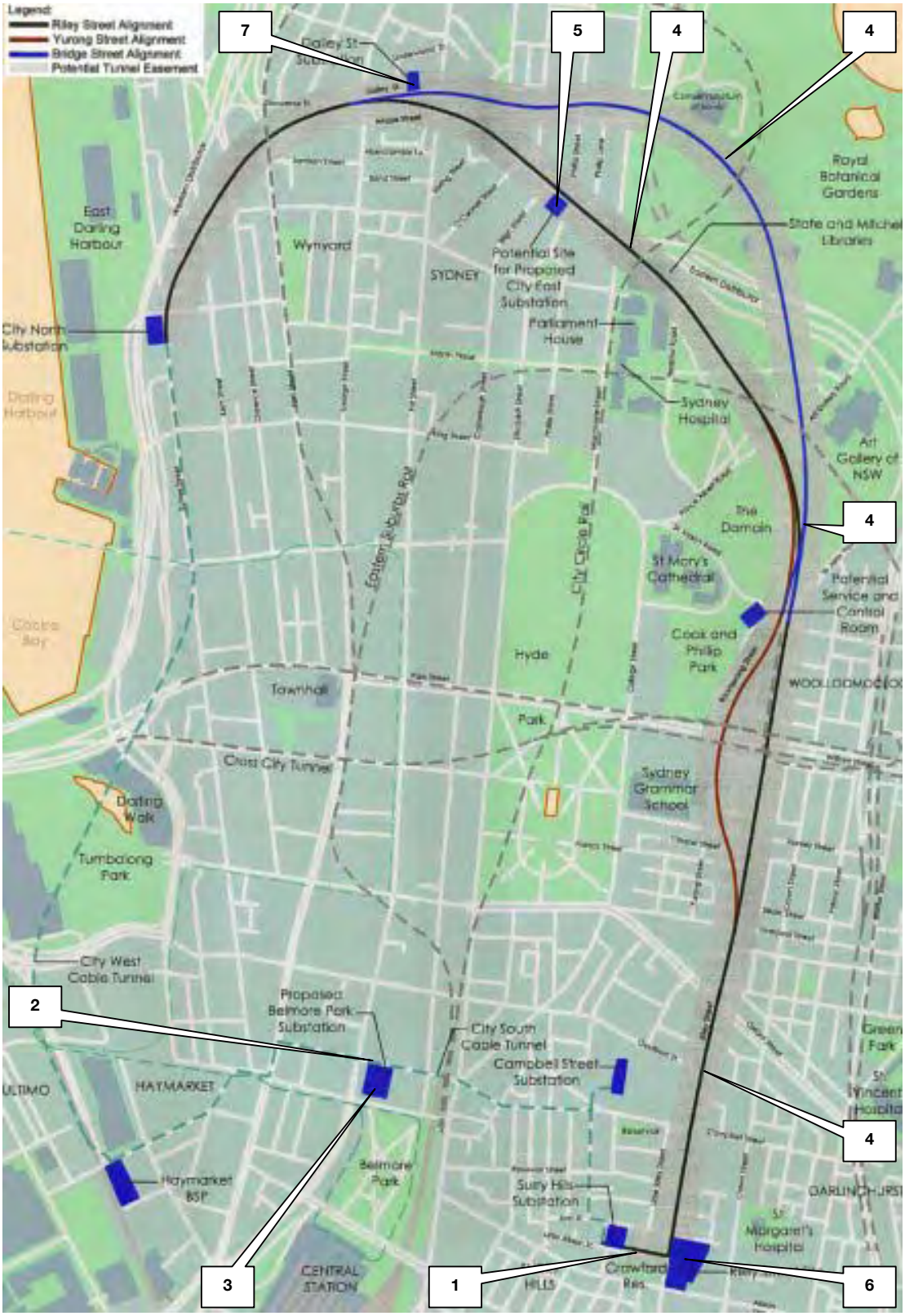
- Site establishment at Riley Street work site.
- Excavation to allow launch of Tunnel Boring Machine.
- Construction of 'acoustic' shed at Riley Street work site.
- Excavate TBM cavern and launch TBM.
- 3,200 m of tunnelling.
- Spoil removal.

2.2.5 City East Zone Substation

(Subject to site selection, to be confirmed)

- Demolition of existing building, if vacant site not selected.
- Excavation.
- Interface with CECT.
- Construction of new Substation building.

Figure 1 Proposed Work Locations and Tunnel Alignment Options



2.2.6 Sub-transmission Switching Station (STSS) at Riley Street

- Site establishment.
- Excavation.

2.2.7 Dalley Street Zone Substation

- Upgrading Dalley Street Substation.
- Interface with CECT.

2.3 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	Estimated Truck Movements/Day
Establishment of Belmore Park Site and bulk excavation	Power tools, concrete saws, rock hammers, bulldozer, excavator, concrete agitator and pump, delivery vehicles, crane	May 2009 - Apr 2010	1-2 deliveries per day plus peak of 20 spoil truck movements per day
Construction of 13 levels combined substation and commercial site, commencement of substation development	Crane, scaffolding, concrete pumps, concrete vibrators, concrete delivery trucks, placement of steel reinforcement, scabbling, air compressor, jack hammers, concrete / bitumen saw cutting	Apr 2010 - Mar 2012 Commercial: 2012 - 2014	Substation: 1-2 deliveries per day Commercial: 3-4 deliveries per day plus peak of 20 spoil truck movements per day
Establishment of Riley Street Site and bulk excavation	Power tools, concrete saws, rock hammers, excavator, concrete agitator and pump, delivery vehicles, crane	Aug 2010 - Mar 2011	1-2 deliveries per day plus peak of 20 spoil truck movements per day
Excavate TBM entry cavern and CSCT extension	Road-header, gantry crane, delivery vehicles, spoil trucks, excavator, dump truck, front-end loader, power tools, ventilation fan	Mar 2011 – Oct 2011	1-2 deliveries per day 4-5 Spoil trucks per day
Construct lining for CSCT extension and tunnel fitout	Delivery vehicles, concrete agitator and pump, power tools and general equipment, ventilation fan	Oct 2011 - Mar 2012	1-2 Concrete deliveries per day during Nov/Dec 2011
Mobilise and assemble TBM	TBM, gantry crane, delivery vehicles, front-end loader	Oct 2011 - Dec 2011	Included above

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements/Day
Excavate TBM tunnel between Riley Street Site and City North Zone Substation	TBM, general delivery vehicles, spoil trucks, semi-trailers (concrete segment delivery), grout rig, gantry crane, ventilation fan, front-end loader, excavator, dump truck, general tools and equipment	Dec 2011 - Apr 2013	Segment delivery - 5 trucks per day for approximately 200 days Spoil removal - 10-15 day
Remove TBM backup assembly and demobilise	Gantry crane, transport vehicles, general plant and equipment	May 2013	General construction traffic only
TBM tunnel fitout	Delivery vehicles, power tools, gantry crane, ventilation fan, general plant and equipment	May 2013 – Jul 2014	1-2 trucks every 3 days
Services control room (if required at Cook & Phillip Park)	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools excavator, front-end loader, road-header, dump truck and crane	Mar 2012 – Aug 2011	2-3 trucks per day for spoil removal plus general deliveries
Construction of Riley St STSS	Crane, scaffolding, concrete pumps, concrete vibrators, concrete delivery trucks, placement of steel reinforcement, scabbling, air compressor, jack hammers, concrete / bitumen saw cutting	May 2013 – Sep 2014	1-2 deliveries per day for substation. 3-4 deliveries per day plus peaking during concrete pours for commercial development
Dalley Street Substation shaft and stub tunnel	Boring rig, concrete agitator and pump	Apr 2013 - Sep 2013	2-3 trucks per day for spoil removal plus general deliveries
General surface works (cable trenching around Dalley, Gresham, Bent Streets)	Excavator, spoil truck, delivery vehicles, concrete agitator and pump	Sep 2013 - Apr 2014	1-2 trucks per day
Bulk excavation for City East Zone Substation	Power tools, concrete saws, rock hammers, bulldozer, excavator, concrete agitator and pump, delivery vehicles, crane	Apr 2012 – Nov 2012	1-2 deliveries per day plus peak of 20 spoil truck movements per day
City East Zone Substation shaft and stub tunnel construction	Boring rig, concrete agitator and pump, delivery vehicles, spoil trucks, power tools, excavator, front-end loader, roadheader, dump truck and crane	Sep 2012 – Oct 2013	2-3 trucks per day for spoil removal plus general deliveries

Construction Activity	Typical Equipment	Approximate Timing	Estimated Truck Movements/Day
Construction City East Zone Substation and commercial component	Crane, scaffolding, concrete pumps, concrete vibrators, concrete delivery trucks, placement of steel reinforcement, scabbling, air compressor, jack hammers, concrete / bitumen saw cutting	Oct 2013 – Dec 2015	1-2 deliveries per day for substation. 3-4 deliveries per day plus peaking during concrete pours for commercial development
Fitout Riley Street control room	Power tools, crane, delivery vehicles	Aug 2014 - Apr 2015	1 truck per day
Reinstate Riley Street Site and demobilise	Excavator, front-end loader, delivery vehicles, power tools	Apr 2015 - Jun 2015	1-2 per day - general deliveries only
132 kV cable installation – Belmore Park	Cranes, semi trailers, delivery vehicles	Nov 2012 - Mar 2014	Semi trailer and crane (cable delivery) - once every 3 weeks
132 kV cable installation – Riley St	Cranes, semi trailers, delivery vehicles	Apr 2015 - Nov 2010	Semi trailer and crane (cable delivery) - once every 3 weeks General deliveries over the period
132 kV cable installation – City East	Cranes, semi trailers, delivery vehicles	Jun 2015 - May 2016	Semi trailer and crane (cable delivery) - once every 3 weeks General deliveries over the period
132 kV cable installation – Dalley St	Cranes, semi trailers, delivery vehicles	Oct 2016 - Mar 2018	Semi trailer and crane (cable delivery) - once every 3 weeks General deliveries over the period

This preliminary information has been used in this 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.

2.4 Timeline of Processes and Activities

Table 2 presents the anticipated construction and operational activities, by work site, combined with an approximation of the anticipated start and completion dates, as at May 2008.

Table 2 Proposed Construction and Operation Schedule

Work Site ID[1]	Work Site Name	Indicative Project Timetable, Year										
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
3	Belmore Park Substation											
2	Belmore Park Stub Tunnel											
1	CSCT Extension											
4	CECT											
6	Riley Street STSS											
5	City East Substation											
7	Dalley Street Substation											

Note 1: As per **Section 2.1** and **Figure 1**

Table 2 Key:

Concept Approval
Project Approval
Final Design and Construction
Operation
Nil

A review of **Table 2** reveals that for all work sites, construction activities are predicted to have a duration of greater than 26 weeks (assuming that construction activities take a reasonable proportion of the 'Final Design and Construction' Period shown by the green fill).

This is of significance (particularly for the 'stationary' work sites) when deriving and establishing demolition and construction noise criteria (refer to **Section 4**). There may be further considerations that would apply to 'transitory' construction activities (such as the CECT construction and all other tunnelling works).

2.5 Identification of Noise and Vibration-Sensitive Receivers

The following sections identify the noise and vibration-sensitive receivers by work site. For each location, the work site or tunnel alignment is indicated with a red graphic, and the most significant noise and/or vibration issues that are envisaged are identified.

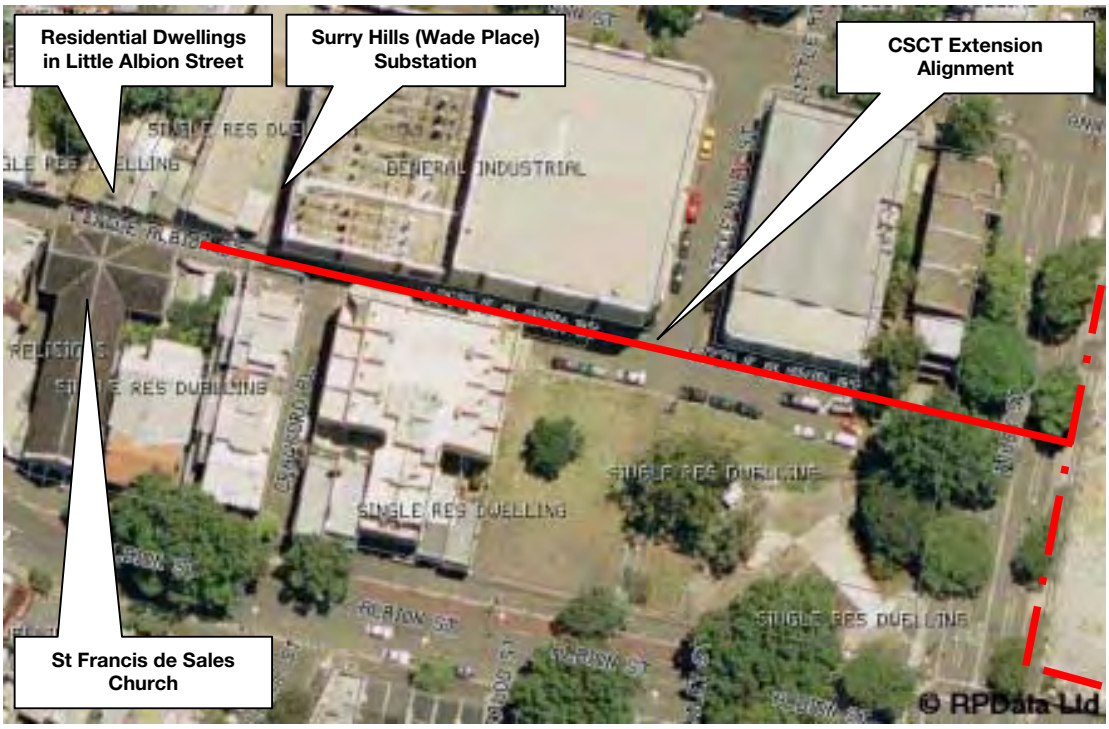
All images are courtesy of *RP Data*.

2.5.1 Extension to the Existing City South Cable Tunnel (CSCT)

It is proposed to provide a tunnel connection from the existing Surry Hills (Wade Place) Sub-transmission Substation (STS) to the City East Cable Tunnel (CECT) and Riley Street worksite, in the form of the City South Cable Tunnel (CSCT) extension.

An aerial photograph showing the vicinity of the Surry Hills (Wade Place) STS and the alignment of the CSCT extension, proposed beneath Little Albion Street, is shown in **Figure 2**.

Figure 2 Land Uses Adjacent to CSCT Extension



In order to construct the CSCT extension, it will be necessary to excavate Little Albion Street in the immediate vicinity of the Surry Hills STS, and thereafter undertake tunnelling works using a roadheader, beneath Little Albion Street, beneath Riley Street and the Riley Street Site.

Airborne noise, regenerated noise and vibration from these activities have the potential to significantly impact residential premises as well as the St Francis de Sales Church and other nearby receivers in Little Albion Street.

Heggies undertook a detailed site inspection on 29 May 2008 and identified the potentially most affected noise and vibration-sensitive receivers in the vicinity of the proposed works.

The nearest noise and vibration-sensitive receivers to the proposed CSCT extension works are identified in **Table 3**.

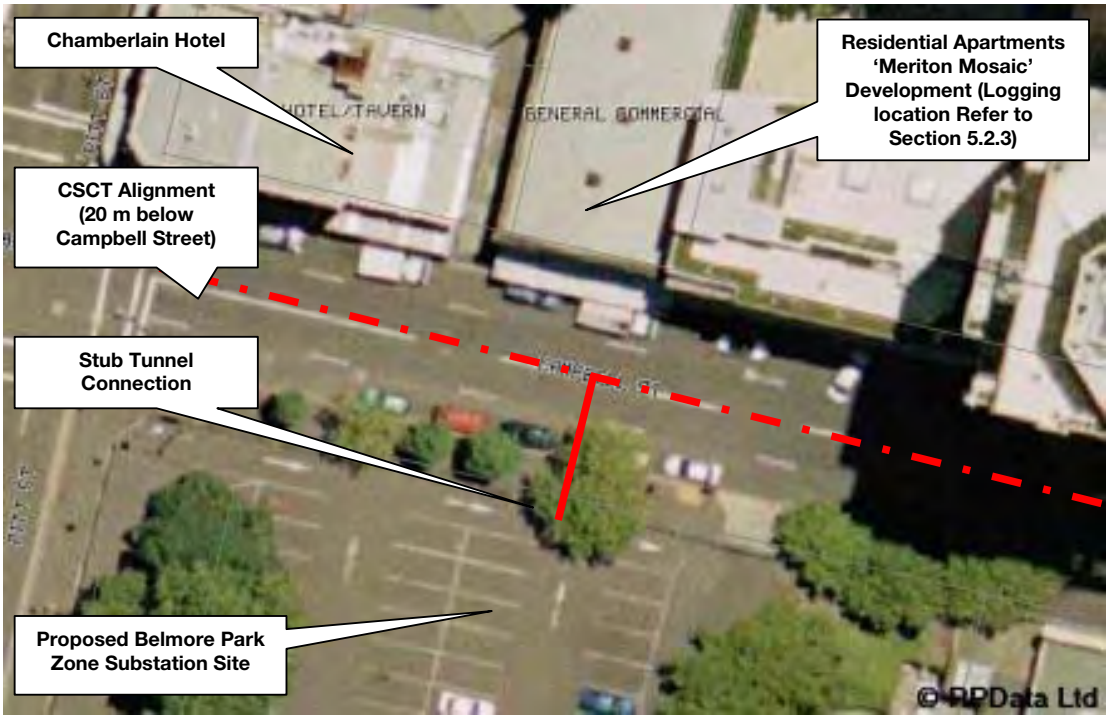
Table 3 Receivers near Surry Hills STS

Receiver Type	Receiver Address
Residential	22 Little Albion Street
	20 Little Albion Street
	18 Little Albion Street
	16 Little Albion Street
	14 Little Albion Street
	2 Little Albion Street
	84 Albion Street
	92 Albion Street - Strata Units
	108 Albion Street
	102 Albion Street - Strata Units
Religious	80 Albion Street - St Francis de Sales Church
Commercial	66 Albion Street
	303 Riley Street - Drop-in Centre
Mixed-Use	63 Ann Street
Passive Recreation Area	'Frog Hollow' Park

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

2.5.2 Stub Tunnel Connection from the Existing City South Cable Tunnel

Figure 3 Land Uses Adjacent to CSCT Stub Tunnel Connection



The nearest noise and vibration-sensitive receivers to the proposed CSCT Stub-Tunnel works are identified in **Table 4**.

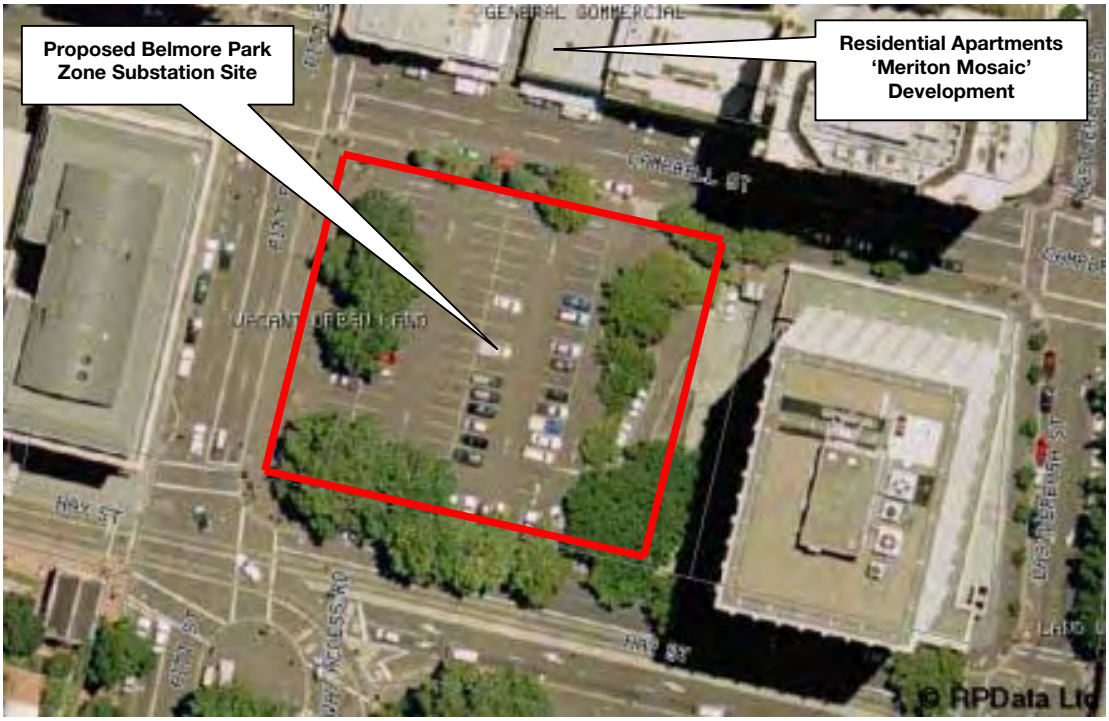
Table 4 Receivers near CSCT Stub Tunnel Works

Receiver Type	Receiver Address
Residential	420 Pitt Street/36 Campbell Street - "Meriton Mosaic" Strata Units
	414 Pitt Street - Strata Units
Hotel/Tavern	428 Pitt Street - "Chamberlain Hotel"
	431 Pitt Street - 'Metro Hotel'
Commercial	323 Castlereagh Street
	441 Pitt Street

Note: This table is not exhaustive; it gives an indication of the most potentially 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 'potentially affected' by airborne noise, regenerated noise and vibration due to the proposed works.

2.5.3 Belmore Park Zone Substation

Figure 4 Land Uses Adjacent to Proposed Belmore Park Zone Substation



The nearest noise and vibration-sensitive receivers to the proposed Belmore Park works are identified in **Table 5**.

Table 5 Receivers near Belmore Park Works

Receiver Type	Receiver Address
Residential	420 Pitt Street/36 Campbell Street - Strata Units
	414 Pitt 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 most potentially 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 'potentially affected' by airborne noise, regenerated noise and vibration due to the proposed works.

2.5.4 City East Cable Tunnel (CECT)

It is proposed that a 3,200 m tunnel, to be known as City East Cable Tunnel (CECT), will be constructed from the Riley Street Site in Surry Hills and terminate at the City North Zone Substation at the corner of Erskine and Sussex Streets to the west of the Sydney CBD, and, en route, interface with the Dalley Street Zone Substation and the proposed future City East Zone Substation in the CBD.

It is proposed that the tunnel will be serviced by a tunnel control room and a ventilation shaft at Riley Street STSS or mid-way along the tunnel alignment (at Cook and Phillip Park), subject to yet-to-be-established needs.

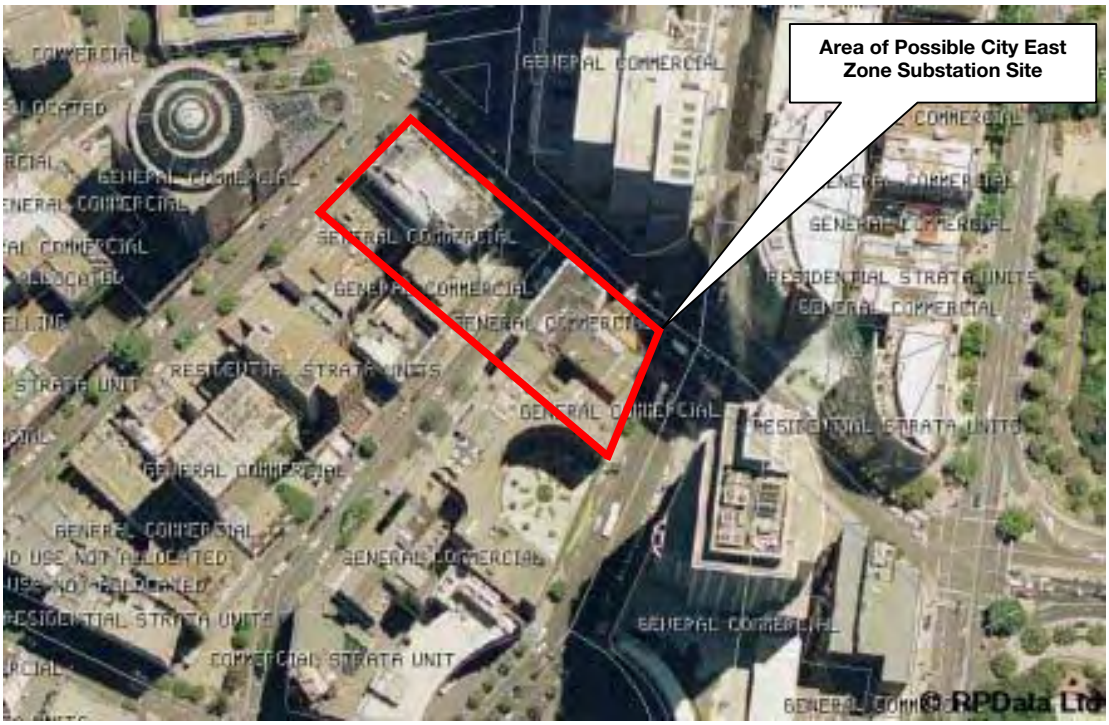
The proposed CECT will be constructed using a Tunnel Boring Machine (TBM), to be launched from the Riley Street Site. The tunnel will follow the north-south alignment of Riley Street, and, subject to several possible options, curve in a northwesterly direction beneath East Sydney, The Domain and the northeastern fringe of the Central Business District. The tunnel will be aligned beneath existing road easements, as much as practicable. It is important to note that due to the practicalities of tunnelling using a Tunnel Boring Machine, it is proposed to maintain a minimum plan radius of 350 m for possible changes in tunnel alignment.

It is not practical, or necessary (at this stage) to identify each and every noise and vibration-sensitive receiver along (above) the proposed tunnel alignment. The final tunnel alignment has not been confirmed in plan or section at this stage, and slant distances (ie the angular distance from the TBM to the receiver when the TBM is not directly below) determined and thus likely regenerated noise and vibration impacts at individual receivers have not been established. It can be assumed, however that the tunnel will pass beneath residential, commercial and other land uses that will require future noise and vibration impact assessment.

Based on Heggies experience and other inputs, likely regenerated noise and vibration impacts at realistic slant distances are discussed later in this report (refer to **Section 7**). This information may be used to later to inform the project team in terms of which options, work methods and extent of community consultation to undertake on the basis of acoustics.

2.5.5 City East Zone Substation

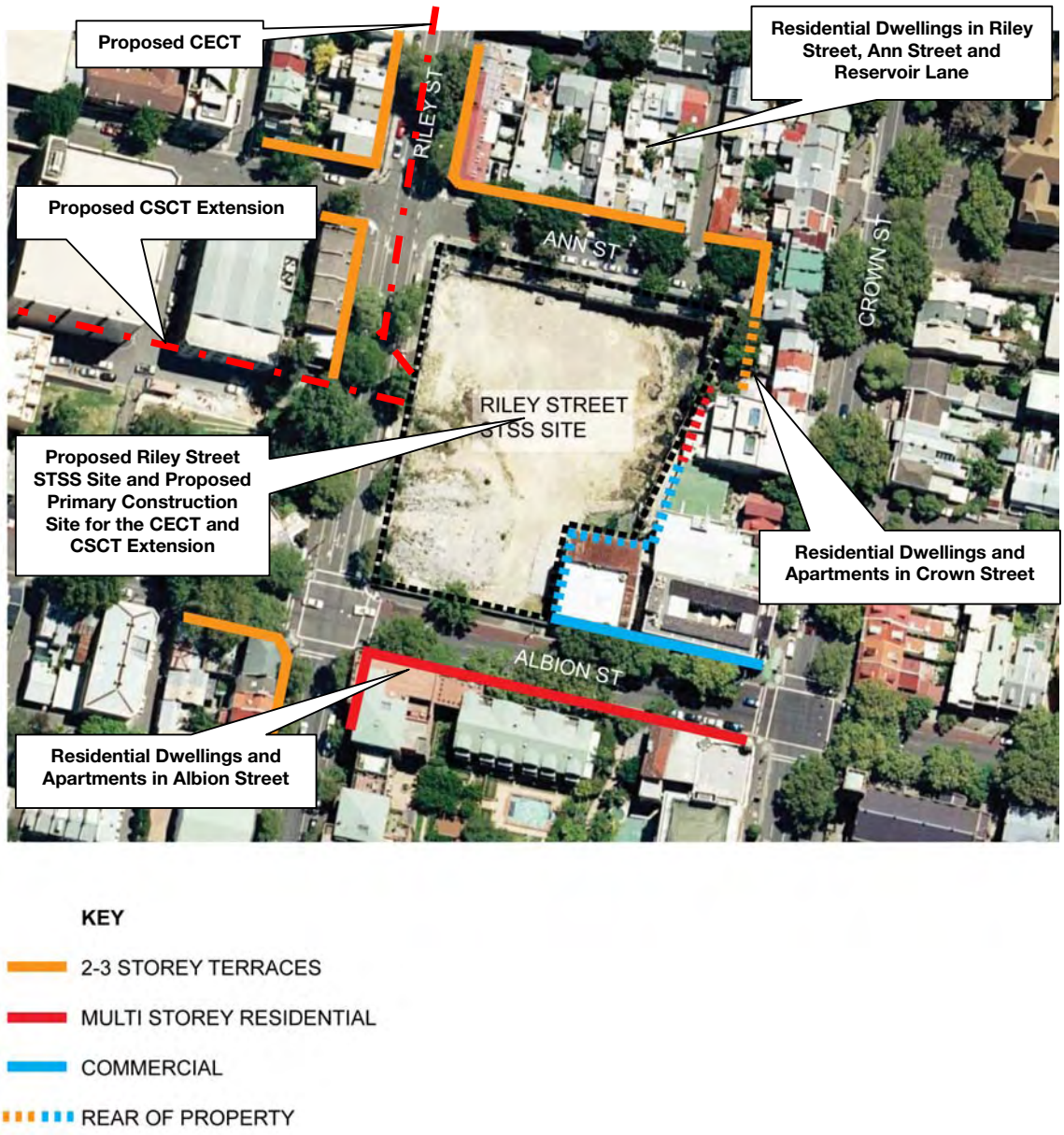
Figure 5 Land Uses Adjacent to Possible City East Zone Substation Site



A potential site for the City East Zone Substation is in the vicinity of Phillip, Bent, Bligh & O'Connell Streets. The surrounding land uses are predominantly commercial office towers with active street frontages and retail activities including Governor Macquarie Tower, Chifley Tower, ABN Amro/Aurora Place, Noble House, Additionally hotels, restaurants and cafes are situated in the locality including the Sheraton Wentworth Hotel, and Macquarie Apartments,

2.5.6 Riley Street Sub-transmission Switching Station (STSS) at Riley Street

Figure 6 Land Uses Adjacent to Proposed Riley Street Worksite



The nearest noise and vibration-sensitive receivers to the proposed Riley Street STSS and TBM launch site are identified in **Table 6**.

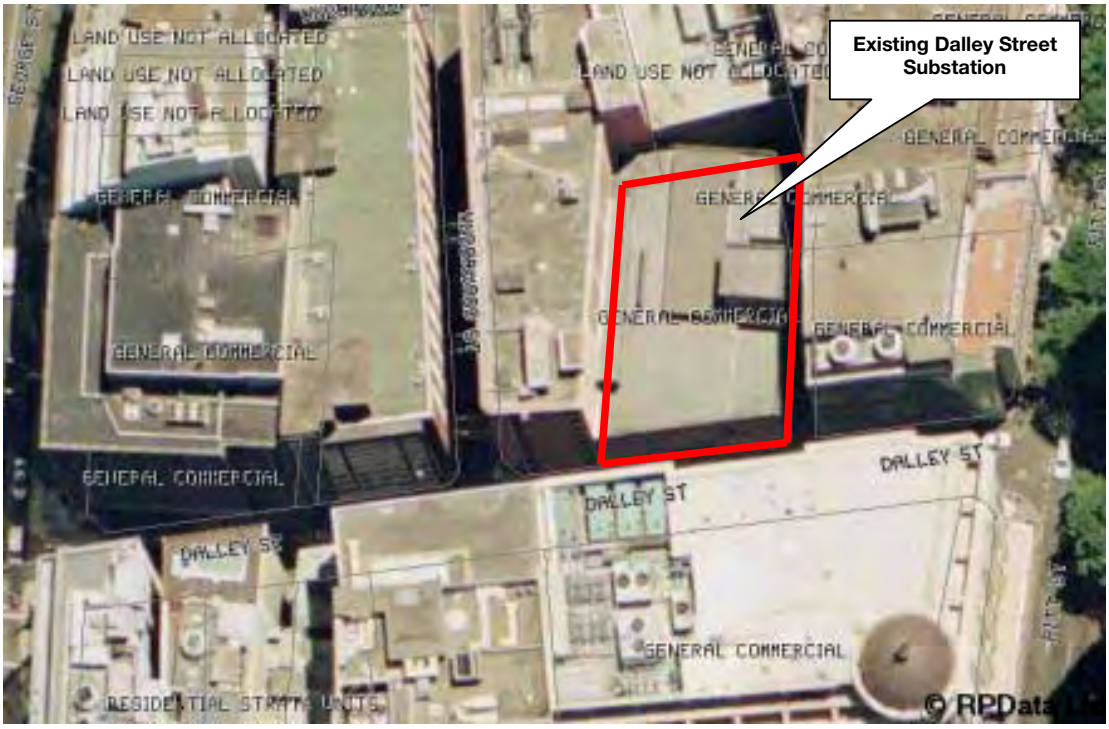
Table 6 Receivers near Riley Street Site

Receiver Type	Receiver Address
Residential	76 - 90 Ann Street - Single Residential Dwellings
	92- 94 Ann Street - Single Residential Dwellings
	315 Crown Street
	317 Crown Street
	319 Crown Street - Units
	321- 327 Crown Street - Single Residential Dwellings
	329 Crown Street - Strata Units
	265 - 293 Riley Street
	295 - 301 Riley Street
	300 Riley Street/127 Albion Street - Strata Units
	319 - 327 Riley Street - Single Residential Dwellings
Mixed-Use	72 - 74 Ann Street
	226- 248 Riley Street
	337-349 Crown Street - Salvation Army and Albion Street Centre
	150 - 154 Albion Street - Albion Street Centre
	303 Riley Street - Drop-in Centre
	351 Crown Street
	117 Albion Street - Buddhist Church
Passive Recreation Area	'Frog Hollow' Park

Note: This table is not exhaustive; it gives an indication of the most potentially affected receivers near to the proposed works, as identified during a site inspection. Other nearby receivers in Crown Street, Albion Street, Riley Street, Ann Street, Mackey Street, Reservoir Lane and other nearby streets should also be considered 'potentially affected' by airborne noise, regenerated noise and vibration due to the proposed works

2.5.7 Dalley Street Zone Substation

Figure 7 Land Uses Adjacent to Dalley Street Substation



It is proposed to refurbish or replace the existing Dalley Street Zone Substation, using the existing building, or a building at an adjacent site.

Surrounding land uses for the Dalley Street site are predominantly commercial office buildings, hotels and parking stations with the major activities being the Australian Stock Exchange, Telstra telephone exchange, AIG building, Exchange Square, Grosvenor Place, Brooklyn Hotel, National Australia Bank House, Macquarie Graduate School of Management, Underwood House, Sydney Harbour Marriott, Gerling House, and Endeavour House.]

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 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 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, these 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 CityGrid Project.

4 NOISE AND VIBRATION GUIDELINES AND CRITERIA

4.1 Construction (Airborne) Noise Assessment Criteria

A former incarnation of the Department of Environment and Climate Change (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.

4.1.1 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 7**.

Table 7 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

4.1.2 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.

(Note that it is a CityGrid project preference for all tunnelling works to be undertaken on as continuous a basis as possible, subject to a later assessment of the noise and vibration impacts of undertaking night-time tunnelling works).

4.1.3 Silencing

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

4.1.4 City of Sydney Code of Practice

The City of Sydney Code of Practice applies to *Construction Hours/Noise within the Central Business District*. 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 8**.

Table 8 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.

4.2 Regenerated (Structure-Borne) Noise Assessment Criteria

The proposed CityGrid Project will involve significant tunnelling activities which are proposed to be conducted using a TBM, to be launched from the Riley Street Site.

Whilst regenerated noise is not identified per se in the *DGRs* or *Input from Agencies*, there is potential for regenerated noise to be an issue for noise-sensitive receivers near to construction (excavation) sites and near to (above) the tunnel alignment, with the potential for greater impact when the proposed tunnel alignment is closer to the ground surface and therefore foundations of noise-sensitive premises.

Regenerated noise in buildings is caused by the transmission of ground-borne vibration rather than by the direct transmission of noise through the air. Vibration may be generated by construction equipment such as TBMs and transmitted through the ground into the adjacent building structures. After entering a building, this vibration causes the walls and floors to faintly vibrate and hence to radiate noise (also commonly referred to as 'structure–borne' or 'ground-borne' noise).

Structure-borne noise is not usually a significant disturbance to building occupants during daytime periods due to higher ambient noise levels which mask the audibility of structure-borne noise emissions. During night-time periods however, when ambient noise levels are often much lower, structure-borne noise is more prominent and may result in adverse comment from building occupants.

Table 9 provides a summary of the structure-borne noise objectives that have been applied on recent tunnelling projects in NSW.

Table 9 Structure-Borne Noise Objectives on Recent NSW Tunnel Projects

Construction Project	Structure-Borne Noise Objectives (Residential)	
	Daytime	**Night-time**
Cross-City Tunnel	Vibration Objectives Only (BS 6472)	$L_{Aeq(15minute)}$ 40 dBA (6 pm to 10 pm) $L_{Aeq(15minute)}$ 35 dBA (10 pm to 7 am)
330 kV Cable Tunnels in CBD	Vibration Objectives Only (BS 6472)	$L_{Aeq(15minute)}$ 40 dBA (6 pm to 10 pm) $L_{Aeq(15minute)}$ 35 dBA (10 pm to 7 am)
Lane Cove Tunnel	Vibration Objectives Only (BS 6472)	$L_{Aeq(15minute)}$ 40 dBA (6 pm to 10 pm) $L_{Aeq(15minute)}$ 35 dBA (10 pm to 7 am)
Epping to Chatswood Rail Line	$L_{Aeq(15minute)}$ 45 dBA	$L_{Aeq(15minute)}$ 40 dBA (6 pm to 7 am) $L_{Aeq(15minute)}$ 35 dBA > 7 Days (10 pm to 7 am)

On this basis, it is likely that for the CityGrid Project that the same criteria that were applied to the 330 kV Cable Tunnels in Sydney CBD are appropriate, and on this basis, this document adopts these criteria, being:

- **Daytime**: Vibration Objectives only (BS 6472); and
- **Night-time**: $L_{Aeq(15minute)}$ 40 dBA (6 pm to 10 pm), $L_{Aeq(15minute)}$ 35 dBA (10 pm to 7 am).

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**), and
- 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 Department of Environment and Climate Change (DECC), *Assessing Vibration: A Technical Guideline,* (August 2006) specifically Table 2.2 and 2.4.

These tables (and indeed the whole document) in the DECC *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) 1 to 80 Hz and also 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 *Technical Guideline* are measured and assessed (acceleration and dose) are not straightforward to measure, 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 *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 10**.

Table 10 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 10 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 *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 11**.

Table 11 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 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 2'* 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 12** and graphically in **Figure 8**.

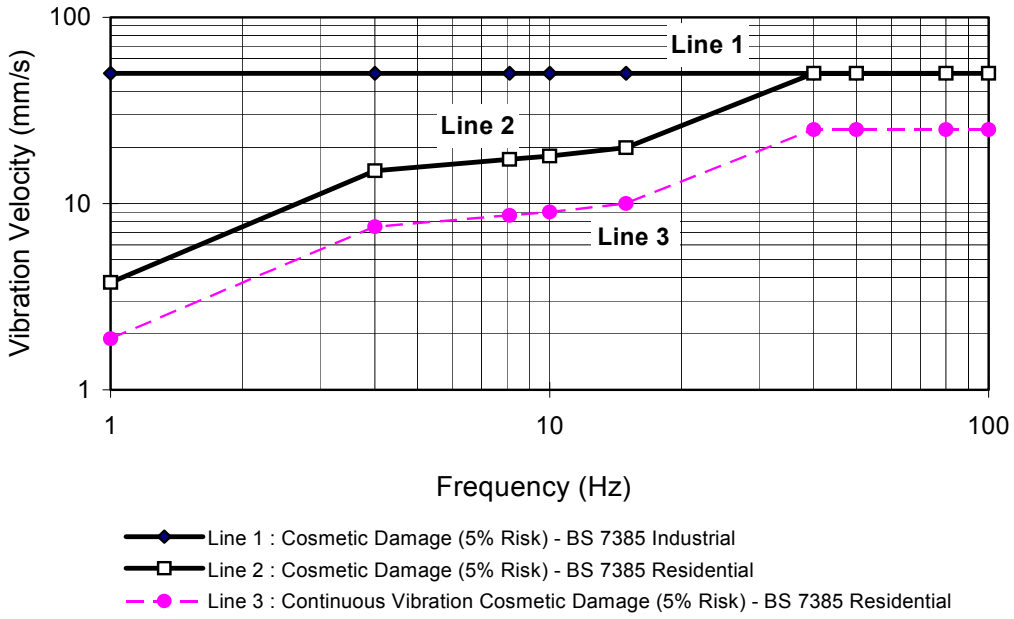
Table 12 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

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 12** 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 12** may need to be reduced by up to 50%.

Figure 8 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 12**, and major damage to a building structure may occur at values greater than four (4) 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 12** should not be reduced for fatigue considerations.

It is noteworthy that extra to the guide values nominated in **Table 12**, 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 Traffic Noise Assessment Criteria

For traffic operating on public roads to and from the site the DECC "*Environmental Criteria for Road Traffic Noise"* 1999 (ECRTN) are appropriate for assessing road traffic noise. The DECC's recommended criteria for collector roads are set out in **Table 13**.

Table 13 DECC Road Traffic Noise Criteria

Development	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
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 L_{Aeq} 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 NOISE AND VIBRATION GOALS

5.1 Construction Noise

Construction noise goals for airborne noise emission, (when established *in accordance with relevant NSW Government and DECC policies and guidance*) are based on the existing ambient or background noise levels within a given area and an allowable increase due to the temporary nature of construction works.

In some instances, construction noise goals may also be based on the sensitivity of particular building spaces. For example, the acceptable noise level within a factory would be much higher than for a recording studio.

On the basis of the scheduling information presented in **Table 2**, it is likely that work at most, if not all work sites that form part of the CityGrid project will require construction activities of 26 weeks or greater.

5.1.1 Residential Receivers

In accordance with the DGRs, which reference *NSW Government and DECC policies and guidance*, the construction noise goals have been set with reference to the DECC's ENCM guidelines as presented in **Table 7**. The corresponding criterion is **Background (RBL) + 5 dBA** for residential receivers.

The Rated Background Level (RBL) is the single figure 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. 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 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 $L_{A90(15minute)}$ samples for each assessment period

Specifically, this means that noise from construction activities should be managed such that the L_{A10} noise level, measured over a period of not less than 15 minutes, should not exceed the background L_{A90} noise level by more than 5 dBA.

The establishment and derivation of airborne noise criteria for residential receivers are presented, by work site, in **Section 5.2.1** to **Section 5.2.7**.

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.

5.1.2 Commercial and Retail Receivers

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

For commercial and retail receivers such as the outdoor eating areas, restaurants, take away shops, hair salons, and the like, an $L_{A10(15minute)}$ noise objective of **Background (RBL) + 10 dBA** has conservatively been applied.

5.2 Ambient Noise Surveys and Derivation of Construction Noise Goals

In order to derive airborne noise goals for noise-sensitive receiver locations, it is necessary to undertake background noise measurements in the absence of construction noise. An ambient noise survey needs to been undertaken in the vicinity of each work site.

The following sections describe ambient noise surveys that have been undertaken to date at each work site. Where no ambient noise survey has been undertaken at this Environmental Assessment Stage, a commitment will be made by the project team to undertake a survey at Heggies suggested locations (or representative locations).

Where ambient noise surveys are yet to be conducted Australian Standard AS 1055.2 "*Acoustics - Description and measurement of environmental noise Part 2: Application to specific situations*" has been referenced to provide guidance on expected background noise levels. Appendix B of the standard provides estimated average background A weighted sound pressure levels for different areas containing residences.

The estimated values presented in the standard can be used to provide indicative information on the ambient noise levels expected in the areas where noise surveys are to be conducted for the CityGrid project. Relevant AS 1055.2 noise area categories and the estimated average background A weighted sound pressure levels are presented in **Table 14**.

Table 14 Estimated Average Background A Weighted Sound Pressure Levels for Different Areas Containing Residences.

Noise Category Area	Description of Neighbourhood	Average Background A weighted Sound Pressure Level, $L_{Abg,T}$						
		Monday to Friday				Weekends and Public Holidays		
		0600 to 0700	0700 to 1800	1800 to 2200	2200 to 0600	0700 to 1800	1800 to 2200	2200 to 0700
R3	Areas with medium density transportation or some commerce or industry	45	50	45	40	50	45	40
R4	Areas with some commerce or industry or with dense transportation	55	55	50	45	55	50	45
R5	Areas in commercial districts or bordering industrial districts or with very dense transportation	55	60	55	50	60	55	50

With reference to **Table 14**, sites within the CBD are deemed to fall into category R5, with Riley Street category R4.

5.2.1 Extension to the Existing City South Cable Tunnel

No noise surveys have yet been undertaken at the receiver locations likely to be affected by airborne noise emissions from works associated with the CSCT extension.

Based on Heggies review of the site, it is recommended that a week-long unattended noise survey is undertaken in Little Albion Street, Surry Hills. Of the nearby residential receivers presented in **Table 3**, the most suitable location for the survey appears to be any of the terraced houses at 14-22 Little Albion Street.

It should be a CityGrid project commitment to undertake such a noise survey, derive construction noise emission criteria in accordance with the principles set out in this document and, ultimately, conduct a detailed construction noise assessment for the CSCT extension site to assess the need for required noise controls during the construction stage.

5.2.2 Stub Tunnel Connection from the Existing City South Cable Tunnel

Refer to **Section 5.2.3**.

5.2.3 Belmore Park Zone Substation

The construction noise emission criteria presented in this Section will also be used in the assessment of the CSCT Stub Tunnel (**Section 5.2.2**).

Unattended environmental noise monitoring was conducted at one location over six days and five nights from Thursday 22 May to Tuesday 27 May 2008.

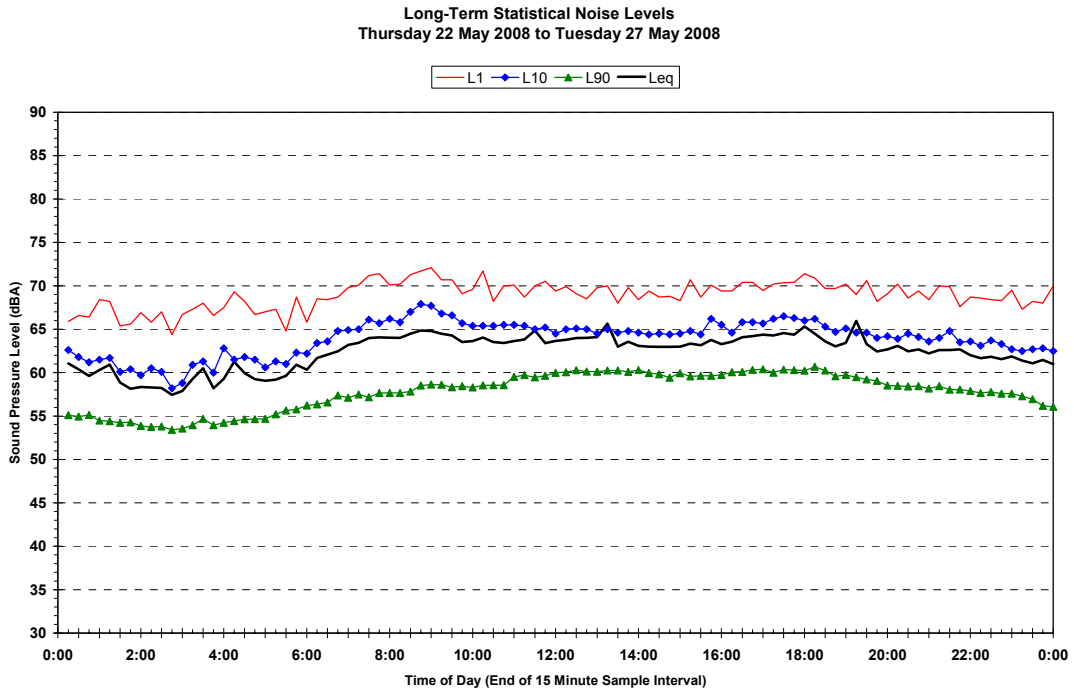
The equipment used was an Acoustic Research Laboratories (ARL) Environmental Noise Logger Type EL-316 (serial number 16-207-045), fitted with a microphone windshield, deployed on the balcony of Apartment 202 on level 20 of the Meriton Mosaic development (overlooking and with direct line of site to the Belmore Park Site).

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 9** and tabulated in **Table 15** and **Table 16** (noise levels are rounded to the nearest 1 dBA and the median values for each of the 15-minute periods are shown).

Figure 9 Long-Term Statistical Noise Levels Receivers near Belmore Park Site



Data Processing to Derive Construction 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 for the defined daytime, evening and night-time periods has been established and is presented in **Table 15**

Table 15 Receivers near Belmore Park Site - Measured Noise Levels

Location	Measurement Descriptor	Measured Noise Level - dBA re 20 µPa			
		Daytime 7.00 am - 1.00 pm[1]	Daytime 7.00 am - 6.00 pm	Evening 6.00 pm - 10.00 pm	Night-time 10.00 pm - 7.00 am

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.

On this basis, the 'normal construction hours' airborne noise goals (at the nearest residential receiver) for construction activity at the Belmore Park (and CSCT Stub Tunnel) Sites are as follows:

- Daytime 7.00 am - 6.00 pm **L_{A10} 66 dBA**
- Saturday Daytime 7.00 am - 1.00 pm **L_{A10} 66 dBA**

Should extended work hours be permitted beyond the 'normal construction hours' presented in **Section 4.1.2**, the following noise goals apply:

- Evening 6.00 pm - 10.00 pm **L_{A10} 64 dBA**
- Night-time 10.00 pm - 7.00 am **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 as indicated in **Table 15** is:

- Night-time 10.00 pm - 7.00 am **L_{AMax} 69 dBA**

Data Processing to Derive Construction Traffic Noise Criteria

In order to assess construction traffic activity associated with the Belmore Park and CSCT Stub Tunnel 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 16**.

Table 16 Measured Ambient Noise Levels Corresponding to Defined ECRTN Periods

Logging Location	Period			
	Daytime		Night-time	
	$L_{Aeq(15\ hour)}$	$L_{Aeq(1\ hour\ day)}$	$L_{Aeq(9\ hour)}$	$L_{Aeq(1\ hour\ night)}$
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**.

As such, 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} noise levels.

Based on the very low (in the context of existing road traffic noise) volume of truck numbers presented in **Table 1**, the project will not result in traffic noise increases that exceed 2 dBA at the receivers near to the Belmore Park Site. It is predicted that, at most, construction-related traffic activity will result in negligible noise increases of less than 0.1 dBA.

5.2.4 City East Cable Tunnel

Tunnelling activity associated with the CECT will primarily warrant acoustical assessment in terms of regenerated (structure-borne) noise and vibration.

However, airborne noise emission will require consideration at the locations where the Tunnel Boring Machine is launched (Riley Street Site), where spoil is brought to the surface and transported from (also Riley Street) and where the tunnel is required to interface with the surface (eg at any vertical shafts mid-tunnel and at the CBD Substations).

Based on Heggies review of the Riley Street Site, it is recommended that a week-long unattended noise survey is undertaken in up to four locations around the work site. Of the nearby residential receivers presented in **Table 6**, the most suitable locations for the survey appear to be:

- **East** of work site - Rear of strata units at 329 Crown Street
- **North** of work site - Front of terrace house at 82 Ann Street
- **West** of work site - Front of townhouse at 299 Riley Street
- **South** of work site - Mid/upper floor balcony of a residential unit in 300 Riley Street/127 Albion Street facing Albion Street

It should be a CityGrid project commitment to undertake such a noise survey, derive construction noise emission criteria in accordance with the principles set out in this document and, ultimately, conduct a detailed construction noise assessment for the Riley Street Site to assess the need for required noise controls during the construction stage.

In addition, once mid-tunnel work sites and CBD Substation interface sites are finalised, then an analysis of noise-sensitive receivers near the selected sites should be undertaken and a commitment to undertake noise logging, derive construction noise criteria and undertake a detailed construction noise assessment should be made.

5.2.5 City East Zone Substation

No noise survey has yet been undertaken at receiver locations likely to be affected by airborne noise emissions from works associated with the City East Zone Substation, as the site of the proposed substation has not yet been finalised.

Once a site has been selected, it should be a CityGrid project commitment to undertake such a noise survey, derive construction noise emission criteria in accordance with the principles set out in this document and, ultimately, conduct a construction noise assessment for the proposed future City East Zone Substation to assess the need for required noise controls during the construction stage.

5.2.6 New Sub-transmission Switching Station (STSS) at Riley Street

Refer **Section 5.2.4** regarding the project commitment to undertake noise logging, to derive construction noise emission criteria and to undertake a detailed constriction noise assessment for receivers near to the Riley Street Site.

5.2.7 Dalley Street Zone Substation

No noise survey has yet been undertaken at receiver locations likely to be affected by airborne noise emissions from works associated with the Dalley Street Zone Substation.

It should be a CityGrid project commitment to undertake such a noise survey, derive construction noise emission criteria in accordance with the principles set out in this document and, ultimately, conduct a detailed construction noise assessment for the upgrades to and CECT interfaces at the Dalley Street Zone Substation to assess the need for required noise controls during the construction stage.

5.3 Airborne 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 example, for the Belmore Park Site, where the daytime construction noise goal is L_{A10} 66 dBA, a construction noise goal of L_{A10} 71 dBA would apply for commercial receivers nearby.

Once the airborne construction noise goals are established for residences near to each work site, the construction noise goals for all nearby retail and commercial receivers can be derived. Given the presence of residential receivers in the vicinity of the work sites, it is highly likely that the residential criteria will be the limiting factor in the assessment and control of construction noise.

5.4 Airborne Noise Goals for Special-Purpose Spaces

For the purposes of airborne noise assessment, Church, parish, retirement, childcare and educational receivers should be considered to have similar sensitivity to construction noise emissions as residential receivers.

5.5 Construction-Related Road Traffic Noise

It is considered highly likely that the DECC ECRTN L_{Aeq} road traffic noise criteria presented in **Table 13** will already be exceeded at many receivers near to the CityGrid work sites, which is not unusual for receivers in inner-city 'urban' areas.

Where this is proven to be the case by way of unattended noise surveys, then the road traffic noise criteria for CityGrid construction-related traffic will revert to managing the impact of additional truck volumes associated with the project to not cause an increase of greater than 2 dBA in overall traffic noise levels.

Based on the truck volumes presented in **Table 1**, it is not considered likely that construction-related vehicle movements will result in increases in noise levels of 2 dBA or more at receivers near to the CityGrid work sites. It is predicted that noise levels, at most, will be increased by less than 0.5 dBA due to increased truck movements in the vicinity of each site. As such, the project team should focus on the assessment and control of actual construction noise impacts, rather than construction-related road traffic noise impacts.

5.6 Operational Noise - Industrial Noise Policy

Once the construction stage for each work site has been completed, noise emission from the operation of fixed plant at each site will be required to comply with the NSW DECC's *Industrial Noise Policy* (INP, 2000).

The Policy is applicable to noise emission from fixed mechanical plant. The Policy has the following broad objectives:

- Controlling **intrusive** noise impacts (to residences only).
- Maintaining noise level **amenity** for residential and other land uses over the medium to long-term.

Where an intrusive and an amenity criterion are established for a receiver, the more stringent (lower) of the two criteria applies.

5.6.1 Intrusiveness Criterion

Normally, an "RBL plus 5 dBA" criterion is applied to the 15-minute L_{Aeq} noise emissions of the noise source in question (usually at the property boundary of the receivers of interest). The exception to this is given in *Section 3.1* of the INP, where it is recommended that if the RBL is found to be below 30 dBA, the intrusive noise criterion is set at 30 dBA. (This latter condition is not likely to be relevant to the CityGrid project).

5.6.2 Amenity Criterion

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

The resulting amenity criterion placed upon noise emissions from a new facility then depends upon whether existing industrial /commercial-related $L_{Aeq(period)}$ 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 criterion acts to limit new industrial noise emissions so that the cumulative industrial/commercial noise emission levels do not increase.

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

5.6.3 Project-Specific Noise Criteria

Project-specific noise criteria will be derived from the results of unattended noise logging committed to be undertaken at the residential receivers near to each work site. The operational noise criteria can be derived from the same logging undertaken to establish construction noise criteria as set out in **Section 5.2.1** to **Section 5.2.7**.

The criteria will be presented in the Project Application acoustic report for each site, and referenced in the design of noise controls for fixed items of plant (such as tunnel ventilation fans) at the detailed design stage of each site.

6 CONSTRUCTION NOISE ASSESSMENT

Preliminary and detailed construction noise assessments will be undertaken for each site once unattended noise logging has been undertaken in order to determine the magnitude of acoustic impacts and the need for construction noise controls at each site. It is noted that the assessment at the Riley Street Site will include the attenuation benefits provided by the 'acoustic shed' enclosure that is intended at that site.

For the Belmore Park site an ambient survey has been conducted and an assessment of likely L_{A10} and L_{Amax} noise levels due to the operation of construction plant items has been undertaken in this section.

6.1 Equipment Sound Power Levels

In order to undertake an assessment of construction noise, it is necessary to establish a benchmark Sound Power Level (L_{A10} and L_{Amax}) for each plant item *likely* to be used on site. Based on numerous measurements undertaken on NSW projects of similar scale to the CityGrid project, Heggies has determined representative reasonable limiting Sound Power Levels for typically-used plant items, as presented in **Table 17**.

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 so to allow a direct comparison of audit results on site with the requirements of this Environmental Assessment.

Table 17 Limiting Construction Equipment Sound Power and Pressure Levels at 7 m

Plant Item	Sound Power (dBA)		Sound Pressure (7 m)	
	LAmax	LA10	LAmax	LA10
Concrete Saw	118	115	93	90
Excavator Hammer	122	116	97	91
Rock-breaker	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 (7 m)	
	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

6.2 Belmore Park Construction Noise Assessment

This assessment has been undertaken for the Belmore Park Site, noting a further detailed assessment is proposed when information on specific construction scenarios for the site is available. For this study the following is relevant:

- the nearest residential receiver has been identified (the Meriton Mosaic apartments overlooking Belmore Park - approximately 40 m from the nearest boundary of the site); and
- background noise levels in the area have been established by way of an unattended noise survey (refer to **Section 5.2.3**).

Based on the Sound Power Levels presented in **Table 17**, 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 anticipated plant items working in isolation at the northern boundary of the site, representative of early ground level works when establishing the site and excavating the roadheader launch site.

Table 18 Belmore Park Construction Noise Assessment Results

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**

Plant Item	Sound Pressure, 40 m	
	LAmax[1]	LA10[2]
Compressor (~ 600 CFM)	59	59
Compressor (~1500 CFM)	64	64
Compressor Standard	**70**	70
Compressor Super silenced	54	54
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 **Table 18** reveals that approximately 50% of the typical plant items modelled would exceed either the night-time sleep disturbance or 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 at site boundaries and selecting the smallest and quietest practicable items for each task, whilst maintaining efficiency of operation.

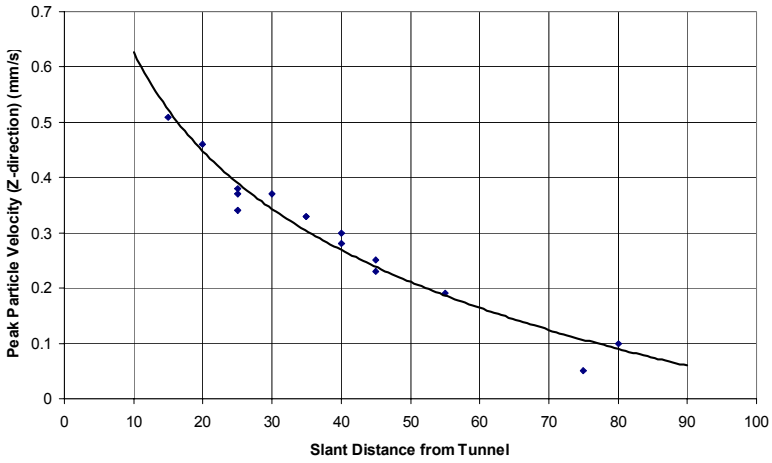
7 ASSESSMENT OF VIBRATION AND STRUCTURE-BORNE NOISE

7.1 Construction Vibration

7.1.1 Tunnel Boring Machine

It is anticipated that the most significant potential long-term source of construction-related vibration will be the use of the Tunnel Boring Machine, used to construct the CECT. Based on the findings presented by the Australian Acoustical Society (Technical Meeting, December 2003), an approximate relationship between tunnel boring machine activity in Sydney rock substrate at a given slant distance from the ground surface and Peak Particle Velocity (PPV, mm/s) vibration levels are presented in **Figure 10**.

Figure 10 TBM Vibration Levels with Distance from Tunnel



A review of **Figure 10** reveals that at a slant distance of 65 m, vibration due to the operation of a tunnel boring machine is likely to meet the human 'threshold of perception (0.15 mm/s), at 30 m the vibration will be 'barely noticeable' and at distances closer than 30m, the vibration will become increasingly noticeable (refer to **Table 10**).

7.1.2 Other Vibration-Intensive Plant

Safe working distances for typical items of 'above-ground' vibration-intensive plant are listed in **Table 19**.

These distances are indicative only and can vary depending upon the particular item of plant and geotechnical conditions. For the purposes 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 19 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.

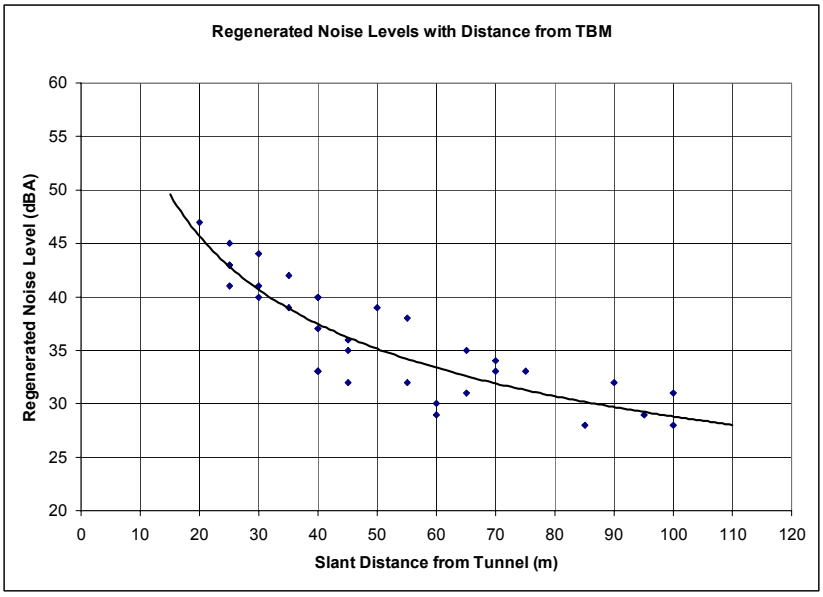
Such site validation would allow mitigation options to be established for any work causing excessive vibration, ensuring that disruptions to building tenants are minimised. Such measures could include minimum buffer distances for certain plant items, preferred hours for particular activities or alternate work methods. A programme of vibration monitoring is further discussed in **Section 10.2**.

7.2 Construction Regenerated Noise

7.2.1 Tunnel Boring Machine

It is anticipated that the most significant potential long-term source of construction-related regenerated noise will be the use of the Tunnel Boring Machine, used to construct the CECT. Based on findings presented by the Australian Acoustical Society (Technical Meeting, December 2003), an approximate relationship between tunnel boring machine activity in Sydney rock substrate at a given slant distance from the ground surface and regenerated noise levels (dBA) are presented in **Figure 11**.

Figure 11 TBM Regenerated Noise Levels with Distance from Tunnel



A review of **Figure 11** reveals that at 50 m slant distance, the operation of a tunnel boring machine results in regenerated noise levels of approximately 35 dBA, and a distance of 30 m results in 40 dBA.

Table 9 presents the assumed regenerated noise level criteria for the CityGrid project and 35 dBA is the limiting criterion for night-time regenerated noise levels.

At this stage of the project, it is reasonable to consider allowing a buffer distance of:

- 50 m between the crown of the CECT tunnel and surface (residential) structures on the basis of regenerated noise control (assuming a project preference to undertake tunnelling on a continuous basis, including during the 10.00 pm to 7.00 am night-time period); and
- 30 m between the crown of the CECT tunnel and surface (residential) structures on the basis of regenerated noise control (assuming a project preference to undertake tunnelling during the 6.00 pm to 10.00 pm evening time period).

With reference to **Figure 10**, allowing a buffer distance of 30 m will result in vibration levels of 0.35 mm/s, at which the vibration will be 'barely noticeable' to humans at ground level.

This preliminary study should be refined for at the Project Application stage for each work site and tunnel alignment. Site-specific regenerated noise and vibration rules can be established following early works, the results of which may require increased buffer distances to be allowed, or, alternatively, may permit a smaller buffer distance where closer-to-surface tunnelling works are preferable (and the regenerated noise and vibration impacts are proven to be less than anticipated at this Draft EA stage).

8 CONSTRUCTION NOISE AND VIBRATION MANAGEMENT

8.1 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.

8.2 Summary of Mitigation Measures

A summary of the noise and vibration mitigation measures that should be implemented for the works is listed in **Table 20**.

Table 20 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 10:00 pm 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, in-so-far-as possible whilst maintaining efficiency of function. Residential-grade silencers will be fitted and all noise control equipment will be maintained in good order.
Rock Hammering	Works will be carried out within specified Rock Breaking 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 in-so-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 Industrial Noise Policy.
PA System	To be used within standard Construction Hours, except in emergency situations.

Item	Description
Noise Barriers - general	Where they are effective and reasonable, solid hoardings and/or site sheds will be erected on work site boundaries 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 rock breaking and vibratory compaction are described in **Table 19**. 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) are to 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.

8.3 Noise and Vibration Monitoring

8.3.1 Noise Monitoring

Appropriate noise levels for the relevant classes of construction equipment (with noise control equipment in good condition) have been identified in **Table 17**. 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 21**. 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 21 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 Site Receivers near Riley Street Site Receivers near Wade Place Site Receivers near mid-tunnel interface sites (once selected)	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 results with levels presented in **Table 17**. 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 be conducted for the assessment and examination of potential reasonable and feasible offsite noise and/or vibration mitigation measures.

8.3.2 Vibration Monitoring and Buffer Distance Tests

Vibration monitoring should be carried out in accordance with the recommendations in **Table 22**.

Table 22 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 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 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

8.4 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 to avoid any recurrence or minimise its adverse effects.

8.5 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 7 days/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 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.

8.6 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 or vibration complaints.

8.7 Community Consultation and Liaison

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

- Prior to works 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.

Due to the proximity and noise sensitivity of St Francis de Sales Church (near to the Wade Place Site) close liaison with the Church will need to be undertaken for noise management (for airborne noise, structure-borne noise and vibration). Where practicable, noise-intensive activities would be limited (or not undertaken) during Church services, as well as during weddings and funerals.

These and other elements of community consultation will be addressed as the anticipated impacts are better defined, likely to be at the Project Application stage for each work site.

9 CONCLUSION

Heggies Pty Ltd (Heggies) has been engaged by PlanCom Consulting Pty Limited (PlanCom), on behalf of *EnergyAustralia* to prepare a Noise and Vibration Assessment, including a statement of commitments, for the construction phase and operational phase of the Sydney CityGrid Project. The project is proposed by *EnergyAustralia* 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 a Draft Environmental Assessment Report in support of the Sydney CityGrid project, and its results and findings are summarised in the following points:

- The project includes Zone Substations at Belmore Park and City East, and a Switching Station at Riley Street. Tunnels for cables are also proposed to extend existing tunnels and to link tunnels to new substations.
- 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."*.
- For the Belmore Park Site, an ambient noise survey has been conducted and accordingly construction noise goals set. Calculations indicate exceedances of the design goals identified and it will be necessary to implement all feasible and reasonable construction noise mitigation measures.
- For other sites it is recommended ambient surveys be conducted to determine design criteria in accordance with relevant NSW Government and DECC policies, with construction noise and vibration assessments to follow as sites and tunnels access locations are finalised.
- Vibration and regenerated noise resulting from the Tunnel Boring Machine (TBM) has been assessed. Based on likely levels of vibration and regenerated noise, buffer slant distances to the TBM have been determined.
- Construction noise and vibration management techniques including noise mitigation, noise and vibration monitoring, non-compliance and complaints handling and reporting and have been discussed.

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 quiet
40 30	Inside private office Inside bedroom	Quiet to very quiet
20	Unoccupied recording studio	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

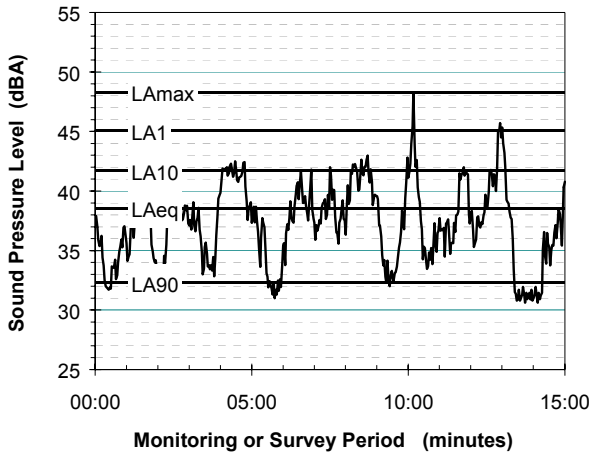
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 1E-12 W.

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

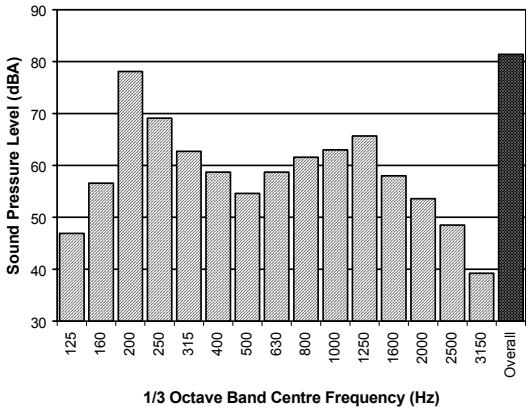
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

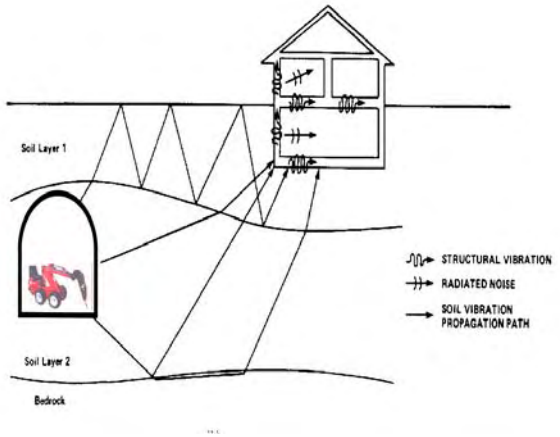
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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.