Technical Paper 2

Noise and vibration impact assessment

Lindfield Substation

Review of Environmental Factors, Noise and Vibration

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Executive Summary

Transport for NSW (TfNSW) proposes to construct a substation at Lindfield to allow for operation of the North West Rail Link (NWRL).

The approved construction and operation of the NWRL has previously been assessed within the NWRL *Environmental Impact Statement, Stage 1-Major Civil Construction Works* and NWRL *Environmental Impact Statement, Stage 2-Stations, Rail Infrastructure and Systems* documents.

The objective of this study is to evaluate and assess the potential noise and vibration impacts associated with the construction and operation of the substation at Lindfield.

Construction

The assessment methodology for the construction works has been undertaken on the basis of the potential impacts and the expected duration of the works.

For the Lindfield Substation, the predicted daytime noise levels indicate high exceedances of the NMLs during Excavation works when rock breaking equipment is in use. This is due to the relative close proximity of the adjacent receivers. During Foundation Preparation and Delivery and Placement of Equipment, minor to medium exceedances of the NMLs are anticipated.

All feasible and reasonable noise mitigation measures would be applied to the works, together with implementation of the NWRL *Construction Noise and Vibration Strategy* (CNVS) to manage the potential noise impacts.

Operation

Without mitigation, the operation of the Lindfield Substation is anticipated to result in moderate exceedances of the noise design goals. Whilst exceedances have been predicted, this represents a “worst case”. However, the substation can be readily designed to meet the noise goals through provision of shielding or upgrading the acoustic performance of the enclosure. Past experience of measurements of similar substations indicates that the major noise source which requires specific attention is the rectifier transformer. Therefore, further detailed design of the substation will be progressed to ensure that the relevant *NSW Industrial Noise Policy* criteria are met.

Glossary

Item	Description / Definition
CNVIS	Construction Noise and Vibration Impact Statement
CNVS	Construction Noise and Vibration Strategy
CORTN	Calculation of Road Traffic Noise
DEC	Department of Environment and Conservation (now OEH / EPA)
DECC	Department of Environment and Climate Change (now OEH / EPA)
DECCW	Department of Environment, Climate Change and Water (now OEH / EPA)
DoP	NSW Department of Planning – now DP&I
DP&I	Department of Planning and Infrastructure
ECRL	Epping to Chatswood Rail Link
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
ICNG	Interim Construction Noise Guideline
INP	Industrial Noise Policy
NML	Noise Management Level
NSW	New South Wales
NWRL	North West Rail Link
OEH	Office of Environment and Heritage
RES	Rail Enclosure Structure
RBL	Rating Background Level
RNP	Road Noise Policy
SLR	SLR Consulting Australia Pty Ltd
SWL	Sound Power Level
TCA	Transport Construction Authority (now TfNSW Transport Projects Division)
TfNSW	Transport for NSW

1 Introduction

Transport for NSW (TfNSW) proposes to construct a substation at Lindfield to allow for operation of the North West Rail Link (NWRL).

The proposed substation will be an above ground structure, located within the rail corridor between the North Shore Line up track and Lindfield Avenue.

The potential noise and vibration impacts during construction and operation of the substation at Lindfield have been assessed.

Specific acoustic terminology is used within this report. A description of acoustic terminology is attached as Appendix A.

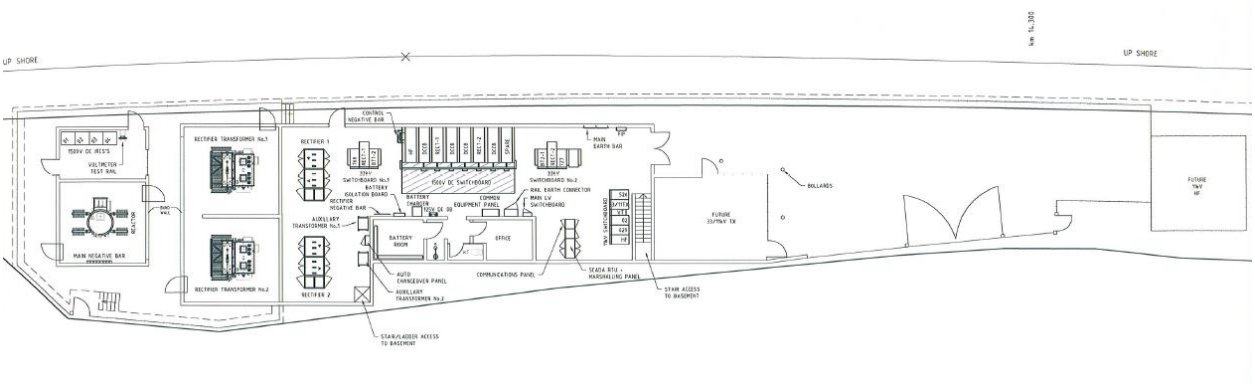
2 Description of Work

2.1 Lindfield Substation

The operation of the NWRL as a rapid transit system will utilise an existing substation at Chatswood North, which will then no longer be available to power the Sydney Trains network. As such, a new substation is proposed at Lindfield to provide power for the existing Sydney Trains North Shore Line.

The proposed substation will be an above ground structure, located within the rail corridor between the North Shore Line up track and Lindfield Avenue, at the intersection with Strickland Avenue. The layout of the proposed substation is illustrated in Figure 1.

Figure 1 Indicative Substation Layout



The proposed major construction activities as part of the works to be undertaken are described below:

Site establishment

The site will be cleared and grubbed, access roads will be constructed to the area for the site facilities and temporary storage areas which will be cut and filled for installation of the facilities and connection to services.

Excavation

Excavation will be undertaken to remove excess material and level the site. Some spoil from the excavation may be reused on site for filling and compaction of the facilities/storage areas. Benching and spoil removal will progress to the south of the site using rock breakers, excavators and trucks.

Civil and building works

The construction of the civil works will commence with construction of the foundations including forming and casting of reinforced concrete sections from the basement level to the final substation equipment floor level.

Equipment installation

Primary (rectifier transformers, rectifiers, reactors) and secondary (switchgear and switchboards, batteries and changers, voice and data communications) will be installed within the site. Large or heavy equipment such as the transformers and rectifiers will be craned into position which may require a temporary closure of Lindfield Avenue during lifting operations.

2.2 Site Plan and Surrounding Receivers

The location of the nearest residential receivers to Lindfield Substation are shown in Figure 2 and the approximate distances to the receivers are shown in Table 1.

Figure 2 Site Plan and Nearest Receivers at Lindfield

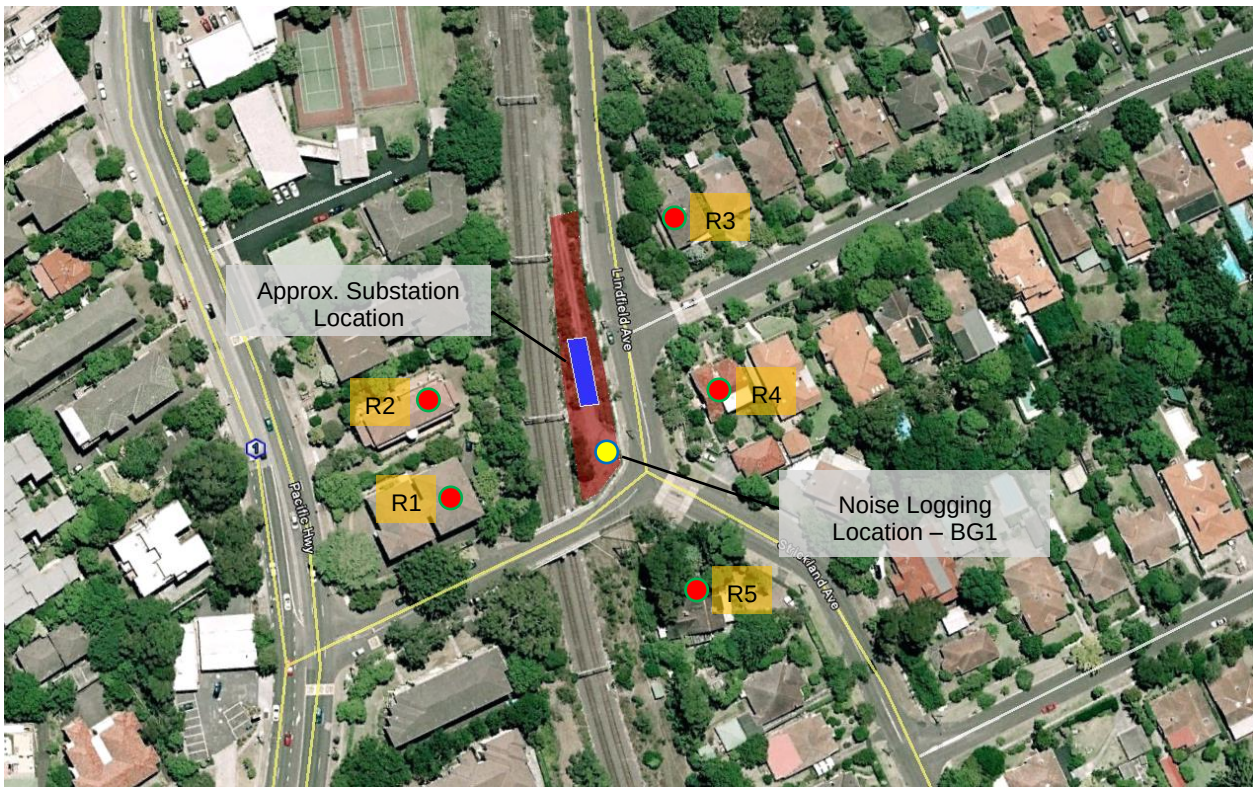


Table 1 Sensitive Receivers near Lindfield Substation

Receiver	Address	Approx. Distance to Site (m)
R1	239 Pacific Highway, Lindfield	25
R2	251 Pacific Highway, Lindfield	25
R3	4 Middle Harbour Road, Lindfield	25
R4	1 Middle Harbour Road, Lindfield	25
R5	36 Strickland Avenue, Lindfield	30

3 Description of Existing Environment

To quantify and characterise the existing ambient noise environment adjacent to the proposed works, a baseline noise survey was undertaken from 11 to 18 December 2013.

The measured noise levels have been applied to establish appropriate noise assessment goals for fixed facilities and as a basis for assessing potential noise impacts during construction.

3.1 Methodology for Unattended Noise Monitoring

The noise logger continuously measured noise levels in 15 minute sampling periods to determine the existing L_{Aeq}, L_{A90} and other relevant statistical noise levels during the daytime, evening and night-time periods.

The noise measurements were carried out with an Acoustic Research Laboratories Type EL 316 Environmental Noise Logger. The equipment was set up with the microphone at 1.5 m above the ground level within the rail corridor. The microphone was fitted with a wind shield.

The noise measurement instrumentation used in the survey was designed to comply with the requirements of Australian Standard AS IEC 61672.1—2004 - *Electroacoustics—Sound level meters, Part 1: Specifications*[i] and carried an appropriate and current NATA calibration certificate.

The calibration of the logger was checked both before and after the measurement survey and the variation in calibration was found to be within the acceptable limits.

The analysis of the measured noise levels was carried out in accordance with the procedures contained in the *NSW Industrial Noise Policy* (INP) to establish representative noise levels. Consistent with the INP, periods of unsatisfactory monitoring conditions of rain and wind speeds greater than 5 metres per second (m/s) have been filtered from the results.

3.2 Unattended Noise Monitoring Results

The results of the unattended ambient noise surveys are presented in Table 2 as the Rating Background Level (RBL) and L_{Aeq} (energy averaged) noise levels for the daytime, evening and night-time periods. The daily noise levels are graphically presented in Appendix B.

Table 2 Summary of Unattended Noise Logging

Location	Address	Noise Level (dBA)[1]					
		Daytime 7.00 am to 6.00 pm		Evening 6.00 pm to 10.00 pm		Night-time 10.00 pm to 7.00 am	
		RBL	L_{Aeq}	RBL	L_{Aeq}	RBL	L_{Aeq}
BG1 - Lindfield	In rail corridor near access gate	48	59	44	58	33	53

Note 1: The RBL and L_{Aeq} noise levels have been obtained using the calculation procedures documented in the INP

3.3 Attended Airborne Noise Measurements

Attended measurement of ambient noise has been used to determine the various noise sources that influence the existing noise environment at the Lindfield Substation site. During the measurement, the observer noted the various noise sources and the contributing noise level.

The attended measurements were performed using a Brüel and Kjær Type 2260 sound level meter for a minimum period 15 minutes. The wind speed was less than 5 m/s at all times, and the measurements were performed at a height of 1.5 m above ground level.

Calibration of the sound level meter was checked before and after the measurement and the variation in calibration was found to be within acceptable limits at all times. The noise environment at the attended monitoring location is described in Table 3.

Table 3 Attended Noise Monitoring Results

Location	Noise Level (dBA)[1]					Description and Typical L_{Amax} Levels (dBA)
	L_{Amax}	L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	
BG1 18/12/13	75	70	66	58	51	60 – 64 cars 55 birds 70 motorbike 66 train

4 Noise and Vibration Guidelines

4.1 Construction Noise and Vibration Guidelines

4.1.1 Construction Noise and Vibration Strategy

A *'Construction Noise and Vibration Strategy'* (CNVS) has been developed by the NWRL project team and will be adopted by contractors to manage construction noise and vibration across the various construction sites. In preparing this strategy, consideration has been given to several guideline documents including the *'Interim Construction Noise Guideline'* (DECC 1999), Transport for NSW (TfNSW) *'Construction Noise Strategy'*, Australian Standard AS 2436-2010 *'Guide to noise and vibration control on construction, demolition and maintenance sites'* and the *'Road Noise Policy'* (DECCW 2011).

The CNVS documents the best-practice techniques specific to the NWRL project for managing construction noise and vibration, and implementing feasible and reasonable mitigation measures.

The CNVS includes a standard suite of mitigation measures to be implemented across all NWRL construction sites (such as periodic notification of proposed works, adherence to construction respite periods, use of non-tonal reversing alarms, etc.). It also includes additional mitigation and management measures when construction noise is predicted to exceed the Noise Management Levels (such as noise monitoring, individual briefings, respite offers and in some instances at night, alternative accommodation). These measures are primarily aimed at proactive engagement with affected sensitive receivers.

In addition to the mitigation measures described in the CNVS, contractors may introduce further measures or mitigation strategies to reduce noise and vibration impacts at sensitive receivers. The CNVS is provided in Appendix C.

4.1.2 Construction Noise Metrics

The three primary noise metrics used to describe construction noise emissions in the modelling and assessments are:

- L_{Amax} The "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods.
- $L_{A1(1minute)}$ The noise level which is exceeded for 1% of a 1 minute sample period, used interchangeably with the L_{Amax} noise level in the assessment of potential sleep disturbance during night-time periods.
- $L_{Aeq(15minute)}$ The "energy average noise level" evaluated over a 15 minute period.
- L_{A90} The "background noise level" or Rating Background Level in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively and is used to set the $L_{Aeq(15minute)}$ noise management levels for residential receivers.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (i.e. A-weighted).

4.1.3 Noise Management Levels

The *Interim Construction Noise Guideline* (ICNG) sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses. It does this by presenting assessment approaches that are tailored to the scale of construction projects.

The ICNG contains a quantitative assessment method which is applicable to new infrastructure projects. Guidance levels are given for airborne noise at residences and other sensitive land uses, including commercial and industrial premises. For residences, guidance in relation to ground-borne noise and sleep disturbance is also provided.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the guidance, or management levels. In this report, the "management levels" will be referred to as noise management levels (NMLs). They have been reproduced from the ICNG and are presented in Table 4. These NMLs apply to all the construction activities and sites associated with the project. For residences, the NMLs are set with reference to the Rating Background Level (RBL).

Table 4 Management Levels for Airborne Construction Noise at Residences

Time of day	Noise Management Level (NML) $L_{Aeq(15minute)}$ [1,2]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of day	Noise Management Level (NML) $L_{Aeq(15minute)}$ [1,2]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1 *Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).*

4.1.4 Sleep Disturbance and Maximum Noise Level Events

There are no specific criteria for sleep disturbance nominated in the ICNG, the INP and associated Application Notes, or in the RNP. The current approach to identifying potential sleep disturbance impacts is to set a screening criterion 15 dB above the RBL during the night-time period (10.00 pm to 7.00 am). When the screening criterion is not met, a more detailed analysis may be required which should cover the maximum (L_{Amax}) noise level or $L_{A1(1minute)}$, the extent that the maximum noise level exceeds the background or RBL level and the number of times this occurs during the night-time period.

Some guidance on possible impacts is contained in the RNP which contains a section on sleep disturbance that includes a summary of current literature. The RNP concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions
- One or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

For this assessment, an external sleep disturbance screening level of RBL + 15 dB (L_{Amax} 48 dBA) has been adopted, applicable at a distance of 1 m outside bedroom windows.

4.1.5 Construction Vibration

The effects of vibration in buildings can be divided into three main categories – those in which the occupants or users of the building are concerned or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

Construction vibration criteria relating to human comfort and potential structural damage are provided in Appendix A of the CNVS.

In relation to human comfort, the vibration management levels are based on guidance contained in the *'Assessing Vibration – a technical guideline'* (DEC, 2006). Mitigation and management measures including consideration of alternative construction methods, attended monitoring and observance of respite periods are required in situations where vibration levels are predicted to exceed the management levels.

Structural damage vibration limits are based on Australian Standard AS 2187: Part 2-2006 *'Explosives - Storage and Use - Part 2: Use of Explosives'* and British Standard BS 7385 Part 2-1993 *'Evaluation and measurement for vibration in buildings Part 2'*. These standards provide frequency-dependent vibration limits related to cosmetic damage, noting that cosmetic damage is very minor and superficial in nature, is readily repairable and does not affect the structural integrity of the building.

In order to simplify the assessment process and provide a conservative assessment of the potential impacts associated with the proposed construction activities, a conservative vibration damage screening level of 7.5 mm/s has been adopted for the project. This level of 7.5 mm/s is also applicable to heritage structures, unless it is known that the structure is already structurally unsound – in which case, a lower screening level may be applicable. At this stage in the assessment, no heritage structures have been identified in close proximity to the project.

At locations where the predicted and/or measured vibration levels are greater than 7.5 mm/s, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be required to determine the applicable safe vibration level.

If there is a risk that vibration levels will be greater than 7.5 mm/s and a building or structure may be damaged, building condition surveys will be undertaken prior to and following construction to record any change in building condition as a result of the construction activities.

4.2 Operational Noise Criteria – Fixed Facilities

Operational noise impacts have been considered for the Lindfield Substation. This plant is considered to be a fixed facility and as such, operational noise levels are required to be assessed in accordance with the *NSW Industrial Noise Policy* (INP).

4.2.1 Operational Noise Metrics

The primary noise metrics used to describe noise emissions from fixed facilities assessments are:

- L_{Amax} The "typical maximum noise level" measured using the 'fast' response setting on a sound level meter. In the INP assessment of sleep disturbance, L_{Amax} is used interchangeably with $L_{A1(1minute)}$.
- $L_{A1(1minute)}$ The noise level which is exceeded for 1% of the 1 minute sample period, used interchangeably with the L_{Amax} noise level in the assessment of potential sleep disturbance during night-time periods.
- $L_{Aeq(15minute)}$ The "energy average noise level" evaluated over a 15 minute period, used in the assessment of the intrusiveness of noise sources.
- $L_{Aeq(period)}$ The $L_{Aeq(period)}$ is the "energy average noise level" evaluated over the relevant time period, either day (11 hours) evening (4 hours) or night (9 hours). It is used in the assessment of amenity.

4.2.2 Fixed Facility Noise Criteria

The INP sets two separate noise criteria to meet environmental noise objectives – one to account for intrusive noise and the other to protect the amenity of particular land uses. When determining project specific noise criteria, both the amenity and intrusive criteria are considered. The more stringent of these two criteria usually defines the project specific noise levels. For both amenity and intrusiveness, night-time criteria are more stringent than daytime or evening criteria. As the substation has the potential to operate during any period, the night-time period is likely to be the controlling time period.

Assessing Intrusiveness

To provide for protection against intrusive noise, the INP states that the L_{Aeq} noise level of the source, measured over a period of 15 minutes, should not be more than 5 dB above the ambient (background) L_{A90} noise level (or RBL), during the daytime, evening and night-time periods at the nearest sensitive receivers. In this case, the RBLs listed in Table 2 describe the noise environment as measured near the proposed fixed facilities.

Assessing Amenity

To protect against impacts on amenity, the INP identifies recommended acceptable and maximum $L_{Aeq(period)}$ noise levels for particular land uses and activities during the daytime, evening and night-time periods. The residences in the vicinity of the proposed facilities are considered to be 'Suburban'. According to the INP, a 'Suburban' area would be characterised by local traffic with intermittent traffic flows, decreasing noise levels in the evening period; and/or evening ambient noise levels defined by the natural environment and infrequent human activity. The amenity criteria for suburban residential receivers are shown in Table 5.

Table 5 INP Amenity Noise Levels for Suburban Residential Receivers

Type of Receiver	Land Use	Time of Day	Recommended L_{Aeq} Noise Level (dBA)	
			Acceptable	Recommended Maximum
Residential	Suburban	Day	55	60
		Evening	45	50
		Night	40	45

4.3 Construction Traffic Noise

The ICNG does not provide specific guidance in relation to acceptable noise levels associated with construction traffic. For assessment purposes, guidance is taken from the '*NSW Road Noise Policy*' (RNP).

One of the objectives of the RNP is to protect sensitive receivers against excessive decreases in amenity as the result of a project by applying relevant noise increase criteria. In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration will also be given to the actual noise levels associated with construction traffic and whether or not these levels comply with the following road traffic noise criteria in the RNP:

- Existing freeway / arterial / sub-arterial roads — $L_{Aeq(15hour)}$ 60 dBA day and $L_{Aeq(9hour)}$ 55 dBA night
- Existing local roads — $L_{Aeq(1hour)}$ 55 dBA day and $L_{Aeq(1hour)}$ 50 dBA night.

5 Construction Assessment

People are usually more tolerant to noise and vibration during the construction phase of projects than during full operations. This response results from recognition that the construction emissions are of a temporary nature – especially if the most noise-intensive construction impacts occur during the less sensitive daytime period. For these reasons, acceptable noise and vibration levels are normally less stringent during construction than during operations.

Construction often requires the use of heavy machinery which can generate high noise and vibration levels at nearby buildings and receivers. For some equipment, there is limited opportunity to mitigate the noise and vibration levels in a cost-effective manner and hence the potential impacts should be minimised by using feasible and reasonable management techniques.

At any particular location, the potential impacts can vary greatly depending on factors such as the relative proximity of sensitive receivers, the overall duration of the construction works, the intensity of the noise and vibration levels, the time at which the construction works are undertaken and the character of the noise or vibration emissions.

5.1 Quantitative Noise and Vibration Assessment

Given the likely duration of the works, a quantitative assessment has been completed for the assessment of Lindfield Substation.

At this early stage in the planning process, detailed information about the proposed construction works and equipment selections is not available. The construction noise and vibration assessment is therefore based on preliminary, indicative information and previous project experience. The assessed quantitative construction scenarios for the works are detailed in Table 6

Table 6 Quantitative Construction Scenarios

Ref.	Works	Scenario	Assumed Timing	Equipment Required
01a	Lindfield Substation	Excavation	Standard Daytime	Road profiler, excavator with breaker attachment, tipper truck
02b		Foundation Preparation		Bobcat, hand tools, concrete pump, concrete truck
03c		Delivery and Placement of Equipment		Flatbed truck, mobile crane, hand tools

5.1.2 Site Specific Construction Noise Management Levels

With reference to the ambient noise survey results in Section 3, the site specific construction NMLs for these works are presented in Table 7.

Table 7 Construction NMLs – Residential Receivers

Works	Receiver Type	Repres. Monitoring Location	$L_{Aeq(15minute)}$ Construction NMLs (dBA)		
			Daytime (RBL+10dB)	Evening (RBL+5dB)	Night-time (RBL+5dB)
Lindfield Substation	Residential	BG1	58	49	38

Construction Hours

Construction hours for the works at Lindfield Substation would generally be restricted to the standard daytime construction hours (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays).

With the exception of emergency work, activities would not take place outside standard hours without prior discussion with and/or notification of local residents, businesses and TfNSW.

5.1.3 Airborne Construction Noise Modelling

Airborne construction noise modelling was undertaken using spreadsheet calculations. To ensure a conservative assessment of the impacts a direct line-of-sight between the source and receiver has been assumed in all calculations. In reality some screening is likely to be apparent which will reduce the receiver noise levels to some degree. At Lindfield there are existing property boundary fences and the equipment would be located in a cutting at rail level, which would screen the view from some receivers.

L_{Amax} sound power levels for equipment assumed in the modelling are presented in Table 8. The sound power levels are maximum noise emission levels of plant that may be used on this project in typical operation.

In order to apply the construction NMLs for the project, it is necessary to convert these maximum power levels to equivalent $L_{Aeq(15minute)}$ sound pressure levels. From numerous field studies on large construction projects, the measured difference values between the L_{Amax} and $L_{Aeq(15minute)}$ noise levels have been found to be up to 10 dB depending on the mixture of the plant, intensity of operation and location of the plant relative to the receiver.

In the present study adjustments of 2 dB to 5 dB have been conservatively applied to convert the L_{Amax} power levels shown in Table 8 to $L_{Aeq(15minute)}$ sound pressure levels for comparison with the construction NMLs.

Table 8 Maximum Sound Power Levels for Equipment

Plant Item	L_{Amax} Sound Power Level (dBA)	L_{Amax} Sound Pressure Level @ 7 m (dBA)
Road Profiler	113	88
Excavator (Breaker)[2]	122	97
Tipper Truck	107	82
Bobcat	110	85
Hand Tools	100	75
Concrete Pump	109	84
Concrete Truck / Agitator	112	87
Flatbed Truck	106	81
Mobile Crane (100 tonne)	110	110

Note 1 *The sound power levels presented are based on the* Construction Noise and Vibration Strategy *(CNVS) and SLRs noise database.*

Note 2 *In accordance with the* Interim Construction Noise Guideline *for activities identified as particularly annoying (such as jack hammering, rock breaking and power saw operation), a 5 dB "penalty" is added to the source sound power level when predicting noise using the quantitative method.*

Consistent with the requirements of the ICNG, the construction noise impacts are based on a worst-case assessment. The guideline recommends that the realistic worst-case or conservative noise levels from the source should be predicted for assessment locations representing the most noise-exposed residences or other sensitive land uses.

For most construction activities, it is expected that the construction noise levels will frequently be lower than predicted at the most-exposed receiver.

5.1.4 Quantitative Noise Assessment

It is anticipated that the Lindfield Substation works will be able to be completed during standard daytime construction hours.

The predicted typical $L_{Aeq(15minute)}$ daytime noise levels exceedances are summarised in Table 9 for the Lindfield Substation. The full noise predictions for all construction scenarios are contained in Appendix D.

Table 9 Lindfield Substation – Predicted Daytime Exceedances

Receiver Area	Noise Modelling Scenario		
	Lindfield Substation		
	02a Excavation	02b Foundation Preparation	02c Delivery and Placement of Equip.
R1 - 239 Pacific Highway, Lindfield			
R2 - 251 Pacific Highway, Lindfield			
R3 - 4 Middle Harbour Road, Lindfield			
R4 - 1 Middle Harbour Road, Lindfield			
R5 - 36 Strickland Avenue, Lindfield			
Legend			
Compliance 	≤ 10 dB exceedance 	10 dB to ≤ 20 dB exceedance 	> 20 dB exceedance or $L_{Aeq(15minute)}$ > 75 dBA 

The findings of the construction noise impact assessment indicate:

- The predicted daytime noise levels indicate high exceedances of the NMLs during Excavation works at nearest residences adjacent to site. The predicted noise levels during this scenario are anticipated to be greater than 75 dBA.
- During Foundation Preparation and Delivery and Placement of Equipment, minor to medium exceedances of the NMLs are anticipated.

Mitigation

The ICNG and the TfNSW *Construction Noise Strategy* describe strategies for construction noise mitigation and control that are applicable to this proposal. The strategies are designed to minimise, to the fullest extent practicable, noise during construction through the application of all feasible and reasonable mitigation measures.

The NWRL *'Construction Noise and Vibration Strategy'* (CNVS), provided in Appendix C, has been developed with consideration of both the above documents.

All construction works associated with the proposal would be managed in accordance with the CNVS.

The CNVS documents the best-practice techniques specific to the NWRL projects for managing construction noise and vibration, and implementing feasible and reasonable mitigation measures.

Example mitigation measures which are considered appropriate for these works include:

- Implementation of proactive community consultation measures
- Site inductions for all contractors
- Restriction of works to standard daytime construction hours
- Use of less noisy equipment
- Shielding of works using site hoardings
- Respite periods.

5.1.5 Construction Vibration Safe Working Distances

During construction of the Lindfield Substation, the major potential sources of vibration emission include rock breakers and other large construction plant and equipment.

As discussed in Section 4.1.5, a conservative cosmetic vibration damage screening level of 7.5 mm/s has been adopted for the project. Table 10 provides a summary of the indicative "safe working distances" for the plant items likely to be used for the construction works. The safe working distances are less than those identified in Section 3.3 of the CNVS on the basis of the conservative nature of the 7.5 mm/s screening level.

Table 10 Safe Working Distances - Cosmetic Damage (based on 7.5 mm/s screening level)

Plant Items	Indicative Safe Working Distance
Hydraulic Impact Hammer – Small	1 m
Hydraulic Impact Hammer – Medium	4 m
Hydraulic Impact Hammer – Large	15 m

As the nearest sensitive receivers are around 25 meters away, the offset distance from the work site is sufficient to mitigate any potential impacts from vibration.

5.2 Construction Traffic

The majority of the construction traffic associated with the proposal would use access routes on busy existing roads. This includes the Pacific Highway in Chatswood.

For Lindfield Substation, construction access to the site will however also be provided from Lindfield Avenue. At this stage, construction traffic is anticipated to enter the site from the Pacific Highway into Strickland Avenue and turn left into Lindfield Avenue. The route avoids the Balfour Street underpass and the shopping precinct in Lindfield Avenue.

Noticeable impacts may result from construction traffic accessing local roads the Lindfield Substation, therefore the assessment of construction traffic to this aspect of the proposal should be revisited during detailed design when more information regarding the likely traffic volumes and exact access routes is known.

6 Operational Noise Assessment

6.1 Lindfield Substation

The location of the proposed Lindfield Substation and surrounding receivers is illustrated in Figure 2.

It is noted that excavation of the existing ground is proposed at the site to locate the substation at approximately rail level.

6.1.1 Noise Criteria

For the proposed operations, the intrusive, amenity and sleep disturbance noise goals will apply. A summary of the operational noise criteria for the facility is provided in Table 11. The amenity and intrusiveness criteria are to be met at the most-affected boundary of the receiver property, or if this is more than 30 m from the residence, at the most affected point within 30 m of the residence.

Since the noise emissions associated with the operation of substations are reasonably continuous, the $L_{Aeq(15minute)}$ and the $L_{Aeq(period)}$ noise criteria are essentially the same and the more stringent of the intrusiveness or the amenity criteria sets the noise goals. The substation will operate continuously 24-hours a day, therefore the night-time is the potentially most affected period. The resulting night-time site-specific noise criteria, based on a suburban area, are shown in Table 11.

Table 11 Summary of Night-time Operational Noise Criteria

Repres. Noise Logging Location	Receiver Type	Noise Level (dBA)				
		Measured Existing Night-time		INP Criteria – New Sources		
		RBL[1]	L_{Aeq}	$L_{Aeq(15min)}$ Intrusive	$L_{Aeq(Period)}$ Amenity[2]	$L_{A1(1minute)}$[3] Sleep Disturbance
BG1	Residential	33	53	38	40	48

Note 1: RBL = Rating Background Level.

Note 2: Based on a suburban area and that existing noise levels are unlikely to decrease.

Note 3: Sleep disturbance can be evaluated on the basis of the $L_{A1(1minute)}$ or L_{Amax}.

6.1.2 Substation Noise Sources

The major noise sources at substations are electric transformers, which operate continually throughout the daytime and night-time. The assumed sound power level, conservatively based on measurements of similar substations on previous projects, is provided in Table 12.

Table 12 Summary of Substation Sound Power Level

Source	Sound Power Level (dBA re 10^{-12} W)
1 x Transformer	80

Substation transformer noise occurs at approximately 100 Hz (and harmonics of 100 Hz), with a humming or buzzing characteristic, which could be considered both low-frequency and tonal. The modifying factors recommended in the INP for tonal/low frequency noise are presented in Table 13.

Table 13 Modifying Factors

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

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

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

The INP states that modifying factors are to be applied to the noise from the source measured or predicted at the receptor, before comparison with the intrusiveness or amenity criteria. For this assessment, the modifying factor is required to account for the potentially annoying tonal and low-frequency characteristics. As shown in Table 13, the total penalty to be applied is 5 dB.

6.1.3 Predicted Noise Impacts

Steady State Noise

Noise levels have been predicted to the nearest sensitive receivers surrounding the proposed site. As shown in Figure 2, a number of receivers surrounding the site are around 25 m away. Whilst excavation is proposed at the site to lower the existing ground elevation so the substation is at rail level, a direct line-of-sight has been assumed between the substation and all surrounding receivers to ensure a conservative assessment.

The predicted base case night-time noise levels during operation of the Lindfield Substation in relation to the criteria are provided in Table 14.

Table 14 Base Case Assessment of Lindfield Substation, Night-time

Period	Noise Level (dBA)			
	Predicted		INP Criteria	
	$L_{Aeq(15minute)}$	$L_{Aeq(Period)}$	$L_{Aeq(15minute)}$ Intrusive	$L_{Aeq(Period)}$ Amenity[3]
Night-time	49	49	38	40

Circuit Breaker Noise

The circuit breakers in the proposed substation can emit an impulsive "bang" when a fault causes a breaker to trip. The frequency of such events is however typically very low and would be assumed to occur approximately twice a week on average. Noise levels are typically 100 dBA to 120 dBA (fast response) at a distance of 6 m from an unenclosed circuit breaker.

The circuit breakers at Lindfield Substation would be located within the main enclosure of the substation, which would provide an appreciable noise attenuation. Non-mechanical ventilation in the form of louvres will also likely be used to provide the required ventilation and reduce noise emissions.

As the noise emissions from this source are intermittent in nature and can occur at any time of the day, it is appropriate to assess the potential noise emissions in relation to the night-time sleep disturbance goals.

The predicted night-time $L_{A1(60second)}$ noise levels during operation of the circuit breakers are provided in Table 15.

Table 15 Assessment of Circuit Breakers

Period	Noise Level (dBA)	
	Predicted[1]	INP Criteria
	$L_{A1(60second)}$	$L_{A1(1minute)}$ Sleep Disturbance[2]
Night-time	64	48

Note 1: Based on a sound power level of 100 dBA from the operation of the enclosed circuit breakers.

Note 2: Sleep disturbance can be evaluated on the basis of the $L_{A1(1minute)}$ or L_{Amax}.

6.1.4 Discussion of Substation Noise Impacts and Mitigation Measures

Airborne Noise Level Summary for Base Case

The predicted base case steady state noise levels result in a worst-case 11 dB exceedance of the night-time intrusive goal at the nearest sensitive receivers.

The predicted $L_{A1(60second)}$ noise levels also exceed the sleep disturbance screening criterion at the nearest residential receiver locations by up to 16 dB. It should be noted, however, that the predicted noise level from circuit breaker operation will not occur on a continuous basis and will likely be a very infrequent occurrence during the night-time period – potentially once or twice a month.

Mitigation of Airborne Noise Levels

Whilst exceedances have been predicted, this represents a “worst case” and it is expected that the substation can be readily designed to meet the noise goals through provision of shielding or upgrading the acoustic performance of the enclosure. Past experience of measurements of similar substations indicates that the major noise source which requires specific attention is the rectifier transformer.

If a noise barrier is required, the height of the barrier would need to be of sufficient height to adequately block line-of-sight between the noise source and the surrounding receivers. Other noise mitigation measures could include the optimisation of the substation layout to orient the main noise sources away from of the nearest receivers, or the use of acoustically absorptive material inside the rectifier transformer enclosure in combination with acoustic louvres.

It is noted that the calculations do not include any noise attention that would be provided by screening from cuttings between the substation and receivers, therefore the current assessment is considered worst-case.

During the detailed design stage of the project, when full details of the substation design are available, the impacts from the substation would be reassessed and the optimum mix of mitigation measures determined to ensure that the *NSW Industrial Noise Policy* criteria (Section 4.2) are met.

7 Conclusion

The construction and operational noise and vibration impacts of the proposed Lindfield Substation have been assessed.

Construction

As a result of the temporary nature of the activities, the potential noise and vibration impacts during the construction phase of a project are often less significant than the long-term operational impacts.

At this early stage in the planning process, detailed information in relation to the proposed construction works, equipment and timeframes is not available. The construction noise and vibration assessments have therefore been based on preliminary, indicative information and previous project experience. The assessments should be reviewed in more detail as the project progresses and more information becomes available regarding specific items of plant and equipment.

For the Lindfield Substation, the predicted daytime noise levels indicate high exceedances of the NMLs during Excavation works, when rock breaking equipment is in use. This is due to the relative close proximity of the adjacent receivers. During Foundation Preparation and Delivery and Placement of Equipment, minor to medium exceedances of the NMLs are anticipated.

All feasible and reasonable noise mitigation measures would be applied to the works together with implementation of the NWRL *Construction Noise and Vibration Strategy* (CNVS) to manage the potential noise impacts.

Operation

The operation of the Lindfield Substation is anticipated to result in moderate exceedances at the nearby residential receivers. Whilst exceedances have been predicted, this represents a “worst case”. However, the substation can be readily designed to meet the noise goals through provision of shielding or upgrading the acoustic performance of the enclosure. Past experience of measurements of similar substations indicates that the major noise source which requires specific attention is the rectifier transformer. Therefore, further detailed design of the substation will be progressed to ensure that the relevant *NSW Industrial Noise Policy* criteria are met.

Appendix A 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 L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-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 4,000 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 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB 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	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (e.g. 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

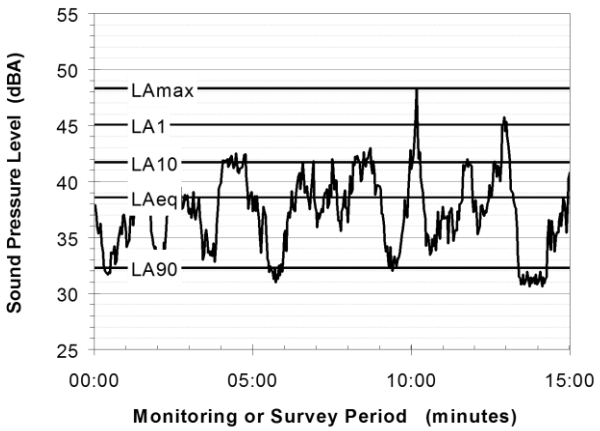
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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 L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} 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_{Amax} The maximum noise level during the 15 minute interval.

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 representative L_{Aeq} and L_{A90} noise levels over the daytime, evening and night-time measurement periods, as required by the EPA. In addition the method produces mean or 'average' levels representative of the other descriptors (L_{Amax}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (i.e. 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

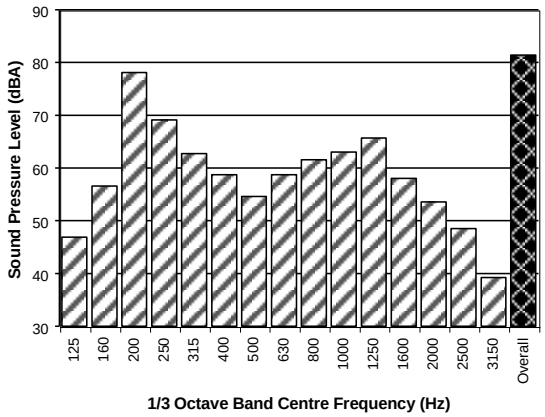
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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/V_o), where V_o is the reference level (10^{-9} m/s or 1 nm/s). Care is required in this regard, as other reference levels may be used by some organisations.

9 Human Perception of Vibration

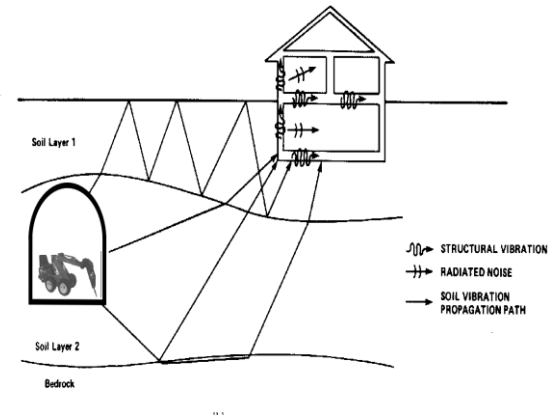
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience 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 Ground-borne Noise, Structure-radiated Noise and Regenerated Noise

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

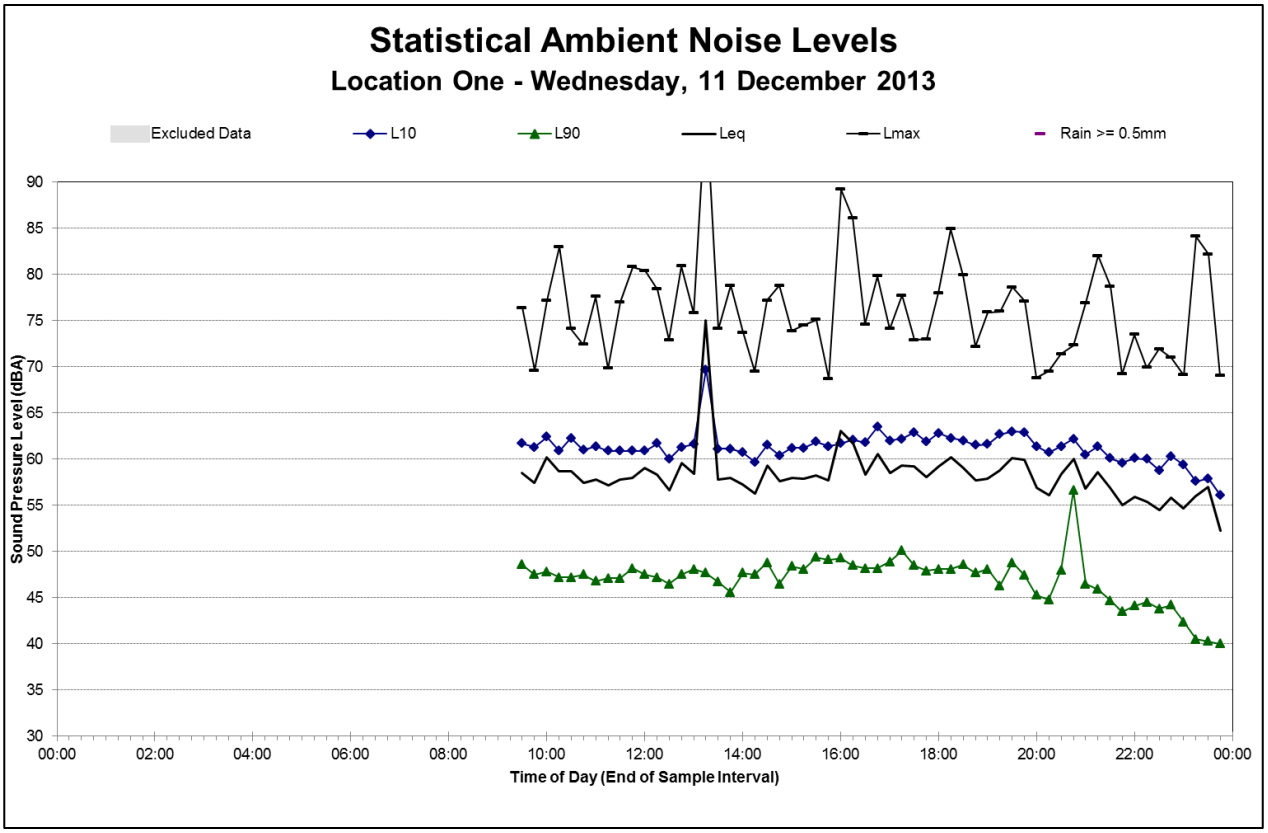
Typical sources of ground-borne or structure-radiated noise include tunnelling works, underground railways, excavation plant (e.g. rock breakers), and building services plant (e.g. fans, compressors and generators).

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



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

Appendix B Noise Data


Statistical Ambient Noise Levels
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Excluded Data
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Lmax
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Sound Pressure Level (dBA)
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80
75
70
65
60
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50
45
40
35
30
00:00
02:00
04:00
06:00
08:00
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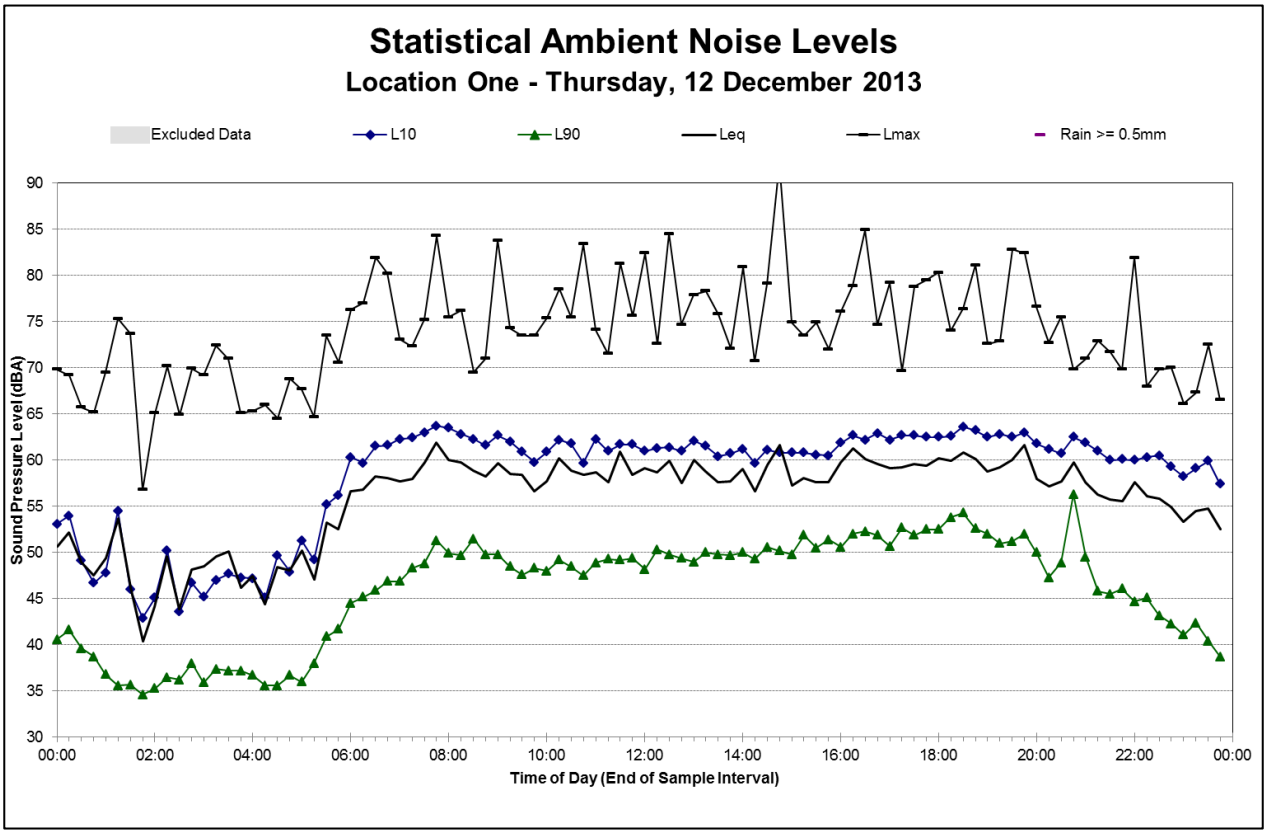
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time of Day (End of Sample Interval)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Lmax
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Sound Pressure Level (dBA)
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80
75
70
65
60
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50
45
40
35
30
00:00
02:00
04:00
06:00
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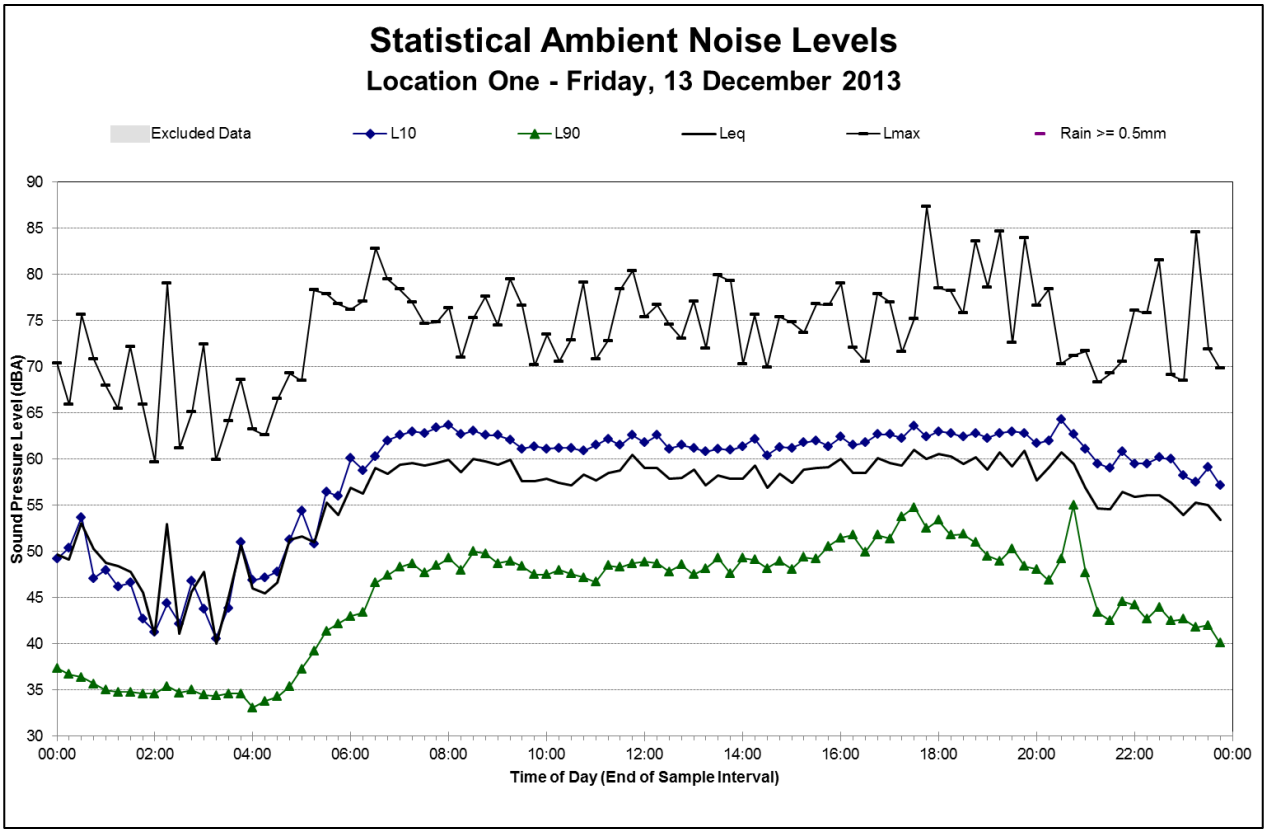
22:00
00:00
Time of Day (End of Sample Interval)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Lmax
Rain >= 0.5mm
Sound Pressure Level (dBA)
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65
60
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45
40
35
30
00:00
02:00
04:00
06:00
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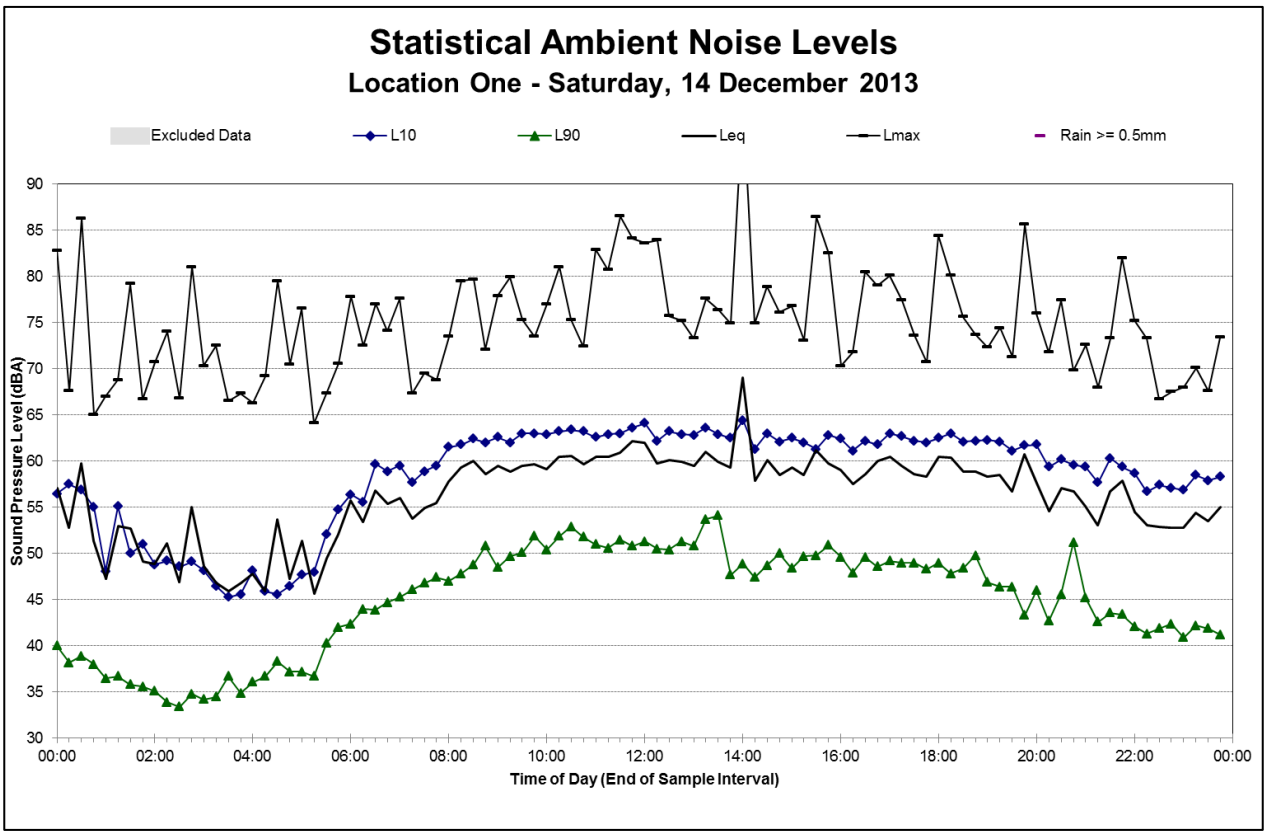
22:00
00:00
Time of Day (End of Sample Interval)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04:00
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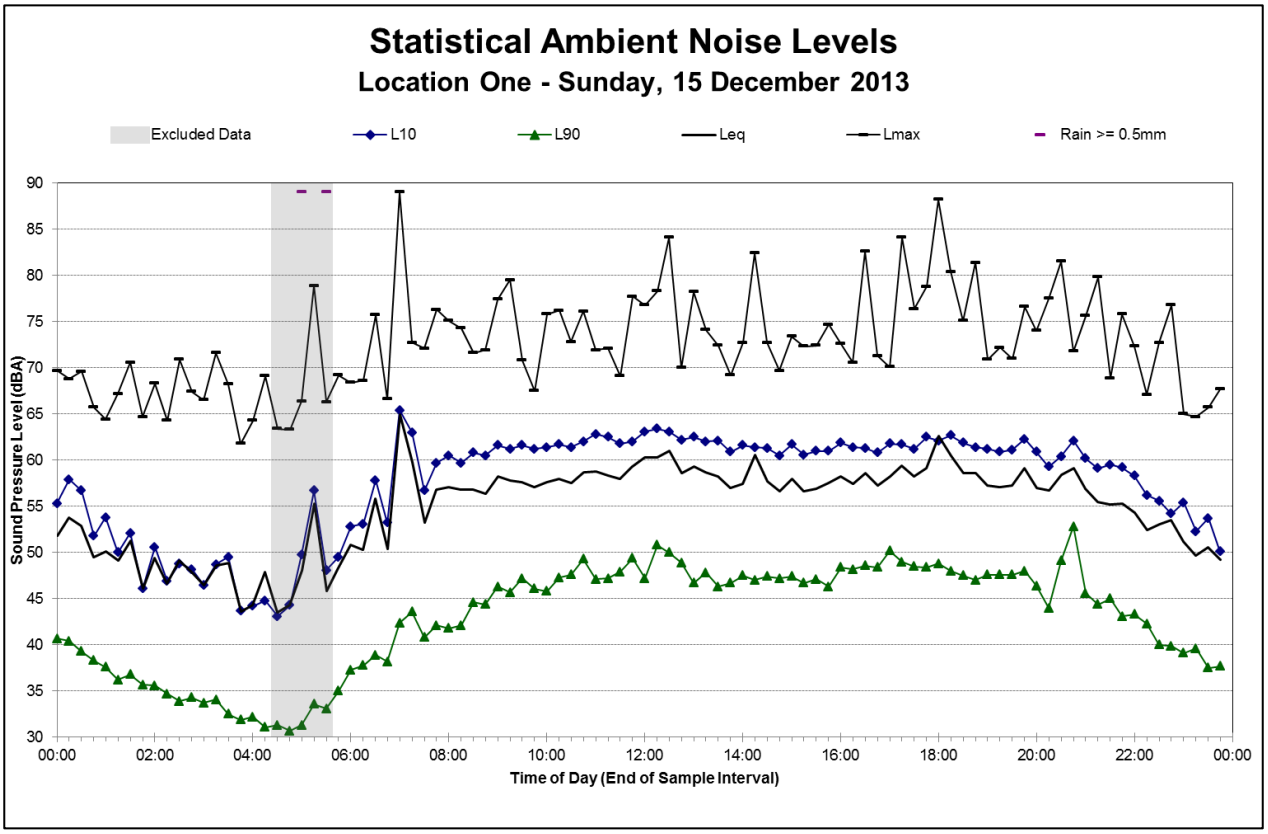
Time of Day (End of Sample Interval)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Sound Pressure Level (dBA)
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04:00
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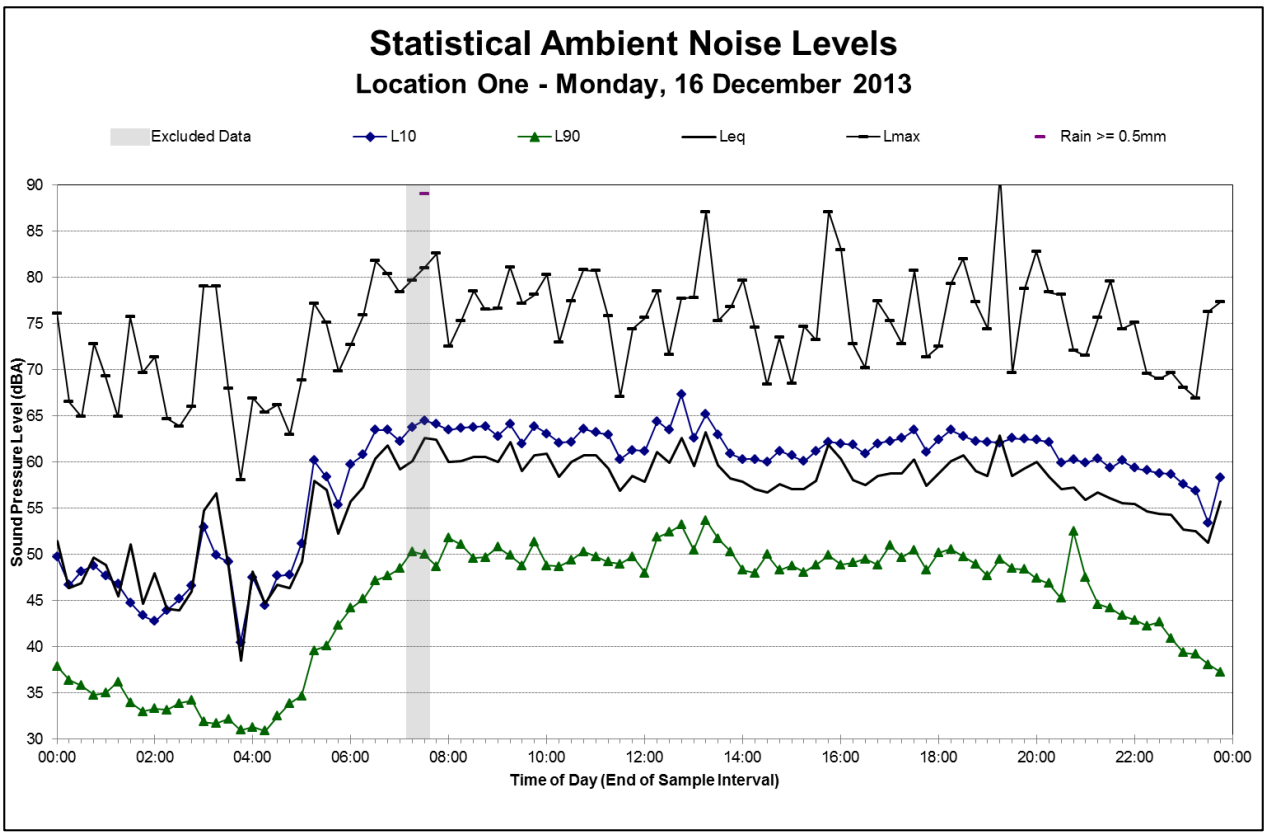
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Sound Pressure Level (dBA)
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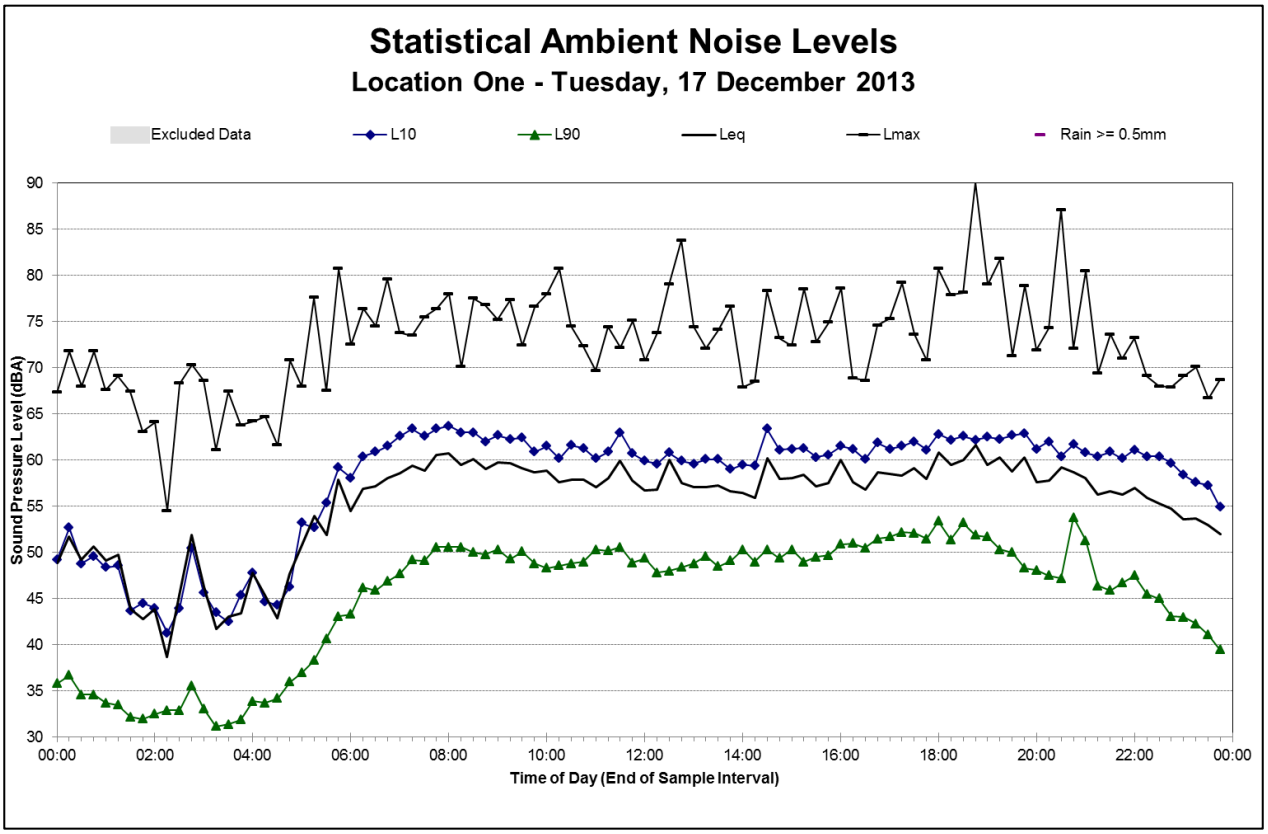
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Sound Pressure Level (dBA)
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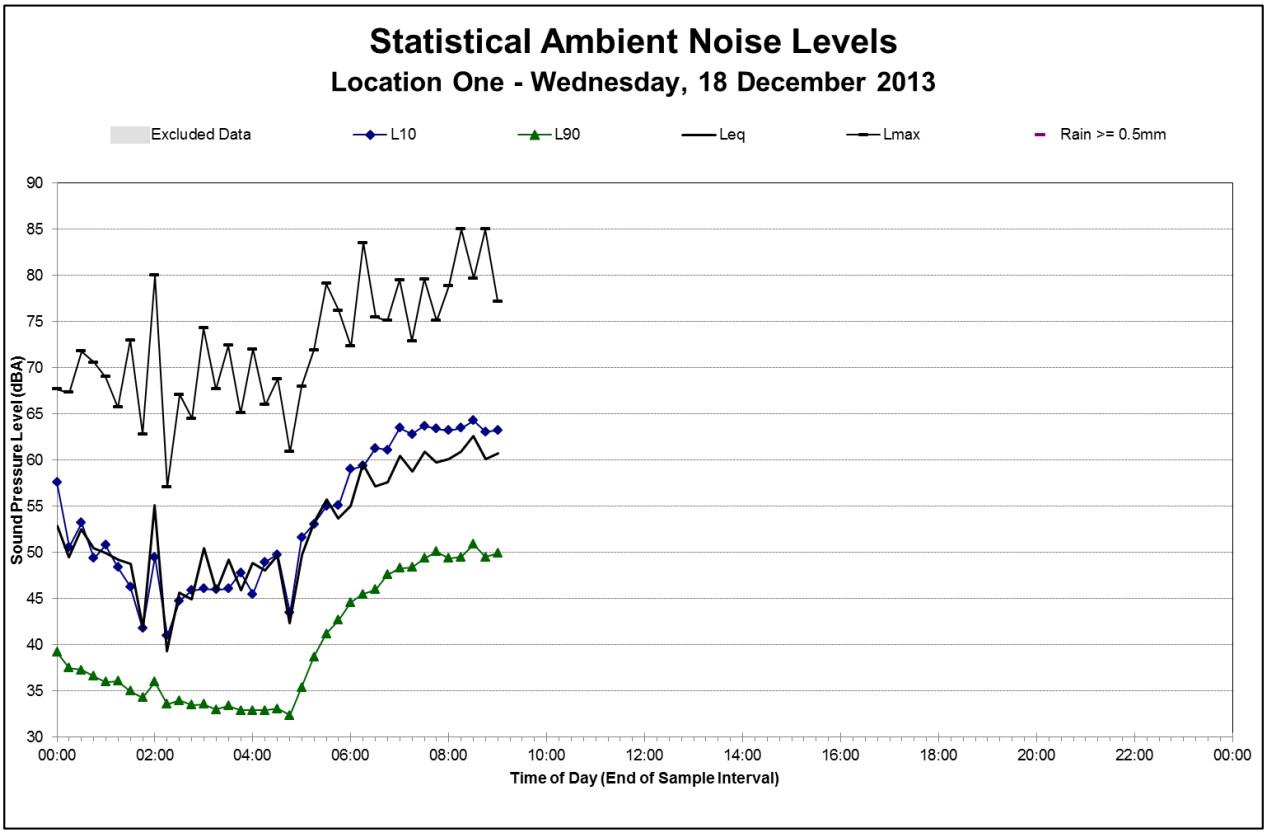
Time of Day (End of Sample Interval)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Time of Day (End of Sample Interval)

Appendix C NWRL CNVS

North West Rail Link

Construction Noise and Vibration Strategy

Date:	**February 2012**
Author:	SLR Consulting
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Status:	Final
	None

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Date	16 February 2012
Prepared by	Conrad Weber
Checked by	John Sleeman
Authorised by	Conrad Weber

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
1.0	16/2/2012	Final	Conrad Weber / Project Manager	

Prepared for:

Transport for NSW

Prepared by:

SLR Consulting Australia Pty Ltd
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Contents

Glossary

Item	Description / Definition
AMMM	Additional Mitigation Measures Matrix
AS	Australian Standard
BS	British Standard
CNVIS	Construction Noise and Vibration Impact Statement
CNVMP	Construction Noise and Vibration Management Plan
CNVS	Construction Noise and Vibration Strategy
DEC	Department of Environment and Conservation NSW – Now OEH
DECC	Department of Environment and Climate Change NSW – Now OEH
DECCW	Department of Environment, Climate Change and Water NSW – Now OEH
EIS	Environmental Impact Statement
EMR	Environmental Management Representative
EPA	Environment Protection Authority – Now OEH
EPL	Environment Protection Licence
ICNG	Interim Construction Noise Guideline
NWRL	North West Rail Link
OEH	Office of Environment and Heritage
OOHW	Out of Hours Work
RBL	Rating Background Level
REF	Review of Environmental Factors
RMS	Root Mean Square
SLR Consulting	SLR Consulting Australia Pty Ltd
SPL	Sound Pressure Level
SWL	Sound Power Level
TBM	Tunnel Boring Machine
TCA	Transport Construction Authority

1 Introduction

1.1 Purpose and Scope

The purpose of this document is to provide practical guidance on how to minimise, to the fullest extent practicable, the impacts on the community from airborne noise, ground-borne noise and vibration generated during the construction of the North West Rail Link (NWRL) project through the application of all feasible and reasonable mitigation measures.

This version of the Construction Noise and Vibration Strategy (CNVS) may be subject to change to reflect the outcomes of the planning approvals process, including Conditions of Approval relating to site-specific mitigation measures.

In addition to the mitigation measures described in this strategy, contractors may introduce further measures or mitigation strategies to reduce noise and vibration impacts at sensitive receivers.

1.2 Definitions

All terminology in this Construction Noise and Vibration Strategy (CNVS) is taken to mean the generally accepted or dictionary definition with the exception of the following terms which have a specifically defined meaning:

L_{Amax}	The “Maximum Noise Level” for an event, used in the assessment of potential sleep disturbance during night-time periods. The subscript “A” indicates that the noise levels are filtered to match normal human hearing characteristics (ie A-weighted).
$L_{Aeq(15minute)}$	The “Energy Average Noise Level” during construction activities, evaluated over a measurement period of 15 minutes. This is the main parameter used to assess the construction noise impacts.
L_{A90}	The “Background Noise Level” in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15minute)}$ construction noise objectives are based on an allowance margin above the L_{A90} background noise levels.
PPV	“Peak Particle Velocity” evaluated at the building footings and used to assess the risk of damage to structures.
Arms	“Root mean squared weighted acceleration”, a vibration parameter used to assess human response to continuous or intermittent vibration.
VDV	“Vibration Dose Value”, the overall vibration exposure assessed over the daytime or night-time period to assess human response to intermittent vibration.

1.3 Overview

The construction noise and vibration emissions associated with a large infrastructure project such as NWRL can cause disturbance to adjacent communities.

For some of the proposed construction works, activities will be required outside normal construction hours because work during daytime periods would be highly disruptive to commuter services and road traffic on major roads. The NWRL proposal includes approximately 15 km of twin underground tunnels which are likely to be constructed using tunnel boring machines (TBMs) and road headers. Additional supporting plant and activities would be required at some sites on a 24 hour per day basis to meet program requirements and facilitate the efficient operations of the tunnelling works. In addition to site-specific mitigation measures, the community should be consulted about the potential impacts, the time periods over which these will occur and the proposed mitigation measures.

This CNVS is based on the Transport Construction Authority (TCA) *"Construction Noise Strategy"*, updated to address the specific requirements of NWRL and recent changes in noise and vibration standards.

The CNVS has been developed to address the assessment requirements documented in DECC's *"Interim Construction Noise Guideline"* (ICNG). The main focus of the interim guideline is to minimise construction noise and vibration impacts, rather than focus only on achieving numeric noise levels, and recognises that some noise and vibration from construction sites is inevitable. The interim guideline encourages organisations involved with construction, maintenance or upgrading works to develop their own best-practice techniques for managing construction noise and vibration, and implementing feasible and reasonable mitigation measures. This CNVS is consistent with this recommendation.

In preparing this document, consideration has also been given to guidance contained in Australian Standard AS 2436-2010 – *"Guide to noise and vibration control on construction, demolition and maintenance sites"*.

The key elements of the CNVS involve:

- evaluating the construction noise and vibration impacts during the environmental impact assessment stage of a project to identify, in consultation with the community and other stakeholders, project specific construction noise and vibration objectives and possible mitigation measures for them
- implementing a standard suite of noise and vibration mitigation measures across all construction sites
- implementing additional mitigation measures when construction noise or vibration is predicted to exceed the project's construction noise and vibration objectives
- verifying the validity of noise assessments undertaken during the environmental impact assessment stage prior to construction commencing to ensure that any changes to the project's design, scope, construction method or the mitigation measures proposed in the environmental impact assessment are re-evaluated and any additional (or changes to the) mitigation measures are identified
- monitoring the implementation and effectiveness of the project's noise and vibration mitigation measures via a three monthly audit cycle.

1.4 Distribution and Use

This document may be used in the development of, or referred to in:

- environmental impact assessment documents
- design and construction environmental management documents
- contract documents
- approvals and licences (subject to the agreement of the relevant regulatory authority).

This document does not take precedence over approval or licence conditions and will be reviewed as required in response to the release of relevant guidelines, standards and policies dealing with construction noise and vibration.

2 Assessing the Impacts of Construction Noise and Vibration

As part of the environmental impact assessment process, the impacts on nearby receivers of airborne noise, ground-borne noise and ground-borne vibration generated during the construction of the NWRL project are evaluated. This assessment shall be undertaken by an acoustic consultant and shall form part of the environmental impact assessment documentation (eg. REF or EIS) that is considered by the approval authorities. The noise and vibration construction assessment:

- is based on an initial design, scope and construction methodology for the project
- identifies sensitive receivers, the existing background noise levels and, in accordance with guidelines administered by the Office of Environment and Heritage (OEH) (see Appendix A), the construction noise and vibration objectives
- provides guidance in relation to project specific feasible and reasonable noise and vibration mitigation measures[1] that are needed to meet or mitigate any predicted exceedances of the construction noise and vibration objectives at the nearest receivers.

In most cases, a noise and vibration assessment is included in the documentation placed on public display (eg EIS or REF). Comments received from the community and other stakeholders on the proposed mitigation measures for the project are considered and, if necessary, changes may be made to the measures proposed, or additional measures included, prior to the project being approved or licensed. Appendix A describes in detail the construction noise and vibration assessment process.

The construction noise and vibration objectives for the project and any accompanying mitigation measures in the environmental impact assessment documentation are based on an initial design and construction methodology. Typically, as the design of a project is further developed following its approval, the construction methodology and staging is also altered.

To ensure the adequacy of the noise and vibration mitigation measures for the actual design and construction method, a Construction Noise and Vibration Impact Statement (CNVIS) must be prepared (for each major construction site and/or stage or key activity), prior to the preparation of the Construction Noise and Vibration Management Plan (CNVMP) for that stage/activity. This process is outlined in Figure 2.1. The CNVIS must be prepared in accordance with the requirements of Appendix B. The CNVIS should be used as the basis on which to develop the CNVMP[2] for the project. A separate CNVIS must be prepared for each major stage of works or activity and the CNVMP revised as required.

[1] For example: physical structures such as construction hoardings, acoustic sheds, dwelling treatments, acoustic barriers around noisy plant, operational noise barriers erected early etc or special construction methods such as penetrating cone fracture or controlled blasting in place of conventional rock breaking, etc.

[2] NB: Any changes to the project must be consistent with the environmental assessment documentation and project approval and cannot cause significant additional impacts on the environment or community.

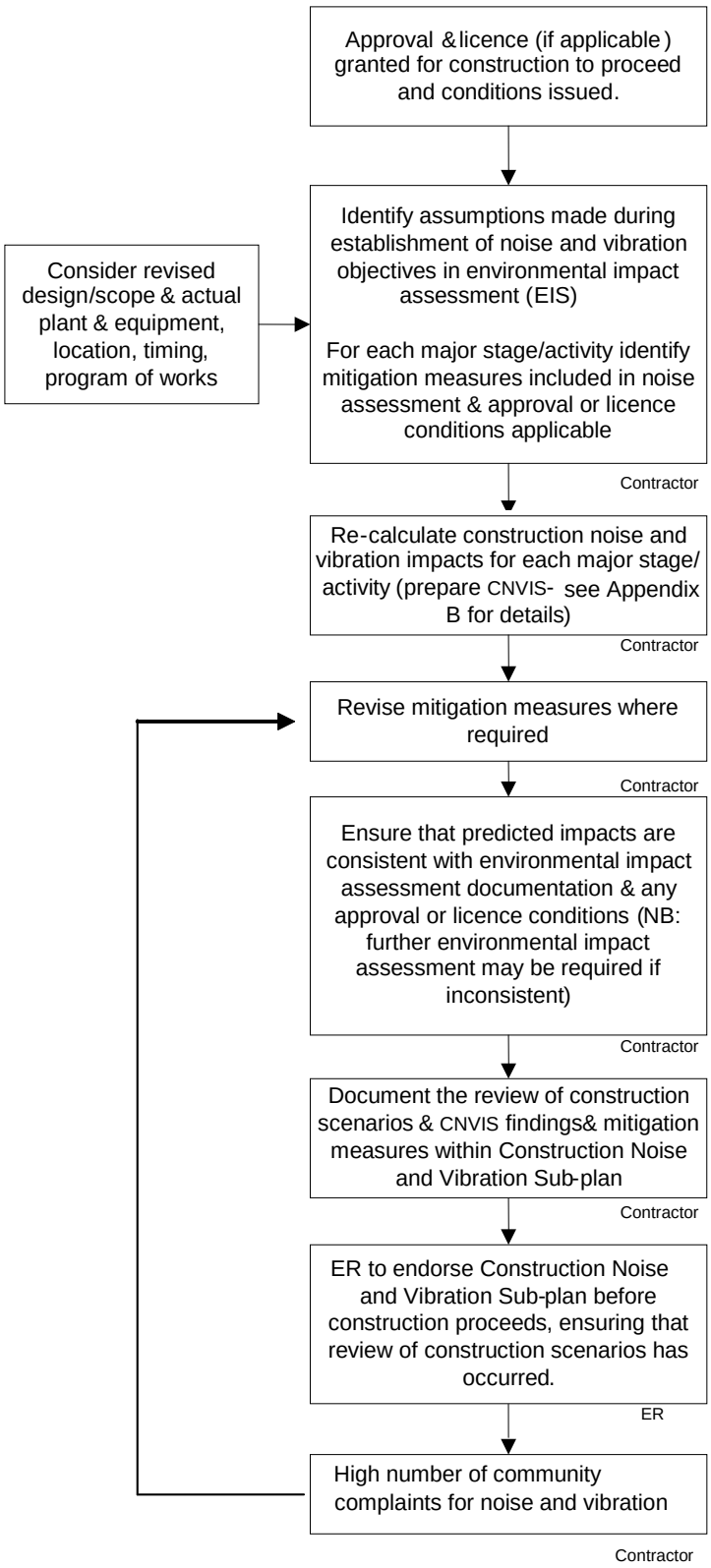

Figure 2.1 Construction Noise and Vibration Assessment Review Procedure

3 Standard Mitigation Measures and Monitoring Requirements

This section sets out the *standard* construction noise and vibration mitigation measures to be implemented on the NWRL project and delivered via relevant procedures, systems, environmental impact assessment, construction environmental management and all relevant contract documentation.

For all NWRL construction activities, the standard mitigation measures in Table 3.1 shall be applied in order to minimise the potential noise and vibration impacts at the nearest receptors. Additional information in relation to specific mitigation measures, the assessment process and relevant objectives are provided in the Appendices.

During the preparation of the environmental impact assessment documentation, a construction noise and vibration assessment is to be undertaken. This includes monitoring requirements in order to validate the modelling assumptions and confirm that noise and vibration levels from individual plant and equipment items are not excessive. This section provides guidance in relation to standard monitoring and survey requirements that are expected for the NWRL project.

Additional information is also provided in this section in relation to satisfactory operating distances to ensure that vibration levels are not excessive at nearby buildings in relation to cosmetic damage and human comfort.

3.1 Standard Mitigation Measures

The actions set out in Table 3.1 must be implemented on all NWRL construction sites.

Table 3.1 Standard Mitigation Measures to Reduce Construction Noise and Vibration

Action Required	Applies to	Details
Management Measures		
Implementation of any project specific mitigation measures required	Airborne noise Ground-borne noise and vibration	In addition to the measures set out in this table, any *project specific* mitigation measures identified in the environmental assessment documentation (e.g. EIS, REF, submissions or representations report) or approval or licence conditions must be implemented.

Action Required	Applies to	Details
Implement community consultation measures (refer to Appendix C for further details of each measure)	Airborne noise Ground-borne noise and vibration	Periodic notification (monthly letterbox drop or equivalent)[3] Website Project Infoline Construction Response Line Email Distribution List Community Based Forums (if required by approval conditions) One-on-one meetings with properties most affected by noise and vibration Prior notification of disruptive work that will generate noise/vibration in excess of guidelines or night works
Site inductions	Airborne noise Ground-borne noise and vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: all relevant project specific and standard noise and vibration mitigation measures relevant licence and approval conditions permissible hours of work any limitations on high noise generating activities location of nearest sensitive receivers construction employee parking areas designated loading/unloading areas and procedures site opening/closing times (including deliveries) environmental incident procedures
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Monitoring	Airborne noise Ground-borne noise and vibration	A noise monitoring program is to be carried out for the duration of the works in accordance with the CNVMP and any approval and licence conditions.

[3] Detailing all upcoming construction activities at least 14 days prior to commencement of relevant works

Action Required	Applies to	Details
Attended vibration measurements	Ground-borne vibration	Attended vibration measurements are required at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Source Controls		
Construction hours and scheduling	Airborne noise Ground-borne noise and vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods, nominally between 8 am and 5 pm with no work on Sundays or public holidays.
Construction respite period	Airborne noise Ground-borne noise and vibration	High noise and vibration generating activities[4] may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block[5]. No more than four consecutive nights of high noise and/or vibration generating work may be undertaken over any seven day period, unless otherwise approved by the relevant authority.
Equipment selection	Airborne noise Ground-borne noise and vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	Airborne noise	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Table 3.2.
Rental plant and equipment	Airborne noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table 3.2.

[4] Includes jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling.

[5] "Continuous" includes any period during which there is less than a 60 minutes respite between ceasing and recommencing any of the work.

Action Required	Applies to	Details
Use and siting of plant	Airborne noise	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.
Plan worksites and activities to minimise noise and vibration	Airborne noise Ground-borne noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Non-tonal reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work (refer Table 7 and Appendix C of ICNG).
Minimise disturbance arising from delivery of goods to construction sites	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Path Controls		
Shield stationary noise sources such as pumps, compressors, fans etc.	Airborne noise	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

3.2 Noise and Vibration Auditing

The implementation of the noise and vibration mitigation measures, compliance with any applicable construction noise and vibration objectives, monitoring requirements and approval and licence conditions is to be audited at least every three months. This will involve the measurement of equipment noise levels (on site) and noise and vibration monitoring at the nearest sensitive receivers. A summary of the measurement requirements is provided below and in Appendix A.

The attended measurements will need to be carried out by an appropriately trained person in the measurement and assessment of construction noise and vibration, who is familiar with the requirements of the relevant standards and procedures.

Maximum levels for plant and equipment

All plant and equipment used for construction must have operating Sound Power or Sound Pressure Levels less than or equal to those in Table 3.2. For construction equipment not listed in Table 3.2, reference should be made to the typical noise levels in AS 2436-2010, BS 5228-1 or DEFRA noise database.

The maximum noise levels in Table 3.2 can also be used as a guide in the prediction of $L_{Aeq(15minute)}$ construction noise. In doing so, the predicted $L_{Aeq(15minute)}$ noise levels will be dependent on several factors including, but not limited to the duration of the construction activities, the number of plant items and their location on site in relation to the nearest receivers.

Attended measurements are to be undertaken within a period of 14 days of equipment arriving on site to confirm that the operating noise levels of all plant items comply with the maximum levels in Table 3.2. The attended measurements are to be repeated on a three-monthly basis to ensure that noise from individual plant items are still within the acceptable noise range.

Table 3.2 Maximum Allowable Noise Levels for Construction Equipment

Equipment	**Maximum Allowable Noise Level (dBA) – L_{Amax} [1,2,3]**	
	Sound Power Level	**Sound Pressure Level at 7 m**
Excavator Hammer	122	97
Excavator (approx. 3 tonne)	90	65
Excavator (approx. 6 tonne)	95	70
Excavator (approx. 10 tonne)	100	75
Excavator (approx. 20 tonne)	105	80
Excavator (approx. 30 tonne)	110	85
Excavator (approx. 40 tonne)	115	90
Skidsteer Loaders (approx. 1/2 tonne)	107	82
Skidsteer Loaders (approx. 1 tonne)	110	85
Dozer (equiv. CAT D8)	118	93
Dozer (equiv. CAT D9)	120	95
Dozer (equiv. CAT D10)	121	96
Backhoe/FE Loader	111	86
Dump Truck (approx. 15 tonne)	108	83

Equipment	Maximum Allowable Noise Level (dBA) – L_{Amax} [1,2,3]	
	Sound Power Level	Sound Pressure Level at 7 m
Concrete Truck	112	87
Concrete Pump	109	84
Concrete Vibrator	105	80
Bored Piling Rig	110	85
Scraper	110	85
Grader	110	85
Vibratory Roller (approx. 10 tonne)	114	89
Vibratory Pile Driver	121	96
Impact Piling Rig	134	109
Compressor (approx. 600 CFM)	100	75
Compressor (approx. 1500 CFM)	105	80
Concrete Saw	118	93
Jackhammer	113	88
Generator	104	79
Lighting Tower	80	55
Flood Lights	90	65
Cherry Picker	102	77
Mobile Crane	110	85

Notes:

1. The Sound Power Level (SWL) represents the total noise output of the plant of equipment. The SWL is normally used in computer noise models to predict the Sound Pressure Levels (SPLs) at nearby receivers. When undertaking site compliance measurements, it is normally the SPL that is measured at a specified distance (typically 7m) from the plant or equipment.
2. The SWLs presented in the above table have been compiled from a selection of field measurements conducted by SLR Consulting (formerly Heggies Pty Ltd) between 2004 and 2006 of plant and equipment operating on construction projects throughout NSW and are therefore considered to be representative of plant and equipment SWLs which are readily achieved by current plant and equipment normally used in the construction industry.
3. Plant and equipment with SWLs higher than those presented in the table would be deemed to be emitting an excessive level of noise and should not be permitted to operate on construction sites.

Noise and vibration monitoring in the community

Attended measurements are to be undertaken within a period of 14 days from the commencement of construction activities to confirm that the noise and vibration levels in the adjacent community are consistent with the predictions in the CNVIS[6], approval and/or licence conditions.

The attended measurements must be undertaken at the potentially most exposed receivers.

Noise measurements shall be undertaken consistent with the procedures documented in AS1055.1-1997 *"Acoustics - Description and Measurement of Environmental Noise - General Procedures"*. Vibration measurements shall be undertaken in accordance with the procedures

[6] Or other relevant acoustic assessment

documented in DEC's *"Assessing Vibration - a technical guideline"* and BS7385 Part 2-1993 *"Evaluation and measurement for vibration in buildings"*.

For construction sites with a duration of greater than three months, the attended measurements are to be repeated on a three-monthly basis as part of the audit cycle to ensure that noise and vibration levels in the adjacent community remain consistent with the predicted levels in the CNVIS, approval and/or licence conditions. For construction sites with a duration of less than three months, or where out of hours works are required, the attended measurements must be undertaken at the time intervals described in the CNVIS, out of hours assessment, approval and/or licence conditions.

Attended measurements will also be undertaken in response to a large number of or sustained complaints about noise and vibration.

3.3 Ground Vibration – Safe Working Distances for Intensive Activities

As a guide, safe working distances for typical items of vibration intensive plant are listed in Table 3.3. The safe working distances are quoted for both "cosmetic" damage (refer BS 7385) and human comfort (refer DEC's *"Assessing Vibration - a technical guideline"*). The safe working distances for cosmetic damage must be complied with at all times, unless otherwise approved by the relevant authority.

Table 3.3 Recommended Safe Working Distances for Vibration Intensive Plant

Plant item	**Rating/description**	**Indicative working distance**	
		Cosmetic damage (BS7385)	**Human response (DEC Vibration Guideline)**
Vibratory roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg - 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg - 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm diameter	2 m (nominal)	N/A
Jack hammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

The safe working distances presented in Table 3.3 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions. Vibration monitoring is recommended to confirm the safe working distances at specific sites.

For highly sensitive receivers (eg, high technology facilities, recording studios and cinemas), specific assessment is required to ensure satisfactory operation of the facility and determine if any mitigation or management measures are required to minimise the potential impacts.

In relation to human comfort (response), the safe working distances in Table 3.3 relate to continuous vibration. For most construction activities, vibration emissions are intermittent in nature and for this reason, higher vibration levels, occurring over shorter periods are allowed (see Appendix A). Where the predicted vibration levels exceed the human comfort objectives, the procedures in Section 5 are to be followed in order to mitigate the potential impacts at sensitive receivers.

3.4 Occupational Health and Safety Considerations

In addition to potential noise and vibration impacts on the community and structures, construction noise and vibration can also have an adverse impact upon the health of workers.

The main adverse impacts of hazardous noise are permanent noise-induced hearing loss and interference with clearly hearing instructions and/or audible warning signals. Excessive vibration from hand-held power tools (such as jack hammers) and whole body vibration (from mobile plant) can lead to adverse impacts such as white-finger disease, damage to tendons and nerves, and lower back pain.

For the above reasons, it is important that contractors adopt management strategies to prevent or minimise worker exposure to excessive noise and vibration. Such measures will also assist in reducing noise and vibration impacts on the surrounding community.

The series of Standards, AS/NZS 1269 Parts 0 to 4, sets out procedures to assess, control, manage and review noise hazards, and the *"National Standard for Occupational Noise"* defines the noise limits that are applicable in NSW.

The *"National Code of Practice for Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work"* contains guidance on assessing and controlling vibration risks.

4 Construction Hours

Standard Construction Hours

The *standard* construction hours are set out in the approval and licence (if applicable) conditions for each project. The recommended standard hours of construction in NSW are:

- 7.00 am to 6.00 pm Monday to Friday
- 8.00 am to 1.00 pm Saturday
- No work on Sundays and Public Holidays.

Other hours may be worked if approved by the relevant authority.

Blasting Hours

For blasting, the recommended standard hours of construction in NSW are:

- 9.00 am to 5.00 pm Monday to Friday
- 9.00 am to 1.00 pm Saturday
- No blasting on Sundays and Public Holidays.

Other hours may be worked if approved by the relevant authority.

Confining construction activities (including the delivery of plant and equipment) to the hours above wherever feasible and reasonable helps reduce noise and vibration impacts by limiting potentially noisy construction activities to the daytime, when background noise levels are higher, and by providing respite from construction noise during the evening, overnight and on weekends.

Out of Hours Work (OOHW)

The ICNG identifies five categories of works that may be required to be undertaken outside the standard construction hours:

1. The **delivery of oversized plant or structures** that police or other authorities determine require special arrangements to transport along public roads
2. **Emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
3. **Maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
4. **Public infrastructure works** that shorten the length of the project and are supported by the affected community
5. Works where a proponent demonstrates and justifies **a need to operate outside the recommended standard hours**.

For the last two categories, the proponent (Transport for NSW) is required to provide the relevant authority with clear justification for the proposed OOHW. This justification should be provided as part of the environmental impact assessment process.

For NWRL, OOHW are likely to be required at several construction sites. These sites are identified in the EIS, together with clear justification why the proposed activities cannot be undertaken within the standard construction hours.

Activities requiring OOHW are likely to include works adjacent to the existing rail network at Epping, works on or near major roads, the delivery of oversize plant and structures and works associated with continuous tunnelling activities (including spoil removal via the road network). These activities are likely to form part of the environment protection licence.

During construction, additional OOHW may be required. For activities which do not form part of the project approval or licence conditions, the procedure for assessing and approving/rejecting proposals is set out in Figure 4.1. The key features of the procedure include:

- All applications for out of hours work must be made on the approved form[7] and accompanied by the required information
- Out of hours work with low or medium risk factors (see Figure 4.1) may be approved by the Environmental Management Representative (EMR) for the project
- Applications for approval of out of hours work with medium or high risk factors *(including those requiring OEH approval)* must be supported by a CNVIS or other acoustic assessment prepared in accordance with the guidance in Appendix B and relevant licence conditions
- Out of hours work with a high risk factor can only be approved by NWRL's Principal Manager, Environment or the Department of Planning and Infrastructure (DP&I) (whichever is applicable) following the endorsement of the EMR.

[7] This form is not used for applications for out of hours work covered by a licence. The licence holder will have their own procedure covering such applications.

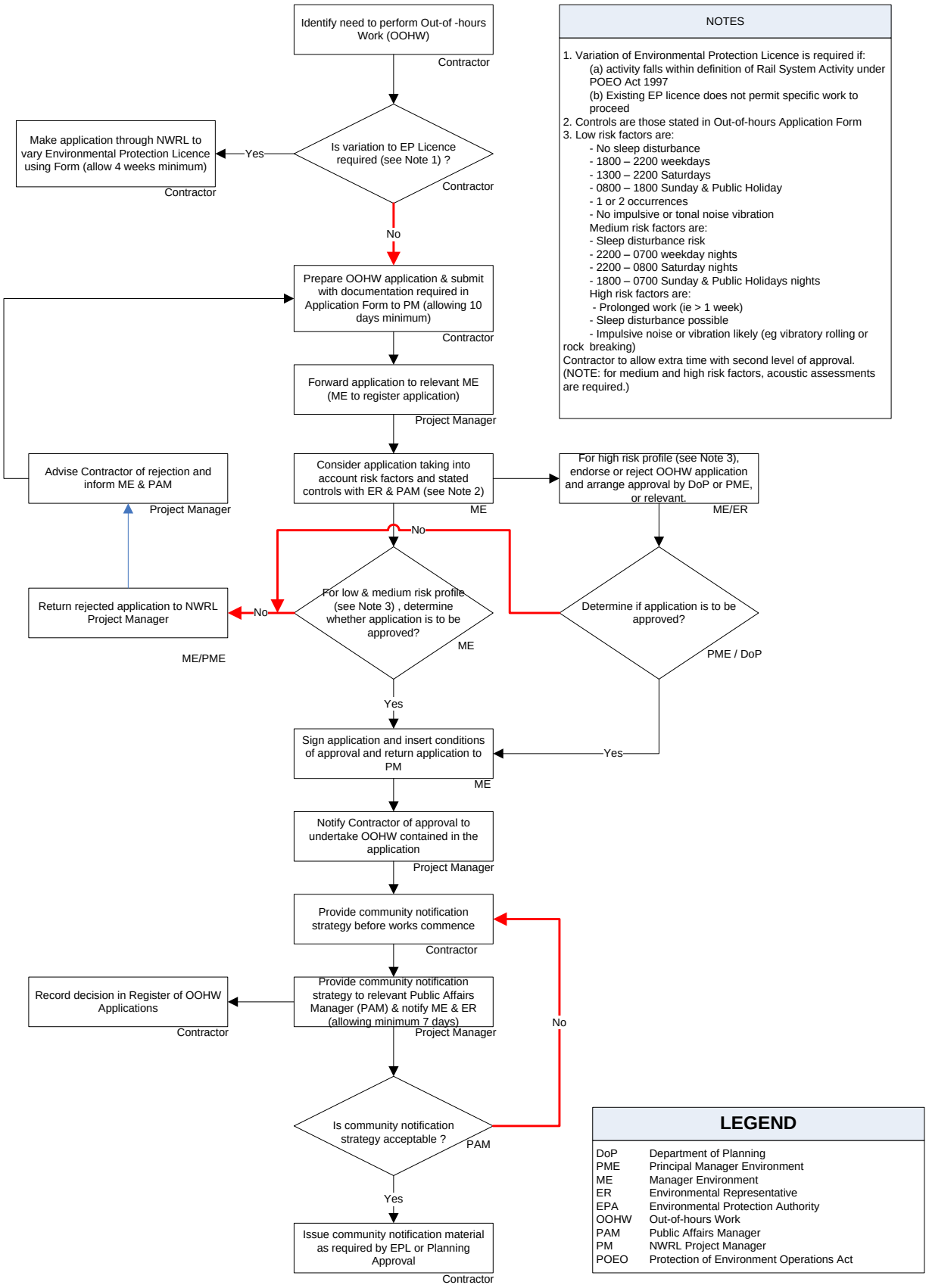

Figure 4.1 Out-of-hours Work Assessment and Approval Procedure

5 Mitigating Exceedances of Construction Noise and Vibration Objectives

5.1 Approach

As part of the environmental impact assessment process (refer Section 2 and Appendix B), it is necessary to identify feasible and reasonable mitigation measures (project specific) to minimise noise and vibration levels at the nearest receivers. In accordance with Section 3 of this CNVS, these measures are to be implemented as part of the standard mitigation measures (Table 3.1).

The implementation of the standard mitigation measures, compliance with maximum sound power levels for plant and equipment, construction hour management and standard community consultation measures in this CNVS should significantly reduce the noise and vibration impacts on nearby sensitive receivers.

Nevertheless, due to the highly variable nature of construction activities and the likelihood of work needing to be undertaken outside the standard construction hours, exceedances of the construction noise and vibration objectives are likely to occur.

Where there is a potential for the construction noise and vibration objectives to be exceeded, a number of additional measures to mitigate such exceedances– primarily aimed at pro-active engagement with affected sensitive receivers – should be explored and have been included in this CNVS. The additional mitigation measures to be applied are outlined in Table 5.1 below. A full description of each measure is provided in Appendix C.

Table 5.1 Additional Mitigation Measures

Measure	Abbreviation
Alternative accommodation	AA
Monitoring	M
Individual briefings	IB
Letter box drops[8]	LB
Project specific respite offer	RO
Phone calls	PC
Specific notifications	SN

[8] In certain circumstances, on a case by case basis, media advertising may also be used to supplement letter box drops where considered effective.

5.2 Applying Additional Mitigation Measures

In circumstances where - after application of the project specific and standard mitigation measures - the construction noise and vibration levels are still predicted[9] to exceed the noise or vibration objectives, the relevant Additional Mitigation Measures Matrix (AMMM) (see Tables 5.2 to 5.4 below) is to be used to determine the additional measures to be implemented.

Using the relevant AMMM, the following steps need to be carried out to determine the additional mitigation measures to be implemented:

1. Determine the time period when the work is to be undertaken
2. Determine the level of exceedance
3. From the relevant AMMM table, identify the additional mitigation measures to be implemented (using the abbreviation codes - expanded in Table 5.1).

Table 5.2 AMMM - Airborne Construction Noise

Time Period		**Mitigation Measures** $L_{Aeq(15minute)}$ **Noise Level Above Background (RBL) Qualitative Assessment of Noise Levels**[1]			
		0 to 10 dB Noticeable	**10 to 20 dB Clearly Audible**	**20 to 30 dB Moderately Intrusive**	**> 30 dB Highly Intrusive**
Standard	Mon-Fri (7.00 am - 6.00 pm)	-	-	LB, M	LB, M
	Sat (8.00 am - 1.00 pm)				
	Sun/Pub Hol (Nil)				
OOHW Period 1	Mon-Fri (6.00 pm - 10.00 pm)	-	LB	M, LB	M, IB, LB, RO, PC, SN
	Sat (1.00 pm - 10.00 pm)				
	Sun/Pub Hol (8.00 am - 6.00 pm)				
OOHW Period 2	Mon-Fri (10.00 pm - 7.00 am)	LB	M, LB	M, IB, LB, PC, SN	AA, M, IB, LB, PC, SN
	Sat (10.00 pm - 8.00 am)				
	Sun/Pub Hol (6.00 pm - 7.00 am)				

Notes:

1. For some types of construction activities (refer Appendix B), a qualitative assessment of the potential noise impacts can be undertaken in lieu of detailed noise modelling. For these activities, noise mitigation measures should be evaluated on the basis of the noise levels being noticeable, clearly audible, moderately intrusive or highly intrusive. The qualitative assessment should consider the type of equipment being used, the character of the noise emissions, time of day, the location of the nearest receivers and the noise sensitivity of the nearest receivers. Where a qualitative assessment is being undertaken, this will need to be approved by the EMR.

[9] In the CNVIS or other acoustic assessment

Table 5.3 AMMM – Ground-borne Construction Noise

Time Period		**Mitigation Measures** **Predicted $L_{Aeq(15minute)}$ Noise Level Exceedance** **Qualitative Assessment of Noise Levels**		
		0 to 10 dB **Clearly Audible**	**10 to 20 dB** **Moderately Intrusive**	**> 20 dB** **Highly Intrusive**
Standard	Mon-Fri (7.00 am - 6.00 pm)	LB	LB	M, LB, SN,
	Sat (8.00 am - 1.00 pm)			
	Sun/Pub Hol (Nil)			
OOHW Period 1	Mon-Fri (6.00 pm - 10.00 pm)	LB	M, LB, RO, SN,	M, IB, LB, PC, SN, RO
	Sat (1.00 pm - 10.00 pm)			
	Sun/Pub Hol (8.00 am - 6.00 pm)			
OOHW Period 2	Mon-Fri (10.00 pm - 7.00 am)	M, LB, SN,	AA, M, IB, LB, PC, RP, SN,	AA, M, IB, LB, PC, RP, SN,
	Sat (10.00 pm - 8.00 am)			
	Sun/Pub Hol (6.00 pm - 7.00 am)			

Table 5.4 AMMM – Ground-borne Vibration

Time Period		**Mitigation Measures** **Predicted Vibration Levels Exceed Maximum Levels**
Standard	Mon-Fri (7.00 am - 6.00 pm)	M, LB, RP
	Sat (8.00 am - 1.00 pm)	
	Sun/Pub Hol (Nil)	
OOHW Period 1	Mon-Fri (6.00 pm - 10.00 pm)	M, IB, LB, RO, PC, RP, SN,
	Sat (1.00 pm - 10.00 pm)	
	Sun/Pub Hol (8.00 am - 6.00 pm)	
OOHW Period 2	Mon-Fri (10.00 pm - 7.00 am)	AA, M, IB, LB, PC, RP, SN,
	Sat (10.00 pm - 8.00 am)	
	Sun/Pub Hol (6.00 pm - 7.00 am)	

5.3 Ground-borne Vibration

If the predicted ground-borne vibration levels exceed the cosmetic damage objectives in Appendix A, a different construction method with lower source vibration levels should be considered. Attended measurements should be undertaken at the commencement of all high vibration generating activities. If there is any risk of exceedance of the cosmetic damage objective, a permanent vibration monitoring system should be installed, to warn plant operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching the cosmetic damage objective.

6 Documentation

A complaints management system will be utilised to maintain a record of all complaints received and the subsequent action taken, in accordance with the approval and licence conditions.

Contractors are to retain records of the following:

- Complaints records (i.e. time and nature of complaint)
- Complaints responses and close out actions
- Correspondence
- Monitoring results
- Mitigation measures
- Construction Environmental Management Plans and associated sub-plans.

7 References

- AS 1055.1 1997, *Acoustics - Description and Measurement of Environmental Noise - General Procedures*. Standards Australia.
- AS 2107, 2000, *Acoustics – Recommended design sound levels and reverberation times for building interiors*. Standards Australia.
- AS 2187, Part 2, 2006, *Explosives - Storage and Use - Part 2: Use of Explosives*. Standards Australia.
- AS 2436, 2010, *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*. Standards Australia.
- AS/NZS 1269, *Occupational Noise Management Series – Parts 0 to 4*. Standards Australia.
- BS 5228 Part 2, *Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 2*. The British Standards Institution.
- BS 7385 Part 2, 1993, *Evaluation and Measurement for Vibration in Buildings Part 2*. The British Standards Institution.
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- Commonwealth of Australia, 2007, *National Code of Practice for Prevention of Musculoskeletal Disorders from Performing Manual Tasks at Work"*.
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Appendix A Overview of Construction Noise and Vibration Objectives

This appendix provides a brief overview of construction noise and vibration and its potential effects on people, buildings and their contents. It also provides guidance on how to establish construction noise and vibration objectives during the environmental assessment phase.

A.1 Construction Airborne Noise Objectives

Where a quantitative noise assessment is to be undertaken, the construction airborne noise objectives are based on DECC's *"Interim Construction Noise Guideline"* (2009).

The interim guideline contains noise management levels for sensitive land uses including commercial and industrial receivers. These are provided in Table A.1 and Table A.2. At locations where the predicted construction noise levels exceed the noise management levels, the proponent should apply all feasible and reasonable work practices, document these within the environmental impact assessment and implement the proposed work practices as part of the standard mitigation measures (refer Table 3.1).

Where the predicted construction noise levels remain above the noise management levels after implementation of all feasible and reasonable work practices, the relevant AMMM is to be implemented (refer Section 5), based on the predicted $L_{Aeq(15minute)}$ noise levels. These are primarily aimed at pro-active engagement with affected sensitive receivers. When communicating with sensitive receivers impacted by the construction works, the guidelines in the *"how to apply"* column should be followed.

Table A.1 Airborne Noise Objectives at Residences Using Quantitative Assessment

Time of Day	Noise Management Level $L_{Aeq(15minute)}$	How to Apply
Recommended standard hours: Monday to Friday 7.00 am to 6.00 pm Saturday 8.00 am to 1.00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the *Interim Construction Noise Guideline*.

The L_{A90} Rating Background Levels (RBL's) should be determined using the *"tenth percentile method"* described in EPA's *"NSW Industrial Noise Policy"* (2000) during the relevant assessment periods (daytime, evening or night-time).

Table A.2 Airborne Noise Objectives at Sensitive Land Uses (other than Residential) Using Quantitative Assessment

Land Use	**Management Level, LAeq(15minute) (Applies when Land Use is being Utilised)**
Classrooms at schools and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of Worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Community Centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

Due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories. The external noise levels should be assessed at the most-affected occupied point of the premises:

- Industrial premises: external $L_{Aeq(15minute)}$ 75 dBA
- Offices, retail outlets: external $L_{Aeq(15minute)}$ 70 dBA
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.

Examples of other noise-sensitive businesses are theatres and child care centres. The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 *"Acoustics – Recommended design sound levels and reverberation times for building interiors"* may assist in determining relevant noise levels.

The proponent should assess construction noise levels for the project, and consult with occupants of commercial and industrial premises prior to lodging an application where required. During construction, the proponent should regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.

A.2 Construction Ground-borne Noise Objectives

Construction ground-borne noise objectives are based on DECC's *"Interim Construction Noise Guideline"* (2009).

Ground-borne construction noise is usually present on tunnelling projects when equipment such as tunnel boring machines, road headers, rock hammers and drilling rigs are operated underground. The ground-borne noise inside buildings initially propagates as ground-borne vibration, before entering the building, which causes floors, walls and ceilings to gently vibrate and hence radiate noise. Sometimes the vibration may be perceptible within the building. For some critical spaces such as recording studios and cinemas, which are designed to reduce airborne noise intrusion, an assessment of ground-borne construction noise for surface construction may also be required.

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

Table A.3 provides a summary of the ground-borne construction noise objectives.

Table A.3 Ground-borne Noise Objectives at Residences

Time of Day	**Ground-borne Noise Objectives $L_{Aeq(15minute)}$**
Daytime 7.00 am to 6.00 pm	Human comfort vibration objectives only
Evening 6.00 pm to 10.00 pm	40 dBA - Internal
Night-time 10.00 pm to 7.00 am	35 dBA - Internal

A.3 Construction Vibration Objectives

The effects of vibration in buildings can be divided into three main categories; those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

Human Perception of Vibration

Guidance in relation to acceptable vibration levels for human comfort are provided in DEC's *"Assessing Vibration: a technical guideline"* (2006).

The DEC guideline provides three assessment methods, depending on whether the vibration is continuous, impulsive or intermittent. The preferred and maximum values are provided in Table A.4.

- **Continuous vibration** would normally be generated by fixed plant items such as generators, fans and the like where the vibration emissions continue uninterrupted (usually throughout the daytime or night-time period).
- **Impulsive vibration** would normally be generated by short duration (ie less than two second) events with no more than three occurrences in an assessment period. A typical example would be ground compaction by dropping a large mass. Higher levels are allowed for impulsive vibration, however if more than three impulsive vibration events occur during the assessment period, the more stringent intermittent objectives are applied.

Table A.4 Preferred and Maximum Vibration Levels for Human Comfort

Location	Assessment Period	Preferred Values		Maximum Values	
Continuous Vibration		**z axis**	**x and y axes**	**z axis**	**x and y axes**
Critical areas	Day- or night-time	0.005 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residences	Daytime	0.010 m/s^2	0.0071 m/s^2	0.020 m/s^2	0.014 m/s^2
	Night-time	0.007 m/s^2	0.005 m/s^2	0.014 m/s^2	0.010 m/s^2
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020 m/s^2	0.014 m/s^2	0.040 m/s^2	0.028 m/s^2
Workshops	Day- or night-time	0.040 m/s^2	0.029 m/s^2	0.080 m/s^2	0.058 m/s^2
Impulsive Vibration		**z axis**	**x and y axes**	**z axis**	**x and y axes**
Critical areas	Day- or night-time	0.005 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residences	Daytime	0.30 m/s^2	0.21 m/s^2	0.60 m/s^2	0.42 m/s^2
	Night-time	0.10 m/s^2	0.071 m/s^2	0.20 m/s^2	0.14 m/s^2
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Workshops	Day- or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Intermittent Vibration		**x, y and z axes**		**x, y and z axes**	
Critical Areas	Day- or night-time	0.10 $m/s^{1.75}$		0.20 $m/s^{1.75}$	
Residences	Daytime	0.20 $m/s^{1.75}$		0.40 $m/s^{1.75}$	
	Night-time	0.13 $m/s^{1.75}$		0.26 $m/s^{1.75}$	
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40 $m/s^{1.75}$		0.80 $m/s^{1.75}$	
Workshops	Day- or night-time	0.80 $m/s^{1.75}$		1.60 $m/s^{1.75}$	

Notes:

For continuous and intermittent vibration, the preferred and maximum values are weighted acceleration values (Wg for z axis and Wd for x and y axes).

For intermittent vibration, the preferred and maximum values are Vibration Dose Values (VDVs), based on the weighted acceleration values

- **Intermittent vibration** can be defined as interrupted periods of continuous vibration (eg vibratory rolling, heavy truck passbys or rock breaking) or continuous periods of impulsive vibration (eg impact pile driving). Higher vibration levels are allowed for intermittent vibration compared with continuous vibration on the basis that the higher levels occur over a shorter time period. Hence, for intermittent vibration, human comfort vibration levels are assessed on the basis of the Vibration Dose Value (VDV), based on the level and the duration of the vibration events.

Effects on building contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect their operation. For most receivers, the controlling vibration criterion is therefore the human comfort criterion and separate objectives are not normally required in relation to the effect of construction vibration on building contents.

Some scientific equipment (eg electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort. Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives.

Effects of vibration on structures

The levels of vibration required to cause cosmetic damage to buildings tend to be at least an order of magnitude (10 times) higher than those at which people may consider the vibration to be intrusive.

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 dependent 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 guide 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) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table A.5 and graphically in Figure A.1.

Table A.5 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 A.5 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to 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 A.5 may need to be reduced by up to 50% - ie 7.5 mm/s at 4 Hz (as shown by Line 3 of Figure A.1 for Residential Buildings).

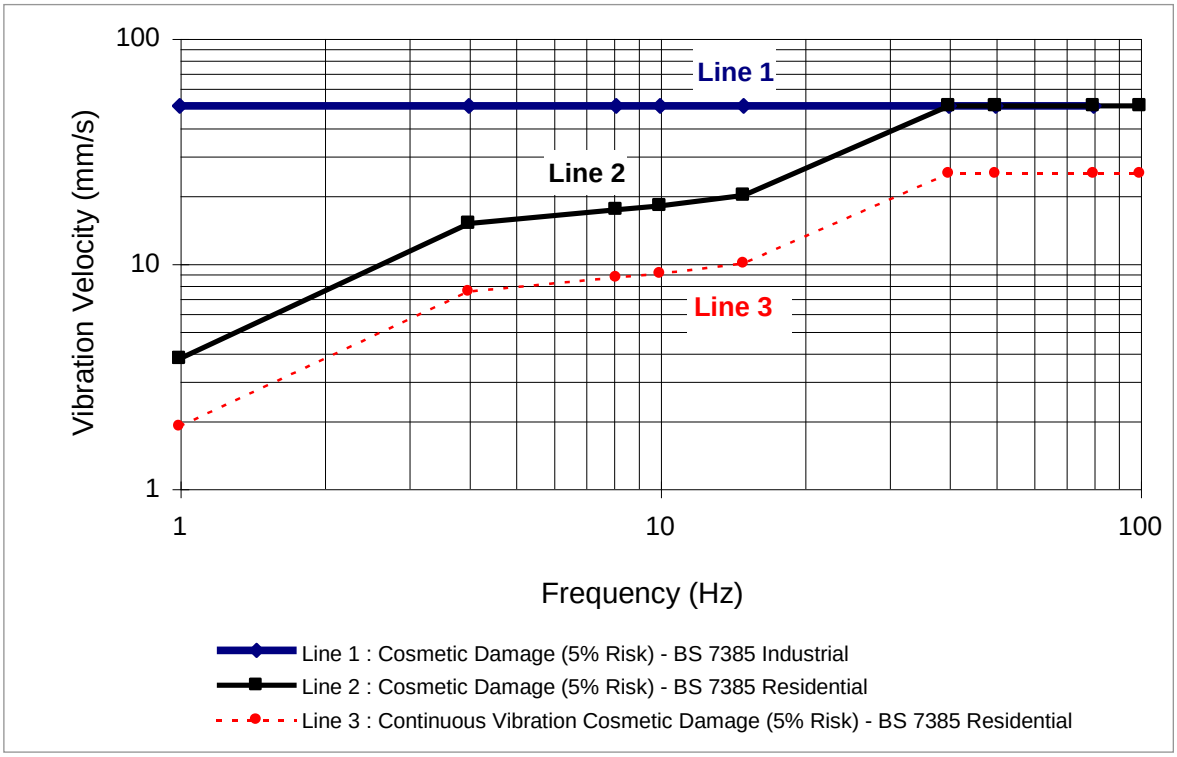

Figure A.1 Graph of Transient Vibration Guide Values for Cosmetic Damage

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 A.5 and major damage to a building structure may occur at values greater than 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 A.5 should not be reduced for fatigue considerations.

It is noteworthy that, extra to the guide values nominated in Table A.5, 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."

In relation to standards used for assessing the risk of vibration damage to structures, the Department of Planning guideline *"Development Near Rail Corridors and Busy Roads – Interim Guideline"* also refers to German Standard DIN 4150 Part 3 1999 *"Structural vibration - Effects of vibration on structures"*. In situations where excavation and other earthworks are undertaken in and around the railway corridor, the potential vibration impacts shall consider the vibration criteria in BS 7385 Part 2-1993 and DIN 4150 Part 3 1999.

Construction-related traffic noise goals

On the roads immediately adjacent to construction sites, the community may associate heavy vehicle movements with the project. Once the heavy vehicles move further from construction sites onto major collector or arterial roads however, the noise may be perceived as part of the general road traffic.

In most situations, it may be sufficient to undertake a qualitative assessment of the potential noise impacts associated with heavy vehicle movements, however for spoil removal sites it is likely a quantitative assessment will be required. This assessment should take into consideration the number of heavy vehicle movements per hour or shift, the proximity of sensitive receivers, the duration of the construction works and the time of day. Where a qualitative assessment is being undertaken, this will need to be approved by the EMR.

If a quantitative assessment is required, construction-related traffic noise goals should be based on the guidance contained in DECCW's *"NSW Road Noise Policy"* (RNP). If the heavy vehicle movements occur during the 10.00 pm to 7.00 am night-time period, guidance on the potential for sleep disturbance is contained in the *"Application Notes to the NSW Industrial Noise Policy"*.

Appendix B Guidelines for Assessing Noise & Vibration Impacts (Including CNVIS)

Whenever construction works are proposed as part of a project, a prediction and assessment of the airborne noise, ground-borne noise and ground-borne vibration levels is required to determine the potential impacts on nearby receivers. The determination of the mitigation measures required will depend on the level of impact, the duration of the works and the time at which the noise or vibration activity occurs.

The intention is to minimise the level of site noise and vibration and inconvenience to affected receivers while having regard to the feasibility and reasonableness of any proposed control or mitigation measures.

B.1 Type of Assessment

The level of detail for a construction assessment will vary depending on the scale of the works and the likely noise and vibration impacts.

For some small construction sites, involving low-powered plant where sensitive receivers are not located in close proximity to the works, it may be sufficient to undertake a qualitative assessment of the potential noise and vibration impacts. DECC's *"Interim Construction Noise Guideline"* indicates that short-term means that the works are not likely to affect an individual or sensitive land use for more than three weeks in total.

For larger construction sites, involving many plant items and extended periods of construction adjacent to sensitive receivers, a quantitative assessment of the potential noise and vibration impacts is required (although some activities or work stages may still require only a qualitative assessment).

The construction of a chain wire safety fence as part of preparatory works during the daytime or evening period, for example, may require only a qualitative assessment of the potential noise impacts. However, the construction of a new bridge out of hours over a period of 4 weeks would require a quantitative assessment of the potential noise and vibration impacts.

Where a qualitative assessment is being undertaken, this will need to be approved by the EMR.

The noise and vibration impact assessments should be undertaken in accordance with the guidance provided in this CNVS and the relevant Environment Protection Licence (EPL) conditions.

B.2 Qualitative Assessment Procedure

For qualitative construction assessments, the following minimum requirements would need to be included as part of the assessment report:

- Justification for undertaking a qualitative assessment including endorsement by EMR
- Duration of the construction works and time periods over which works will be undertaken
- Equipment expected to be used (during noisiest operations)
- Identification and description of nearest sensitive receivers potentially impacted by the proposed construction works

- List of standard mitigation measures that will be employed to minimise the potential noise impacts (including management measures, source controls and path controls)
- Discussion of the Qualitative Assessment with reference to the relevant Additional Mitigation Measures Matrix (AMMM) in Tables 5.2 to 5.4
- List of additional mitigation measures that will be employed to minimise the potential impacts (including monitoring and management measures)
- Documented complaints management process including a strategy for identifying any additional mitigation measures that may be required.

B.3 Quantitative Assessment Procedure

Quantitative construction assessments are performed by comparing the predicted noise and vibration levels with the appropriate objectives for the receiver types and time of day.

Quantitative assessment reports will need to address the same minimum requirements as per the qualitative assessment procedure above, plus detailed information in relation to the source noise levels, the determination of appropriate noise and vibration objectives, relevant construction scenarios and predicted noise and vibration levels.

The quantitative assessment procedure steps are as follows:

Step 1: Determine noise and vibration objectives

The relevant noise and vibration objectives for the nearest sensitive receivers that may be potentially impacted by the construction works should be determined with reference to Appendix A.

Step 2: Assess construction scenarios

Identify a representative range of construction scenarios.

If the assessment is being carried out for the environmental impact assessment documentation (eg EIS or REF) it will be based on a concept design and construction scenarios for the project (usually prepared by a technical advisor and/or planning consultant).

If the assessment is being undertaken prior to construction (eg CNVIS) it will be based on a more detailed design and actual construction scenario (usually prepared by the design and/or construction contractors).

The assessment should be conservative and sufficiently detailed to identify any project specific noise or vibration mitigation measures (including, but not limited to: physical structures such as construction hoardings, acoustic sheds, dwelling treatments, acoustic barriers around noisy plant, operational noise barriers erected early or special construction methods such as penetrating cone fracture or controlled blasting in place of conventional rock breaking) that are both necessary to meet the construction noise or vibration objectives and feasible and reasonable to implement.

In determining feasible and reasonable mitigation measures, proponents are directed to DECC's *"Interim Construction Noise Guideline"* which provides several worked examples on how construction noise can be minimised at sensitive receivers (particularly section 6 and Appendix A). Proponents are also directed to Appendix C and Appendix D of Australian Standard 2436-2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"*.

In predicting the level of noise or vibration at nearby sensitive receivers, the assessment (whether based on concept or detailed design) must include the implementation of all relevant mitigation measures in Table 3.1.

Step 3: Predicting noise and/or vibration impacts

For airborne construction noise

1. Determine the source noise levels (SWLs) of each plant item proposed as part of the construction scenario. Note that the noise levels (SWLs) of each plant or equipment item should be less than the maximum allowable levels in Table 3.2. If the noise from a particular plant item is tonal or impulsive in nature, a 5 dB penalty should be added to the noise source level.

2. Determine the location of each plant or equipment item in relation to each receiver.

3. Include the effects of all project specific (see above) mitigation measures.

4. Include the effects of all relevant standard mitigation measures.

5. Include the effects of noise shielding provided by site offices, noise barriers or natural topographic features.

6. Include the effects of noise reflections and ground attenuation.

7. On the basis of the duration of each activity (over a typical "worst-case" 15-minute period), determine whether any correction between the L_{Amax} and $L_{Aeq(15minute)}$ is required.

8. Calculate the $L_{Aeq(15minute)}$ noise levels from the proposed construction activities at each receiver and compare these with the airborne construction noise objectives.

9. For night-time activities, calculate the maximum (L_{Amax}) noise levels and compare with the OEH's RBL plus 15 dB sleep disturbance screening criterion (refer *"Application Notes to the NSW Industrial Noise Policy"*). Factors that may be important in assessing the extent of impact on sleep include how often high noise events occur at night, the predicted maximum noise levels at night, whether there are times when there is a clear change in the noise environment (such as during early morning shoulder periods), and the degree to which maximum noise levels are above the background noise level at night.

Notes:

The number of receivers would be dependent on the size of the construction site, the time at which the construction noise occurs and the level of potential noise impact. Calculations would normally be undertaken at locations considered to be representative of a group of receivers with a similar level of exposure to the construction works.

For night-time construction works or large construction sites with many nearby receivers, it may be more appropriate to provide noise contour plots in order to illustrate the degree to which each receiver or group of receivers are impacted by the construction works.

For ground-borne construction noise

1. Determine the location of each plant or equipment item in relation to each receiver.

2. On the basis of ground-borne noise levels versus distance prediction curves for each plant item, determine the level of ground-borne noise at each building location. For highly sensitive building occupancies, the assessment may need to incorporate the acoustic properties of the building space and the structural response of the building.

3. Include the effect of all relevant standard mitigation measures as part of the construction scenario.

4. Calculate the $L_{Aeq(15minute)}$ noise levels from the proposed construction activities at each receiver and compare these with the ground-borne construction noise objectives.

For ground-borne construction vibration

1. Determine the location of each plant or equipment item in relation to each receiver.

2. On the basis of ground-borne vibration levels versus distance prediction curves for each plant item, determine the level of ground-borne vibration at each building location. For highly sensitive equipment, the assessment may need to incorporate the structural response of the building and particular sensitivities of the equipment.

3. Incorporate all relevant standard mitigation measures as part of the construction scenario.

4. Calculate the continuous, intermittent and impulsive vibration levels from the proposed construction activities at each receiver and compare these with the ground-borne construction vibration objectives.

Step 4: Determining additional mitigation measures required

1. Consult the relevant Additional Mitigation Measures Matrix (AMMM) in Tables 5.2 to 5.4 to determine, based on the level of exceedance of the background noise or ground-borne noise or vibration level, the additional mitigation measures to be implemented.

Appendix C Standard and Additional Mitigation Measures

Community Relations plan

For each worksite, a Community Relations plan will be developed outlining additional mitigation measures and communication activities. At a minimum these will include signage with project contact details at each site, 7 days notification before noisy work begins and responding to complaints within 1 day. These will be tailored to meet the needs of impacted stakeholders but may include the activities outlined below.

Periodic notification (monthly letterbox drop or advertisement in local papers)

For the NWRL, a newsletter entitled 'Project Update' or 'Construction Update' will be produced and distributed to the local community via letterbox drop and the project mailing list or the same information will be advertised in the local paper and distributed to the project mailing list. These will provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (eg traffic changes, noisy works or TBM movements) can assist in reducing the impact on the community. The approval conditions for projects specify requirements for notification to the community about works that may impact on them.

Website

The NWRL project website (http://northwestrail.com.au/) will serve as a key resource for members of the community to seek further information on the project, including noise and vibration management plans, current and upcoming construction activities. It will be available on a 24-hour basis and provides a constant and additional layer of information over-and-above the periodic notifications.

The website is reviewed and updated on a monthly basis or in line with construction works.

As the website is a public forum, all information to be uploaded is approved by NWRL's Deputy Project Director, Stakeholder and Community Engagement. The aim is to provide a visually appealing, easy-to-navigate tool for members of the public. Information is provided in plain English with use of illustrative graphics and photos and a minimum of jargon.

Project Infoline

A free-call project information telephone number has been set up for the NWRL project and will provide a contact point for interested stakeholders:

- **Project Infoline, 1800 019 989** – providing a dedicated contact point for any project enquiries.

This line is answered by staff at the NWRL Community Information Centre and is the key mechanism for the receipt of enquiries/complaints in relation to the NWRL project. This numbers is listed with Telstra and is advertised in all project-related communications materials.

During the construction stage, all complaints received directly by community relations personnel will require a verbal acknowledgement within 2 hours. All enquiries will require a verbal response (confirming actions to be undertaken) within 24 hours during standard construction hours, or on the next working day during out of hours work (unless the enquirer agrees otherwise).

Project team members will be available 24 hours per day during construction to ensure complaints are managed by experienced personnel to facilitate swift resolution.

Email distribution list

Email distribution lists may be used to disseminate project information to interested stakeholders. Advanced warning of audible activities can assist to reduce the impact of projects experienced by the community.

NWRL and its contractors maintain mailing lists of stakeholders interested in receiving project information via email.

Signage

Signage will be provided at each construction site to notify stakeholders of project details and project emergency and enquiry contact information. Where possible and when appropriate, the full community notification, detailing likely audible construction noise will be on display at the work site.

Specific notifications (SN)

Specific notifications are letterbox dropped or hand distributed to identified stakeholders no later than seven days ahead of construction activities that are likely to exceed the noise objectives. The exact conditions under which specific notifications would proceed are defined in the relevant Additional Mitigation Measures Matrix (Tables 5.2 to 5.4). This form of communication is used to support periodic notifications, or to advertise unscheduled works.

Phone calls (PC)

Phone calls may be made to identified/affected stakeholders within seven days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.

Individual briefings (IB)

Individual briefings may be used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project.

Project specific respite offer (RO)

Residents subjected to lengthy periods of noise or vibration may be eligible for a project specific respite offer. The purpose of such an offer is to provide residents with respite from an ongoing impact. The offer could comprise pre-purchased movie tickets or similar offer. This measure is determined on a project-by-project basis, and may not be applicable to all construction sites.

The project may also consider other mitigation measures such as noise cancelling headsets or installing double-glazed/insulated windows to reduce noise reception for sensitive receivers.

Alternative accommodation (AA)

NWRL will consider providing alternative accommodation options for residents living in close proximity to construction works that are likely to incur noise levels significantly above the applicable level (Tables 5.2 to 5.4). The value of the offer will be determined on a site-by-site basis.

Appendix D Construction Noise Predictions

Works	Scenario	Receiver	RBL	Noise Level – $L_{Aeq(15minute)}$ (dBA)		Exceedance (dB)
				Worst-case Predicted	NML	
			Day		Day	Day
Lindfield Substation	01a Excavation	R1 - 239 Pacific Highway	48	76#	58	18
		R2 - 251 Pacific Highway	48	76#	58	18
		R3 - 4 Middle Harbour Road	48	78#	58	20
		R4 - 1 Middle Harbour Road	48	78#	58	20
		R5 - 36 Strickland Avenue	48	75	58	17
	01b Foundation Preparation	R1 - 239 Pacific Highway	48	68	58	10
		R2 - 251 Pacific Highway	48	68	58	10
		R3 - 4 Middle Harbour Road	48	70	58	12
		R4 - 1 Middle Harbour Road	48	70	58	12
		R5 - 36 Strickland Avenue	48	67	58	9
	01c Delivery and Placement of Equip.	R1 - 239 Pacific Highway	48	63	58	5
		R2 - 251 Pacific Highway	48	63	58	5
		R3 - 4 Middle Harbour Road	48	65	58	7
		R4 - 1 Middle Harbour Road	48	65	58	7
		R5 - 36 Strickland Avenue	48	62	58	4

Note #: Where receivers are “highly noise affected” (i.e. where the predicted noise level exceeds 75 dBA) or the NMLs are exceeded by more than 20 dB, the proponent may need to implement respite periods and liaise with the community.