Construction Noise and Vibration Management Plan

Resource Recovery Facility - 13 Pembury Road, Minto

Report Number 610.14692.00121-R1

10 April 2017

Skylife Properties Pty Ltd c/- APP Corporation
13 Pembury Road
MINTO NSW 2566

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Construction Noise and Vibration

Management Plan

Resource Recovery Facility - 13 Pembury Road, Minto

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1 INTRODUCTION

SLR consulting Australia Pty Ltd (SLR) has been engaged by APP Corporation Pty Ltd (APP) on behalf of its client Skylife Properties Pty Ltd to prepare a Construction Noise and Vibration Management Plan (CNVMP) for the proposed upgrades to the existing Resource Recovery Facility at 13 Pembury Road, Minto NSW (the Project Site).

The waste storage and processing facility currently accepts waste materials for the purpose of resource recovery and the proposed upgrades include an increase in the processing capacity and new office, amenities building and weighbridge.

It is understood that the current approval for the site permits 30,000 tonnes/annum of non-putrescible waste to be processed at the Project site, and the objective of the study is to seek approval to increase the throughput of the Project site to up to 220,000 tonnes/annum of non-putrescible waste to be processed. No additional plant would be required at the facility to achieve the increase in throughput.

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

2 SCOPE OF WORKS

The project requires the development of a Construction Noise and Vibration Management Plan for the subject construction works addressing the following aspects:

- Identification of the specific activities that will be carried out and associated noise and vibration sources.
- Identification of the nearby potentially most affected sensitive receivers.
- Determination of appropriate construction noise objectives based on the results of background noise monitoring in accordance with the EPA's *Interim Construction Noise Guideline* (ICNG).
- Determination of appropriate construction vibration criteria in accordance with the EPA's *Assessing Vibration Guidelines*.
- Determination of appropriate noise and vibration objectives methodology for each identified sensitive receiver.
- Noise and vibration monitoring, reporting and response procedures.
- Description of indicative mitigation treatments, management methods and procedures that could be implemented to control noise (and vibration) during construction.
- Procedures for notifying residents of construction activities that may affect their amenity through noise and vibration.

3 PROJECT DESCRIPTION AND SURROUNDING ENVIRONMENT

3.1 Overview

Approval is sought to increase the processing capacity of the existing waste storage and processing facility from 30,000 tonnes per annum to permit up to 220,000 tonnes per annum. The facility will continue to process general solid waste (non-putrescible), as described in the Waste Classification Guidelines, 2014, prepared by the NSW Environment Protection Authority (EPA).

The existing operations include:

- Three sheds with push walls and machinery used for tipping, processing and storage of waste materials.
- Site office.
- Two weighbridges for small trucks.

Approval is also sought for the following works on site:

- Construction of new substation, site office and amenities block.
- Proposed in-ground wheelwash at existing outbound weighbridge.
- Installation of a new in-ground weighbridge (20 m x 3.5 m) for large trucks.
- Relocate existing 30,000 litre fuel tank with roof over.
- Proposed concrete slab for carparking (118sqm) for 10 carparking spaces.

3.2 Site Location and Local Topography

The site comprises an area of 8,957 m^2, is legally described as Lot 1 in DP 1013852 and known generally as 13 Pembury Road, Minto. The site is situated in the IN1 General Industrial zone under the Campbelltown Local Environmental Plan 2015.

The regional locality of the Project site is shown in **Figure 1**. The proposed layout of the Project site is shown in **Figure 2**.

The ground elevation ranges from approximately 5 m to 10 m within 500 m of the site. The most significant topographical feature in the vicinity of the site is the Georges River, located approximately 3 km to the southeast.

The topographical data used in the noise impact assessment was sourced from the United States Geological Service's Shuttle Radar Topography Mission (STRTM) database that has recorded topography across Australia with a 3 arc second (~90 m) spacing. **Figure 3** illustrates the topography of the region surrounding the Project Site based on the SRTM data

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Figure 1 Regional Location of the Project Site

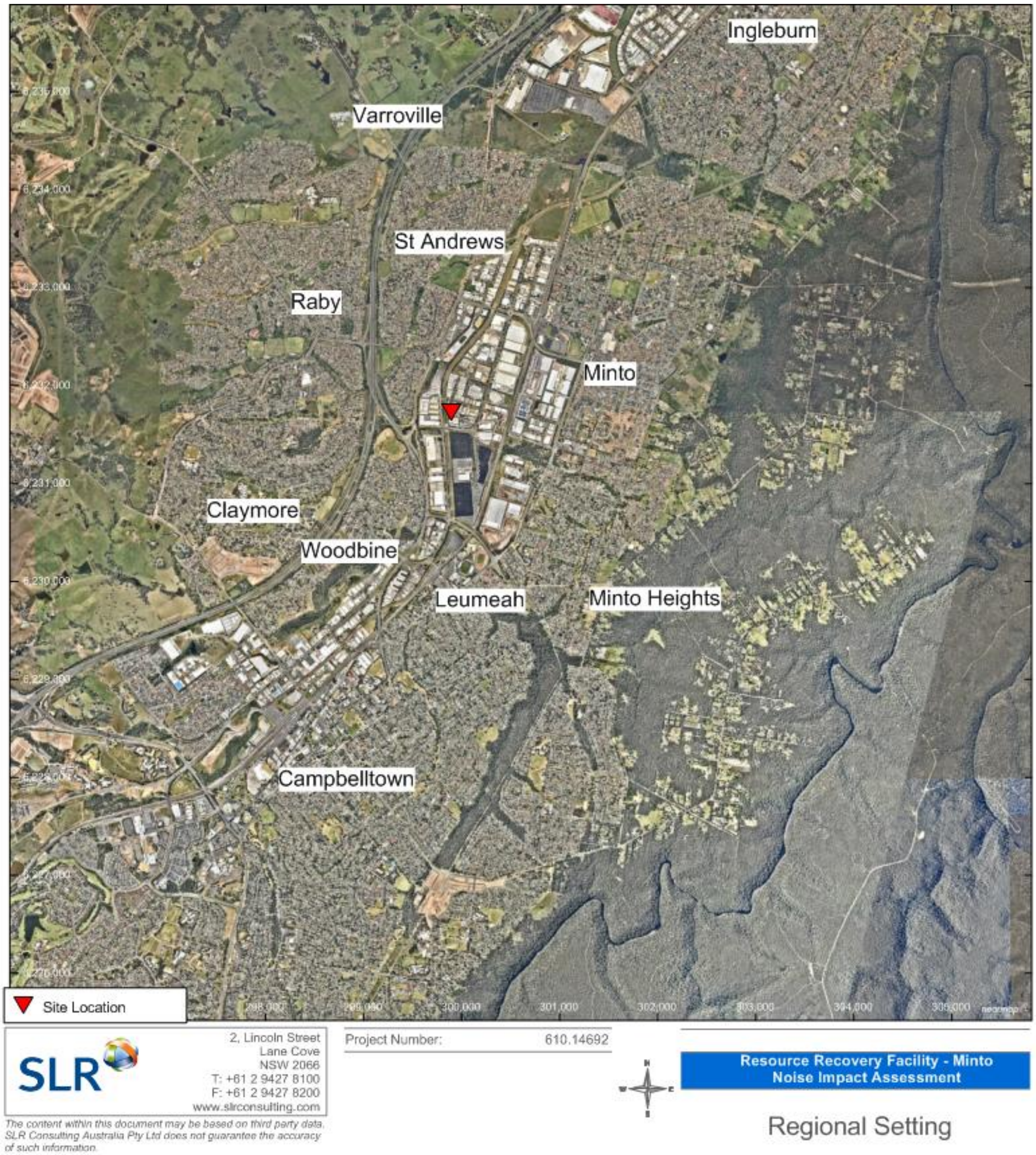


Figure 2 Project Site Layout

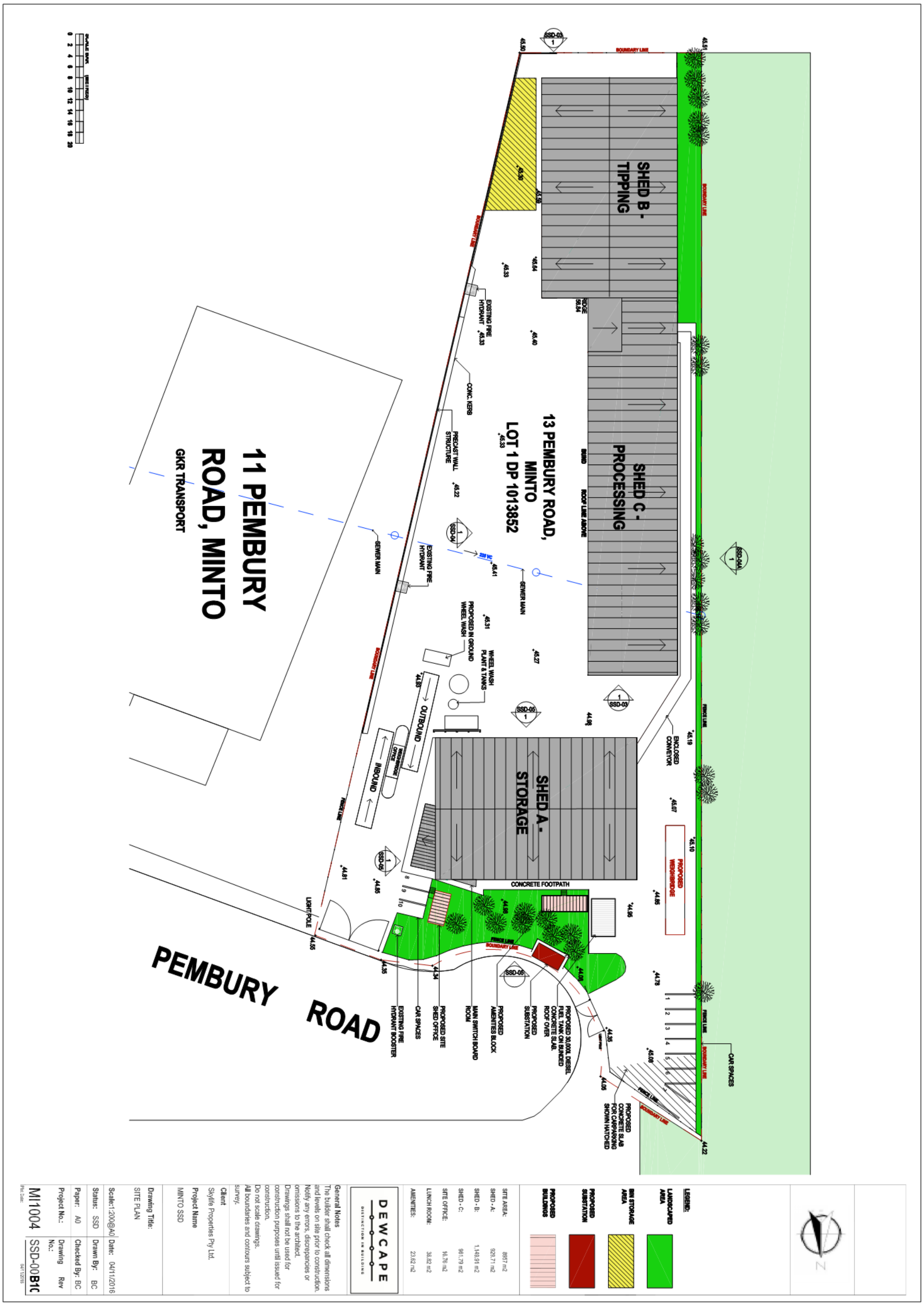
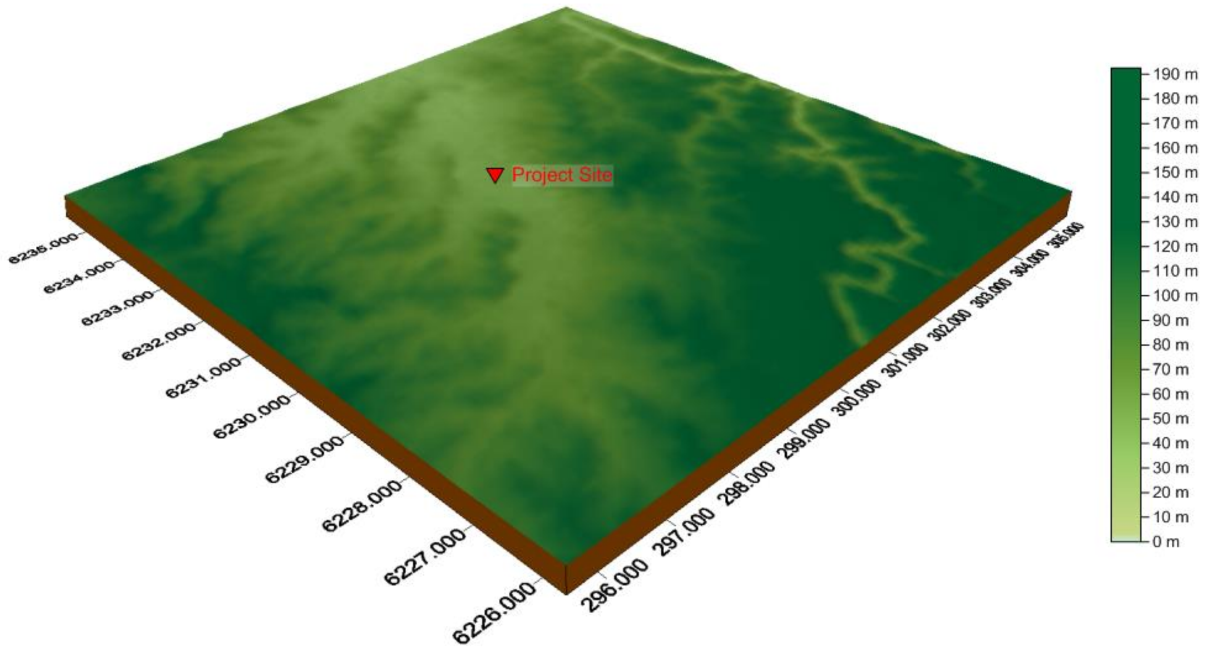


Figure 3 Topography Surrounding the Site



3.3 Description of Subject Works

The development of the site will include the construction of a new substation, site office and amenities block as well as the installation of a new in-ground weighbridge (20 m x 3.5 m) for large trucks relocation of the fuel tank and the construction of 10 car parking spaces.

The anticipated construction equipment items and numbers are presented in **Table 1**.

Table 1 Anticipated Construction Equipment

Activity	Plant/Equipment Item	Number of items per 15 minute period
Construction	Elevated Working Platform	1
	Hand Tools	1
	Grinder	1
	Circular Saw	1
	Truck (10 tonne)	1
	Dozer	1
	Bobcat	1
	Excavator (20 tonne)	1
	Front End Loader (FEL) 962	2
	Tipper Truck	4
	Franna Crane	2
	Concrete Truck / Agitator	1
	Water Tanker (8000 litre)	2
	Excavator (Breaker)	1

3.4 Surrounding Environment

The surroundings are characterised by a mix of industrial developments including factories, automotive servicing, parts, panel beaters and painters, printing facilities, hardware and general supplies, manufacturing and warehousing. The industrial nature of the surrounding developments means they would not be considered as sensitive in the way that an office, school or hospital would be, hence this report focusses on potential impacts at the nearest residential receivers.

The nearest residential receivers are located approximately 350 m to the west across Campbelltown Road. Seventeen (17) discrete receptor locations were used in this study to assess the potential noise impacts of the site operations at sensitive receptor locations identified in the area surrounding the Project Site and were selected based on their close proximity to the Project Site. These locations are presented in **Figure 4** and **Table 2**.

In addition, six community receptors have also been identified and included in this assessment. These locations are presented in **Table 2** and **Figure 4**.

As outlined in **Section 3.12**, the site is located in the general industrial zone and surrounded by a number of industrial units. Five industrial receptors have also been identified and included in this assessment. The locations of these industrial receptors are also presented in **Table 2** and **Figure 4**.

The noise environment is dominated by traffic on Campbelltown Road, neighbourhood noise (dogs, birds, etc), distant road traffic noise on Raby Road and Hume Highway, and infrequent industrial noise (eg container impact noise, reverse alarms etc).

Figure 4 Sensitive Receptor Locations

Table 2 Sensitive Receptor Locations Used in this Assessment

Receptor ID	UTM Zone 56H		Receptor Type
	Easting (m)	Northing (m)	
Residential Receptors			
R1	301,332	6,232,327	Residential
R2	300,956	6,232,650	Residential
R3	301,012	6,233,168	Residential
R4	300,365	6,233,376	Residential
R5	299,933	6,232,914	Residential
R6	299,679	6,232,370	Residential
R7	299,567	6,232,073	Residential
R8	299,491	6,231,799	Residential
R9	299,491	6,231,277	Residential
R10	299,600	6,230,993	Residential
R11	299,540	6,230,488	Residential
R12	299,649	6,229,921	Residential
R13	300,474	6,230,271	Residential
R14	300,685	6,230,670	Residential
R15	300,854	6,231,036	Residential
R16	301,035	6,231,508	Residential
R17	301,190	6,231,927	Residential
Industrial Receptors			
I1	299,751	6,231,935	Industrial
I2	299,903	6,231,943	Industrial
I3	300,045	6,231,899	Industrial
I4	300,070	6,231,698	Industrial
I5	299,903	6,231,491	Industrial
Community Receptors			
C1	299,460	6,232,477	Community
C2	300,558	6,232,509	Community
C3	301,261	6,232,456	Community
C4	301,280	6,231,579	Community
C5	300,675	6,230,249	Community
C6	300,052	6,230,176	Community

4 NOISE AND VIBRATION GUIDELINES AND CRITERIA

4.1 Construction Noise Criteria - EPA

4.1.1 Construction Noise Guidelines

When dealing with noise from construction works, the NSW Environmental Protection Authority (EPA) recognises that higher levels of noise are likely to be tolerated by people in view of the relatively short duration of the works. As a result, the EPA has published guidelines in its "*Interim Construction Noise Guideline*", 2009 (Guideline) for the management of construction works noise.

The Guideline recommends the following approaches to mitigating adverse noise impacts from construction sites.

4.1.2 Hours of Construction

The EPA's Guideline recommends confining permissible work times as outlined in **Table 3**.

Table 3 Preferred Hours of Construction

Day	Preferred Construction Hours
Monday to Friday	7:00 am to 6:00 pm
Saturdays	8:00 am to 1:00 pm
Sundays or Public Holidays	No construction

4.1.3 Construction Noise Assessment Method

The Guideline recognises that people are usually annoyed more by noise from longer-term works than by the same type of works occurring for only a few days. For this reason the Guideline identifies two methods of assessing noise from construction:

- The quantitative assessment method which applies to long-term duration work; and
- The qualitative assessment method which applies to short-term duration work.

Quantitative Assessment Method

The Guideline recommends that the $L_{Aeq(15minute)}$ noise levels arising from a construction project, measured within the curtilage of an occupied noise-sensitive premises (ie at boundary or within 30 m of the residence, whichever is the lesser, should not exceed the levels indicated in **Table 4**. These noise management levels are generally consistent with community reaction to construction noise. The Guideline also recognises other kinds of noise sensitive receivers and provides recommended construction noise levels for them. Those specific receivers and their recommended noise levels are presented in **Table 5** and **Table 6**.

Table 4 Recommended EPA General Noise Management Levels for Construction Works

Period of Noise Exposure	$L_{Aeq(15minute)}$ Construction Noise Management Level
Recommended Standard Hours	Noise affected[1] RBL[2] + 10 dBA
	Highly Noise affected[3] 75 dBA
Outside Recommended Standard Hours	Noise affected[1] RBL + 5 dBA

Note 1: The noise affected level represents the point above which there may be some community reaction to noise.
Note 2: Refer to **Appendix A**.
Note 3: The highly noise affected level represents the point above which there may be strong community reaction to noise.

Table 5 Noise at Sensitive Land Uses (other than Residences)

Land use	$L_{Aeq(15minute)}$ Construction Noise Management Level
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

Table 6 Management Levels at Commercial and Industrial Premises

Land Use	Management Level, $L_{Aeq(15minute)}$ (applies when properties are being used)
Offices, retail outlets	External noise level 70 dBA
Industrial premises	External noise level 75 dBA
Other noise sensitive businesses such as theatres and childcare centres	Assess on a case by case basis. Refer to the recommended 'maximum' internal levels in AS2107 for specific uses.

The Guideline recommends using the following quantitative assessment when the noise affected level is not met:

Mitigation

Recommended Standard Hours - Noise affected RBL + 10 dBA

- Where the predicted or measured $L_{Aeq(15minutes)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices in order 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.

Recommended Standard Hours - Highly Noise affected RBL 75 dBA

- Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours during which 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

Qualitative Assessment Method

The qualitative method for assessing construction noise is a simplified way to identify the cause of potential noise impacts. It avoids the need to perform complex predictions by using a checklist approach to assessing and managing noise. Short-term means that the works are not likely to affect an individual or sensitive land use for more than three weeks in total.

The following checklist for work practice can be used:

- Community notification.
- Operate plant in a quiet and efficient manner.
- Involve workers in minimising noise.
- Handle complaints.

4.2 Vibration Damage Criteria - Surface Structures

Most commonly specified "*safe*" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

4.2.1 British Standard 7385: Part 2 - 1993

In terms of the most recent relevant vibration damage criteria, 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 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.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 7** and graphically in **Figure 5**.

Table 7 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

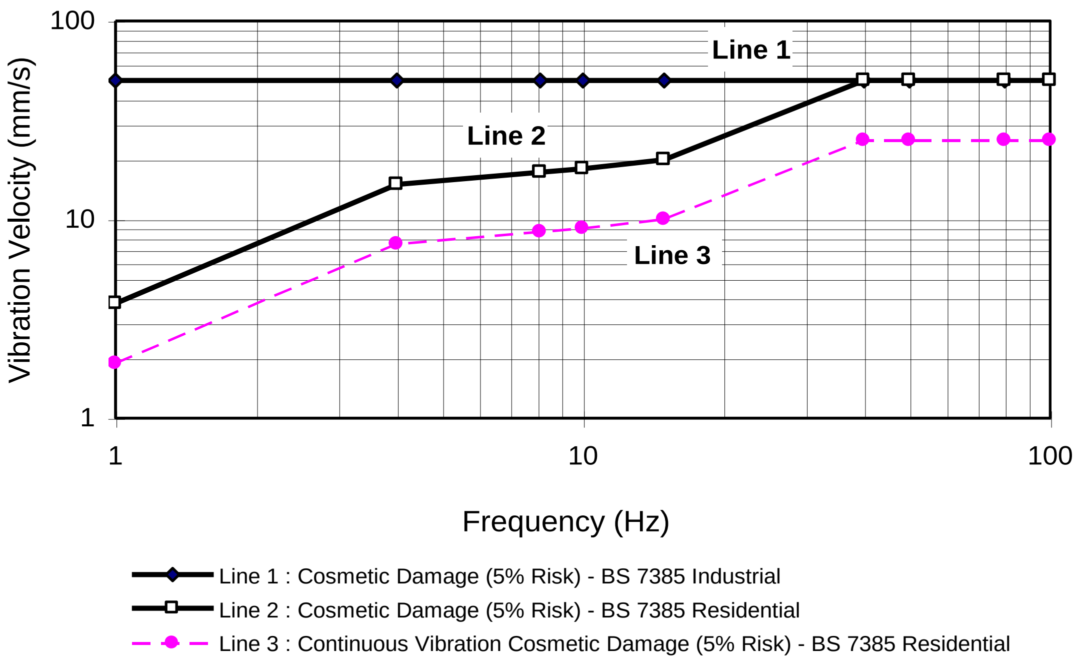
Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	**15 Hz and Above**
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial 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 7** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 7** may need to be reduced by up to 50%.

Rockbreaking/hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may therefore be appropriate to reduce the transient values by 50%.

Figure 5 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 7**, and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 7** should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measured should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in **Table 7**.

It is noteworthy that extra to the guide values nominated in **Table 7**, the standard states that:

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

Also that:

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

4.2.2 German Standard DIN 4150: Part 3-1999

For continuous long-term vibration or repetitive vibration with the potential to cause fatigue effects, DIN 4150 provides the following Peak Particle Velocity (PPV) values as safe limits, below which even superficial cosmetic damage is not to be expected:

- 10 mm/s for commercial buildings and buildings of similar design.
- 5 mm/s for dwellings and buildings or similar design.
- 2.5 mm/s for buildings of great intrinsic value (eg heritage listed buildings).

For short-term vibration events (ie those unlikely to cause resonance or fatigue), DIN 4150 offers the criteria shown in **Table 8**. These are maximum levels measured in any direction at the foundation or in the horizontal axes in the plane of the uppermost floor.

Table 8 DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration

Group	Type of Structure	Peak Particle Velocity (mm/s)			
		At Foundation			Plane of Floor of Uppermost Storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design20	20	20 at 10 Hz increasing to 40 at 50 Hz	40 at 50 Hz increasing to 50 at 100 Hz	40
2	Dwellings and buildings of similar design and/or use	5	5 at 10 Hz increasing to 15 at 50 Hz	15 at 50 Hz increasing to 20 at 100 Hz	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 ad have intrinsic value (eg buildings that are under a preservation order	3	3 at 10 Hz increasing to 8 at 50 Hz	8 at 50 Hz increasing to 10 at 100 Hz	8

Note 1: For frequencies above 100 Hz the upper value in this column should be used.

As opposed the "*minimal risk of cosmetic damage*" approach adopted in BS 7385 (95% probability of no effect), the "*safe limits*" given in DIN 4150 are the levels up to which no damage due to vibration effects has been observed for the particular class of building. "*Damage*" is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

4.3 Human Comfort Vibration Criteria

4.3.1 General

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

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

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2-1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in **Table 9**.

Table 9 Peak Vibration Levels and Human Perception of Motion

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

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

Table 9 suggests that people will just be able to feel floor vibration at levels of about 0.15 mm/s and that the motion becomes "*noticeable*" at a level of approximately 1 mm/s.

4.3.2 Human Comfort Vibration Criteria

"*Assessing Vibration: a technical guideline*" (DEC, 2006) recommends the use of BS 6472-1992 for the purpose of assessing vibration in relation to human comfort.

British Standard BS 6472-1992 "*Guide to evaluation of human exposure to vibration in building*" (BS 6472-1992) nominates guideline values for various categories of disturbance, the most stringent of which are the levels of building vibration associated with a "*low probability of adverse comment*" from occupants.

BS 6472-1992 provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV), rather than a continuous vibration level. The vibration dose value is dependent on the level and duration of the short-term vibration event, as well as the number of events occurring during the daytime period.

The vibration dose values recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in **Table 10**.

Table 10 Vibration Dose Values ($m/s^{1.75}$) above which Various Degrees of Adverse Comment May Be Expected in Residential Buildings, Offices and Workshops

Location	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Residential buildings 16 hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Offices 16 hour day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshops 16 hour day	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

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

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

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

5 EXISTING BACKGROUND NOISE ENVIRONMENT, AIRBORNE NOISE GOALS AND RECOMMENDED NOISE AND VIBRATION CRITERIA

5.1 Introduction

Construction noise goals for airborne noise emission are generally based on the existing background noise levels within a given area with an allowable increase due to the temporary nature of construction works (refer to **Section 4**).

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

5.2 Ambient Noise Surveys

In order to derive airborne noise goals for residential receiver locations, it is necessary to undertake background noise measurements in the absence of construction noise. Accordingly, the results of a background (unattended) noise survey undertaken at 37 Stromeferry Crescent for the project was used to derive the subject construction noise goals.

This background noise monitoring location, 37 Stromeferry Crescent, is labelled R7 in **Table 2** and **Figure 4**.

5.2.1 Ambient Noise Survey Methodologies

The background noise survey was conducted at Location R7 during the period Friday 27 November 2015 to Tuesday 8 December 2015 in order to quantify the ambient noise environment at the closest potentially affected receiver locations prior to the commencement of construction.

For this background noise survey, an SVAN noise logger was continuously monitored noise levels and stored the results as statistical noise levels for each consecutive 15 minute period.

The equipment used for the survey carried current manufacturer's calibration certification. Calibration was checked before the measurement and at the downloading of data from the noise logger. Calibration drift was within acceptable limits and did not exceed ± 0.5 dBA.

5.2.2 Background Noise Monitoring Results

A summary of the measured background noise levels is presented in **Table 11**. The data has been segregated into the relevant times of day in order to assist in setting noise criteria for construction noise emissions.

The L_{A90} noise levels are the Rating Background Levels (RBL's), determined using the procedures set out in the EPA's "*Industrial Noise Policy"*, 2000 (INP).

Table 11 Summary of Background Noise Levels at Monitoring Locations - $L_{Aeq(15minute)}$ dBA (re 20 µPa)

Monitoring Location	Noise Level for Preferred and Outside Preferred Construction Hours					
	Preferred		Outside Preferred			
	Day[1]		Evening[2]		Night[3]	
	LA90	LAeq	LA90	LAeq	LA90	LAeq
R7 – 37 Stromeferry Crescent	53	67	51	66	44	61

Note 1: 7:00 am to 6:00 pm Mon-Fri; 8:00 am to 1:00 pm Sat.

Note 2: Evening 6:00 pm to 10:00 pm.

Note 3: Night 10:00 pm to 7:00 am.

5.3 Airborne Noise Goals for Residential Receivers

The airborne noise objective for residential/commercial receivers indicates that noise from construction activities should be managed such that the L_{Aeq} noise level, measured over a period of not less than 15 minutes, should not exceed the background (L_{A90}) noise level by more than 10 dBA during the EPA's preferred construction hours and 5 dBA outside the preferred hours.

Based on the measured $L_{A90(15minute)}$ RBL's, the airborne $L_{Aeq(15minute)}$ construction noise goals apply during the preferred hours of construction.

5.4 Summary of Recommended Noise and Vibration Criteria

5.4.1 Airborne Construction Noise - Residences

The Noise Management Levels (NML's) have been established based on the ambient noise levels presented in **Table 11**. The resulting construction Noise Management Levels are presented in **Table 12**.

Table 12 Construction Noise Goals

Receiver	Measured Ambient Noise Levels			Noise Management Levels - NMLs (dBA)					
	Daytime[1]	Evening[1]	Night-time[1]	Standard Hours Daytime	Highly Noise Affected	Out of Hours Daytime	Out of Hours Evening	Out of Hours Night-time	Sleep Disturbance Screening Criterion
Residential Receivers	53	51	44	63	75	58	56	49	59

Note 1: Standard hours are 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays with no work on Sundays or Public Holidays. Evening is 6.00 pm to 10.00 pm. Night-time is 10.00 pm to 7.00 am Sundays to Saturday and 10.00 pm to 8.00 am on Sunday.

5.4.2 Construction Vibration - Cosmetic Damage

Table 13 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

Vibration monitoring equipment will be set so that visual and audible alarms are triggered when vibration from vibration generating works, or any other construction works, exceeds the levels shown in **Table 14**.

Table 14 Nominated Site Control Vibration Criteria (ie Operator Warning and Halt Levels)

Structure	Site Control Criteria (PPV in any Orthogonal Direction)	
	Operator Warning Level	Operator Halt Level
All Structures - to be measured at base	6 mm/s	8 mm/s

Exceedance of the “Operator Warning Level” would not require excavation activity to cease, but rather alerts the Site Manager to proceed with caution at reduced force or load.

An exceedance of the “Operator Halt Level” would require the Project Manager to implement an alternative excavation technique pending further analysis of the vibration frequency content in order to determine any potential exceedance of the criteria presented in **Table 13**.

6 NOISE AND VIBRATION GENERATING WORKS

6.1 Airborne Construction Noise

The basis for the project-specific construction airborne noise goals for approved daytime hours is shown in **Table 12**.

Where the noise goals shown in **Table 12** cannot be achieved, the construction contractor will use all reasonable and feasible noise mitigation and management measures to reduce noise generation and impacts.

6.1.1 Vibration

The construction contractor will, if required, ensure compliance with the criteria of **Table 13**.

Note that in the event of complaint vibration monitoring equipment will be set so that visual and audible alarms are triggered when the levels of vibration exceed the control criteria presented in **Table 13**.

If the "Operator Warning Level" is reached, the contractor will immediately, either:

- Reduce the number of vibration-generating plant/equipment items; or
- Cease operation, pending further analysis of the potential for building damage. An Acoustical Consultant must endorse the conclusions of such an investigation.

6.2 Vibration

Disturbance to building occupants can potentially occur at much lower vibration levels than the safe limits relating to building damage.

The risk of exceeding the recommended building damage criteria should be managed, in the event of complaint, by carrying out vibration measurements during excavation works in order to establish satisfactory buffer zones, as outlined in **Section 7.3**.

6.3 Typical Sound Pressure Levels

Sound pressure levels for the anticipated items of construction equipment (as presented in **Table 1**) are listed in **Table 15**. These noise levels are representative of modern plant operating with noise control measures in good condition.

Table 15 Typical Noise Levels of the Anticipated Construction Equipment - dBA (re 20 µPa)

Plant/Equipment Item	No of Items per 15 minute Period	Noise Level at 7 m	Likely Maximum for Activity
Elevated Working Platform	1	72	72
Hand Tools	1	71	
Grinder	1	73	
Circular Saw	1	79	
Truck (10 tonne)	1	73	
Dozer	1	85	
Bobcat	1	79	
Excavator (20 tonne)	1	74	
Front End Loader (FEL) 962	2	87	
Tipper Truck	4	72	
Franna Crane	2	74	
Concrete Truck / Agitator	1	81	
Water Tanker (8000 litre)	2	73	
Excavator (Breaker)	1	96	96

6.4 Predicted Construction Noise Levels

Noise levels were predicted to the neighbouring residential properties for the demolition and site establishment, excavation and construction phases for assessment against the approved daytime hours criteria. Predictions have been based on the equipment noise levels presented in **Table 15**.

Construction noise from the worst case (concurrent operations) from each of the construction phases at each of the surrounding residential areas is presented in **Table 16**.

Table 16 Predicted Construction Noise Levels - dBA (re 20 µPa)

Activity	Receiver ID	Receiver Type	Worst Case Predicted	Daytime RBL	Daytime NML	Daytime Exceedance
Construction	R1	Residential	32	53	63	-
	R2	Residential	36	53	63	-
	R3	Residential	32	53	63	-
	R4	Residential	25	53	63	-
	R5	Residential	27	53	63	-
	R6	Residential	43	53	63	-
	R7	Residential	49	53	63	-
	R8	Residential	49	53	63	-
	R9	Residential	44	53	63	-
	R10	Residential	38	53	63	-
	R11	Residential	36	53	63	-
	R12	Residential	37	53	63	-
	R13	Residential	35	53	63	-
	R14	Residential	36	53	63	-
	R15	Residential	35	53	63	-
	R16	Residential	37	53	63	-
	R17	Residential	33	53	63	-
	I1	Industrial	59	n/a	75[2]	-
	I2	Industrial	67	n/a	75[2]	-
	I3	Industrial	66	n/a	75[2]	-
	I4	Industrial	51	n/a	75[2]	-
	I5	Industrial	59	n/a	75[2]	-
	C1	Community	27	n/a	70[2]	-
	C2	Community	39	n/a	70[2]	-
	C3	Community	31	n/a	70[2]	-
	C4	Community	32	n/a	70[2]	-
	C5	Community	30	n/a	70[2]	-
	C6	Community	28	n/a	70[2]	-

Activity	Receiver ID	Receiver Type	Worst Case Predicted	Daytime RBL	Daytime NML	Daytime Exceedance
Noise Intensive Works	R1	Residential	35	53	63	-
	R2	Residential	39	53	63	-
	R3	Residential	35	53	63	-
	R4	Residential	28	53	63	-
	R5	Residential	30	53	63	-
	R6	Residential	46	53	63	-
	R7	Residential	52	53	63	-
	R8	Residential	52	53	63	-
	R9	Residential	47	53	63	-
	R10	Residential	41	53	63	-
	R11	Residential	39	53	63	-
	R12	Residential	40	53	63	-
	R13	Residential	38	53	63	-
	R14	Residential	39	53	63	-
	R15	Residential	38	53	63	-
	R16	Residential	40	53	63	-
	R17	Residential	36	53	63	-
	I1	Industrial	62	n/a	75[2]	-
	I2	Industrial	70	n/a	75[2]	-
	I3	Industrial	69	n/a	75[2]	-
	I4	Industrial	54	n/a	75[2]	-
	I5	Industrial	62	n/a	75[2]	-
	C1	Community	30	n/a	70[2]	-
	C2	Community	42	n/a	70[2]	-
	C3	Community	34	n/a	70[2]	-
	C4	Community	35	n/a	70[2]	-
	C5	Community	33	n/a	70[2]	-
	C6	Community	31	n/a	70[2]	-

Note 1: Predicted amenity noise levels for Industrial and Community Receptors.
Note 2: Amenity noise criteria - LAeq(period).

Predicted noise levels presented in **Table 16** do not trigger the NMLs for all surrounding receivers.

6.5 Safe Working Distances for Vibration Intensive Activities

Safe working distances for the anticipated items of equipment are listed in **Table 17**. These distances are indicative only and can vary depending on the particular item of plant and geotechnical conditions.

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

Table 17 Safe Working Distances for Vibration from the Anticipated Construction Equipment

Plant/Equipment Item	Safe Working Distance	Comments
Elevated Working Platform	1.3 m	Based on a 5 mm/s criterion
Hand Tools	0.3 m	
Grinder	0.5 m	
Circular Saw	0.5 m	
Truck (10 tonne)	1.3 m	
Dozer	0.1 m	
Bobcat	1.3 m	
Excavator (20 tonne)	0.1 m	
Front End Loader (FEL) 962	1.3 m	
Tipper Truck	1.3 m	
Franna Crane	1.3 m	
Concrete Truck / Agitator	1.3 m	
Water Tanker (8000 litre)	1.3 m	
Excavator (Breaker)	5 m	

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

7 NOISE AND VIBRATION MONITORING

7.1 Noise Monitoring

In the event of complaint, noise monitoring would be performed by an Acoustical Consultant directly engaged by the client.

Where conducted, noise monitoring for the construction works would be undertaken at the two closest, potentially most affected, residences to the major noise generating construction activities using statistical noise loggers. This monitoring would be supplemented by attended monitoring (where necessary) in order to differentiate between construction noise sources and other sources (such as road traffic and aircraft noise) and also in order to observe and identify any abnormally noisy construction equipment or operations.

If required, attended noise monitoring would also be conducted in the event of complaint.

During any attended monitoring, typical maximum noise levels associated with particular operations and/or plant items will be noted. Where possible, extraneous noise events such as road and air traffic noise will be excluded from the results or highlighted in accompanying notes.

Where conducted, noise monitoring would be undertaken by the Acoustical Consultant. Equipment and methods will comply with AS 1055.1-1989. The statistical parameters to be measured will be the L_{Amin}, L_{A90}, L_{A10}, L_{A1}, L_{Amax} and L_{Aeq} evaluated over consecutive 15 minute periods.

7.2 Vibration Monitoring

In the event of complaint, structural vibration monitoring would be carried out on the two closest, potentially most affected residences during the construction period.

A single geophone mounting plate would be installed on the closest residential buildings. The monitoring locations would be on a stiff part of the structures (at the foundations) on the side of the buildings adjacent to the subject construction works, in accordance with BS 7385:Part 2:1993.

The vibration monitoring system would be configured to record the peak vibration levels and to trigger an audible/visual alarm or send SMSs when predetermined vibration thresholds are exceeded. The thresholds correspond to an "Operator Warning Level" and an "Operator Halt Level", where the Warning Level is 75% of the Halt Level

The vibration threshold would be set to an "Operator Warning Level" of 6 mm/s (ppv) and an "Operator Halt Level" of 8 mm/s (ppv), the exceedance of which would be indicated by the audible/visual alarm in the construction site or SMS.

Based on the foregoing information, the nominated site control vibration criteria are presented in **Table 18** together with the minimal risk of cosmetic damage criterion from BS 7385.

Table 18 Nominated Site Control Vibration Criteria (ie Operator Warning and Halt Levels)

Structure	**Site Control Criteria**	
	Operator Warning Level	**Operator Halt Level**
Nearest Potentially Affected	6 mm/s	8 mm/s

Exceedance of the "Operator Warning Level" does not require excavation activity to cease but rather alerts the construction contractor to proceed with caution at reduced force or load.

An exceedance of the "Operator Halt Level" requires the construction contractor to implement an alternative excavation technique.

A report of the measured vibration levels and their likely impacts would be prepared by the Acoustical Consultant and distributed by the Project Manager.

Attended vibration monitoring (structural damage and/or human comfort) would also be carried out in response to potential structural damage criterion exceedances. This monitoring would provide direct feedback to the operators in order to allow appropriate modification of excavation techniques, if required.

7.3 Site Validation Vibration versus Safe Distance Criteria

Significant variations in vibration versus distance data occur under actual site conditions, due primarily to the specific make and model of plant item, operational factors, local geotechnical conditions, structural response of the structure and coupling of the structure to the ground. The safe distances presented in **Table 17** have conservatively taken such factors into account.

7.4 Supplementary Noise and Vibration Monitoring

Supplementary noise and structural damage and/or human comfort vibration monitoring will be carried out in response to ongoing complaints criteria, exceedances or for the purpose of refining construction techniques in order to minimise noise and vibration emissions. Monitoring would be attended under these circumstances, in order to provide immediate feedback to the operators.

8 NOISE MITIGATION MEASURES

8.1 Noise Control

The following noise mitigation measures will, if required, be implemented.

The construction contractor will, where reasonable and feasible, apply best practice noise mitigation measures including:

- Maximising the offset distance between noisy plant items and nearby noise sensitive receivers.
- Avoiding the coincidence of noisy plant working simultaneously close together and adjacent to sensitive receivers.
- Minimising consecutive works in the same locality.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.

In order to minimise noise impacts during the works, the construction contractor will take all reasonable and feasible measures to mitigate noise effects.

The contractor will also take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.

Silenced air compressors, fitted with noise labels indicating a maximum (L_{Amax}) sound pressure level of not more than 75 dBA at 7 m will be used on site. The sound pressure level of noise emitted from a compressor used will comply with noise label requirements.

9 VIBRATION MITIGATION MEASURES

The following vibration mitigation measures will be implemented by the construction contractor:

- Relocate any vibration generating plant and equipment to areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of excavation plant and equipment eg smaller capacity rockbreaker hammers.
- Minimise consecutive works in the same locality (if applicable).
- Schedule a minimum respite period of at least 0.5 hour before activities commence which are to be undertaken for a continuous 4 hour period.
- If applicable, use only dampened rockbreakers and/or “city” rockbreakers to minimise the impacts associated with rockbreaking works.

10 SUMMARY OF MITIGATION MEASURES

The noise and vibration mitigation measures to be implemented by the construction contractor are listed in **Table 19**.

Table 19 Noise and Vibration Mitigation Measures

Item	Description
Construction Hours	Works will be carried out within the standard construction hours.
Deliveries	Deliveries will be carried out within the standard construction hours.
Site Layout	Where possible, plant and equipment will be located and orientated to direct noise away from sensitive receivers.
Quietest Suitable Equipment	Plant and equipment will be selected to minimise noise emission, where possible, whilst maintaining efficiency of function. Residential grade silencers will be fitted and all noise control equipment will be maintained in good order.
Hammer Equipment	Maximise hammer penetration (and reduce blows) by using sharp hammer tips. Keep stocks of sharp profiles at site, and monitor the profiles in use.
Reversing Alarms	Mobile plant and trucks operating on site for a significant portion of the project will have reversing alarm noise emissions minimised, where possible, recognising the need to maintain occupational safety standards.
PA System	No public address system will be used at this site.
Vibration Buffer Zones	General safe working distances for construction items are described in **Table 17**. Monitoring should be carried out to confirm these buffer zones at locations where buildings are closest.
Vibration Monitoring	Vibration monitoring will be carried out where vibration intensive activities (eg rockbreaking) are required to be carried out within the established buffer zones, or where there is considered to be a risk that vibration levels may exceed the relevant structural damage criteria.
Truck Noise (off site)	All trucks regularly used for the project are to have mufflers, and any other noise control equipment, maintained in good working order. Trucking routes will use main roads, where feasible.
Community Liaison	A programme of community liaison and complaint response will be implemented, where required.
Training	Site induction training will include a noise awareness component.

11 IDENTIFYING AND MANAGING FUTURE NOISE AND VIBRATION ISSUES

If additional activities or plant are found to be necessary that will emit noise and/or vibration emissions significantly exceeding those assumed for this assessment, these will be assessed by the Acoustical Consultant on a case-by-case basis and appropriate mitigation measures will be implemented.

12 REPORTING

If noise and/or vibration monitoring has been conducted, the Acoustical Consultant will, if required, submit reports to the Project Manager at monthly intervals. These reports will cover the preceding months' activities and will include the following:

- Location of unattended monitoring instruments.
- Unattended monitoring results (noise data graphed with one day per page).
- Attended monitoring locations.
- Tabulation of attended noise measurement results together with notes identifying the principal noise sources.
- Vibration monitoring results summary together with notes describing any vibration-intensive activities (if applicable).

- Summary of measurements exceeding the criteria levels and descriptions of the plant or operations causing these exceedances (if available).
- Details of corrective action applicable to criteria exceedances and confirmation of its successful implementation. Where corrective action has not yet been implemented, it may be shown as pending and the status of its implementation shall be carried forward to following reports.

13 NON-COMPLIANCE AND CORRECTIVE ACTION

Where the noise and/or vibration monitoring identifies non-compliance with the relevant criteria, the construction contractor will plan and carry out corrective action.

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

14 COMPLAINT HANDLING

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

- The construction contractor will record all verbal and telephone complaints in writing and will forward all complaints to the Project Manager, together with details of the circumstance leading to the complaint and all subsequent actions.
- Complaints received will be referred to the construction contractor. The construction contractor will respond as described above.
- The Project Manager will investigate the complaint in order to determine whether a criterion exceedance has occurred or whether noise and/or vibration have occurred unnecessary.
- If excessive or unnecessary noise and/or vibration have been caused, corrective action will be planned and implemented by the construction contractor
- Complainants will be informed by the Project Manager that their complaints are being addressed, and (if appropriate) that corrective action is being taken.
- Follow-up monitoring or other investigations will be carried out by the construction contractor to confirm the effectiveness of the corrective action.
- Complainants will be informed of the implementation of the corrective action that has been taken to mitigate the adverse effects.

15 COMMUNITY CONSULTATION AND LIAISON

Community consultation will be undertaken via the construction contractor, including:

- Recording and managing any complaints.

These and other elements of the community consultation will be addressed under the relevant procedures for the subject works.

ACOUSTIC TERMINOLOGY

1 Sound Level or Noise Level

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

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

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

2 “A” Weighted Sound Pressure Level

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

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

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

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

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

3 Sound Power Level

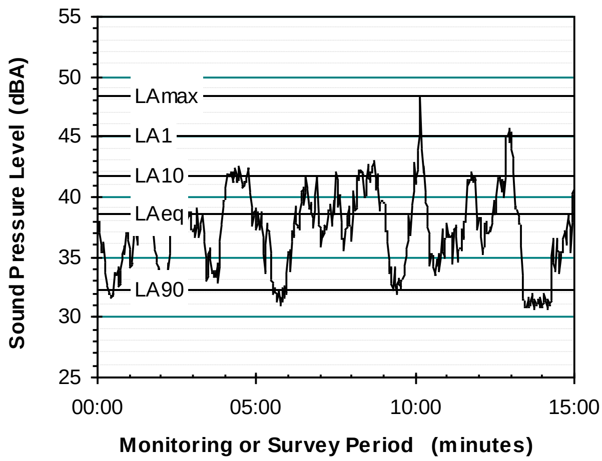
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 1E-12 W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels 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 the statistical indices.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} Is the A-weighted equivalent continuous noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

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

This method produces a level representing the “repeatable minimum” L_{A90} noise level over the daytime and night-time measurement periods, as required by the DECCW. In addition the method produces mean or “average” levels representative of the other descriptors (L_{Aeq}, L_{A10} etc).

5 Tonality

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

6 Impulsiveness

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

7 Frequency Analysis

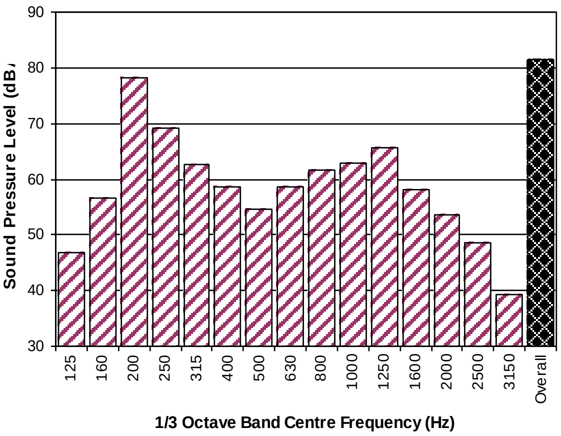
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

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

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

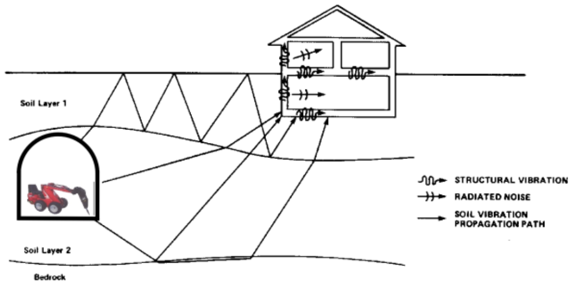
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Regenerated Noise

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

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

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



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