M4-M5 Link Mainline Tunnels

Construction Noise and Vibration Impact Statement | Campbell Road Ancillary Facility - Operations

Prepared for ASBJV

June 2022

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ASBJV

J180225 RP5

June 2022

Version	Date	Prepared by	Approved by	Comments
Rev 14.1	17 June 2022	Rick Scully	Carl Fokkema	
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Approved by

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28 June 2022

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Executive Summary

EMM has completed a construction noise and vibration impact statement (CNVIS) to review potential noise and vibration impacts from the operation and demobilisation of the Campbell Road ancillary facility at St Peters.

The Site will be extensively mitigated and managed to reduce noise emissions, most notably for activities during the night time period. The mitigation and management applied at site satisfies the reasonable and feasible approach as outlined in the ICNG (EPA 2009) and the requirements of the conditions of approval (CoA).

This CNVIS assesses noise levels from the following stages:

- Stage 4A and 4B – worst case scenario for tunnel support activities including backfilling and spoil hauling (Stage 4A) and tunnel grouting (Stage 4B) occurring without an acoustic shed. At any time, either Stage 4A or 4B will be undertaken so will not occur concurrently; and

- Stage 5 – worst case site demobilisation activities including hammering out pavement and hardstand, removal of temporary inground structures, site clearing and land reinstatement.

It is noted that the activities proposed are not strictly permissible during out of hour periods, unless NMLs are satisfied (refer CoA E73), excluding spoil hauling and deliveries (refer CoA E70). The proposed activities and scenarios have been mitigated and limited so they will be NML compliant during all periods.

There is a possibility that some activities assessed in Stage 5 may occur at the same time as either Stage 4A or 4B. This would only occur during standard daytime construction hours and is unlikely to result in an exceedance of NML. Should this occur, it would typically result in a 1-2 dB increased in predicted noise levels, or a worst-case increase of 3 dB. This is unlikely in practice, as it assumes all equipment of each scenario operating concurrently.

For Stage 4A and 4B, noise levels from site operations are predicted to be compliant with (equal or less than) the relevant NMLs for all periods. The 'average' (L_{Aeq}) noise generated by the proposed tunnel support activities represented in these scenarios is therefore unlikely to cause noise impacts at surrounding residential receivers.

For Stage 4A, noise levels above the sleep disturbance screening criteria have been predicted at several residential properties around the Site. The predicted maximum noise levels are typically generated by spoil trucks arriving and leaving the Site. Notwithstanding the above, the predicted maximum noise levels are below upper levels expected to generate awakenings of 60 to 65 dB L_{Amax} external (equating to 50 to 55 dB L_{Amax} internal) as referenced in the RNP (EPA 2011). Further, long-term noise logger results from 4-16 Campbell Street, St Peters (New M5 EIS, Vol 2D, App J) indicate existing L_{Amax} noise levels which are typically greater than 65 dB during the night period and generally in the order of 70 dB on many occasions per night.

For Stage 4B, predicted maximum noise levels comply with (are below) the sleep disturbance criteria at all residential assessment locations.

Sleep impacts generated by the 24 hour operation of the facility are therefore unlikely, however, will be managed in accordance with the Site's Noise and Vibration Management Plan (NVMP).

The activities proposed as part of Stage 5 relate to the demobilisation of site. This includes the hammering out pavement and hardstand, removal of temporary inground structures, site clearing and land reinstatement. These activities are consistent with the approved activities already assessed in the project's Site Establishment Construction Noise and Vibration Impact Statement (SECNVIS) prepared by EMM (Report number J180225 RP1, dated 17 October 2018). The sound power levels from the proposed activities in both the SECNVIS and Stage 5 demobilisation have been compared and are considered to be consistent.

Nevertheless, noise mitigation and management measures are recommended to be implemented, consistent with those in Section 10 of the SECNVIS (EMM 2018).

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1 Introduction

1.1 Context

This Construction Noise and Vibration Impact Statement (CNVIS) has been prepared to identify the noise and vibration impacts from a portion of Stage 1 of the WestConnex 3A – M4-M5 Link Mainline tunnels project (the Project). In addition, this CNVIS also responds to (as required) the various noise and vibration requirements detailed within the Minister's Conditions of Approval (CoA), the WestConnex M4-M5 Link Environmental Impact Statement (EIS), the revised environmental management measures (REMM) listed in the Submissions and Preferred Infrastructure Report (SPIR) and all applicable legislation.

1.2 Background and project description

An EIS (AECOM 2017) assessed the potential impacts of construction and operation of the project on noise and vibration, within Chapter 10.

The EIS identified the potential noise impacts during the 24/7 operations phase of the tunnelling support facilities. It concluded any potential impacts could be managed by standard mitigation and management measures.

The WestConnex M4-M5 Link project is being constructed in two stages (refer to Figure 1.1):

- Stage 1 (the Project and subject of this document): M4-M5 Link Mainline tunnels.
- Stage 2: Rozelle interchange.

WestConnex Transurban has engaged Acciona Samsung Bouygues Joint Venture (ASBJV) to design and construct Stage 1 of the project (refer Figure 1.1). The key features of the Mainline tunnels project include:

- twin mainline motorway tunnels between the M4 East at Haberfield and the New M5 at St Peters. Each tunnel would be around 7.5 kilometres (km) long and would generally accommodate up to four lanes of traffic in each direction;
- connections of the mainline tunnels to the M4 East project, comprising:
  - a tunnel-to-tunnel connection to the M4 East mainline stub tunnels east of Parramatta Road near Alt Street at Haberfield;
  - entry and exit ramp connections between the mainline tunnels and the Wattle Street interchange at Haberfield (constructed as part of the M4 East project); and
  - minor physical integration works with the surface road network at the Wattle Street interchange including road pavement and line marking;
- connections of the mainline tunnels to the New M5 project, comprising:
  - a tunnel-to-tunnel connection to the New M5 mainline stub tunnels north of the Princes Highway near the intersection of Mary Street and Bakers Lane at St Peters;
  - entry and exit ramp connections between the mainline tunnels and the St Peters interchange at St Peters (which is currently being constructed as part of the New M5 project); and
  - minor physical integration works with the surface road network at the St Peters interchange including road pavement and line marking;

- construction of tunnel stubs to provide for future underground connection of the mainline tunnels to the Rozelle interchange and Iron Cove Link;
- a motorway operations complex at St Peters (Campbell Road) (MOC5). The types of facilities that would be contained within the motorway operations complexes would include substations, water treatment plants, ventilation facilities and outlets (the Campbell Road ventilation facility), offices, on-site storage and parking for employees;
- tunnel ventilation systems, including ventilation supply and exhaust facilities, ventilation fans, ventilation outlets and ventilation tunnels;
- fitout (mechanical and electrical) of part of the Parramatta Road ventilation facility at Haberfield (constructed as part of M4 East project) for use by the M4-M5 Link project;
- drainage infrastructure to collect surface and groundwater for treatment at dedicated facilities;
- water treatment would occur at the operational water treatment facility at the Campbell Road motorway operations complex;
- ancillary infrastructure and operational facilities for electronic tolling and traffic control and signage (including electronic signage);
- emergency access and evacuation facilities, including pedestrian and vehicular cross and long passages and fire and life safety systems;
- utility works, including protection and/or adjustment of existing utilities, removal of redundant utilities and installation of new utilities;
- temporary construction ancillary facilities to facilitate construction of the project at the following locations:
    - Northcote Street civil and tunnel site, Haberfield;
    - Parramatta Road East civil site, Haberfield;
    - Parramatta Road West civil site, Ashfield;
    - Wattle Street civil and tunnel site, Haberfield;
    - Pyrmont Bridge Road tunnel site, Camperdown/Annandale; and
    - Campbell Road civil and tunnel site, St Peters.

An overview of the project footprint and ancillary facilities is presented in the Construction Environmental Management Plan (CEMP). Further detail of the project description is presented in Section 1.3 of the CEMP.

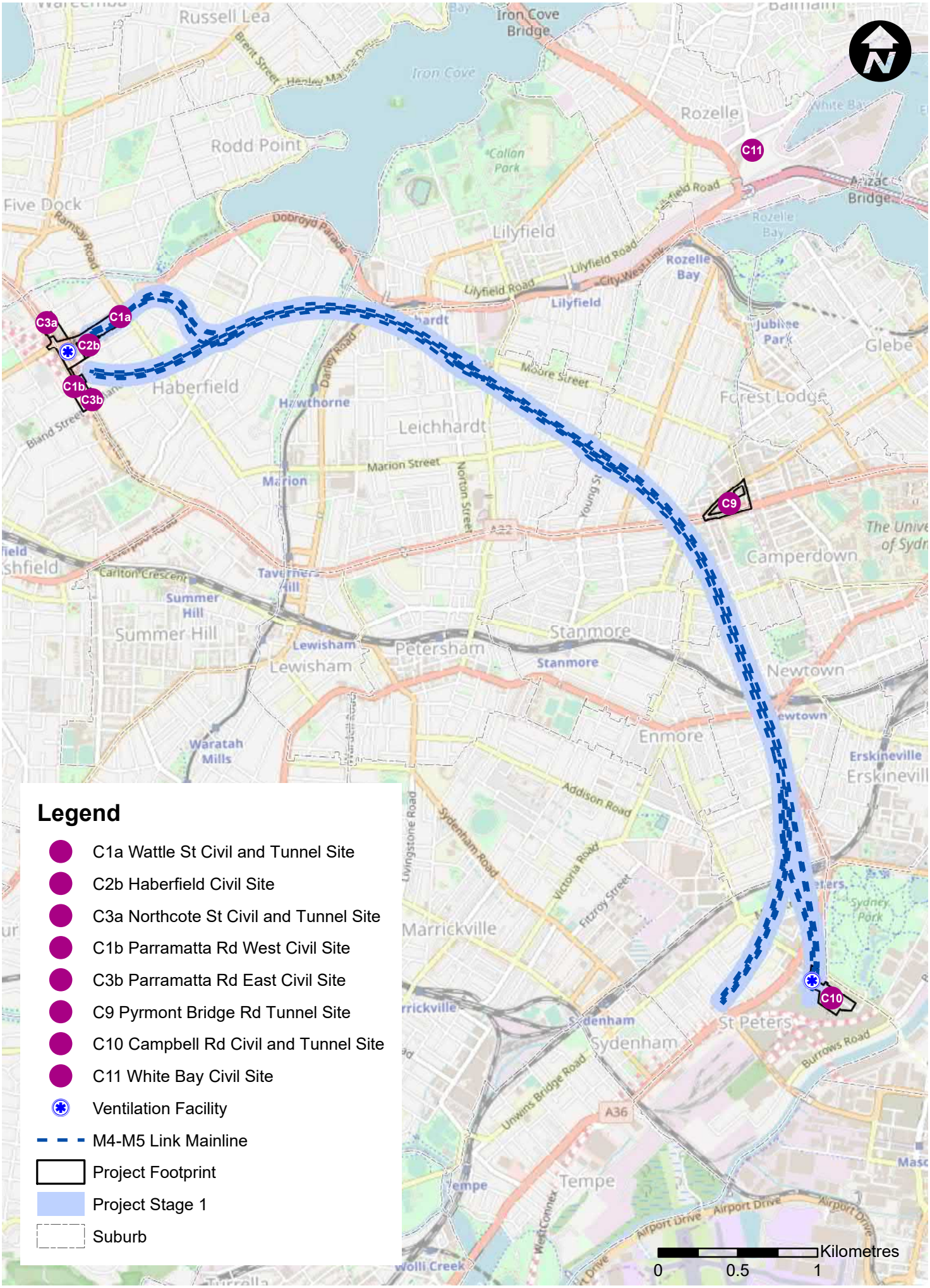


Figure 1-1 Overview of Stage 1 - M4-M5 Link Mainline Tunnels (the Project)

1.3 Scope of this CNVIS

The scope of this CNVIS is to assess potential noise impacts from construction scenarios which represent typical worst case noise levels from the use of the Campbell Road ancillary facility at St Peters. The proposed activities at this site assessed in this CNVIS include:

- Tunnelling and tunnelling support:
  - tunnel backfilling and grouting;
  - spoil handling outside an acoustic shed and haulage within site; and
  - civil fit out (pavement, concreting works).
- Site demobilisation
  - removal of the acoustic shed;
  - removal of site fixtures; and
  - site clearing and concreting.

The purpose of the CNVIS is to identify potential noise and vibration impacts and to develop feasible and reasonable noise management and mitigation measures where potential impacts are identified.

1.4 Environmental management systems overview

The environmental management system overview is described in Section 1.5 of the CEMP. Noise and vibration impacts are managed through the implementation of the Noise and Vibration Management Plan (NVMP) as required by CoA C4 (b).

2 Purpose and objectives

The key objective of the CNVIS is to ensure all CoA, REMM and licence/permit requirements relevant to noise and vibration are described, scheduled and assigned responsibility as outlined in:

- the EIS prepared for WestConnex M4-M5 Link;
- the submissions report prepared for WestConnex M4-M5 Link;
- Conditions of Approval granted to the project on 17 April 2018 and updated on 25 February 2019;
- Roads and Maritime specifications G36;
- WestConnex M4-M5 Link Mainline Tunnel Modification report (September 2018);
- WestConnex M4-M5 Link Mainline Tunnel Modification Response to Submissions (November 2018); and
- the Project's Environmental Protection Licence (EPL).

All relevant legislation and other requirements described in Section 3 of this report.

3 Environmental requirements

3.1 Legislation

This CNVIS has been prepared in accordance with:

- *Environmental Planning and Assessment Act 1979*; and
- *Protection of the Environment Operations Act 1997* (POEO Act).

3.2 Guidelines

The following guidelines apply to project related construction noise and vibration:

- NSW Industrial Noise Policy (INP) 2000, Environmental Protection Authority[1];
- NSW Interim Construction Noise Guideline (ICNG) 2009, Department of Environment and Climate Change;
- NSW Road Noise Policy, Department of Environment 2011, Climate Change and Water;
- NSW Assessing Vibration – a technical guideline (AVTG) 2006, Department of Environment and Conservation;
- NSW Noise Criteria Guideline (NCG) 2015, Roads and Maritime Services;
- NSW Noise Mitigation Guideline (NMG) 2015, Roads and Maritime Services;
- Construction noise and vibration guideline (CNVG) 2016, Roads and Maritime Services;
- Australian Standard AS/NZS 2107:2000 'Acoustics - Recommended design sound levels and reverberation times for building interiors';
- Australian Standard 2834-1995 Computer Accommodation, Chapter 2.9 Vibration;
- Australian Standard AS 2187.2 'Explosives - Storage and use - Part 2 Use of explosives';
- Australian Standard AS2436-1981 'Guide to Noise Control on Construction, Maintenance and Demolition Sites';
- British Standard BS 6472-2008, 'Evaluation of human exposure to vibration in buildings (1-80Hz)';
- British Standard 7385: Part 2-1993 'Evaluation and measurement of vibration in buildings';
- German Standard DIN4150-1999 'Structural vibration Part 3: Effects of vibration on Structures';
- Construction Noise Strategy 7TP-ST-157/2.0 (CNS) 2012, Transport for NSW; and
- Environmental Noise Management Manual (ENMM) 2001, Roads and Traffic Authority.

[1] This document has since been superseded by the NSW Noise Policy for Industry (NPfI) 2017. However, the INP remains the relevant policy in accordance with the project's Instrument of Approval and NPfI transitional requirements.

3.3 Conditions of approval

The CoA relevant to this CNVIS are listed in Table 3.1.

Table 3.1 Conditions of Approval for construction noise and vibration

Condition	Key requirement
Land Use Survey	
E66	A detailed land use survey must be undertaken to confirm sensitive receivers (including critical working areas such as operating theatres and precision laboratories) potentially exposed to construction noise and vibration, construction ground-borne noise and operational noise. The survey may be undertaken on a progressive basis but must be undertaken in any one area prior to the commencement of works which generate construction or operational noise, vibration or ground-borne noise in that area. The results of the survey must be included in the Construction Noise and Vibration Management Sub-plan.
Noise Assessments	
E67	All noise and vibration assessment, management and mitigation required by this approval must consider the cumulative noise impacts of approved CSSI and SSI projects. This includes using ambient and background levels which do not include other WestConnex M4 East and New M5 (SSI 6307 and SSI 6788) projects. This condition applies to all works and operation.
Works Hours	
E68	Works must be undertaken during the following hours: (a) 7:00 am to 6:00 pm Mondays to Fridays, inclusive; (b) 8:00 am to 1:00 pm Saturdays; and (c) at no time on Sundays or public holidays..
E69	Notwithstanding **Condition E68**, works may be undertaken between 1:00 pm to 6:00 pm on Saturday.
E70	Notwithstanding **Conditions E68** and **E69** the following works are permitted to be undertaken 24 hours a day, seven days a week: (a) tunnelling activities excluding cut and cover tunnelling; (b) haulage of spoil and delivery of material; (c) works within an acoustic shed; and (d) tunnel fit out works. Other surface works associated with tunnelling must only be undertaken in accordance with the requirements of **Condition E73**.
Variation to Work Hours	
E73	Notwithstanding Conditions E68 to E72 works may be undertaken outside the hours specified under those conditions in the following circumstances: (a) for the delivery of materials required by the NSW Police Force or other authority for safety reasons; or (b) where it is required in an emergency to avoid injury or the loss of life, to avoid damage or loss of property or to prevent environmental harm; or (c) where different construction hours are permitted or required under an EPL in force in respect of the CSSI; or (d) works approved under an Out-of-Hours Work Protocol for works not subject to an EPL as required by Condition E77; or (e) construction that causes $L_{Aeq(15\ minute)}$ noise levels: (i) no more than 5 dB(A) above the rating background level at any residence in accordance with the Interim Construction Noise Guideline (DECC, 2009), and (ii) no more than the 'Noise affected' noise management levels specified in Table 3 of the Interim Construction Noise Guideline (DECC, 2009) at other sensitive land uses, and

Table 3.1 Conditions of Approval for construction noise and vibration

Condition	Key requirement
	(iii) continuous or impulsive vibration values, measured at the most affected residence are no more than the maximum values for human exposure to vibration, specified in Table 2.2 of Assessing Vibration: a technical guideline (DEC, 2006), and (iv) intermittent vibration values measured at the most affected residence are no more than the maximum values for human exposure to vibration, specified in Table 2.4 of Assessing Vibration: a technical guideline (DEC, 2006).
Construction Noise and Vibration – General	
E79	Construction Noise and Vibration Impact Statements must be prepared for construction ancillary facility(s) before any works that result in noise and vibration impacts commence, and include specific mitigation measures identified through consultation with affected sensitive receivers. The Statements must supplement the Construction Noise and Vibration Management Sub-plan or Site Establishment Management Plan(s) and are to be implemented for the duration of the works. The Construction Noise and Vibration Impact Statement for the White Bay Civil Site (C11) must be prepared in consultation with the Port Authority of NSW and NSW Heritage Council.
E80	Noise generating works in the vicinity of potentially-affected community, religious, educational institutions and noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) resulting in noise levels above the NMLs must not be timetabled within sensitive periods, unless other reasonable arrangements with the affected institutions are made at no cost to the affected institution.
E81	Mitigation measures must be implemented with the aim of achieving the following construction noise management levels and vibration criteria: (a) construction 'Noise affected' noise management levels established using the *Interim Construction Noise Guideline* (DECC, 2009); (b) vibration criteria established using the *Assessing vibration: a technical guideline* (DEC, 2006) (for human exposure); (c) Australian Standard AS 2187.2 - 2006 "*Explosives - Storage and Use - Use of Explosives*"; (d) BS 7385 Part 2-1993 "*Evaluation and measurement for vibration in buildings Part 2*" as they are "applicable to Australian conditions"; and (e) the vibration limits set out in the *German Standard DIN 4150-3: Structural Vibration- effects of vibration on structures* (for structural damage). Any works identified as exceeding the noise management levels and/or vibration criteria must be managed in accordance with the **Construction Noise and Vibration Management Sub-plan.** *Note: The Interim Construction Noise Guideline identifies 'particularly annoying' activities that require the addition of 5 dB(A) to the predicted level before comparing to the construction Noise Management Level.*
Construction Noise Mitigation – Acoustic Sheds	
E86	All acoustic sheds must be erected as soon as site establishment works at the facilities are completed and before undertaking any works which are required to be conducted within the sheds.

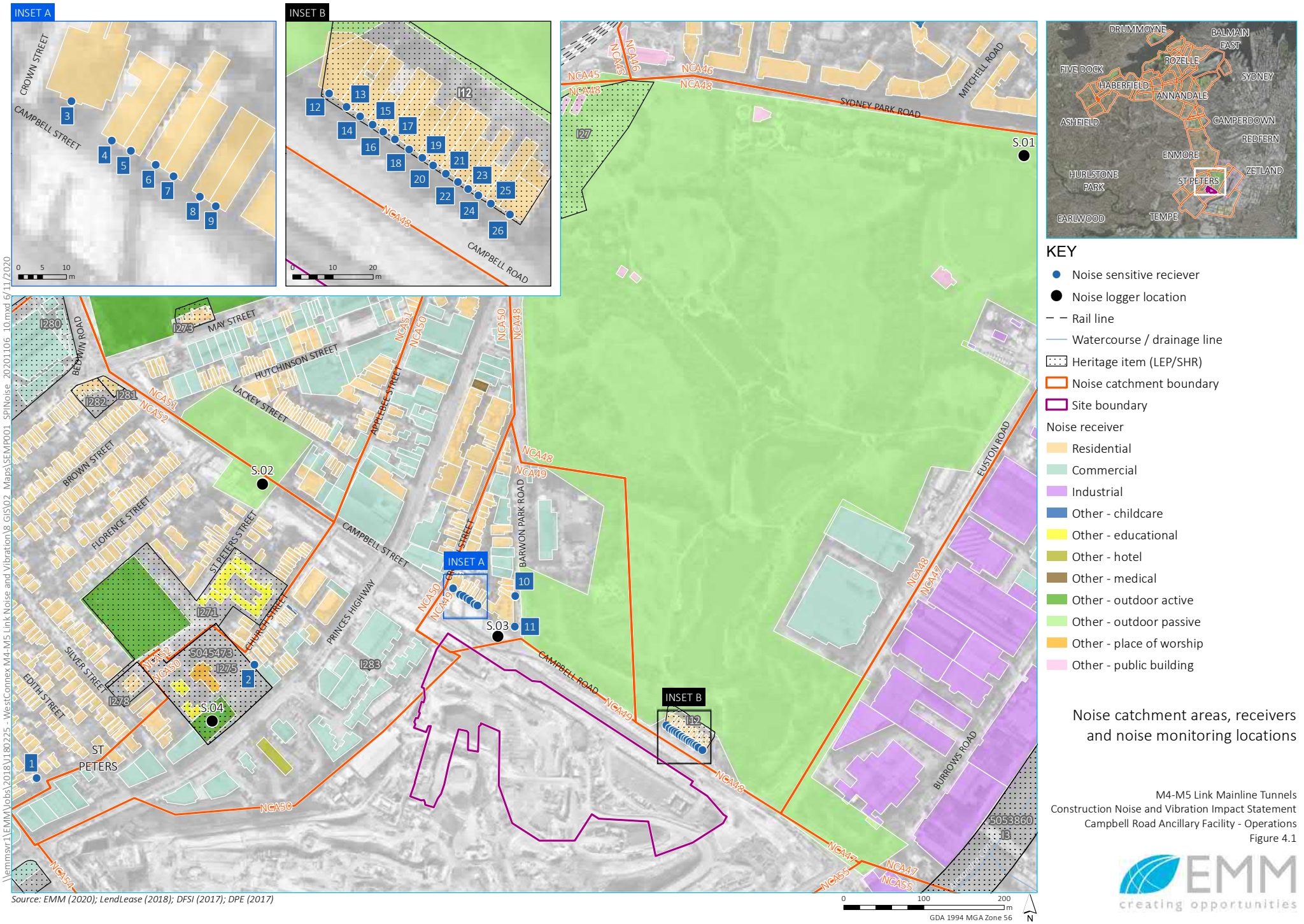
4 Existing environment

4.1 Noise and vibration sensitive receivers

A detailed land use survey has been undertaken to address E66 of the CoA. The outcomes of the land use survey have been incorporated into this CNVIS. A visual representation of the survey is provided in the NVMP. For the purpose of this assessment, receivers potentially sensitive to noise have been categorised as:

- residential dwellings;
- commercial, retail and industrial properties; and
- other, including:
  - education institutions;
  - childcare centres;
  - medical (hospital wards or other uses including medical centres);
  - places of worship;
  - outdoor open areas (passive and active recreation);
  - aged care;
  - hotel;
  - theatre/auditorium;
  - public building; and
  - recording studio.

The sensitive receivers in proximity to the Site is shown in Figure 4.1. Heritage items of importance where vibration emission needs to be considered are also shown.


INSET A
INSET B
CROWN STREET
CAMPBELL STREET
CAMPBELL ROAD
SYDNEY PARK ROAD
MITCHELL ROAD
EUSTON ROAD
BURROWS ROAD
BARWON PARK ROAD
PRINCES HIGHWAY
BECKWIN ROAD
MAY STREET
HUTCHINSON STREET
LACKEY STREET
APPLEBEE STREET
BROWN STREET
FLORENCE STREET
ST PETERS STREET
CHURCH STREET
SILVER STREET
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NCA47
NCA55
DRUMMOYNE
BALMAIN EAST
ROZELLE
FIVE DOCK
SYDNEY
HABERFIELD
ANNANDALE
ASHFIELD
CAMPERDOWN
REDFERN
ENMORE
ZETLAND
HURLSTONE PARK
ST PETERS
EARLWOOD
TEMPE
KEY
Noise sensitive reciever
Noise logger location
Rail line
Watercourse / drainage line
Heritage item (LEP/SHR)
Noise catchment boundary
Site boundary
Noise receiver
Residential
Commercial
Industrial
Other - childcare
Other - educational
Other - hotel
Other - medical
Other - outdoor active
Other - outdoor passive
Other - place of worship
Other - public building
Noise catchment areas, receivers and noise monitoring locations
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Figure 4.1
EMM
creating opportunities
Source: EMM (2020); LendLease (2018); DFSI (2017); DPE (2017)
GDA 1994 MGA Zone 56
N
\\emmsvr1\EMM\Jobs\2018\J180225 - WestConnex M4-M5 Link Noise and Vibration\8 GIS\02 Maps\SEMP001 SPINoise 20201106 10.mxd 6/11/2020

4.2 Noise catchment areas

The study area has been divided into Noise Catchment Areas (NCAs). NCAs group individual sensitive receivers by common traits such as existing noise environment and location in relation to the works.

The noise catchment areas of relevance to this CNVIS are shown in Figure 4.1 and described in Table 4.1.

Table 4.1 Noise catchment areas

NCA	Description
NCA46	North of Sydney Park Road between Concord Street, Coulson Street and Maddox Street. Land use comprises of a mix of residential receivers and isolated commercial receivers.
NCA47	East of Euston Road, between Maddox Street and Campbell Road. Land use consists of commercial receivers.
NCA48	South of Sydney Park Road between Barwon Park Road, Campbell Road and Euston Road. Land use comprises of a passive recreation area and isolated commercial receivers.
NCA49	Catchment area adjoins either side of Barwon Park Road, between Campbell Road and Crown Street. Land use comprises of a mix of residential and commercial receivers.
NCA50	Catchment area adjoins either side of Princes Highway, between Mary Street, Church Street/Applebee Street and May Street. Land use comprises of a mix of residential and commercial receivers, an educational facility and an active recreation area.
NCA51	North of Campbell Street between Applebee Street and the Illawarra Rail Line/St Peters Rail Station. Land use comprises of a mix of residential and commercial receivers and active and passive recreation areas.
NCA52	South of the Illawarra Rail Line between Campbell Street, Sutherland Street and Princes Highway premises. Land use comprises of a mix of residential and commercial receivers, an educational facility and active and passive recreation areas.
NCA53	West of Princes Highway, south of Sutherland Street. Land use comprises of a mix of residential and commercial receivers.
NCA54	East of Princes Highway between Canal Street and Alexandra Canal. Land use comprises of a mix of residential and commercial receivers.
NCA55	East of Burrows Road. Land use comprises of a mix of residential and commercial receivers.

Source: M4-M5 Link EIS

4.3 Background noise levels

This CNVIS has adopted background noise monitoring levels obtained as part of the EIS which are presented in Table 4.2 for each relevant NCA. Representative monitoring locations are shown in Figure 4.1.

The majority of the NCAs surrounding the project are influenced by road traffic noise levels from major roads. In accordance with prescribed methods in the NSW Industrial Noise Policy (Section 3.3) and the NSW Road Noise Policy (Section 2.5.5), the background noise logging data for the Project was reviewed in greater detail to identify potential shoulder periods. Shoulder periods are defined as periods between the standard INP day, evening and night periods where there may be a steady rise or fall in background noise levels and therefore a justification to define an RBL specific to that time period.

It is proposed to adopt shoulder period Noise Management Levels (NMLs) during 5am to 7am (morning shoulder) and 10pm to midnight (evening shoulder) in order to manage noise according to the noise characteristics of the catchments.

It is noted that the Interim Construction Noise Guideline (ICNG) relies on methodologies contained within the NSW Industrial Noise Policy for the establishment of RBLs. Hence, this approach is deemed consistent with the guidance provided by the ICNG.

Table 4.2 Rating background levels

Rep monitoring location[2]	Rating background level (RBL), $L_{A90(15min)}$				
	Morning shoulder (5am to 7am)[3]	Day	Evening	Evening shoulder (10pm to 12am)[4]	Night
S.01	49	57	51	46	40
S.02	45	50	46	43	39
S.03	47	54	45	43	40
S.04	48	52	50	47	44
S.05	54	58	56	53	49

Notes: 1. ICNG defines daytime period as 7:00am to 6:00pm Monday to Saturday, 8:00am to 6:00 pm Sunday; Evening as 6:00pm to 10:00pm; Night as 10:00pm to 7:00am Monday to Saturday, 10:00pm to 8:00am Sunday.

2. Taken from New M5 EIS.

3. There is a steady rise in background noise levels between 5am and 7am. Hence a shoulder period has been applied in accordance with the INP by taking the mid-point of day and night RBLs.

4. There is a steady fall in background noise levels between 10pm and 12am. Hence a shoulder period has been applied in accordance with the INP by taking the mid-point of evening and night RBLs.

5 Construction noise criteria

5.1 Interim Construction Noise Guideline

The ICNG provides guidelines for the assessment and management of noise from construction works.

Table 5.1 is an extract from the ICNG and provides construction NMLs for residential receivers for both recommended standard construction hours and outside of these periods.

It is noted that the CoA allows extended standard hours of construction during 1pm to 6pm on Saturdays which deviates slightly from ICNG recommended standard hours.

Table 5.1 ICNG residential noise management levels

Time of day	Management level $L_{Aeq,15\ minute}$	How to apply
Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 6:00 pm[2] 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 LAeq,15 minute 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.
	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 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; and • 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(A) above the noise affected level, the proponent should negotiate with the community.

Notes: 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.

2. ICNG defines the standard construction period as Saturday 8:00am to 1:00pm, however the CoA defines it as 8:00am to 6:00pm.

Table 5.2 summarises noise management levels for non-residential land uses as defined in the ICNG.

Table 5.2 ICNG noise management levels at other land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB (when in use)
Offices, retail outlets	External noise level 70 dB (when in use)
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use)
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)
Places of worship	Internal noise level 45 dB (when in use)
Active recreation areas	External noise level 65 dB (when in use)
Passive recreation areas	External noise level 60 dB (when in use)

Source: ICNG (DECC, 2009).

The ICNG provides further guidance for construction noise levels at commercial and industrial premises as follows:

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

5.2 Sleep disturbance at residents

The Site will operate during the night-time period (10pm to 7am). Therefore, the assessment of potential sleep disturbance at residences is required in accordance with the INP application notes. Sleep disturbance is defined as both awakenings and disturbance to sleep stages.

The INP application notes suggests that an $L_{A1(1min)}$ or L_{Amax} level of RBL plus 15 dB is a suitable screening criteria for sleep disturbance for the night-time period. This applies at the most affected façade of a building.

A detailed maximum noise level event assessment is required if the screening criteria is exceeded. Further guidance in regard to potential impact on sleep is provided in the NSW Road Noise Policy (RNP) (DECCW 2011). The RNP calls upon a number of studies that have been conducted into the effect of maximum noise levels on sleep, and provides the following factors that are key in assessing the extent of impacts on sleep:

- how often high noise events would occur;
- the distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the project;
- whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods); and
- current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night.

The RNP also quotes the following internal noise levels with respect to potential sleep disturbance:

- maximum internal noise levels (L_{max}) below 50 to 55 dBA are unlikely to awaken people from sleep; and
- one or two noise events per night, with maximum internal noise levels (L_{max}) of 65 to 70 dBA, are not likely to affect health and wellbeing significantly.

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade of a residential building of standard construction including a partially open window will reduce external noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB L_{Amax} calculated at the facade of a residence are unlikely to cause sleep disturbance affects.

5.3 Project specific NMLs – residential

The ICNG provides guidelines for the assessment and management of noise from construction works.

In accordance with the ICNG and based on the RBLs presented in Table 4.2, Table 5.3 presents the project specific construction noise affected NMLs applicable to residential premises during the proposed work hours. The highly noise affected NML also applies to all residential receivers during standard hours.

Table 5.3 Project specific NMLs at residential locations

NCA	Rep monitoring location	Standard construction NMLs (RBL + 10dB) Day[1]	Out of hours NMLs (RBL + 5dB)[1]					
			Morning shoulder (5am to 7am)	Day	Evening	Evening shoulder (10m to 12am)	Night	Sleep disturbance screening criteria (RBL + 15dB)
NCA47	S0.1	67	54	62	56	51	45	55
NCA48	S0.1	67	54	62	56	51	45	55
NCA49	S0.3	64	52	59	50	48	45	55
NCA50	S0.4	62	53	57	55	52	49	59
NCA51	S0.2	60	50	55	51	48	44	54
NCA52	S0.2	60	50	55	51	48	44	54
NCA54	S0.5	68	59	63	61	58	54	64
NCA55	S0.5	68	59	63	61	58	54	64

Notes: 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.

5.4 Project specific NMLs – non-residential

Table 5.4 presents the project specific construction NMLs applicable to non-residential land uses as defined in the NSW ICNG and AS2107.

Table 5.4 Project specific NMLs at non-residential land uses

Land use	Noise management level (when in use), $L_{Aeq,15\ minute}$
Industrial premises	External noise level 75 dB
Offices, retail outlets	External noise level 70 dB
Classrooms at schools and other educational institutions	Internal noise level 45 dB
Hospital wards and operating theatres	Internal noise level 45 dB
Places of worship	Internal noise level 45 dB
Active recreation areas	External noise level 65 dB
Passive recreation areas	External noise level 60 dB
Child care centres[1]	External noise level 65 dB
Aged care[1]	External noise level 65 dB (7am to 10pm) 60 dB (10pm to 7am)
Hotels[1]	External noise level 65 dB (7am to 10pm) 60 dB (10pm to 7am)
Theatre/auditorium[1]	External noise level 45 dB

Table 5.4 Project specific NMLs at non-residential land uses

Land use	Noise management level (when in use), $L_{Aeq,15\ minute}$
Recording studio[1]	External noise level 45 dB
Public building[1]	Determined on site specific basis

Notes: 1. NML based on AS2017 recommend maximum internal noise level and the premise that windows and doors for such development would typically remain closed, providing 20 dB of outdoor to indoor construction noise level reduction.

2. Notwithstanding NMLs in this table, Condition E80 states "Noise generating works in the vicinity of potentially-affected community, religious, educational institutions and noise and vibration-sensitive businesses and critical working areas (such as theatres, laboratories and operating theatres) resulting in noise levels above the NMLs must not be timetabled within sensitive periods, unless other reasonable arrangements with the affected institutions are made at no cost to the affected institution."

6 Construction vibration criteria

6.1 Overview

Vibration criteria adopted for the works are consistent with those established in the EIS and in accordance with the Instrument of Approval (SSI 7485). Condition E81 of SSI 7485 states that mitigation measures must be implemented with the aim of achieving the following vibration criteria:

- vibration criteria established using the Assessing vibration: a technical guideline (DEC 2006) (for human exposure);
- Australian Standard AS 2187.2 - 2006 “Explosives - Storage and Use - Use of Explosives”;
- BS 7385 Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2” as they are “applicable to Australian conditions”; and
- the vibration limits set out in the German Standard DIN 4150-3: Structural Vibration- effects of vibration on structures (for structural damage).

It is noted that blasting is not part of the scope for works relevant to this CNVIS.

6.2 Human comfort – Assessing vibration: a technical guideline (DEC)

Environmental Noise Management – Assessing Vibration: a technical guideline (DEC, 2006) is based on guidelines contained in BS 6472 – 2008, Evaluation of human exposure to vibration in buildings (1-80Hz).

The Guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the Guideline provides examples of the three vibration types and has been reproduced in Table 6.1.

Table 6.1 Examples of types of vibration (from Table 2.1 of the guideline)

Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

Intermittent vibration is representative of activities such as impact hammering, vibratory rolling or general excavation work (such as an excavator tracking) and, as such, is most relevant to this assessment.

Intermittent vibration (as defined in Section 2.1 of the Guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted RMS (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate VDV the following formula (refer *section 2.4.1* of the Guideline) was used:

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The Acceptable Vibration Dose Values (VDV) for intermittent vibration are reproduced in Table 6.2.

Table 6.2 Acceptable vibration dose values (VDV) for intermittent vibration ($m/s^{1.75}$)

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical Areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am.

2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The Guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

6.3 Structural vibration criteria

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.

6.3.1 Australian Standard AS 2187.2 - 2006

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 “Explosives - Storage and Use - 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” be used 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 6.3 and graphically in Figure 6.1.

Table 6.3 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

Source: BS 7385 Part 2-1993.

The Standard states that the guide values in Table 6.3 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 6.3 may need to be reduced by up to 50%.

Sheet piling activities (for example) 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%.

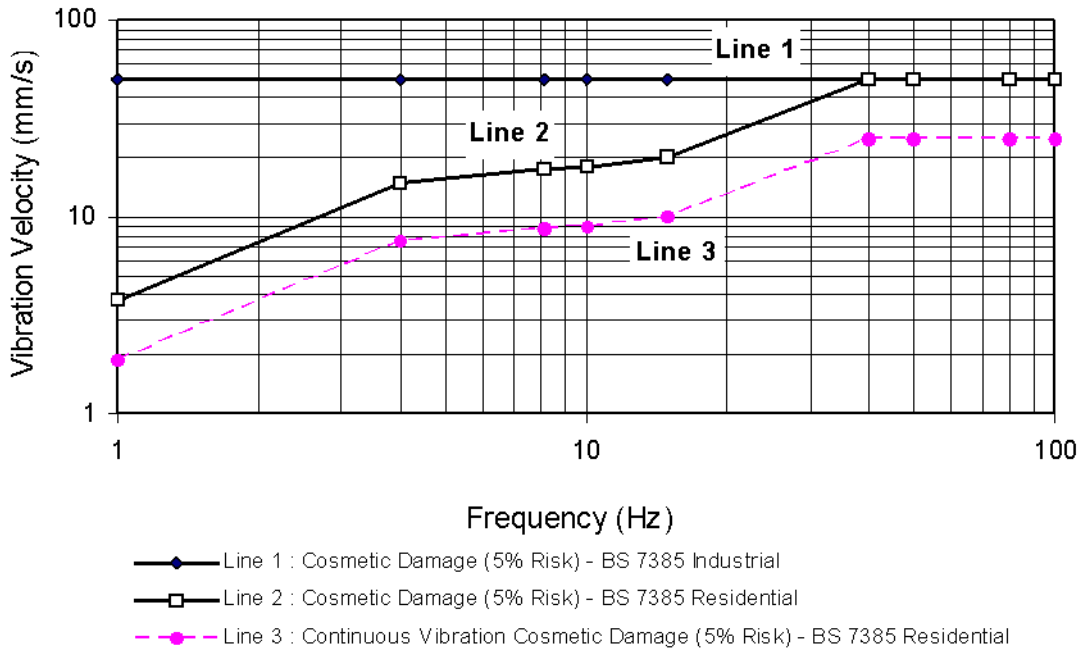

Figure 6.1 Graph of transient vibration guide values for cosmetic damage

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 6.3, 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 6.3 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements 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 Figure 6.1.

It is noteworthy that extra to the guide values nominated in Table 6.3, 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."

A vibration screening criterion of 15 mm/s is recommended for structures surrounding the Site for vibration inducing construction. This should be reduced to 7.5mm/s (by 50%) if the vibration activity is continuous and has the potential to cause resonance effects in surrounding structures (eg sheet piling).

6.3.2 German Standard DIN 4150-3:1999

The German Standard DIN 4150 - Part 3: 1999, provides the strictest guideline levels of vibration velocity for evaluating the effects of vibration in structures. The limits presented in this standard are generally recognised to be conservative.

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 6.4 and shown graphically in Figure 6.2.

For residential and commercial type structures, the Standard recommends safe limits as low as 5mm/s and 20mm/s respectively. These limits increase with frequency values above 10Hz. The operational frequency of construction plant typically ranges between 10Hz to 30Hz, and hence according to DIN4150, the safe vibration guide limit range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings, the limit is as low as 20mm/s, while for heritage or sensitive structures the lower limit is 3mm/s.

Table 6.4 Structural damage guideline values of vibration velocity – DIN4150

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

Notes: 1. "Line" refers to curves in Figure 1 of DIN4150.

2. For frequencies above 100Hz the higher values in the 50Hz to 100Hz column should be used.

These levels are "safe limits", for which damage due to vibration effects is unlikely to occur. "Damage" is defined in 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.

Should such damage be observed without vibration levels exceeding the "safe limits" then it is likely to be attributable to other causes. DIN 4150 also states that when vibration levels higher than the "safe limits" are present, it does not necessarily follow that damage will occur.

As indicated by the guide levels from DIN 4150 in Figure 6.2, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the "point source" nature of vibration from plant causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

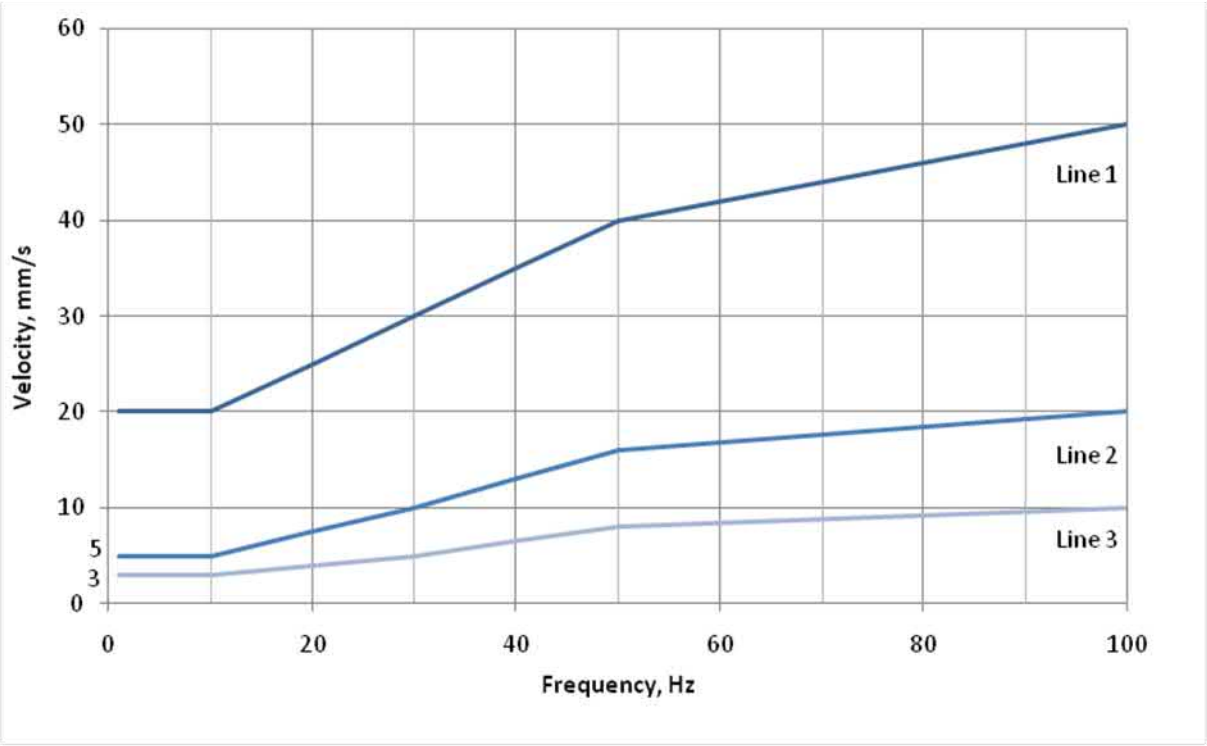

Figure 6.2 DIN4150 structural damage guideline values of vibration velocity

6.3.3 Project specific structural vibration criteria

Condition E81 requires that BS7385-2 and DIN4150-3 are both satisfied. DIN4150-3 is more conservative and provides more information for the assessment of heritage structures. If DIN4150-3 limits are satisfied, the limits in BS7385-2 will also be satisfied.

DIN4150-3 has therefore been adopted as the structural vibration criteria for the project.

7 Construction noise assessment

7.1 Assessment method

The following sections outline the modelling method and key assumptions adopted to assess noise levels from operational scenarios of the Site in accordance with the ICNG (EPA 2009) and CNVG (RMS 2015) requirements.

Noise emissions from the Site were modelled using DGMR Software proprietary modelling software, iNoise, from the same developers of Bruel & Kjaer's Predictor. The model allows prediction under the ISO9613-2 "Acoustics – Attenuation of Sound during Propagation Outdoors – general method" algorithm. This algorithm is accepted by the EPA. Features which affect the predicted noise level that are considered in the noise modelling include:

- equipment sound power levels and locations;
- screening from structures (excluding internal walls);
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

The model was populated with 3-D topography of the Site area and surrounding area, extending out to nearest assessment locations and 3-D buildings. Construction plant and equipment representing the range of proposed construction scenarios was placed at locations which would represent typical to worst case noise levels throughout the construction program.

7.2 Scenarios

The following broad work stages have been assessed:

- Stage 4A and 4B – worst case scenario for tunnel support activities including backfilling (Stage 4A) and tunnel grouting (Stage 4B) occurring without an acoustic shed. At any time, either Stages 4A and 4B will be undertaken so will not occur concurrently; and
- Stage 5 – worst case site demobilisation activities including dismantling the acoustic shed, site clearing and concreting.

Table 7.1 provides a summary of the work stages and the noise criteria applicable to them.

Table 7.1 Summary of scenarios and applicable noise criteria

Scenario	Activities included	Applicable noise criteria
Stage 4A and 4B	Spoil haulage and delivery	N/A (as per CoA E70)
	Spoil handling and tunnel support activities outside of acoustic shed	ICNG Noise Management Levels (as per CoA E73)
Stage 5	Additional activities as described in Appendix A	ICNG Noise Management Levels (as per CoA E73)

It is noted that activities which are required for civil works are not strictly permissible during out of hour periods, unless NMLs are satisfied (refer CoA E73), excluding spoil hauling and deliveries (refer CoA E70). For Stage 4A and 4B, all modelling scenarios assessed, plant and equipment listed and noise mitigation adopted are summarised in Appendix A with maps identifying work locations for Stage 4A and 4B shown in Figure 7.1 and Figure 7.2.

For Stage 5, all modelling scenarios assessed, plant and equipment listed are summarised in Appendix B.

There is a possibility that some activities assessed in Stage 5 may occur at the same time as either Stage 4A or 4B. This would only occur during standard daytime construction hours and is unlikely to result in an exceedance of NML. Should this occur, it would typically result in a 1-2 dB increased in predicted noise levels, or a worst-case increase of 3 dB. This is unlikely in practice, as it assumes all equipment of each scenario operating concurrently.

For all scenarios, it has been assumed that all plant and equipment is operating simultaneously, unless specific utilisation percentages are stated otherwise. This is considered to be a conservative representation of a typical worst-case scenario.

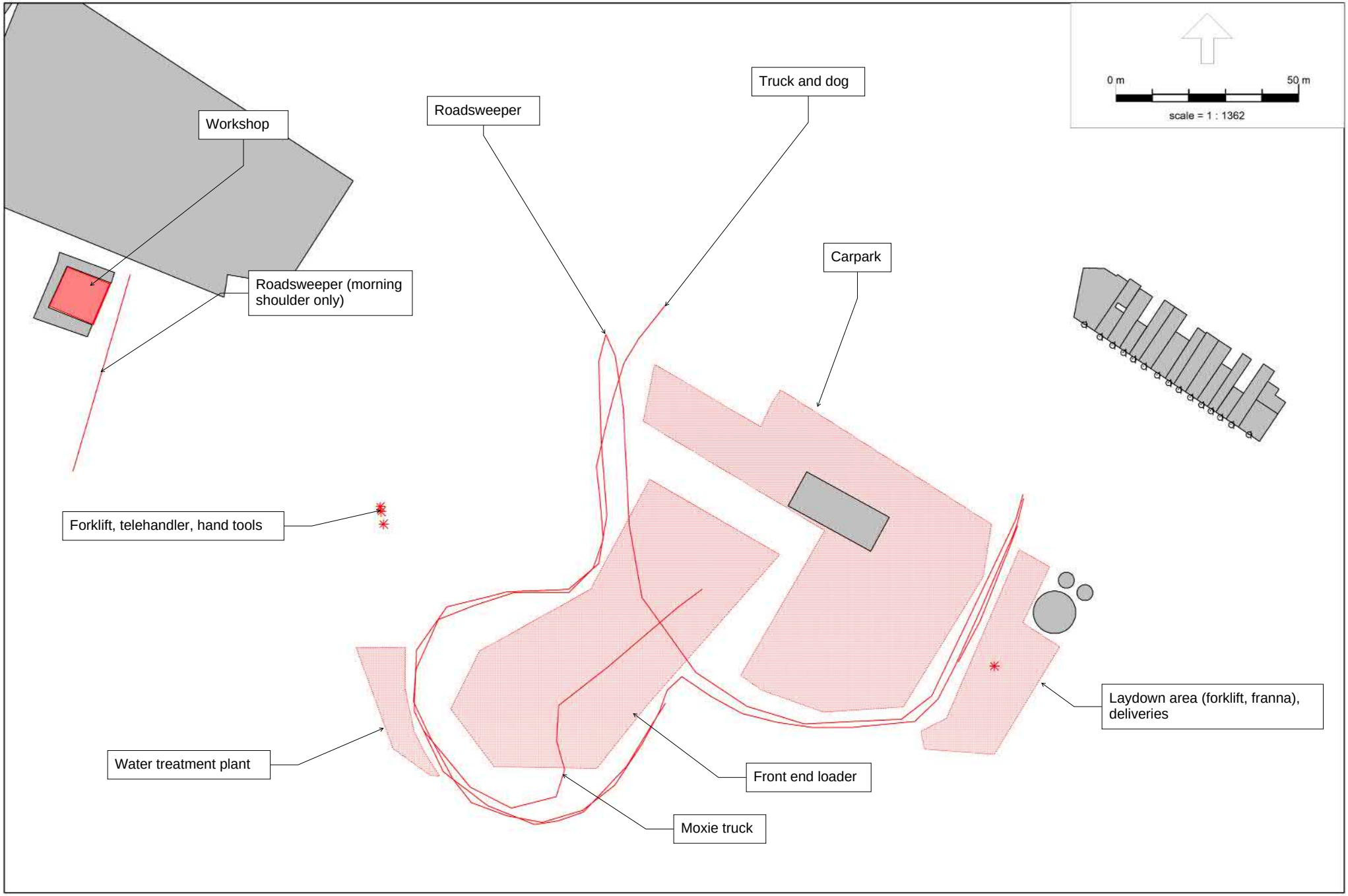

Figure 7.1 **Stage 4A modelled equipment locations**

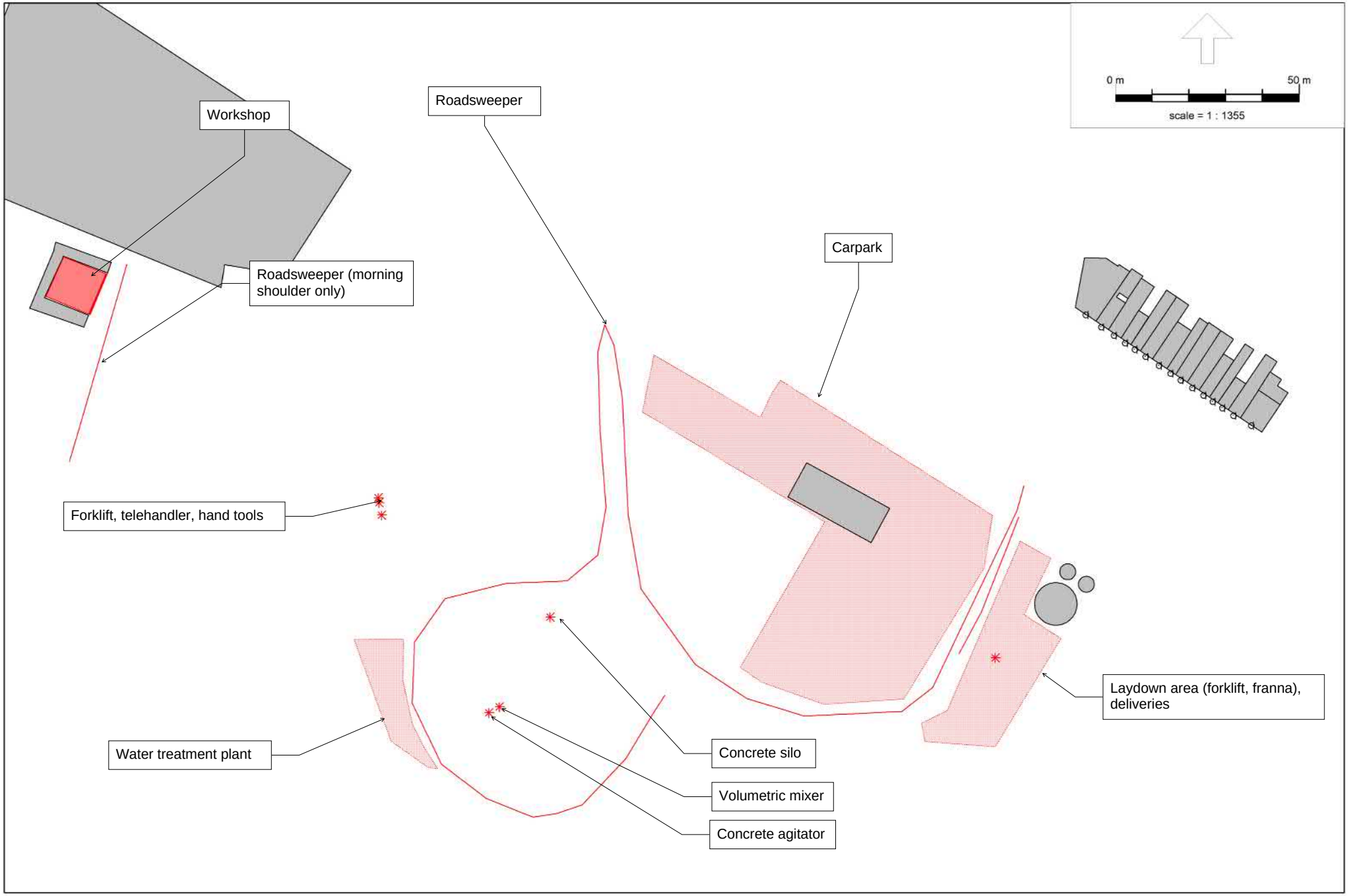

Figure 7.2 **Stage 4B modelled equipment locations**

7.3 Stage 4A and 4B

7.3.1 Results

Predicted noise levels for Stage 4A and 4B are provided in Appendix C and Appendix D, respectively.

Predicted noise levels are provided for each of the assessment locations shown in Figure 4.1. The predictions relate to the most affected façade of each assessment location building.

i Residential assessment locations

Noise levels from Stage 4A and Stage 4B operations are predicted to comply with NMLs during all periods. The 'average' (L_{Aeq}) noise generated by the proposed tunnel support activities represented in these scenarios is therefore unlikely to cause noise impacts at surrounding residential receivers.

ii Other sensitive receivers

Based on predicted noise levels at adjacent residential properties, which are the most sensitive receiver type at this location, noise levels from Stage 4A and 4B are also expected to satisfy NMLs at all other land use types across all time periods.

iii Sleep disturbance

Sleep disturbance impacts from transient night-time construction activities which relate to Stage 4A and 4B have been assessed. The predicted maximum noise levels at the nearest representative assessment locations are provided in Appendix C and Appendix D. The predictions relate to the most affected façade of the building for multiple floors where applicable.

For Stage 4A, predicted maximum noise levels exceed the sleep disturbance screening criteria at several residential assessment locations by up to 8 dB. Notwithstanding, the predicted maximum noise levels are below the upper levels expected to generate awakenings of 60 to 65 dB L_{Amax} external (equating to 50 to 55 dB L_{Amax} internal) as referenced in the RNP (EPA 2011).

Further, long-term noise logger results from 4-16 Campbell Street, St Peters (New M5 EIS, Vol 2D, App J) indicate existing L_{Amax} noise levels which are typically greater than 65 dB during the night period and generally in the order of 70 dB. Furthermore, residential assessment location 10 is a three-storey apartment building. The predicted noise level in Table 7.1 applies to the south façade which is mostly a solid wall with small slot windows, indicative of non-bedroom spaces. This building has very likely been designed in anticipation of future road traffic noise levels from St Peters Interchange. Therefore, the actual internal maximum noise level from site activity would very likely be at least 20 dB below the external level given the building construction, with windows closed.

For Stage 4B, predicted maximum noise levels comply with (are below) the sleep disturbance criteria at all residential assessment locations.

Sleep disturbance impacts generated by the 24-hour operation of the facility as represented in Stage 4A and 4B are therefore unlikely, however, will be managed in accordance with the Site's NVMP. This will include monitoring driver behaviour as drivers enter and leave site.

7.4 Stage 5

Stage 5 represents the activities involved with the demobilisation of site. This includes but is not limited to, the removal of the acoustic shed, general demolition and demobilisation, site clearing and concreting. These activities are consistent with the approved activities already assessed in the project's Site Establishment Construction Noise and Vibration Impact Statement (SECNVIS) prepared by EMM (report number J180225 RP1, dated 17 October 2018).

The sound power levels from the proposed activities in the SECNVIS (see Appendix A of the SECNVIS) have been compared to the demobilisation activities presented in Appendix B. The loudest proposed activity for demobilisation is general demolition (Stage 5B), with a total scenario sound power level of 122 dBA. This is 1 dB less than the loudest proposed activity in the SECNVIS (Stage 9 – decline cut and cover earthworks and shaft excavation). Hence noise impacts from the demobilisation of site are considered to be consistent with those approved under the SECNVIS.

Nevertheless, noise mitigation and management measures are recommended to be implemented, consistent with those in Section 10 of the SECNVIS (EMM 2018).

7.5 Road traffic noise

Road traffic noise impacts due to increased truck movements on public roads generated by 24/7 activities was assessed in M4-M5 Link Mainline Tunnels Noise and Vibration Assessment - Proposed heavy vehicle changes – Campbell Road Ancillary Facility (EMM October 2019).

8 Construction vibration

Vibration impacts from the Stage 4A and 4B operations of the St Peters ancillary facility are not expected due to the offset distances between the facility and the sensitive receivers. Stage 5 impacts are consistent with those addressed in the SECNVIS (EMM 2018).

9 Noise mitigation and management

9.1 General

The EPA's NSW ICNG requires that construction noise levels are assessed against NMLs.

With the exception of spoil haulage and deliveries which are permitted under CoA 70, it is noted that all tunnel support activities which are proposed in this assessment are not strictly permissible during out of hour periods, unless NMLs are satisfied (refer CoA E73).

Noise mitigation and management that have been adopted to satisfy these requirements are described in this section.

9.2 Site specific mitigation and management

This CNVIS assumes the following mitigation shall be implemented on site:

- operate equipment associated with the laydown areas in Stage 4A and 4B in less exposed areas during the morning shoulder, evening, evening shoulder and night periods, where practicable;
- instruct all truck drivers (haul trucks and concrete agitators) to reduce speed and minimise noise when entering and exiting site during the night; and
- other mitigation and management as detailed in Figure 7.1 and Figure 7.2, Appendix A and Appendix E. It is noted that plant and equipment utilisations in Appendix A and B (where provided) are indicative of typical worst-case operations and can be adjusted (up or down) based on actual measured noise levels, subject to compliance with CoA requirements.

Notwithstanding, works identified as not permissible may still be undertaken, if it can be confirmed that NML compliance from all site noise can be achieved to within 2 dB. This may be addressed through validation monitoring of noise levels during non-sensitive periods, confirmation of plant sound power levels used in this modelling, and installation of additional mitigation measures, discussed further below.

9.3 Compliance noise monitoring

Noise monitoring will be undertaken to verify sound power levels and operating assumptions contained within this CNVIS. The monitoring will target activities that are proposed outside of standard construction hours.

It is noted that if activities proposed in Appendix A and Appendix B are not occurring, there may be greater capacity to undertake other activity whilst remaining NML compliant and adhering to CoA 73.

9.4 General mitigation and management

9.4.1 Work practices

Work practice methods include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;
- regular identification of noisy activities and adoption of improvement techniques;
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents;

- develop routes for the delivery of materials and parking of vehicles to minimise noise;
- where possible, avoid the use of equipment that generates impulsive noise;
- minimise the movement of materials and plant and unnecessary metal-on-metal contact;
- minimise truck movements; and
- schedule respite periods for intensive works as determined through consultation with potentially affected neighbours (eg a daily respite period for a minimum of one hour at midday).

9.4.2 Plant and equipment

Additional measures for plant and equipment include:

- where possible, choose quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks;
- movement alarms and beepers to be replaced with non-tonal level varying quackers or equivalent;
- operate plant and equipment in the quietest and most efficient manner; and
- regularly inspect and maintain plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

9.4.3 Quantifying noise reductions

Approximate noise reductions provided by some of these measures are provided in Table 9.1.

Table 9.1 Relative effectiveness of various forms of noise control

Noise control	Nominal noise reduction possible, in total A-weighted sound pressure level, dB
Increase source to receiver distance[1]	approximately 6 dB for each doubling of distance
Reduce equipment operating times or turn off idling machinery[2]	approximately 3 dB per halving of operating time
Operating training on quiet operation[2]	up to 3 to 5 dB
Screening (eg noise barrier)[1]	normally 5dB to 10 dB, maximum 15 dB
Enclosure (eg shed/building)[1]	normally 15 dB to 25 dB, maximum 50 dB
Silencing (eg exhaust mufflers) [1]	normally 5 dB to 10 dB, maximum 20 dB

Notes: 1. Sourced from AS2436-2010.

2. Based on EMM's measurement experience at construction and mining sites

9.5 Additional noise mitigation measures – Construction Noise and Vibration Guideline

In many instances, impacts from construction noise and vibration are unavoidable where works are undertaken in relatively close proximity to surrounding receivers. The CNVG includes a list of additional mitigation measures which aim to manage the potential noise impacts. Additional mitigation measures from the CNVG that have been adopted for the project are summarised in Table 9.2.

Table 9.2 CNVG additional noise mitigation measures

ID	Name	Description
N	Notification (letterbox drop or equivalent)	Advanced warning of works and potential disruptions can assist in reducing the impact to the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of seven calendar days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.
SN	Specific notifications	Specific notifications are letterbox drops (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification should provide additional information to that covered in the general notifications and be targeted at highly affected receivers.
RO	Respite offers	Respite Offers should be considered and or adopted where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed three hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.
R1	Respite period 1	Out of hours construction conducted during the OOHW period 1 (Monday to Friday 6:00 pm to 10:00 pm, Saturday 7:00 am to 8:00 am and 1:00 pm – 10:00 pm, Sunday/Public Holiday 8:00 am to 6:00 pm) shall be limited to no more than three consecutive evenings per week except where there is a duration respite. For night work these periods of work should be separated by not less than one week and no more than six evenings per month.
R2	Respite period 2	Night time construction in OOHW period 2 (Monday to Friday 10:00 pm to 7:00 am, Saturday 10:00 pm to 8:00 am, Sunday/Public Holiday 6:00 pm to 7:00 am) shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and six nights per month. Where possible, high noise generating works shall be completed before 11 pm.
AA	Alternative accommodation	Alternative accommodation options may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels (refer to Tables C1-C3 of the CNVG). The specifics of the offer will be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
DR	Duration respite	Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified that it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite Where there are few receivers above the NML each of these receivers should be visited to discuss the project to gain support for Duration Respite.
V	Verification	Refer to Appendix F of the CNVG for more details about verification of noise and vibration levels as part of routine checks of noise levels or following reasonable complaints. This verification should include measurement of the background noise level and construction noise. Note this is not required for projects less than three weeks unless to assist in managing complaints.

The level of additional mitigation is then assigned based on the impact classification (ie predicted noise level above NML) and the list of measures in Table 9.3.

Table 9.3 Additional mitigation measures matrix – airborne construction noise

Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			Additional mitigation measures	
Perception	**dBA above RBL**	**dBA above NML**	**Type**	**Mitigation levels**
All hours				
75 dBA or greater			N, V, RO	HA
Standard hours: Mon - Fri (7am – 6pm), Sat (8am – 1pm), Sun/Pub Hol (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly audible	10 to 20	<10	-	NML
Moderately intrusive	20 to 30	10 to 20	N, V	NML + 10
Highly intrusive	>30	> 20	N, V	NML + 20
OOHW Period 1: Mon – Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Pub Hol (8am – 6pm)				
Noticeable	5 to 10	<5	-	NML
Clearly audible	10 to 20	5 to 15	N, R1, DR	NML +5
Moderately intrusive	20 to 30	15 to 25	V, N, R1, DR	NML + 15
Highly intrusive	>30	>25	V, N, SN, R2, DR	NML + 25
OOHW period 2: Mon - Fri (10pm – 7am), Sat (10pm – 8am), Sun/Pub Hol (6pm – 7am)				
Noticeable	5 to 10	<5	N	NML
Clearly audible	10 to 20	5 to 15	V, N, R2, DR	NML + 5
Moderately intrusive	20 to 30	15 to 25	V, N, SN, R2, DR	NML + 15
Highly intrusive	>30	>25	AA, V, N, SN, R2, DR	NML + 25

Note: 1. The following abbreviations are used: Alternative Accommodation (AA), Respite Period 1 (R1), Verification (V), Specific Notifications (SN), Notification drops (N), Respite Period 2 (R2), Negotiated Respite (NR), Highly Affected (HA), Respite Offer (RO), Duration Respite (DR).

No additional noise mitigation measures for the Site are recommended accordance with the CNVG, as all proposed activities in Stage 4A and 4B are predicted to be NML compliant. Additional mitigation measures for Stage 5 are consistent with those assessed in the SECNVIS (EMM 2018).

9.6 Community consultation and complaints handling

Community consultation and complaints handling will be undertaken in accordance with the project's Community Communication Strategy (CCS).

10 Conclusion

EMM has completed a construction noise and vibration impact statement (CNVIS) to review potential noise and vibration impacts from the operation and demobilisation of the Campbell Road ancillary facility at St Peters.

The Site will be extensively mitigated and managed to reduce noise emissions, most notably for activities during the night time period. The mitigation and management applied at site satisfies the reasonable and feasible approach as outlined in the ICNG (EPA 2009) and the requirements of the conditions of approval (CoA).

This CNVIS assesses noise levels from the following stages:

- Stage 4A and 4B – worst case scenario for tunnel support activities including backfilling and spoil hauling (Stage 4A) and tunnel grouting (Stage 4B) occurring without an acoustic shed. At any time, either Stage 4A or 4B will be undertaken so will not occur concurrently; and

- Stage 5 – worst case site demobilisation activities including hammering out pavement and hardstand, removal of temporary inground structures, site clearing and land reinstatement.

It is noted that the activities proposed are not strictly permissible during out of hour periods, unless NMLs are satisfied (refer CoA E73), excluding spoil hauling and deliveries (refer CoA E70). The proposed activities and scenarios have been mitigated and limited so they will be NML compliant during all periods.

There is a possibility that some activities assessed in Stage 5 may occur at the same time as either Stage 4A or 4B. This would only occur during standard daytime construction hours and is unlikely to result in an exceedance of NML. Should this occur, it would typically result in a 1-2 dB increased in predicted noise levels, or a worst-case increase of 3 dB. This is unlikely in practice, as it assumes all equipment of each scenario operating concurrently.

For Stage 4A and 4B, noise levels from site operations are predicted to be compliant with (equal or less than) the relevant NMLs for all periods. The 'average' (L_{Aeq}) noise generated by the proposed tunnel support activities represented in these scenarios is therefore unlikely to cause noise impacts at surrounding residential receivers.

For Stage 4A, noise levels above the sleep disturbance screening criteria have been predicted at several residential properties around the Site. The predicted maximum noise levels are typically generated by spoil trucks arriving and leaving the Site. Notwithstanding the above, the predicted maximum noise levels are below upper levels expected to generate awakenings of 60 to 65 dB L_{Amax} external (equating to 50 to 55 dB L_{Amax} internal) as referenced in the RNP (EPA 2011). Further, long-term noise logger results from 4-16 Campbell Street, St Peters (New M5 EIS, Vol 2D, App J) indicate existing L_{Amax} noise levels which are typically greater than 65 dB during the night period and generally in the order of 70 dB on many occasions per night.

For Stage 4B, predicted maximum noise levels comply with (are below) the sleep disturbance criteria at all residential assessment locations.

Sleep impacts generated by the 24 hour operation of the facility are therefore unlikely, however, will be managed in accordance with the Site's Noise and Vibration Management Plan (NVMP).

The activities proposed as part of Stage 5 relate to the demobilisation of site. This includes the hammering out pavement and hardstand, removal of temporary inground structures, site clearing and land reinstatement. These activities are consistent with the approved activities already assessed in the project's Site Establishment Construction Noise and Vibration Impact Statement (SECNVIS) prepared by EMM (Report number J180225 RP1, dated 17 October 2018). The sound power levels from the proposed activities in both the SECNVIS and Stage 5 demobilisation have been compared and are considered to be consistent.

Nevertheless, noise mitigation and management measures are recommended to be implemented, consistent with those in Section 10 of the SECNVIS (EMM 2018).

Appendix A

Plant and equipment sound power levels – Stage 4A and 4B

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Table A.1 Description of scenarios – Stage 4A and 4B

Scenario	Description	Equipment	Item sound power level[4]		Equipment quantity per assessment period (% utilisation per 15 minutes where shown)[2]					Physical noise mitigation
			$L_{Aeq, 15min}$	L_{Amax}	MS	D(s)	Day (o)	E	ES	N	
Stage 4A	Tunnel support activities including backfilling and spoil handling without an acoustic shed	FEL	110	118	1	1	1	1 (50%)	1 (50%)	1 (25%)	Refer Figure 7.1 and Appendix E. Modelling assumes double stacked shipping containers around external stockyard have been removed.
		Moxie	109	107	1	1	1	1	1	-	
		Truck and Dog	103	106	1	1	1	1	1	1	
		Water treatment plant	75	-	1	1	1	1	1	1	
		Forklift	103	-	1	1	1	1 (50%)	1 (50%)	-	
		Road sweeper	109	-	1 (on Euston Road ramps towards cut and cover)	1	1	-	-	-	
		Workshop activity	104	106	1	1	1	1	1	1	
		Light vehicles	74	-	98	98	98	98	98	98	
		Deliveries (semi-trailer or heavy vehicle) – permitted 24 hours under CoA E70	105	111	1	1	1	1	1	1	
		Hand tools	94	110	1	1	1	1	-	1 (50%)	
		Franna crane	104	113	1	1	1	1	-	-	
		Telehandler	97	102	1	1	1	1	-	-	
Stage 4B	Tunnel support activities including grouting without an acoustic shed	Silo	93	-	1	1	1	1	-	-	Refer Figure 7.2 and Appendix E. Modelling assumes double stacked shipping containers
		Volumetric mixer	109	-	1	1	1	1	-	-	
		Concrete agi[3]	108	108	1	1	1	1	-	-	

Table A.1 Description of scenarios – Stage 4A and 4B

Scenario	Description	Equipment	Item sound power level[4]		Equipment quantity per assessment period (% utilisation per 15 minutes where shown)[2]					Physical noise mitigation
			$L_{Aeq, 15min}$	L_{Amax}	MS	D(s)	Day (o)	E	ES	N	
		Water treatment plant	75	-	1	1	1	1	1	1	around external stockyard have been removed.
		Forklift	103	-	1	1	1	1 (50%)	1	1 (50%)	
		Road sweeper	109	-	1 (in cut & cover only)	1	1	-	-	-	
		Workshop activity	104	106	1	1	1	1	1	1	
		Light vehicles	74	-	98	98	98	98	98	98	
		Deliveries (semi-trailer or heavy vehicle)	105	111	1	1	1	-	1	-	
		Hand tools	94	110	1	1	1	1 (50%)	1	1	
		Franna crane	104	113	1	1	1	-	1 (50%)	-	
		Telehandler	97	102	1	1	1	-	1	1	

Notes: MS = morning shoulder, Day(s) = day standard hours; Day(o) = day out of hours; E = evening; N = night; ES = evening shoulder.

1. Sound power level does not include the attenuation provided by the workshop enclosure, as applicable.

2. Utilisation indicates the percentage of time a piece of equipment will be used per 15 minutes. When combined with all other plant assumed to operate simultaneously, this approach is representative of typical activities.

3. LAmax noise level based on attended measurements of concrete agitators entering/leaving site at max 10km/h, conducted 14 May 2020

4. Item sound power levels sourced from Department for Environment, Food & Rural Affairs UK (DEFRA), TfNSW databases or EMM measurements.

Appendix B

Plant and equipment sound power levels – Stage 5

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Table B.1 Description of scenarios – Stage 5

Scenario	Description	Equipment	Item sound power level[2]		Equipment quantity per assessment period (% utilisation per 15 minutes where shown)[1]					Group Sound Power Level, $L_{Aeq,15min}$	Group Sound Power Level, L_{Amax}
			$L_{Aeq, 15min}$	L_{Amax}	MS	D(s)	Day (o)	E	ES	N	
Stage 5A	General demobilisation	Hand tools (power tools)	99	-	-	1	-	-	-	-	106	-
		Small grinder	93	-	-	1	-	-	-	-		
		Small generator	101	-	-	1	-	-	-	-		
		Rattle gun	99	-	-	1	-	-	-	-		
		50T mobile crane	98	-	-	1	-	-	-	-		
		Elevated working platform	97	-	-	1	-	-	-	-		
Stage 5B	General demolition	35T excavator	106	-	-	1	-	-	-	-	122	-
		20T excavator	104	-	-	1	-	-	-	-		
		20T excavator with hammer	117	-	-	1	-	-	-	-		
		Loader	102	-	-	1	-	-	-	-		
		Concrete saw	120	-	-	1	-	-	-	-		
		Concrete pulverizer	108	-	-	1	-	-	-	-		
		Excavator with nibler	110	-	-	1	-	-	-	-		
		200T crane	104	-	-	1	-	-	-	-		
Stage 5C	Earthworks and drainage	Heavy vehicle	105	-	-	1	-	-	-	-	118	-
		Backhoe	102	-	-	1	-	-	-	-		
		Mobile crane	104	-	-	1	-	-	-	-		

Table B.1 Description of scenarios – Stage 5

Scenario	Description	Equipment	Item sound power level[2]		Equipment quantity per assessment period (% utilisation per 15 minutes where shown)[1]						Group Sound Power Level, $L_{Aeq,15min}$	Group Sound Power Level, L_{Amax}
			$L_{Aeq, 15min}$	L_{Amax}	MS	D(s)	Day (o)	E	ES	N		
		Rubber tyred drill rig	114	-	-	1	-	-	-	-		
		Grader	105	-	-	1	-	-	-	-		
		Watercart	98	-	-	1	-	-	-	-		
		996 loader	102	-	-	1	-	-	-	-		
		Bogie tippers	107	-	-	3	-	-	-	-		
		30T excavator	104	-	-	2	-	-	-	-		
		Hand tools	94	-	-	1	-	-	-	-		
Stage 5D	Foundations and pavements	Heavy vehicle	105	-	-	1	-	-	-	-	117	-
		Backhoe	102	-	-	1	-	-	-	-		
		Concrete agitator	106	-	-	1	-	-	-	-		
		Concrete vibrator	102	-	-	1	-	-	-	-		
		Bogie tippers	107	-	-	3	-	-	-	-		
		30T excavator	104	-	-	2	-	-	-	-		
		20T vibrating roller	109	-	-	2	-	-	-	-		
		996 loader	102	-	-	1	-	-	-	-		
		Ashpalt paver	105	-	-	1	-	-	-	-		
Stage 5E	Deliveries	Heavy vehicle	105	106	1	1	1	1	1	1	105	106
		Forklift	94	-	1	1	1	1	1	1		

Table B.1 Description of scenarios – Stage 5

Scenario	Description	Equipment	Item sound power level[2]		Equipment quantity per assessment period (% utilisation per 15 minutes where shown)[1]					Group Sound Power Level, $L_{Aeq,15min}$	Group Sound Power Level, L_{Amax}
			$L_{Aeq, 15min}$	L_{Amax}	MS	D(s)	Day (o)	E	ES	N	
Stage 5F	Removal of acoustic shed	Excavator with nibbler	106	-	-	1	-	-	-	-	113	-
		Elevated work platform	97	-	-	1	-	-	-	-		
		30T crane	98	-	-	1	-	-	-	-		
		Power tools	108	-	-	1	-	-	-	-		
		Heavy vehicle	105	-	-	2	-	-	-	-		
Stage 5G	Decline cut and cover reinstatement	30T excavator	104	-	-	1	-	-	-	-	119	-
		Concrete boom pump	106	-	-	1	-	-	-	-		
		Concrete agitator	106	-	-	1	-	-	-	-		
		20T vibrating roller	109	-	-	1	-	-	-	-		
		30T excavator with hammer	117	-	-	1	-	-	-	-		
		Loader	102	-	-	1	-	-	-	-		
		Grader	105	-	-	2	-	-	-	-		

Notes: MS = morning shoulder, Day(s) = day standard hours; Day(o) = day out of hours; E = evening; N = night; ES = evening shoulder.

1. Utilisation indicates the percentage of time a piece of equipment will be used per 15 minutes. When combined with all other plant assumed to operate simultaneously, this approach is representative of typical activities.

2. Item sound power levels sourced from Department for Environment, Food & Rural Affairs UK (DEFRA), TfNSW databases or EMM measurements.

Appendix C

Noise modelling results – Stage 4A

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Table C.1 Predicted construction noise levels – Stage 4A

ID	NCA	NML							Stage 4A						
		MS	D(s)	D(o)	E	ES	N	SD	MS	D(s)	D(o)	E	ES	N	SD
1	52	50	60	55	51	48	44	54	34	35	35	32	29	26	28
2	50	53	62	57	55	52	49	59	35	35	35	32	29	27	30
3	49	52	64	59	50	48	45	55	47	49	49	45	43	41	38
4	49	52	64	59	50	48	45	55	48	50	50	46	44	41	47
5	49	52	64	59	50	48	45	55	48	50	50	46	44	42	48
6	49	52	64	59	50	48	45	55	49	50	50	47	45	42	48
7	49	52	64	59	50	48	45	55	49	51	51	47	45	42	48
8	49	52	64	59	50	48	45	55	49	51	51	47	45	43	48
9	49	52	64	59	50	48	45	55	50	51	51	48	46	43	49
10	49	52	64	59	50	48	45	55	51	53	53	49	47	44	50
11	49	52	64	59	50	48	45	55	52	54	54	50	48	45	51
12	48	54	67	62	56	51	45	55	53	55	55	52	47	45	62
13	48	54	67	62	56	51	45	55	53	55	55	52	47	45	63
14	48	54	67	62	56	51	45	55	53	55	55	52	47	45	63
15	48	54	67	62	56	51	45	55	53	55	55	53	47	45	63
16	48	54	67	62	56	51	45	55	53	55	55	53	47	45	63
17	48	54	67	62	56	51	45	55	53	55	55	53	47	45	62
18	48	54	67	62	56	51	45	55	53	55	55	52	46	45	62

Table C.1 Predicted construction noise levels – Stage 4A

ID	NCA	NML							Stage 4A						
		MS	D(s)	D(o)	E	ES	N	SD	MS	D(s)	D(o)	E	ES	N	SD
19	48	54	67	62	56	51	45	55	53	55	55	52	46	45	62
20	48	54	67	62	56	51	45	55	52	54	54	51	46	45	62
21	48	54	67	62	56	51	45	55	52	54	54	50	46	45	61
22	48	54	67	62	56	51	45	55	51	54	54	50	46	44	61
23	48	54	67	62	56	51	45	55	51	54	54	50	46	44	60
24	48	54	67	62	56	51	45	55	51	54	54	50	46	44	60
25	48	54	67	62	56	51	45	55	51	54	54	50	46	44	60
26	48	54	67	62	56	51	45	55	51	53	53	50	46	44	59

Notes:
1. Light grey shading with bold text denotes an exceedance of 1 to 2 dB.
2. Dark grey shading with bold text denotes an exceedance of 3 to 5 dB.
3. Orange shading with bold text denotes an exceedance of greater than 5 dB.
4. MS = Morning Shoulder; D(s) = Standard daytime hours; D(o) = Out of hours day; E = Evening; ES = Evening Shoulder; N = Night; SD = Sleep Disturbance

Appendix D

Noise modelling results – Stage 4B

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Table D.1 Predicted construction noise levels – Stage 4B

ID	NCA	NML							Stage 4B						
		MS	D(s)	D(o)	E	ES	N	SD	MS	D(s)	D(o)	E	ES	N	SD
1	52	50	60	55	51	48	44	54	33	34	34	30	28	26	27
2	50	53	62	57	55	52	49	59	35	35	35	32	28	25	29
3	49	52	64	59	50	48	45	55	43	47	47	41	37	33	39
4	49	52	64	59	50	48	45	55	44	47	47	41	38	33	39
5	49	52	64	59	50	48	45	55	44	47	47	42	38	33	39
6	49	52	64	59	50	48	45	55	44	48	48	42	38	33	40
7	49	52	64	59	50	48	45	55	44	48	48	42	39	33	41
8	49	52	64	59	50	48	45	55	44	48	48	42	39	34	46
9	49	52	64	59	50	48	45	55	45	48	48	42	39	34	46
10	49	52	64	59	50	48	45	55	50	52	52	48	44	41	46
11	49	52	64	59	50	48	45	55	52	53	53	50	46	43	47
12	48	54	67	62	56	51	45	55	52	55	55	48	50	44	47
13	48	54	67	62	56	51	45	55	52	55	55	47	50	44	47
14	48	54	67	62	56	51	45	55	53	55	55	47	50	44	47
15	48	54	67	62	56	51	45	55	53	55	55	48	50	44	46
16	48	54	67	62	56	51	45	55	53	55	55	48	50	44	46
17	48	54	67	62	56	51	45	55	53	55	55	48	50	44	46
18	48	54	67	62	56	51	45	55	52	55	55	47	50	43	46

Table D.1 Predicted construction noise levels – Stage 4B

ID	NCA	NML							Stage 4B						
		MS	D(s)	D(o)	E	ES	N	SD	MS	D(s)	D(o)	E	ES	N	SD
19	48	54	67	62	56	51	45	55	52	55	55	47	50	43	46
20	48	54	67	62	56	51	45	55	51	54	54	47	49	42	46
21	48	54	67	62	56	51	45	55	51	54	54	47	48	42	46
22	48	54	67	62	56	51	45	55	51	54	54	48	48	42	46
23	48	54	67	62	56	51	45	55	51	54	54	48	48	41	46
24	48	54	67	62	56	51	45	55	51	54	54	48	48	41	46
25	48	54	67	62	56	51	45	55	51	53	53	48	47	41	46
26	48	54	67	62	56	51	45	55	50	53	53	48	47	41	45

Notes:
1. Light grey shading with bold text denotes an exceedance of 1 to 2 dB.
2. Dark grey shading with bold text denotes an exceedance of 3 to 5 dB.
3. Orange shading with bold text denotes an exceedance of greater than 5 dB.
4. MS = Morning Shoulder; D(s) = Standard daytime hours; D(o) = Out of hours day; E = Evening; ES = Evening Shoulder; N = Night; SD = Sleep Disturbance

Appendix E

Detailed description of Stage 4A and 4B

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E.1 External haul truck and concrete truck movements

The following assumptions have been made in reference to truck movements on-site:

- truck ingress and egress routes are shown in Figure 7.1 and Figure 7.2;
- number of concrete agitator trucks or truck & dogs per 15 minute period as per Appendix A;
- concrete agitator trucks were modelled with a sound power level of 105 dBA $L_{Aeq,15min}$ and 108 L_{max} travelling at 10 km/h; and
- spoil haul trucks were modelled with a sound power level of 103 dB $L_{Aeq,15min}$ and 106 dB L_{max} travelling at 10 km/h.

E.2 Tunnel support activities

As the acoustic shed is to be removed, all tunnel support activities and equipment on-site will no longer be enclosed. Backfilling and grouting activities are to continue to be completed at the location of the acoustic shed, external stockpile and decline. These activities are different to the tunnelling activities that were previously being run from inside the acoustic shed and are described in Appendix A. Stage 4A and 4B activities will not be completed concurrently, so an assessment of each scenario has been provided. A summary of each scenario is provided below:

- Stage 4A - includes equipment related to the backfilling of the decline, including truck and dogs delivering spoil, a front end loader managing stockpiles and loading a moxie truck, which then transports the spoil for backfilling down the decline; and
- Stage 4B - includes equipment related to the grouting of the tunnel, including a concrete agitator, a volumetric mixer and a concrete silo.

E.3 Other noise generating site activities

In addition to the tunnel support activities detailed in Section E.2, other activities that have been considered and included in modelling are:

- water treatment plant consisting of various pumps and mixers with a total sound power level of 75 dB, $L_{Aeq,15min}$;
- a road sweeper attending to all internal roads with a sound power level of 109 dB, $L_{Aeq,15min}$. During the morning shoulder this will only operate in the cut and cover area;
- a forklift/manitou, franna crane, telehandler and various hand tools unloading deliveries and also operating in the laydown area, with sound power levels as per Table A.1;
- noise generated from the workshop with a nominal worst-case sound power level of 104 dB, $L_{Aeq,15min,}$ and L_{Amax} of 114 dB. The workshop has moved to the cut and cover area.

The above items are representative of likely plant and equipment however it is expected that there will be some variation in the above noise generating items. The location of these equipment items is shown on Figure 7.1 and Figure 7.2.

E.4 Site specific noise mitigation

There is no specific mitigation measures recommended to achieve compliance with noise management levels other than the equipment utilisation limitations as per Appendix A.

The existing double stacked shipping containers around the external stockpile are scheduled to stay in place for the entirety of the backfilling and grouting activities. However, predicted noise levels from site have been modelled without them present in the case they are removed at any stage. Noise modelling has confirmed that they provide minimal benefit to site and are able to be removed without causing predicted noise levels from site to exceed relevant NMLs.

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