Transport for NSW

St Marys Commuter Car Park Expansion
Noise and Vibration Impact Assessment

November 2020

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1. Introduction

1.1 Introduction

Transport for NSW is responsible for strategy, planning, policy, procurement, regulation, funding allocation and other non-service delivery functions for all modes of transport in NSW including road, rail, ferry, light rail, point to point, cycling and walking. Transport for NSW is the proponent for the St Marys Commuter Car Park Expansion (the Proposal).

This Noise and Vibration Impact Assessment (NVIA) has been prepared by GHD Pty Ltd (GHD) to assess potential construction noise, vibration and operational noise impacts arising from the Proposal, and where required provide mitigation strategies to minimise its impact on the surrounding community.

1.2 Key features of the Proposal

The Proposal, which is being delivered by the Commuter Car Park Program on behalf of Sydney Metro, involves upgrading the existing commuter car park to the north of St Marys Station. The upgrade would consist of an additional two stories to the existing multi-storey car park to provide for future growth and offset potential future parking loss.

The key features of the Proposal are summarised as follows:

- addition of two storeys to the existing four-storey car park with approximately 250 additional commuter car parking spaces, including motorcycle parking spaces with lift and stair access
- a new lift shaft to the south of the existing shaft. The new lift shaft would match the existing fabric and materials
- consideration of Transport Park&Ride infrastructure
- extension of the existing stairwells and lift shaft
- additional accessible parking spaces
- additional motorcycle parking spaces
- installation of closed-circuit television (CCTV), lighting and wayfinding signage for improved safety and security
- consideration of roof top solar panels subject to detailed design
- installation of additional structural elements to reinforce and support the new levels to meet the current construction code
- provision for future electric vehicle charging spaces
- construction of a new communications room
- ancillary works including utility adjustments, drainage works and landscaping.

No works are proposed in the existing at-grade car park to the east of the Proposal site as part of this planning approval. Future works proposed as part of the Sydney Metro – Western Sydney Airport project are subject to a separate planning approval.

1.3 Scope of work

The scope of work for the NVIA includes:

- review of previous background noise monitoring results
- identification of surrounding sensitive receivers potentially impacted by construction and operational noise and vibration
- review of potential noise impacts due to construction and operational traffic generation
- provision of construction and operational mitigation measures to minimise potential noise and vibration impacts on the surrounding community

This report has been prepared with consideration to the following documents:

- Construction Noise and Vibration Strategy (TfNSW, 2019) (CNVS).[1]
- *Road Noise Policy* (DECCW, 2011) (RNP)
- Assessing Vibration: a technical guideline (EPA, 2006) (AVTG)
- Interim Construction Noise Guideline (EPA, 2009) (ICNG)
- Noise Policy for Industry (EPA, 2017) (NPfI).

1.4 Scope and limitations

This report: has been prepared by GHD for Transport for NSW and may only be used and relied on by Transport for NSW for the purpose agreed between GHD and the Transport for NSW as set out in section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Transport for NSW arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Transport for NSW and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

[1] Recent addendum for November 2019 version of CNVS includes replacements for Tables 8 and 9 and included in this assessment

2. Existing environment

2.1 Proposal location

The Proposal is located in the suburb of North St Marys, in the local government area of Penrith City, about 41 kilometres west of Sydney's Central Business District (CBD).

The Proposal site is situated about 10 metres north of St Marys Station on Harris Street. St Marys town centre, a commercial district centred along Queen Street, is located about 80 metres south of the Proposal site.

2.2 Sensitive receivers and land uses

Noise and vibration sensitive receivers are defined by the type of occupancy and the activities performed within the land parcel. The receivers are classified within the following categories:

- residential premises
- classrooms at educational institutes
- hospital wards and operating theatres
- places of worship
- passive and active recreation areas
- commercial or industrial premises.

The Proposal site is located in a predominately industrial area and is bordered by Harris Street to the north, Forrester Road to the west, industrial property to the east and St Marys Station to the south. A pedestrian area, bus interchange and taxi rank are located to the south of the station along Station Street. The St Marys town centre which includes St Marys Station Plaza, St Marys Village and other retail and commercial properties, is located about 80 metres south of the Proposal site. Residential areas of St Marys are located to the east and west of the town centre.

Sensitive land uses surrounding the Proposal site include:

- an industrial area to the immediate north, west, north-east and east
- residential areas to the south-west, south-east and north-east
- a commercial precinct south of the station
- a combined commercial gym and coffee shop located in the ground floor of the existing structure in the Proposal site
- a medical centre about 280 metres to the south – St Marys Medical Centre
- an educational institute about 390 metres to the south-west – St Marys Senior High School.

The Proposal site location and noise sensitive receivers are presented below in Figure 2-1. Residential receivers have been grouped into noise catchment areas (NCAs).

2.3 Previous background noise monitoring

Background noise monitoring conducted as part of the Sydney Metro – Western Sydney Airport project was adopted for this assessment. The noise monitoring details are presented in Table 2-1. This background noise monitoring data has been used for the determination of construction and operational noise criteria as discussed in section 3.

Table 2-1 Noise monitoring details and results

Noise monitoring location	Rating Background Level (RBL) $L_{A90(15min)}$, dB(A)[1]			Ambient noise level $L_{Aeq(15min)}$, dB(A)[1]		
	Day	Evening	Night	Day	Evening	Night
47 Kalang Ave, St Marys	37	(40)37[2]	36	55	59	51

Note 1: The *Noise Policy for Industry* defines day, evening and night-time periods as:

- Day: 7am to 6pm Monday to Saturday and 8am to 6pm Sunday
- Evening: 6pm to 10pm
- Night: 10pm to 7am Monday to Saturday and 10pm to 8am Sunday.

Note 2: Where evening or night background noise levels exceed that of the previous period, they have been set at the background noise level of the previous period, in line with the NPfI, to reflect community's expectation for greater noise control during more sensitive periods.

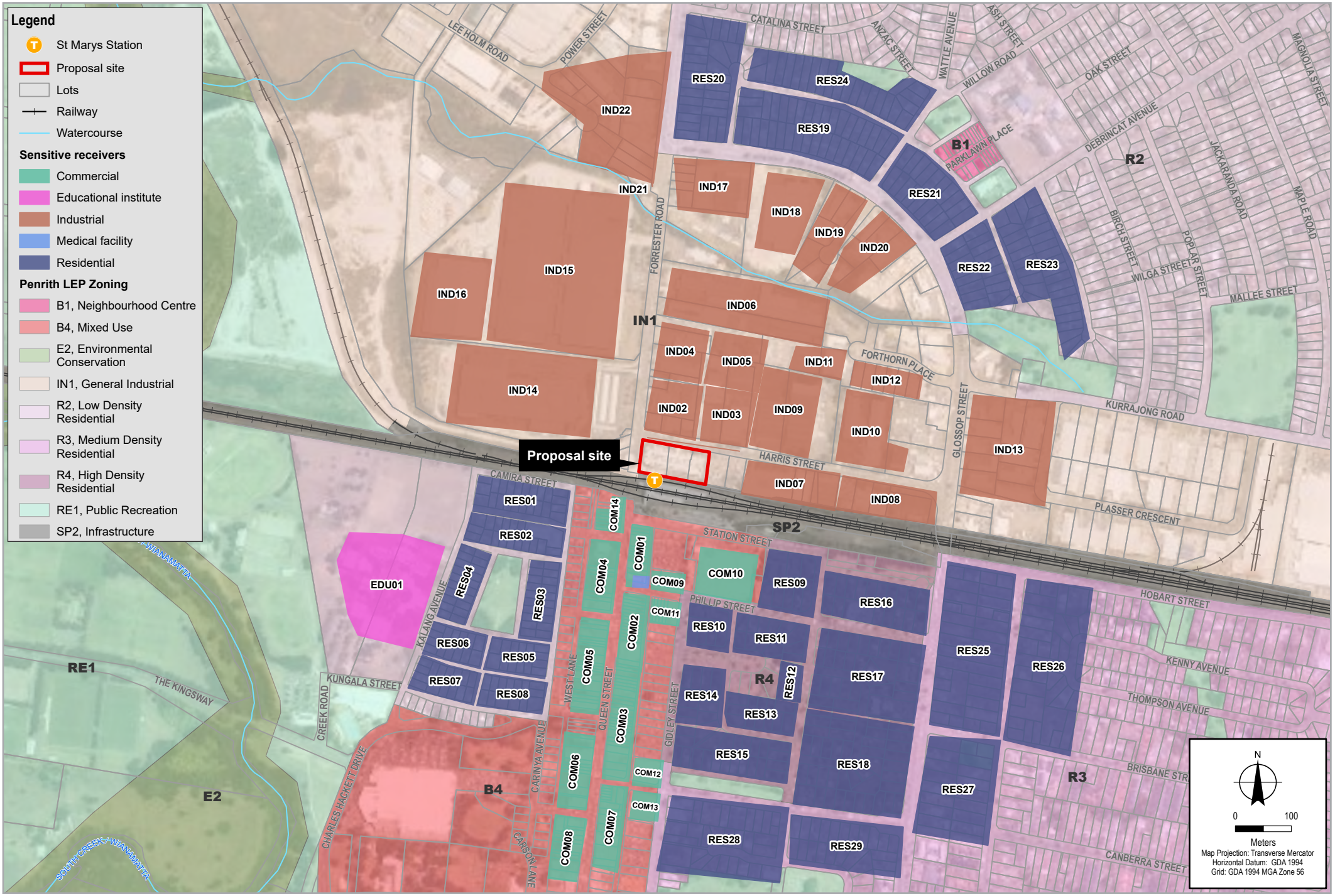

Figure 2-1 Proposal location, sensitive receivers and land use map

\\ghdnet\ghd\AU\Sydney\Projects\21\12539071\GIS\Maps\Deliverables\12539071 - St Marys Commuter Car Park Expansion\NV.aprx Print date: 16 Nov 2020 - 12:29 Imagery: SIXMAPS, 2020; Land Zoning: EPI NSW, 2020; Rail: SIXMAPS, 2020; Cadastre: SIXMAPS, 2020; Train Station Location: EPI, 2020

3. Compliance criteria

3.1 Construction noise criteria

3.1.1 Proposed construction hours

Construction noise management levels for the Proposal are based on ICNG and CNVS. Subject to planning approval, construction is expected to commence in early 2021 and take about 12 months to complete.

Construction works would be conducted during *Interim Construction Noise Guideline* recommended standard construction hours, defined as:

- Monday to Friday 7:00 am to 6:00 pm
- Saturday 8:00 am to 1:00 pm
- No work on Sundays or public holidays.

Constructions hours definition is provided below in Figure 3-1.

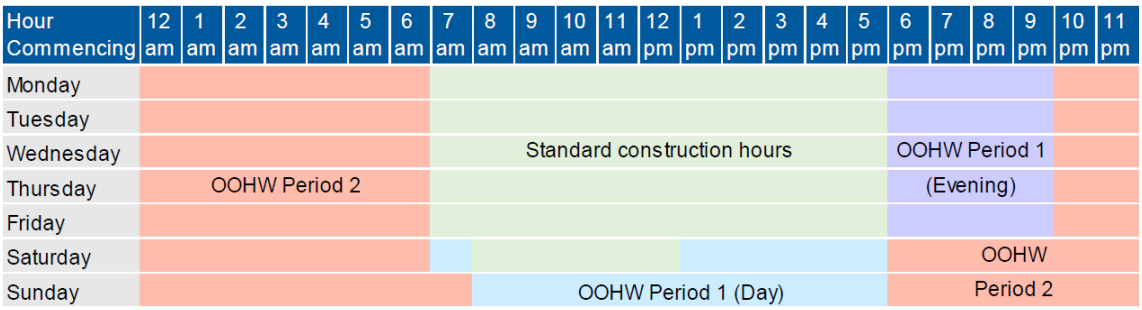

Figure 3-1 Construction hours

Works outside standard construction hours should only be conducted when it is not feasible or reasonable to work within standard hours. Construction work may need to be completed outside standard construction hours to maintain a safe work environment or to minimise impacts to operational transport infrastructure and services. Approval from Transport for NSW would be required for any out of hours work and the affected community would be notified as outlined in Transport for NSW's *Construction Noise and Vibration Strategy* (TfNSW, 2019).

3.1.2 Construction noise management levels

Construction noise management levels for residential premises and other sensitive land uses are provided in the *Construction Noise and Vibration Strategy* and based on the *Interim Construction Noise Guideline*. The method to determine the noise management levels for residentials receivers in accordance with the *Construction Noise and Vibration Strategy* is outlined in Table 3-1.

Table 3-1 Noise management levels for residential receivers

Time of day	Noise management level, $L_{Aeq(15\ min)}$	Application notes
Recommended standard hours	Noise affected: RBL + 10 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • where the predicted or measured $L_{Aeq(15\ min)}$ 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(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. • If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended standard hours	Noise affected: RBL + 5 dB(A)	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 measures have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should consult with the community. For guidance on negotiating agreements see Section 7.2.2 of the *Interim Construction Noise Guideline*.

Noise management levels for other sensitive land uses are provided in Table 3-2 and only apply when the properties are in use.

Table 3-2 Noise management levels for other sensitive land uses

Land use	Noise management level, $L_{Aeq(15\ min)}$
Commercial premises	70 dB(A) (external)
Industrial premises	75 dB(A) (external)
Educational institutes	45 dB(A) (internal)
Hospital wards and operating theatres	45 dB(A) (internal)

3.1.3 Sleep disturbance

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the Proposal should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL. The potential for both sleep disturbance and awakenings should be considered in the assessment.

The NPI provides the latest EPA guidance for the assessment of sleep disturbance. The NPI recommends a maximum noise level assessment to assess the potential for sleep disturbance impacts which include awakenings and disturbance to sleep stages. An initial screening test for the maximum noise levels events should be assessed to the following levels.

- $L_{Aeq(15\ min)}$ 40 dBA or the prevailing RBL plus 5 dB, whichever is greater, and/or
- L_{AFmax} 52 dBA or the prevailing RBL plus 15 dB, whichever is greater.

If the screening test indicates there is a potential for sleep disturbance then a detailed maximum noise level assessment should be undertaken. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

3.1.4 Proposal noise management levels

A summary of the Proposal construction noise management levels for each identified sensitive receiver type is provided in Table 3-3.

Table 3-3 Proposal construction noise management levels, dB(A)

Receiver Type	Time of day		Management level
Residential	Recommended standard hours		Noise affected: 47 dB(A)
			Highly affected: 75 dB(A)
	Outside recommended standard hours[1]	Day	42 dB(A)
		Evening	42 dB(A)
		Night	41 dB(A)
			L_{AFmax} 52 dB(A)
Commercial premises	When in use		70 dB(A) (external)
Industrial premises	When in use		75 dB(A) (external)
Classrooms for educational institutes	When in use		45 dB(A) (internal)
Hospital wards and operating theatres	When in use		45 dB(A) (internal)

Note 1: The *Noise Policy for Industry* (EPA, 2017) defines day, evening and night-time periods as:

- Day: the period from 7am to 6pm Monday to Saturday or 8am to 6pm on Sundays and public holidays.
- Evening: the period from 6pm to 10pm.
- Night: the remaining periods.

3.2 Construction traffic noise criteria

The *Road Noise Policy* provides road traffic noise criteria for residential land uses affected by construction traffic on the public road network.

The *Road Noise Policy application notes* state that any increase in the total noise level at existing residences and other sensitive land uses affected by traffic generation on existing roads should be limited to 2 dB(A) above current levels. This limit only applies when the noise level without the development is within 2 dB(A) or exceeds the road traffic noise criterion provided in the RNP.

This has been used to identify potential impacts as a result of noise produced by construction traffic. If road traffic noise increases as a result of construction works within 2 dB(A) of current levels then the objectives of the RNP are considered to be met and no specific mitigation measures would be required.

Where construction traffic increases the existing road traffic noise levels by more than 2 dB(A) then further assessment against the road traffic noise criteria in Table 3-4 is required.

Table 3-4 Road traffic noise criteria, dB(A)

Type of development	Day 7am to 10pm	Night 10pm to 7am
Existing residence affected by additional traffic on freeway/arterial/sub-arterial roads	60 $L_{Aeq(15\ hour)}$	55 $L_{Aeq(9\ hour)}$
Existing residence affected by additional traffic on local roads	55 $L_{Aeq(1\ hour)}$	50 $L_{Aeq(1\ hour)}$

3.3 Construction vibration criteria

3.3.1 Human comfort

Acceptable vibration levels for human comfort have been set with consideration to *Assessing Vibration: a technical guideline* (DEC, 2006) which is based on the guidelines contained in British Standard *BS 6472 – 1992, Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)*.

Typically, construction activities generate ground vibration of an intermittent nature. Intermittent vibration is assessed using the vibration dose value. Acceptable values of vibration dose are presented in Table 3-5 for sensitive receivers.

Table 3-5 Human comfort intermittent vibration limits (BS 6472-1992)

Receiver type	Period	Intermittent vibration dose value ($m/s^{1.75}$)	
		Preferred value	Maximum value
Residential	Day (7am and 10pm)	0.2	0.4
	Night (10pm and 7am)	0.13	0.26
Offices, schools, educational institutes and places of worship	When in use	0.4	0.8

Whilst the assessment of response to vibration in BS 6472:1992 is based on vibration dose value and weighted acceleration, for construction related vibration, it is considered more appropriate to provide guidance in terms of a peak value, since this parameter is likely to be more routinely measured based on the more usual concern over potential building damage.

Humans are capable of detecting vibration at levels which are well below those causing risk of damage to a building. The degrees of perception for humans are suggested by the vibration level categories given in British Standard, *BS 5228.2 – 2009, Code of Practice Part 2 Vibration for noise and vibration on construction and open sites – Part 2: Vibration* and are shown below in Table 3-6.

Table 3-6 Guidance on effects of vibration levels for human comfort

Vibration level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration at this level in residential environments will cause complaints, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure.

3.3.2 Guidelines for general structures

The effects of transient vibration on structures is considered in *BS 7385 Part 2 – 1993 Evaluation and measurement for vibration in buildings*. The criteria provided in BS 7385 are presented in Table 3-7.

Table 3-7 Transient vibration guide values – minimal risk of cosmetic damage

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	50 mm/s at 4 Hz and above
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 guide values in Table 3-7 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 may give rise to dynamic magnification due to resonance, especially at lower frequencies, then the guide values may need to be reduced by up to 50 per cent.

The predominant vibration for most construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers and excavators occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, a conservative vibration damage screening level per receiver type is given below:

- reinforced or framed structures: 25.0 mm/s
- unreinforced or light framed structures: 7.5 mm/s

3.3.3 Guidelines for vibration sensitive structures

Heritage buildings and structures would be assessed using the guide values in Table 3-7. A heritage building or structure should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. If a heritage building or structure is found to be structurally unsound (following inspection) a more conservative cosmetic damage criterion of 3 mm/s peak component particle velocity (from DIN 4150) should be considered.

3.4 Operational noise criteria

3.4.1 Project noise trigger levels

Operational noise emanating from the Proposal are assessed to the project trigger noise levels (PTNL) in the NPfI. The project noise trigger level is the lower value of the intrusiveness noise level and the amenity noise level. The intrusiveness noise aims to protect against significant changes in noise levels and the amenity noise level aims to protect against cumulative noise impacts from existing industry.

The PTNL for residential receivers is presented below in Table 3-8 and non-residential receivers Table 3-9.

Table 3-8 NPfI Operational criteria for residential receivers

Time of Day	Intrusiveness noise criteria $L_{Aeq(15min)}$ (BG[1] + 5 dB), dB(A)	Amenity noise criteria $L_{Aeq(15min)}$, dB(A)[2 3]	PNTL $L_{Aeq(15min)}$, dB(A)
7 am to 6 pm (daytime)	***42 dB(A)***	53 dB(A)	42 dB(A)
6 pm to 10 pm (evening)	***42 dB(A)***	43 dB(A)	42 dB(A)
10 pm to 7 am (night time)	41 dB(A)	***38 dB(A)***	38 dB(A)

Note 1: Background noise level $L_{A90(15min)}$

Note 2: The amenity noise criteria is defined as the recommended amenity noise level minus 5 dB. The recommended amenity $L_{Aeq(period)}$ noise level for residential suburban is defined as:

- Day: 55 dB(A)
- Evening: 45 dB(A)
- Night: 40 dB(A)

Note 3: A – 3 dB correction is applied to convert the LAeq(period) descriptor to the $L_{Aeq(15min)}$ descriptor

Table 3-9 NPfI Operational criteria for non-residential receivers

Receiver type	Time of day	PNTL $L_{Aeq(15min)}$, dB(A)
Commercial	When in use	63
Industrial	When in use	68
Educational	Noisiest 1 hour	35 (internal) 45 (external)
Hospital/medical	When in use	35 (internal) 45 (external)

3.4.2 Maximum noise events

The NPfI recommends a maximum noise level assessment based on guidance from the World Health Organisation to assess the potential for sleep disturbance impacts which include awakenings and disturbance to sleep stages. An initial screening test for the maximum noise levels events should be assessed to the following levels:

- $L_{Aeq(15\ min)}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is greater.

If the screening test indicates there is a potential for sleep disturbance then a detailed maximum noise level assessment should be undertaken. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period.

3.5 Operational traffic

The RNP provides road traffic noise criteria for residential land uses affected by additional operational traffic on the public road network.

The *Road Noise Policy application notes* state that any increase in the total noise level at existing residences and other sensitive land uses affected by traffic generation on existing roads should be limited to 2 dB(A) above current levels. This limit only applies when the noise level without the development is within 2 dB(A) or exceeds the road traffic noise criterion provided in the RNP.

This has been used to identify potential impacts as a result of noise produced by additional operational traffic. If road traffic noise increases as a result of construction works within 2 dB(A) of current levels then the objectives of the RNP are considered to be met and no specific mitigation measures would be required.

Where additional operational traffic increases the existing road traffic noise levels by more than 2 dB(A) then further assessment against the road traffic noise criteria in Table 3-10 is required.

Table 3-10 Road traffic noise criteria, dB(A)

Type of development	Day 7 am to 10 pm	Night 10 pm to 7 am
Existing residence affected by additional traffic on freeway/arterial/sub-arterial roads	60 $L_{Aeq(15\ hour)}$	55 $L_{Aeq(9\ hour)}$
Existing residence affected by additional traffic on local roads	55 $L_{Aeq(1\ hour)}$	50 $L_{Aeq(1\ hour)}$

4. Construction impacts assessment

4.1 Construction noise

4.1.1 Construction methodology

The plant and equipment likely to be required throughout each proposed stage of construction have been used to predict the noise levels that would be expected during construction works. The predicted noise levels were assessed against the construction noise management levels identified in section 4.1.

Construction scenarios have been created based on construction equipment operating simultaneously at any given time. Although this is unlikely to occur (as the modelling assumes), the 'worst-case' scenario has been adopted to identify where noise impacts could be a concern and require mitigation.

Construction activities

Subject to approval, construction is expected to commence in early-2021 and take around 12 months to complete. The construction methodology would be further developed during the detailed design of the Proposal by the nominated Contractor in consultation with Transport for NSW.

The proposed construction activities for the Proposal are identified in Table 4-1. This staging is indicative and is based on the current concept design and may change once the detailed design methodology is finalised. The staging is also dependent on the Contractor's preferred methodology, program and sequencing of work

Table 4-1 Indicative construction activities

Stage	Duration	Activities	Likely equipment
Site preparation	4 weeks	• secure site boundary with temporary fencing and hoarding • provide traffic and pedestrian controls in the vicinity of the Site in accordance with Penrith City Council requirements • undertake survey to identify site boundary and mark out existing services and proposed foundations of car park • clear site of any existing vegetation not being retained, and demolish obsolete kerbs and pavements • establish site office, amenities and plant/material storage areas • establish other environmental controls, such as erosion and sediment controls.	• mobile cranes • hand tools • concrete saw • generators
Superstructure construction	19 weeks	• construct suspended levels, including stairs, walls and columns one level at a time • construct block work on each level • make good of at grade car park where existing surface has been disturbed for installation of services or construction of new foundations • install new lifts and extend existing lift and stairs • install electrical, hydraulic and mechanical services infrastructure. • installation of the façade	• tower cranes • mobile cranes • water trucks • street sweepers • road saw • rollers • trench compactors • concrete trucks • semi-trailers and spoil trucks (truck and dog) • welding equipment • air compressors • concrete saws • generators • concrete vibrators • concrete pumps • jack hammer • elevated work platforms • hand tools

Four construction scenarios representative of the activities listed in Table 4-1 were then modelled to determine the potential construction noise impacts on the environment (see Table 4-2).

Table 4-2 Construction scenarios considered for the noise model

Construction scenario	Construction activity	Construction hours
CS01	Site establishment/decommissioning	Standard hours
CS02	Demolition of existing kerb and pavements	Standard hours
CS03	Carpark construction	Standard hours
CS04	Lift installation	Standard hours

Noise generating equipment

Plant and equipment needed for the Proposal would be determined during the construction planning phase. Noise level data has been obtained from the Australian Standards *AS2436 – Guide to noise and vibration control on construction, demolition and maintenance sites* and the CNVS. Other equipment may be used, however, it is anticipated that they would produce similar net noise emissions when used concurrently with the equipment listed.

The magnitude of off-site noise impacts associated with construction is dependent upon a number of factors:

- the intensity and location of construction activities
- the type of equipment used
- existing background noise levels
- intervening terrain and structures
- prevailing weather conditions.

Construction machinery would likely move about the proposal site altering the received noise for individual receivers. During any given period, the machinery items to be used would operate at maximum sound power levels for only brief stages. At other times, the machinery would produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Certain types of construction machinery would be present in the Proposal site for only brief periods during construction. Therefore, noise predictions are considered conservative.

Table 4-3 presents the construction equipment proposed for each construction scenario. The activity sound power level has been calculated based on the two noisiest plant to determine the worst-case noise impacts during construction. The activity noise levels have been used to predict the noise levels that would be expected during construction.

Table 4-3 Construction equipment and sound power levels, dB(A)

Plant description	Sound power level	Construction scenario			
		CS01	CS02	CS03	CS04
Activity sound power level		114	124	119	116
Concrete agitator truck	109			✓	
Concrete pencil vibrator[1]	118 (113)			✓	
Concrete pump truck	109			✓	
Concrete saw[1]	123 (118)		✓		

Plant description	Sound power level	Construction scenario			
		CS01	CS02	CS03	CS04
Activity sound power level		114	124	119	116
Crane (mobile)	113	✓		✓	✓
Crane (tower)	113			✓	✓
Generator diesel	103	✓		✓	✓
Hand tools (electric)	97	✓			
Jack hammers	118		✓		
Truck (> 20 tonne)	103		✓		
truck (dump)	110		✓		
Vehicle (Light commercial eg 4WD)	106	✓		✓	
Welder	110				✓

Note 1: The CNVS stipulates that these pieces of equipment possess special audible characteristics. As such, a + 5 dB correction has been applied to the noise levels stipulated in CNVS (bracketed).

4.1.2 Construction noise modelling

Noise modelling was undertaken using CadnaA 2020. CadnaA is a computer program for the calculation, assessment and prognosis of noise exposure. CadnaA calculates environmental noise propagation according to *ISO 9613-2 'Acoustics – Attenuation of sound during propagation outdoors'.*

The following noise modelling assumptions were made:

- surrounding land was modelled assuming a mix of 50 per cent soft and 50 per cent hard ground with a ground absorption coefficient of 0.5
- atmospheric absorption was based on an average temperature of 10°C and an average humidity of 70 per cent
- atmospheric propagation conditions were modelled with noise enhancing wind conditions for noise propagation (downwind conditions) or an equivalently well-developed moderate ground based temperature inversions
- modelled scenarios take into account the shielding effect from surrounding buildings and structures on and adjacent to the site
- noise sources for each scenario are in some cases modelled at different locations. As such the noise modelling assesses the noise source at multiple locations and takes the maximum L_{Aeq} received noise level.

4.1.3 Construction noise impacts

Predicted construction noise levels from the construction scenarios outlined in Table 4-2 are presented in Appendix B. Construction noise contours for each modelled scenario is provided in Appendix C. A summary of the number of exceedances of the noise management levels for sensitive receivers is presented in Table 4-4.

Exceedances of the construction noise management levels are typical for construction projects of this scale. The noise impacts would be limited to the construction period only and would not have lasting effects on the community. The maximum noise impacts would be expected during the required demolition of pavements and kerbs and is primarily due to the use of a concrete saw and jackhammer.

Table 4-4 Construction noise results summary

Result	Construction scenario			
	CS01	CS02	CS03	CS04
Residential receivers – standard construction hours				
Number of NCAs exceeding NML of 47 dB(A)	3	26	9	4
Highest noise level	53	66	60	55
Highest exceedance above NML	6	19	13	8
Worst affected NCA	RES01	RES01	RES01	RES01
Commercial receivers				
Number of receivers exceeding NML of 70 dB(A)	0	1	0	0
Highest noise level	62	75	69	64
Highest exceedance above NML	-	5	-	-
Worst affected receiver	COM14	COM14	COM14	COM14
Industrial receivers				
Number of receivers exceeding NML of 75 dB(A)	2	2	2	0
Highest noise level	77	89	83	66
Highest exceedance above NML	2	14	8	-
Worst affected receiver	IND02	IND02	IND02	IND02
Medical receivers				
Number of receivers exceeding NML of 55 dB(A)[1]	0	1	1	0
Highest noise level	50	62	56	49
Highest exceedance above NML	-	7	1	-
Worst affected receiver	MED01	MED01	MED01	MED01
Educational receivers				
Number of receivers exceeding NML of 55 dB(A)[1]	0	0	0	0
Highest noise level	42	51	46	42
Highest exceedance above NML	-	-	-	-
Worst affected receiver	EDU01	EDU01	EDU01	EDU01

Note 1: The criteria for this receiver type is an internal noise criteria. A + 10 dB correction has been applied to convert from an internal to external noise criteria assuming that a partially open window provides a 10 dB reduction.

All construction equipment would be operational intermittently and not continuously. As such, impacts on nearby sensitive receivers would only occur over a short duration.

All feasible and reasonable work practices would be applied to minimise noise during construction. It is unlikely however that mitigation measures would reduce the construction noise levels to below the noise management levels. The magnitude of construction noise impacts are dependent upon a number of factors including the intensity and location of activities, the type of equipment used, background noise levels during the construction period and the prevailing weather conditions. Based on these parameters, the predicted construction noise levels are generally conservative and do not represent a constant noise emission that would be experienced by the community on a daily basis throughout the project construction period.

Construction noise impacts on the community and surrounding environment would not be permanent and would be limited to the duration of the construction period. These impacts can be minimised by implementing noise management controls and standard noise mitigation measures documented in the CNVS. Further details of the recommended noise mitigation measures are detailed in section 6.

Impacts for residential receivers

Residences located up to about 790 metres away from the proposal site are expected to be noise impacted at some point during construction. The noise management level is predicted to be exceeded by up to 19 dB, and this is primarily due to the use of the concrete saw and jackhammer during demolition works of pavements and kerbs. Residential receivers exceeding the noise management level, along with noise contours are presented in Appendix C. Due to limited kerb and pavement required to be demolished however, noise impacts are anticipated to be short in duration with minimal long term noise impacts on nearby sensitive receivers.

Despite such use of these noise intensive equipment, the CNVS considers this level of exceedance as only "moderately intrusive" and the mitigation measures discussed in Section 6.1.2 would be implemented to minimise noise impacts during construction.

The highly noise affected management of 75 dB(A) is not predicted to be exceeded at any residential receiver.

Impacts for other noise sensitive land uses

Other noise sensitive land uses would only be noise impacted if they are in use during the time of construction. It is likely that this would eventuate as all construction activities are to take place within standard construction hours. At some point, noise impacts are predicted for commercial uses within 140 metres, industrial uses within 122 metres, and medical land uses within 236 metres due to the use of the jackhammer. Non-residential receivers that exceed the noise management level are graphically shown in Appendix C.

A combined commercial gym and coffee is located on the ground floor of the existing carpark structure within the Proposal site, which would likely be operational during construction works. It is likely that this receiver would experience construction noise impacts as a result of the Proposal. Due to its operation as a gym which would likely have higher internal noise levels, significant noise impacts are not anticipated. Recommendations to minimise noise impacts for this commercial receiver are presented in Section 6.1.3.

4.2 Construction traffic impacts

The RNP recommends that "*any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario."* Construction would generate heavy vehicle movements associated with the transportation of construction machinery, equipment and materials to the site. Light vehicle movements would be associated with employees and smaller deliveries.

Construction traffic routes and traffic numbers have been sourced from *St Marys Station Commuter Car Park Upgrade – Traffic & Transport Access Impact Assessment* (Mott MacDonald, September 2020), and are as follows:

- Harris Street
- Forrester Road
- Glossop Street
- Debrincat Avenue

Being that no hourly traffic data for the entire day was available at the time of this assessment, the 2 dB screening testing has been for the time period of maximum impact, being when the greatest number of construction traffic will be arriving/departing the Proposal site during the morning and evening peak periods respectively. Road traffic noise levels have been calculated based on the *Road Traffic Noise Estimator* tool within the *Construction and maintenance noise estimator* (TfNSW, 2017), and are presented below in Table 4-5.

Based on the existing and anticipated additional road traffic volumes, the predicted increase in road traffic noise levels is below 2 dB for all roads along the construction traffic routes. As such, no additional construction traffic assessment is required.

Table 4-5 Construction traffic noise assessment

Road	Time period	Existing traffic volumes		Additional traffic volumes		Difference in noise level, dB
		Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Harris Street	AM peak	78	7	25	3	1.4
	PM peak	93	2	1	0	0
Forrester Road – south of Glossop Street	AM peak	273	28	23	3	0.4
	PM peak	433	22	47	6	0.6
Forrester road – north of Glossop Street	AM peak	1498	194	22	3	0.2
	PM peak	1757	97	22	3	0.1
Glossop Street	AM peak	1373	118	25	3	0.1
	PM peak	1685	106	24	3	0.1
Debrincat Avenue	AM peak	925	2	1	0	0
	PM peak	971	3	1	0	0

4.3 Construction vibration assessment

4.3.1 Assessment methodology

Vibration from surface construction plant and equipment was predicted and assessed with consideration to *Assessing Vibration: a Technical Guideline* and German Standard *DIN 4150-3: 1999 Structural Vibration – Part 3: Effects of vibration on structures.* Where noise and vibration levels were predicted to exceed the construction noise management levels, appropriate construction noise and vibration mitigation measures were provided to minimise impacts from each construction phase.

Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- the efficiency of the energy transfer mechanism of the equipment (impulsive; reciprocating, rolling or rotating equipment)
- the frequency content
- the impact medium stiffness
- the type of wave (surface or body)
- the ground type and topography.

Construction and demolition works have the potential to impact human comfort and / or cause structural damage to buildings. Potential vibration inducing activities identified during construction and demolition works include:

- piling, grinding and cutting will generate impulsive vibration emissions
- bulk earthworks, construction traffic movements and demolition works will be a source of intermittent or continuous vibration.

Safe working buffer distances to comply with the human comfort, cosmetic damage and heritage structural damage criteria were taken from the CNVS and are provided in Table 4-6. Safe working buffer distances for heritage buildings were estimated by doubling the buffer distance for standard structures.

Table 4-6 Vibration safe working buffer distances, metres

Activity	Human comfort	Structural damage	
		Heritage building/structure	Standard dwellings
Piling rig – Bored	N/A	4 m (nominal)	2 m (nominal)
Piling rig–Hammer	50 m	30 m	15 m
Vibratory roller (>18 tonnes)	100 m	50 m	25 m
Vibratory roller (13-18 tonnes)	100 m	40 m	20 m
Vibratory roller (7-13 tonnes)	100 m	30 m	15 m
Vibratory roller (4-6 tonnes)	40 m	24 m	12 m
Vibratory roller (2-4 tonnes)	20 m	12 m	6 m
Vibratory roller (1-2 tonnes)	15 m	10 m	5 m
Large hydraulic hammer	73 m	44 m	22 m
Jackhammer	Avoid contact with structure	2 m (nominal)	1 m (nominal)

4.3.2 Construction vibration impacts

Based on the identified construction equipment proposed during construction, the jackhammer has been identified as potentially causing vibration impacts.

Impacts for standard structures

With consideration to the buffer distances provided in Table 4-6, structures located within 1 metre of jackhammering works may experience structural damage impacts. Section 6.2 provides mitigation measures for potential construction vibration impacts.

Impacts for vibration sensitive or heritage listed structures

With consideration to the buffer distances provided in Table 4-6, vibration sensitive or heritage listed structures located within two metres of jackhammering works may experience structural damage impacts. St Marys Station is a heritage listed item and is inclusive of all structures pertaining to the station. If jackhammering works are located within 2 metres of any structures pertaining to St Marys Station may experience structural damage impacts. Section 6.2 provides mitigation measures for potential construction vibration impacts.

Human comfort impacts

With consideration to the buffer distances provided in Table 4-6, human comfort impacts may be experienced by anyone who is contact with the structure in which jackhammering works are taking place. Section 6.2 provides mitigation measures for potential construction vibration impacts.

5. Operational impact assessment

5.1 Assessment methodology

The multi-storey car park will result in addition of about 250 parking spaces in total and vehicles would continue to enter/exit the car park via Harris Street.

Noise from the Proposal would be generated from the following sources:

- car park traffic movements from the existing commuter car park and the Proposal
- mechanical plant noise from air-conditions units, ventilation fans and exhaust fans
- maximum noise level events from car door slams, car horns, sudden vehicle accelerations and tyre squeals.

The operational impact assessment only considers receivers at a distance of 300 metres or less from the Proposal.

5.2 Modelling inputs

5.2.1 Modelling inputs and assumptions

Noise modelling was undertaken using CadnaA 2020. The following noise model inputs and assumptions were adopted:

- surrounding land was modelled assuming a mixture of 50 per cent hard surfaces and 50 per cent soft surfaces, with an absorption coefficient of 0.5
- atmospheric absorption was based on an average temperature of 10°C and an average humidity of 70 per cent
- atmospheric propagation conditions were modelled with noise enhancing wind conditions for noise propagation (downwind conditions) or equivalently a well-developed moderate ground based temperature inversions
- noise from the car park has been modelled using Recommendations for the calculation of sound emissions of parking areas, motorcar centers and bus stations as well as of multi-storey car parks and underground car parks 6th Edition (Bavarian Landesamt für Umwelt 2007)
- environmental noise propagation has been calculated using *ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors*. The ISO 9613-2 algorithm also takes into account the presence of a well developed, moderate ground-based temperature inversion. This commonly occurs on clear calm nights or 'downwind' conditions which are favourable for sound propagation.

5.2.2 Car park movements

Number of modelled spaces

The number of spaces and the type of road surface for each level of the existing commuter car park and the Proposal is provided below in Table 5-1.

Table 5-1 Operational parking space summary

Floor level	Number of spaces	Road surfaces
Ground floor (existing)	82[1]	Asphalt
Level 1 (existing)	133	Concrete
Level 2 (existing)	133	Concrete
Level 3 (existing)	133	Concrete
Level 4 (proposed)	133	Concrete
Level 5 (proposed)	133	Concrete
At-grade (existing)	10	Asphalt
At grade car park (existing, outside the Proposal site)[2]	126	Asphalt

Note 1: Out of the 82 spaces, 71 are designated as car spaces whilst 11 are designated as motorcycle spaces

Note 2: It is noted that the at grade car park located outside the Proposal site is proposed to be redeveloped in the future as part of the Sydney Metro – Western Airport project (subject to separate planning approval). It has been included as part of the assessment as a worst-case scenario to remain conservative.

Traffic movements

Traffic movements during the peak hours traffic periods were taken from the from the *St Marys Station Commuter Car Park Upgrade – Traffic & Transport Access Impact Assessment* (Mott MacDonald, September 2020) which are summarised in Table 5-2.

Table 5-2 Predicted traffic movements

Peak period	Period	Total movements	Peak hour traffic generation
AM peak	7am to 8am	547	0.62 vehicles per space
PM peak	5pm to 6pm	486	0.55 vehicles per space

The following assumptions have been made for the operational noise assessment:

- The AM peak hour traffic movements have been assumed across the entire day-time assessment period (7am to 6pm)
- The PM peak hour traffic movements have been assumed across the entire evening assessment period (6pm to 10pm)
- Traffic movements during the night-time period between 10pm to 7am have been assumed as 0.03 vehicle movements per space based on a Park&Ride located at a train station more than 20 kilometres from the city centre (Table 4, Bavarian Landesamt für Umwelt 2007).

Traffic movements used in the operational noise assessment are summarised in Table 5-3 for assessment against the criteria presented in section 3.4.

Table 5-3 Assumed commuter car park traffic movements

Assessment period	Time period	Hourly traffic generation (vehicles/space)	Overall traffic generation (vehicles/space/h)
Day	7am to 6pm	0.62	0.62
Evening	6pm to 10pm	0.55	0.55
Night	10:00 pm to 7:00 am	0.03	0.03

5.2.3 Mechanical plant

The assessment of mechanical plant is based on the following mechanical noise sources, and have been assumed based on the mechanical services specification drawings for the Proposal (Engineering Design Solutions, September 2020):

- one wall mounted air conditioning condenser unit located on level 4 – radiated sound power level (SWL) of 48 dB(A)
- one lift shaft supply air fan located at ground level adjacent to lift shaft – SWL of 56 dB(A)
- one direct drive motor providing power to supply air fan at 1.2 kW – SWL of 60 dB(A).

5.3 Operational noise impacts

5.3.1 Car park traffic movements noise impacts

The predicted operational car park noise levels are presented in Table 5-4 and Table 5-5. Noise levels at all residential and non-residential receiver are predicted to comply with the project trigger noise levels during all assessed time periods.

Table 5-4 Car park traffic movements noise results – residential receivers

Receiver ID	Receiver type	Day $L_{Aeq(15min)}$, dB(A)	Evening $L_{Aeq(15min)}$, dB(A)	Night $L_{Aeq(15min)}$, dB(A)
Criteria		42	42	38
RES01	Residential	37	36	27
RES02		33	33	23
RES03		31	31	21
RES09		36	36	26
RES10		34	34	24

Table 5-5 Car park traffic movements noise results – sensitive land uses

Receiver ID	Receiver type	Criteria	Day $L_{Aeq(15min)}$, dB(A)	Evening $L_{Aeq(15min)}$, dB(A)	Night $L_{Aeq(15min)}$, dB(A)
COM01	Commercial	63	41	41	31
COM02	Commercial		32	32	22
COM04	Commercial		37	36	27
COM09	Commercial		37	36	27
COM10	Commercial		39	39	29
COM11	Commercial		33	33	23
COM14	Commercial		43	42	33
IND02	Industrial	68	52	52	42
IND03	Industrial		51	51	41
IND04	Industrial		35	35	25
IND05	Industrial		37	37	27
IND06	Industrial		28	28	19
IND07	Industrial		47	48	38
IND09	Industrial		43	44	34

Receiver ID	Receiver type	Criteria	Day $L_{Aeq(15min)}$, dB(A)	Evening $L_{Aeq(15min)}$, dB(A)	Night $L_{Aeq(15min)}$, dB(A)
IND10	Industrial		33	33	23
IND11	Industrial		26	26	16
IND14	Industrial		39	39	29
IND15	Industrial		35	34	25
MED01	Medical	43	34	33	24

5.3.2 Mechanical plant noise impacts

Predicted operational noise levels from mechanical plant operation are provided in Table 5-6. Noise levels at all receivers are below the project noise trigger levels, and no noise impacts are anticipated due to the operation of additional mechanical plant.

Table 5-6 Predicted residential mechanical plant noise levels, dB(A)

Receiver ID	Receiver type	Criteria	Predicted $L_{Aeq(15min)}$ noise level, dB(A)
RES01	Residential	Day: 42 Evening: 42 Night: 38	4
RES02	Residential		1
RES03	Residential		0
RES09	Residential		4
RES10	Residential		0
COM01	Commercial	63	8
COM02	Commercial		0
COM04	Commercial		4
COM09	Commercial		3
COM10	Commercial		6
COM11	Commercial		0
COM14	Commercial		12
IND02	Industrial	68	18
IND03	Industrial		15
IND04	Industrial		4
IND05	Industrial		1
IND06	Industrial		0
IND07	Industrial		9
IND09	Industrial		6
IND10	Industrial		0
IND11	Industrial		0
IND14	Industrial		5
IND15	Industrial		1
MED01	Medical	43	0

5.3.3 Sleep disturbance

The assessment of sleep disturbance from the use and operation of the Proposal is based on the following scenario, and is assessed against the relevant criteria presented in Section 3.4.2. It is expected that maximum noise events from within the restaurant would be similar to this or less:

- a car door slam, sudden vehicle acceleration or tyre squeal at any location within the Proposal site,– SWL 100 dB(A).

The results of the sleep disturbance noise assessment against residential receivers is presented in Table 5-7. All predicted L_{Amax} noise levels are below the sleep disturbance screening criteria, and as such no sleep disturbance impacts are anticipated during operation of the Proposal.

Table 5-7 Sleep disturbance assessment results

Receiver ID	Receiver type	Criteria L_{Amax}, dB(A)	Predicted L_{Amax} noise level, dB(A)
RES01	Residential	52	45
RES02			42
RES03			39
RES09			43
RES10			40

5.4 Road traffic noise impacts

The RNP recommends that "*any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without development' scenario."* Operational traffic routes and numbers have been sourced from *St Marys Station Commuter Car Park Upgrade – Traffic & Transport Access Impact Assessment* (Mott MacDonald, September 2020).

As no hourly traffic data for the entire day was available at the time of this assessment, the 2 dB screening testing has been for the time period of maximum impact, when the greatest number of traffic will be arriving/departing the Proposal site during the morning an evening peak periods respectively. Road traffic noise levels have been calculated based on the *Road Traffic Noise Estimator* tool within the *Construction and maintenance noise estimator* (TfNSW, 2018), and are presented below in Table 5-8. These are based off the sum of existing and additional traffic numbers as a result of the Proposal.

Table 5-8 Operational traffic noise assessment

Road	Time period	Existing traffic volumes		Additional traffic volumes		Difference in noise level, dB
		Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Harris Street	AM peak	78	7	86	0	***2.1***
	PM peak	93	2	5	0	0.0
Forrester Road – south of Glossop Street	AM peak	273	28	80	0	0.6
	PM peak	433	22	142	0	0.9
Forrester Road – north of Glossop Street	AM peak	1498	194	75	0	0.3
	PM peak	1757	97	69	0	0.1
Glossop Street	AM peak	1373	118	86	0	0.1
	PM peak	1685	106	72	0	0.1

Road	Time period	Existing traffic volumes		Additional traffic volumes		Difference in noise level, dB
		Light vehicles	Heavy vehicles	Light vehicles	Heavy vehicles	
Debrincat Avenue	AM peak	925	2	5	0	0.1
	PM peak	971	3	5	0	0.1

A predicted increase in road traffic noise levels of 2.1 dB has been identified for Harris Street in the morning peak period, and as such a detailed noise assessment has also been undertaken. Resulting road traffic noise levels from the Proposal along Harris Street have been modelled to the nearest residential receiver, and the results have been presented in Table 5-9. The results of the detailed assessment indicate that operational road traffic noise levels are compliant with the requirements of the RNP.

Table 5-9 Detailed operational road traffic noise assessment

Parameter	Value
Calculation method	CoRTN[1], L_{Aeq} = L10 – 3.0 dB
Traffic speeds	50 km/hr
Number of vehicles / hour	171
Heavy vehicle percentage	8.0 %
Road surface correction	No correction for low traffic speeds
Predicted incident road noise level	$L_{Aeq(1hr)}$ 45.8 dB(A)
Predicted incident façade corrected road noise level	***$L_{Aeq(1hr)}$ 48.8 dB(A)***[2, 3]
Criteria	$L_{Aeq(1hr)}$ 55 dB(A)[4]

Note 1: Comparison of Road Traffic Noise Prediction Models.

Note 2: A + 2.5 dB correction factor has been applied as the road traffic noise criteria is presented in the RNP as façade corrected.

Note 3: The most affected residential receiver was RES09 at a distance of 160 metres.

Note 4: As per Table 3-10 for local roads during the day period. Compliance with RNP is predicted.

6. Mitigation measures

6.1 Construction noise

6.1.1 Standard mitigation measures

Mitigation recommendations are provided in Table 6-1 to reduce the noise levels during construction activities, and have been sourced from Section 8.1 of the CNVS. These standard mitigation measures shall be applied to mitigate noise and vibration impacts of the Proposal where reasonable and feasible.

Table 6-1 Construction noise mitigation measures

Action required	Details
Management measures	
Implementation of any Proposal specific mitigation measures required	In addition to the measures set out in this table, any Proposal specific mitigation measures identified in the REF must be implemented.
Implement stakeholder consultation measures	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least seven days prior to commencement of relevant works. In addition to periodic notification, the following strategies may be adopted on a case-by-case basis: • Proposal specific website • Proposal Infoline • construction response line • email distribution list • web-based surveys • social media • community and stakeholder meetings and • community based forums (if required by approval conditions)
Register of noise and vibration sensitive receivers	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • address of receiver • category of receiver • contact name and phone number The register may be included as part of the Proposal's Community Liaison Plan or similar document and maintained in accordance with the requirements of this plan.
Construction hours and scheduling	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating noise with special audible characteristics and/or vibration levels should be scheduled during less sensitive time periods.

Action required	Details
Construction respite period	Noise with special audible characteristics and vibration generating activities (including jack and rock hammering, sheet and pile driving, rock breaking and vibratory rolling) may only be carried out in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than 1 hour respite between ceasing and recommencing any of the work. No more than two consecutive nights of noise with special audible characteristics and/or vibration generating work may be undertaken in the same Noise Catchment Area (NCA) over any 7-day period, unless otherwise approved by the relevant authority.
Site inductions	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all relevant Proposal specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on noise generating activities with special audible characteristics • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.
Behavioural practices	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.
Monitoring	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Source control measures	
Plan worksites and activities to minimise noise and vibration	Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site.
Equipment selection	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits.
Maximum noise levels	The noise of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels in Appendix C of the CNVS (TfNSW, 2019).
Use and siting of plant	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers.

Action required	Details
Non-tonal reversing alarms	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work, including delivery vehicles.
Minimise disturbance arising from delivery of goods to construction sites	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.
Construction related traffic	Schedule and route vehicle movements away from sensitive receivers and during less sensitive times. Limit the speed of vehicles and avoid the use of engine compression brakes. Maximise on-site storage capacity to reduce the need for truck movements during sensitive times.
Silencers on mobile plant	Where possible reduce noise from mobile plant through additional fittings including: • residential grade mufflers • damped hammers such as “City” Model Rammer Hammers • air parking brake engagement is silenced.
Prefabrication of materials off-site	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.
Engine compression brakes	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer that complies with the National Transport Commissions ‘in-service test procedure’ and standard.
Path control measures	
Shield stationary noise sources such as pumps	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436:1981 lists materials suitable for shielding
Shield sensitive receivers from noisy activities	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

6.1.2 Additional mitigation measures

The CNVS provides the following information regarding further mitigation measures for certain receivers exceeding noise management levels, and are presented below in Table 6-2. The Additional Mitigation Measures Matrices (AMMM) would be used to determine the additional measures after the application of standard mitigation measures where reasonable and feasible.

Table 6-2 CNVS additional management measures

Measure	Description	Abbreviation
Periodic Notification	For each TfNSW Infrastructure and Services Division (I&S) project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the Proposal postal and/or email mailing lists. Periodic notifications provide an overview of current and upcoming works across the Proposal and other topics of interest. The objective is to engage, inform and provide Proposal-specific messages. Advanced warning of potential disruptions (eg traffic changes or noisy works) can assist in reducing the impact on stakeholders. The approval conditions for projects specify requirements for notification to sensitive receivers where works may impact on them. Content and length is determined on a project-by-project basis and must be approved by TfNSW prior to distribution. Most projects distribute notifications on a monthly basis. Each notification is graphically designed within a branded template. In certain circumstances media advertising may also be used to supplement Periodic Notifications, where considered effective. Periodic Notification may be advised by the I&S Community Engagement Team in cases where AMMM are not triggered as shown in Tables 9 to 11, for example where community impacts extend beyond noise and vibration (traffic, light spill, parking etc). In these circumstances the I&S Community Engagement Team will determine the community engagement strategy on a case-by-case basis.	PN
Verification Monitoring	Verification monitoring of noise and/or vibration during construction may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver has been identified). Monitoring can be in the form of either unattended logging (ie for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (ie for specific periods of construction noise). The purpose of monitoring is to confirm that: • construction noise and vibration from the Proposal are consistent with the predictions in the noise assessment • mitigation and management of construction noise and vibration is appropriate for receivers affected by the works Where noise monitoring finds that the actual noise levels exceed those predicted in the noise assessment then immediate refinement of mitigation measures may be required and the Construction Noise and Vibration Impact Statement (CNVIS) amended.	V
Specific Notification	Specific notifications are in the form of a personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing.	SN

Measure	Description	Abbreviation
	• letters may be letterbox dropped or hand distributed • phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and their specific needs • individual briefings are used to inform stakeholders about the impacts of noisy activities and mitigation measures that will be implemented. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the Proposal Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.	
Respite Offer	The purpose of a Proposal specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise prepurchased movie tickets, bowling activities, meal vouchers or similar offer. This measure is determined on a case-by-case basis, and may not be applicable to all I&S projects.	RO
Alternative Accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts. Alternative accommodation will be determined on a case-by-case basis and should provide a like-for-like replacement for permanent residents, including provisions for pets, where reasonable and feasible.	AA
Alternative construction methodology	Where the vibration assessment identifies that the proposed construction method has a high risk of causing structural damage to buildings near the works, the proponent will need to consider alternative construction options that achieve compliance with the Vibration Management Level (VMLs) for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.	AC
Respite Period	OOHW during evening and night periods will be restricted so that receivers are impacted for no more than 3 consecutive evenings and no more than 2 consecutive nights in the same NCA in any one week. A minimum respite period of 4 evenings/5 nights shall be implemented between periods of evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (eg to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHW Approval Protocol. Note; this management measure does not apply to OOHW Period 1 – Days.	RP

Measure	Description	Abbreviation
Duration Reduction	Where Respite Periods (see management measure above) are considered to be counterproductive to reducing noise and vibration impacts to the community it may be beneficial to increase the number of consecutive evenings and/or nights through Duration Reduction to minimise the duration of the activity. This measure is determined on a project-by-project basis, and may not be applicable to all I&S projects. Impacted receivers must be consulted and evidence of community support for the Duration Reduction must be provided as justification for the Duration Reduction. A community engagement strategy must be agreed with and implemented in consultation with I&S Community Engagement Representatives.	DR

The CNVS outlines the various trigger levels to warrant these mitigation measures, and such is presented below in. The predicted noise levels for each receiver, and hence any additional noise mitigation measures, are presented in Appendix B.

Table 6-3 Triggers for additional mitigation measures – airborne noise

Construction hours	Receiver perception	dB(A) above RBL[1]	dB(A) above NML	Additional management measures
Standard Hours: Mon – Fri (7am – 6pm), Sat (8am – 1pm), Sun/Public Holiday (Nil)	Noticeable	5 to 10	0	-
	Clearly audible	> 10 to 20	< 10	-
	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 0	PN, V
	75 dB(A) or greater	N/A	N/A	PN, V, SN
OOHW Period 1: Mon – Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Public Holiday (8am – 6pm)	Noticeable	5 to 10	< 5	-
	Clearly audible	> 10 to 20	5 to 15	PN, RP[2], DR[2]
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO, RP[2], DR[2]
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP[2], DR[2]
OOHW Period 2: Mon – Sat (12am – 7am), Sun/Pub Holiday (12am – 8am, 6pm – 12am)	Noticeable	5 to 10	< 5	PN
	Clearly audible	> 10 to 20	5 to 15	PN, V, SN, RO[3], RP[2], DR[2]
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO[3], RP[2], DR[2]
	Highly intrusive	> 30	> 25	PN, V, SN, RO[3], AA[2], RP[2], DR

Note 1: SWLs used for the purpose of estimating noise impact shall be increased by 5dB(A) where works will include: power saws for the cutting of timber, masonry & steel; grinding of metal, concrete or masonry; rock/line drilling; bitumen milling & profiling; jack hammering, rock hammering & rock breaking; or impact piling as a correction factor for noise with special audible characteristics. It is noted that this correction factor is automatically calculate under Step 2 of the Construction Noise Estimator Tool (see Appendix E).

Note 2: Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (ie Saturday 6am - 7am & 1pm - 6pm, Sundays / public holidays 8am - 6pm).

Note 3: Respite offers during OOHW Period 2 are only applicable for evening periods (ie Sundays / Public Holidays 6pm - 10pm) and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

6.1.3 Ground floor commercial gym

A commercial gym is located in the ground floor of the existing carpark structure within the Proposal site, which would likely be operational during construction works. It is likely that this receiver would experience construction noise impacts as a result of the Proposal. Due to its operation as a gym which would likely have higher internal noise levels, significant noise impacts are not anticipated. Despite such, it is recommended that they are notified of construction prior to works commencing.

6.2 Construction vibration

As discussed above in Section 4.3 no construction vibration impacts are anticipated. As such, no specific construction vibration mitigation measures are recommended.

Where construction is required within the safe working buffer distance, alternative work methods are required, such as using smaller equipment. If no alternative work method is feasible or reasonable, then compliance vibration monitoring should be undertaken where works are required within the safe working buffer distance and include:

- site tests to review the measured frequency content in order to determine the structural damage criteria as per Table 3-7 for standard dwellings
- continuous vibration monitoring with a visual alarm installed to warn the equipment operator when the structural damage vibration criteria (considering frequency content) is exceeded.

6.3 Operational noise

Operational noise levels due to the operation of the Proposal are predicted to be below the project noise trigger levels during all assessment period at all modelled receivers. In order to ensure that acoustic compliance is maintained, the following mitigation measures are recommended. These should be incorporated as part of the design where feasible and reasonable:

- vehicle speeds within the car park be limited to 10 km/h
- speed bumps are to be installed at the centre of each aisle to limit vehicle speeds within the car park
- a low squeal car park surface should be installed
- mechanical plant should be well maintained and operational in an efficient manner. This is to limit any excess noise generation that may arise when plant is not functioning correctly.

7. Conclusion

Noise and vibration impacts for the construction and operational phases of the Proposal have been assessed. The assessment included appropriate construction and operational noise and vibration criteria based on noise monitoring levels provided by Transport for NSW.

7.1 Construction noise

Construction for the Proposal is expected to commence in early 2021 and take around 12 months to complete. Construction activities are proposed to be undertaken during standard construction hours only.

The predicted noise levels are expected to exceed the noise management levels during standard construction hours, with no residential receivers experiencing noise levels above the highly noise affected management level of 75 dB(A).No construction activities are expected to take place outside of standard construction hours.

Traffic noise impacts due to construction are not expected as noise levels along the construction traffic is not predicted to significantly increase road traffic noise levels.

It is typical for construction projects to exceed the construction noise management levels. Any impacts due to construction works are temporary in nature and would not represent a permanent impact on the community and surrounding environment. The predicted noise levels are generally conservative and would only be experienced for limited periods during construction. Impacts may be reduced through the introduction of feasible and reasonable mitigation measures which have been recommended in section 6.1.

7.2 Construction vibration

Safe working distances for vibration activities have been identified for standard structures and heritage listed structures, which includes St Marys Station as a heritage listed structure. Site specific safe working distances are to be established on-site prior to vibration generating works commencing.

No structures, aside from the existing carpark structure within the proposal boundary, are identified within the safe working distances.

7.3 Operational noise

Operational noise levels from the use and operation of the Proposal is expected to comply with the relevant criteria for operational noise, sleep disturbance and road traffic noise. Mitigation measures are presented in section 6.3 to ensure that operational noise levels for the Proposal remain at complaint levels.

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Appendices

Appendix A – Acoustic concepts and terminology

Definition of 'noise'

Sound may be defined as any pressure variation that the human ear can detect. The terms "sound" and "noise" are more or less interchangeable however, "noise" is generally often referred to as unwanted sound.

Factors that contribute the environmental noise

Noise from an activity such as construction noise or noise during the operation of a facility at a given receiver location can be affected by a number of different factors, including:

- How loud the source activity is and the type of source:
  - Point (for eg a pump or motor)
  - Line (for eg a road or railway line)
  - Area (for eg the external façades of an industrial building)
- The distance from the source to receiver
- The type of ground between the sound and receiver locations (eg hard surfaces or porous ground)
- The ground topography between the source and the receiver. For eg is it flat or hilly? Blocking the line of sight will generally reduce the noise level for the receiver
- Obstacles that may block the line of sight between the source and the receiver. For eg buildings or noise walls
- Atmospheric absorption (dependent on humidity and temperature)
- Meteorological conditions that may increase or reduce environmental sound propagation (for eg wind direction or temperature inversions)

Noise measurements

Noise is generally measured using a specially designed 'sound level meter' (SLM) and must meet internationally recognized performance standards. To avoid expressing sound or noise in terms of Pa, which could involve some unmanageable numbers, the logarithmic decibel or dB scale is used. The scale uses the hearing threshold of 20 μPa or 20 x 10^{-6} Pa as the reference level and is defined as 0 dB.

Typical noise levels

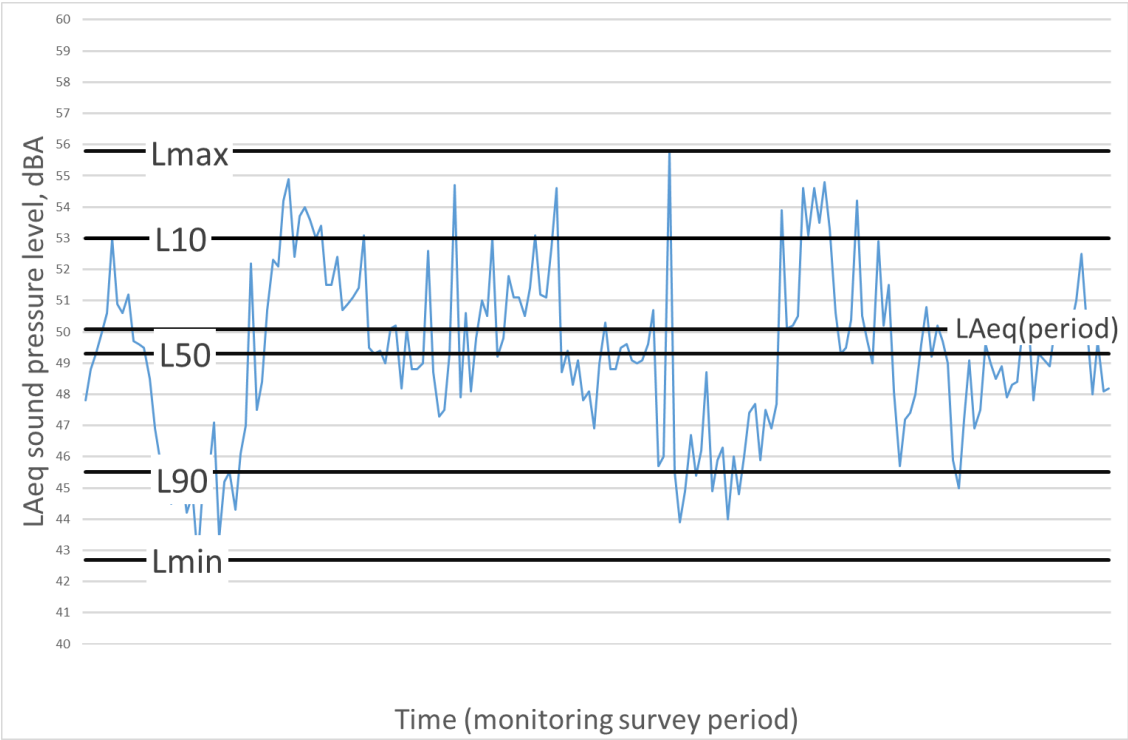
The table below presents typical noise sources for each various sound pressure levels and a corresponding subjective noise level description.

Subjective level	Sound pressure level (dB(A))	Typical sources
Silent	0	Threshold of hearing
Almost silent	20	Recording studio
Quiet	30	Bedroom
	40	Private office
Moderate	50	General office
	60	Department store
Loud	70	Loud television
	80	Kerb side of busy street
Very loud	90	Construction site
	100	Loud car horn (3 m away)

Subjective level	Sound pressure level (dB(A))	Typical sources
Extremely loud	110	Grinding on steel
	120	Heavy rock concert
Intolerable	130	Threshold for pain

Typical noise descriptors

Noise is represented by the descriptor L_{AN}, representing a statistical sound measurement recorded on the 'A' weighted scale. A typical noise monitoring chart is shown in the graph below along with the noise descriptors.



Where:

- L_{Amax}: The maximum sound level recorded during the measurement period.
- L_{Amin}: The minimum sound level recorded during the measurement period.
- $L_{A10(period)}$: The A-weighted sound pressure level that is exceeded for 10% of the measurement period.
- $L_{Aeq(period)}$: Equivalent sound pressure leve, the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
- $L_{A90(period)}$: The A-weighted sound pressure level that is exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise eg $L_{A90(15min)}$.

Changes in noise levels

The table below presents a qualitative description of average human responses to changes in noise levels.

Difference	Human response
Difference of 2 dB(A)	Generally imperceptible by the human ear
Difference of 5 dB(A)	Considered significant
Difference of 10 dB(A)	Perceived as a doubling (or halving) of the noise source
Addition of two identical noise levels	Increase levels by 3 dB(A)
Addition of second noise level of similar character	If the secondary noise level is a minimum 8 dB(A) below the primary noise level, the noise level will not significantly increase
Doubling of distance between source and receiver	Results in a 3 dB(A) decrease for a line source and 6 dB(A) for a point source
A doubling of traffic volume	Results in a 3 dB(A) increase in noise

Audibility of noise

The table below presents quantitative guidance and qualitative descriptions regarding the audibility of noise.

Audibility	Description
Inaudible	Noise source cannot be heard. The noise level is generally less than the background noise level, potentially by more than 10 dB(A) or greater
Barely audible	Characteristics of the noise is difficult to define or masked by extraneous noise. The noise level is generally 5-7 dB(A) below the background noise or ambient noise level, depending on the nature of the noise eg constant or intermittent
Just audible	Characteristics of the noise can be defined but extraneous noise sources are also contributing to the received noise. The noise level is typically below the background and ambient noise level.
Audible	Characteristics of the noise can be easily defined. The noise level may be at the level of the background noise and above.
Dominant	The noise source is significantly ‘louder’ than all other noise sources. The noise level will likely be significantly greater than the background noise level.

Types of noise sources

The table below offers a qualitative description of various noise types and provides the noise descriptor that is typically used to measure the type of noise.

Duration of the noise	Description
Continuous noise	Continuous noise is produced by equipment or activities that operates without interruption in the same mode, for eg blowers, pumps and processing equipment. Measuring for just a few minutes with hand-held equipment is sufficient to determine the noise level. If tones or low frequencies are heard, the frequency spectrum can be measured for documentation and further analysis. Continuous noise sources are generally captured by the L90 noise descriptor.
Intermittent noise	Intermittent noise is a noise level that increases and decreases rapidly. This might be caused by a train passing by, factory equipment that operates in cycles, or aircraft flying above. Intermittent noise is measured in a similar way to continuous noise, with a sound level meter. The duration of each occurrence and the time between each event is important to note. To gain a more reliable estimate of the noise level, multiple occurrences of the noise source is measured to gain a reliable estimate. Intermittent noise sources are generally captured by the Leq noise descriptor.
Impulsive noise	The noise from impacts or explosions, for eg from a pile driver, punch press or gunshot, is called impulsive noise. It is brief and abrupt, and its startling effect causes greater annoyance than would be expected from a simple measurement of sound pressure level. To quantify the impulsiveness of noise, the difference between a quickly responding and a slowly responding parameter can be used. Impulsive noise sources are generally captured by the Lmax or Lpeak noise descriptor.
Low frequency	Noise containing major components in the low-frequency range (10 hertz [Hz] to 160 Hz) of the frequency spectrum
Tonal noise	Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous.
Subject noise	The noise in question removed from any extraneous noise in the area
Offensive noise	The definition of offensive noise in the POEO Act is noise: (a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances: (i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or (ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or (b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations.

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).

Definition of '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.

Vibration descriptors

These may be expressed in terms of 'peak' velocity or 'rms' velocity. The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period. Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse. The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organisations.

How humans perceive 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.

Types of vibration

Vibration in buildings can be caused by many different external sources, including industrial, construction and transportation activities. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time). A description of each vibration type including examples are presented in the table below.

Vibration type	Description	Examples
Continuous vibration	Vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time). This type of vibration is assessed on the basis of weighted rms acceleration values	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery)
Impulsive vibration	A vibration source (continuous or intermittent) which has a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). This type of vibration is assessed on the basis of weighted rms acceleration values	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Interrupted periods of continuous (eg a drill) or repeated periods of impulsive vibration (eg a pile driver), or continuous vibration that varies significantly in magnitude. This type of vibration is assessed on the basis of vibration dose values	Trains, nearby intermittent 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 this would be assessed against impulsive vibration criteria

Typical vibration levels

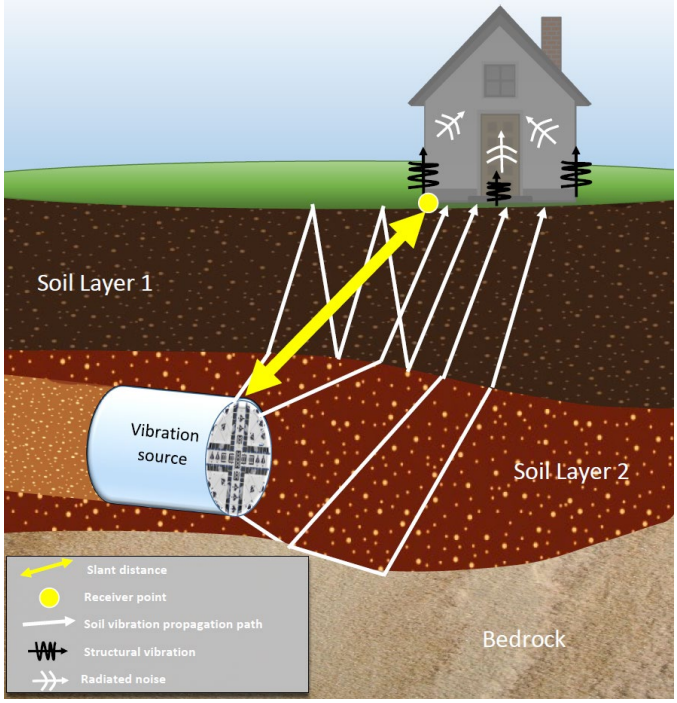
Typical ground vibration from civil construction activities occurs in the frequency range of approximately 8 Hz to 100 Hz. Within this frequency range, building contents such as blinds and pictures would commence visible movement at 0.5 mm/s. At vibration levels higher than 0.9 mm/s, rattling of windows, crockery or loose objects would be audible and annoying.

Velocity level (mm/s)	Typical source	Response
0.01	Typical background vibration level	Scanning electron microscopes to 50000 x amplification
0.03		500x amplification bench microscopes
0.1	Average passenger train vibration	Approximate threshold for human perception of vibration
0.3	Average freight train vibration Max passenger train vibration	Approx. residential annoyance for train passbys
1	Large rock breaker	Vibration level that will generally result in complaints
3	Blasting/ Impact pile driving	Threshold for minor cosmetic damage

Ground-borne noise and vibration

Noise that propagates through a structure as vibration and is radiated by vibrating wall, ceiling and floor surfaces is termed “ground-borne noise”, “regenerated noise”, or sometimes “structure borne noise”. Ground-borne noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air. Typical sources of ground-borne noise include tunnelling construction works or underground railway operations.

The figure below presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities that occur below the ground level (for eg a tunnel boring machine).



Acronyms and abbreviations

Term	Definition
AWS	Automatic Weather Station
BOM	Bureau of Meteorology
dB	Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics.
dB(A)	Decibel expressed with the frequency weighting filter used to measure 'A-weighted' sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at low and high frequencies.
dBZ or dBL	The unit used to measure 'Z-weighted' sound pressure levels with no weighting applied, linear.
CEMP	Construction Environmental Management Plan
CNVS	Construction Noise and Vibration Strategy (TfNSW, 2018)
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EPA	Environmental Protection Authority
ICNG	Interim Construction Noise Guideline (DECC, 2009).
NPfI	Noise Policy for Industry (EPA, 2017).
LAeq(period)	Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.
LA10(period)	The noise level exceeded for 10 per cent of the time and is approximately the average of the maximum noise levels.
LA90(period)	The sound pressure level that is exceeded for 90% of the measurement period.
LAmax	The absolute maximum noise level in a noise sample
NSW	New South Wales
OOHW	Out-of-hours Works
PPV	Peak particle velocity is the maximum vector sum of three orthogonal time-synchronized velocity components regardless of whether these component maxima occurred simultaneously.
RBL	Rating Background Level . The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
rms	Root Mean Square Amplitude (rms) is the square root of the average of the squared values of the waveform. In the case of the sine wave, the RMS value is 0.707 times the peak value, but this is only true in the case of the sine wave.
RNP	Road Noise Policy (DECCW, 2011).
SEARs	Secretary's Environmental Assessment Requirements
SPL	Sound Pressure Level
SWL	Sound Power Level
SWRO	Seawater Reverse Osmosis
Rw	Weighted Sound Reduction Index which provides a single-number quantity which characterises the airborne sound insulation of a material or building element over a range of frequencies

Term	Definition
TBM	Tunnel Boring Machine
VDV	Vibration dose value - As defined in BS6472 – 2008, VDV is given by the fourth root of the integral of the fourth power of the frequency weighted acceleration.
WFP	Water Filtration Plant

Common terms

Term	Definition
A weighting	The human ear responds more to frequencies between 500 Hz and 8 kHz and is less sensitive to very low-pitch or high-pitch noises. The frequency weightings used in sound level measurements are often related to the response of the human ear to ensure that the meter better responds to what you actually hear
Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far. This is described using the Leq descriptor
Background noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L90 descriptor
Compliance	The process of checking that source noise levels meet with the noise limits in a statutory context.
Determining authority	Defined by Section 110 of the Environmental Planning and Assessment Act 1979 as 'a Minister or public authority and, in relation to any activity, means the Minister or public authority by or on whose behalf the activity is or is to be carried out or any Minister or public authority whose approval is required in order to enable the activity to be carried out.'
Extraneous noise	Noise resulting from activities that are not typical of the area. Atypical activities may include construction, and traffic generated by holiday periods and by special events such as concerts or sporting events. Normal daily traffic is not considered to be extraneous
EIS	Environmental Impact Assessment
Feasible and reasonable measures	Feasibility relates to engineering considerations and what is practical to build. reasonableness relates to the application of judgement in arriving at a decision, taking into account the following factors: - Noise mitigation benefits (amount of noise reduction provided, number of people protected); Cost of mitigation (cost of mitigation versus benefit provided); Community views (aesthetic impacts and community wishes); Noise levels for affected land uses (existing and future levels, and changes in noise levels)
Ground-borne noise	Noise heard within a building that is generated by vibration transmitted through the ground into the structure from construction works, sometimes referred to as 'regenerated noise' or 'structure-borne noise'. Ground-borne noise can be more noticeable than airborne noise for underground works such as tunnelling. The ground-borne noise levels are only applicable when ground-borne noise levels are higher than airborne noise levels.

Term	Definition
Ground-borne vibration	Vibration transmitted from a source to a receptor via the ground
Hertz	The measure of frequency of sound wave oscillations per second. 1 oscillation per second equals 1 hertz.
Masking	The phenomenon of one sound interfering with the perception of another sound. For example, the interference of traffic noise with use of a public telephone on a busy street.
Maximum noise event	The loudest event or events within a given period of time. This is generally described using the Lmax descriptor
Meteorological conditions	Wind and temperature inversion conditions
Most-affected location	Location(s) that experience (or will likely experience) the greatest noise impact from the construction works under consideration. In determining these locations, existing background noise levels, noise source location(s), distance and any shielding between the construction works (or proposed works) and the residences and other sensitive land uses need to be considered.
Noise management level	The Noise Management Level (NML) as defined as the EPA's ICNG. To be measured and assessed at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the residential property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most affected point within 30 m of the residence.
Noise sensitive receiver	An area or place potentially affected by noise which includes: • a residential dwelling • an educational institution, library, childcare centre or kindergarten • a hospital, surgery or other medical institution • an active (eg sports field, golf course) or passive (eg national park) recreational area • commercial or industrial premises • a place of worship.
Non-compliance	Development is deemed to be in non-compliance with its noise consent/ licence conditions if the monitored noise levels exceed its statutory noise limit (exceptions may be given if the noise level exceeds by less than 2 dB)
Octave	A division of the frequency range into bands, the upper frequency limit
Project noise trigger level	Target noise levels for a particular noise generating facility. They are based on the most stringent of the intrusive criteria or amenity criteria. Which of the two criteria is the most stringent is determined by measuring the level and nature of existing noise in the area surrounding the actual or propose noise generating facility.
Proposal	The construction and operation of the SWRO site, the modifications to the Illawarra WFP site and associated infrastructure including the power route, the delivery pipeline, the se and the intake and outlet tunnels.
Proposal site	The immediate location of the Proposal, which is the area that has the potential to be directly disturbed by construction and operation.
Resonance	Resonance describes the phenomenon of increased amplitude that occurs when the frequency of a periodically applied force is equal or close to a natural frequency of the system on which it acts.

Term	Definition
Study area	Land in the vicinity of, and including, the Proposal site. The ‘study area’ is the wider area surrounding the Proposal site.
Temperature inversion	An atmospheric condition in which temperature increases with height above the ground.
Third-octave	Single octave bands divided into three parts.

Appendix B – Predicted construction noise levels, dB(A)

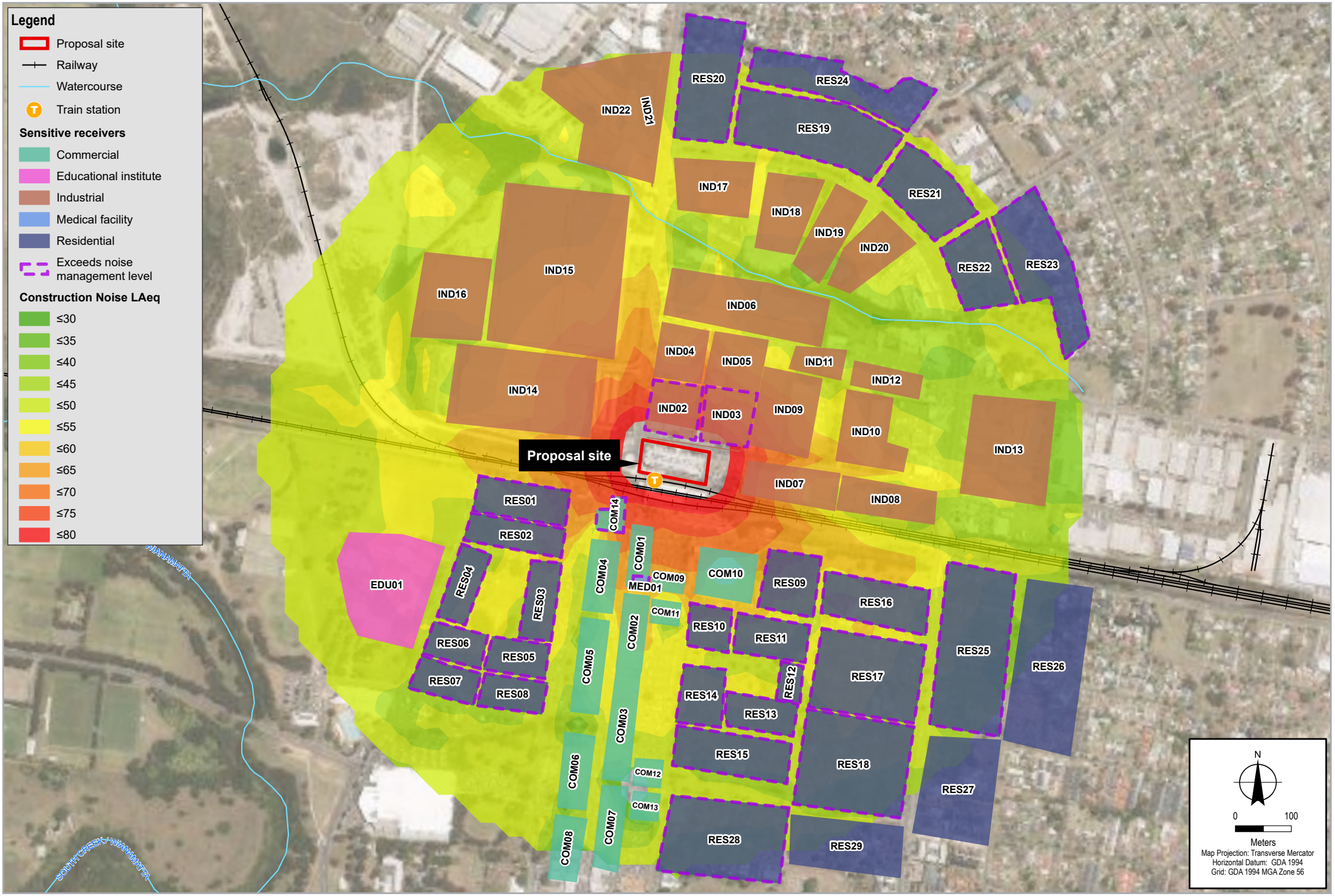
Receiver ID	Receiver Type	NCA	CS01	CS02	CS03	CS04	Additional management measures
Residential: Noticeable / Clearly audible Moderately intrusive Highly intrusive Bold Highly noise affected							
Non-residential: Exceeds noise management level							
COM01	Commercial	NCA01	57 - 38	70 - 43	64 - 42	59 - 39	N
COM02	Commercial	NCA01	48 - 40	60 - 49	54 - 45	49 - 38	-
COM03	Commercial	NCA01	41 - 27	51 - 31	46 - 31	41 - 27	-
COM04	Commercial	NCA01	54 - 33	67 - 38	61 - 37	55 - 33	-
COM05	Commercial	NCA01	46 - 25	57 - 32	51 - 30	47 - 26	-
COM06	Commercial	NCA01	39 - 27	49 - 32	44 - 32	40 - 28	-
COM07	Commercial	NCA01	37 - 24	48 - 28	42 - 28	37 - 24	-
COM08	Commercial	NCA01	36 - 23	46 - 27	41 - 27	37 - 23	-
COM09	Commercial	NCA01	52 - 37	65 - 42	59 - 42	52 - 37	-
COM10	Commercial	NCA01	55 - 42	68 - 48	62 - 46	55 - 42	-
COM11	Commercial	NCA01	47 - 33	59 - 39	53 - 38	49 - 33	-
COM12	Commercial	NCA01	38 - 31	49 - 35	43 - 35	40 - 30	-
COM13	Commercial	NCA01	37 - 25	48 - 29	42 - 29	38 - 24	-
COM14	Commercial	NCA01	62 - 38	75 - 45	69 - 42	64 - 38	N
EDU01	Educational institute	NCA01	42 - 37	51 - 48	46 - 42	42 - 34	-
IND02	Industrial	NCA01	77 - 56	89 - 69	83 - 63	66 - 54	N
IND03	Industrial	NCA01	76 - 52	88 - 64	82 - 58	60 - 48	N
IND04	Industrial	NCA01	54 - 43	66 - 55	60 - 50	52 - 41	-
IND05	Industrial	NCA01	55 - 41	68 - 53	62 - 47	49 - 39	-
IND06	Industrial	NCA01	47 - 32	59 - 44	53 - 38	39 - 31	-
IND07	Industrial	NCA01	61 - 39	74 - 50	68 - 44	55 - 36	-
IND08	Industrial	NCA01	43 - 33	55 - 44	49 - 38	43 - 26	-
IND09	Industrial	NCA01	60 - 41	73 - 53	66 - 47	54 - 37	-
IND10	Industrial	NCA01	47 - 36	59 - 47	53 - 41	45 - 30	-
IND11	Industrial	NCA01	39 - 30	50 - 41	45 - 36	36 - 28	-
IND12	Industrial	NCA01	37 - 31	48 - 40	42 - 36	33 - 25	-
IND13	Industrial	NCA01	40 - 27	51 - 38	45 - 32	39 - 28	-
IND14	Industrial	NCA01	56 - 43	68 - 55	63 - 49	57 - 33	-
IND15	Industrial	NCA01	50 - 33	63 - 45	57 - 39	52 - 34	-
IND16	Industrial	NCA01	41 - 30	53 - 41	47 - 35	43 - 28	-
IND17	Industrial	NCA01	40 - 29	52 - 41	46 - 35	41 - 29	-
IND18	Industrial	NCA01	40 - 28	51 - 39	45 - 34	39 - 29	-
IND19	Industrial	NCA01	39 - 26	50 - 37	44 - 32	40 - 25	-
IND20	Industrial	NCA01	38 - 28	50 - 39	44 - 34	40 - 25	-
IND21	Industrial	NCA01	41 - 33	53 - 45	47 - 38	43 - 35	-
IND22	Industrial	NCA01	42 - 31	53 - 42	47 - 37	43 - 33	-
MED01	Medical facility	NCA01	50 - 39	62 - 44	56 - 43	49 - 39	N
RES01	Residential	NCA01	**53 - 43**	**66 - 54**	**60 - 48**	**55 - 38**	N, V
RES02	Residential	NCA01	**50 - 36**	**61 - 47**	**56 - 42**	**51 - 37**	N, V
RES03	Residential	NCA01	46 - 40	**57 - 50**	**51 - 45**	47 - 36	-
RES04	Residential	NCA01	42 - 35	**53 - 46**	47 - 40	43 - 34	-
RES05	Residential	NCA01	41 - 37	**51 - 48**	46 - 42	41 - 36	-
RES06	Residential	NCA01	42 - 37	**53 - 48**	47 - 42	43 - 37	-
RES07	Residential	NCA01	38 - 34	**50 - 45**	44 - 39	40 - 34	-
RES08	Residential	NCA01	39 - 35	**49 - 46**	44 - 41	40 - 34	-
RES09	Residential	NCA01	**52 - 43**	**65 - 54**	**59 - 49**	**50 - 43**	N, V
RES10	Residential	NCA01	47 - 42	**59 - 53**	**53 - 47**	**49 - 43**	N, V
RES11	Residential	NCA01	46 - 37	**57 - 49**	**51 - 43**	45 - 38	-
RES12	Residential	NCA01	41 - 37	**51 - 48**	46 - 43	41 - 37	-
RES13	Residential	NCA01	41 - 38	**52 - 49**	46 - 43	42 - 39	-
RES14	Residential	NCA01	43 - 37	**54 - 48**	**48 - 42**	43 - 38	-
RES15	Residential	NCA01	39 - 36	**50 - 47**	44 - 41	41 - 35	-

Receiver ID	Receiver Type	NCA	CS01	CS02	CS03	CS04	Additional management measures
Residential: Noticeable / Clearly audible Moderately intrusive Highly intrusive Bold Highly noise affected							
Non-residential: Exceeds noise management level							
RES16	Residential	NCA01	45 - 38	**57 - 49**	**51 - 44**	45 - 38	-
RES17	Residential	NCA01	44 - 37	**56 - 48**	**50 - 42**	44 - 37	-
RES18	Residential	NCA01	40 - 34	**53 - 44**	46 - 39	40 - 35	-
RES19	Residential	NCA01	39 - 34	**51 - 46**	44 - 40	39 - 35	-
RES20	Residential	NCA01	39 - 34	**50 - 45**	44 - 39	41 - 34	-
RES21	Residential	NCA01	38 - 34	**50 - 46**	44 - 40	40 - 36	-
RES22	Residential	NCA01	38 - 34	**49 - 45**	43 - 39	39 - 36	-
RES23	Residential	NCA01	37 - 33	**48 - 43**	42 - 37	38 - 34	-
RES24	Residential	NCA01	37 - 33	**49 - 43**	42 - 38	38 - 33	-
RES25	Residential	NCA01	39 - 33	**50 - 44**	44 - 38	39 - 35	-
RES26	Residential	NCA01	35 - 30	46 - 40	40 - 34	36 - 30	-
RES27	Residential	NCA01	35 - 29	46 - 40	40 - 34	36 - 31	-
RES28	Residential	NCA01	37 - 34	**48 - 44**	42 - 39	38 - 35	-
RES29	Residential	NCA01	36 - 33	47 - 44	41 - 38	37 - 34	-

Appendix C – Predicted construction noise contours

Construction Scenario 1

\\ghdnet\ghd\AU\Sydney\Projects\21\12539071\GIS\Maps\Deliverables\12539071 - St Marys Commuter Car Park Expansion\NV.aprx Print date: 16 Nov 2020 - 12:31 Imagery: SIXMAPS, 2020; Land Zoning: EPI NSW, 2020; Rail: SIXMAPS, 2020; Cadastre: SIXMAPS, 2020; Train Station Location: EPI, 2020



\\ghdnet\ghd\AU\Sydney\Projects\21\12539071\GIS\Maps\Deliverables\12539071 - St Marys Commuter Car Park Expansion\NV.aprx Print date: 16 Nov 2020 - 12:28 Imagery: SIXMAPS, 2020; Land Zoning: EPI NSW, 2020; Rail: SIXMAPS, 2020; Cadastre: SIXMAPS, 2020; Train Station Location: EPI, 2020

Construction Scenario 2

Construction Scenario 3

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\\ghdnet\ghd\AU\Sydney\Projects\21\12539071\GIS\Maps\Deliverables\12539071 - St Marys Commuter Car Park Expansion\NV.aprx Print date: 16 Nov 2020 - 12:30 Imagery: SIXMAPS, 2020; Land Zoning: EPI NSW, 2020; Rail: SIXMAPS, 2020; Cadastre: SIXMAPS, 2020; Train Station Location: EPI, 2020

Construction Scenario 4

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12539071-74236-14/https://projectsportal.ghd.com/sites/pp15_01/stmaryscommutercarpa/ProjectDocs/12539071-REP_St Marys Commuter Car Park Extension_NVIA.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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