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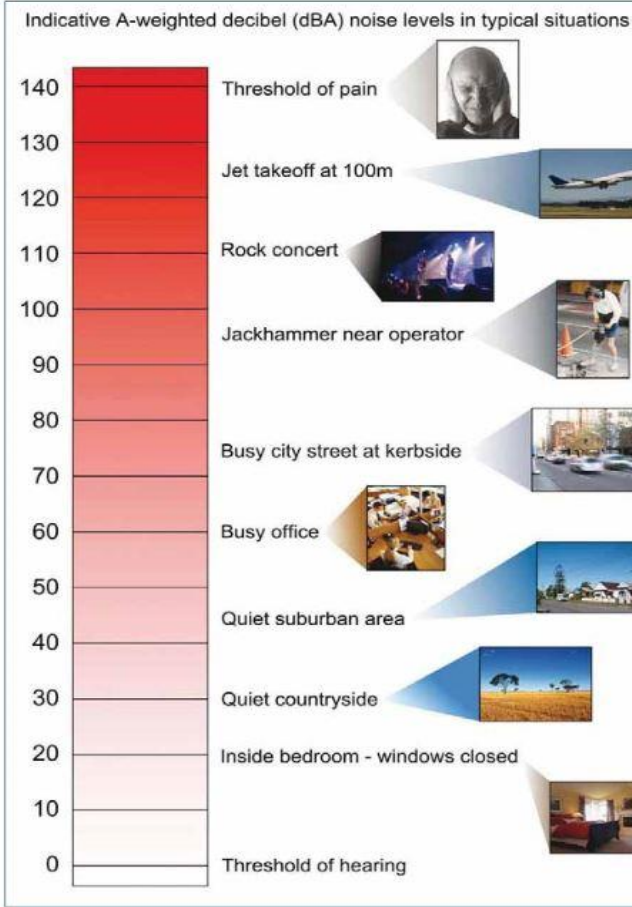
Noise and Vibration Assessment, Warwick Farm
Commuter Carpark - July 2020

Relationships Attention Professional Trust

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Glossary of Acoustic Terms

Term	Definition
dB	<p>Decibel is the unit used for expressing the sound pressure level (SPL) or power level (SWL) in acoustics. The picture below indicates typical noise levels from common noise sources.</p> 
dB(A)	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 very low and very high frequencies.
$L_{Aeq}(\text{period})$	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.
$L_{A10}(\text{period})$	The sound pressure level that is exceeded for 10% of the measurement period.
$L_{A90}(\text{period})$	The sound pressure level that is exceeded for 90% of the measurement period.
L_{Amax}	The maximum sound level recorded during the measurement period.
Noise sensitive receiver	An area or place potentially affected by noise which includes:

	<p>A residential dwelling.</p> <p>An educational institution, library, childcare centre or kindergarten.</p> <p>A hospital, surgery or other medical institution.</p> <p>An active (e.g. sports field, golf course) or passive (e.g. national park) recreational area.</p> <p>Commercial or industrial premises.</p> <p>A place of worship.</p>
Rating Background Level (RBL)	The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
Feasible and Reasonable (Noise Policy for Industry Definition)	<p>Feasible mitigation measure is a noise mitigation measure that can be engineered and is practical to build and/or implement, given project constraints such as safety, maintenance and reliability requirements.</p> <p>Selecting Reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure. To make a judgement, consider the following:</p> <p>Noise impacts</p> <p>Noise mitigation benefits</p> <p>Cost effectiveness of noise mitigation</p> <p>Community views.</p>
Sound power level (SWL)	The sound power level of a noise source is the sound energy emitted by the source. Notated as SWL, sound power levels are typically presented in dB(A).

1. Executive Summary

The NSW Government recognises the important role Commuter Car Parks (CCPs) continue to play in improving the quality of access to public transport in the customer's first and last mile. The provision of CCP's increase public transport patronage and make public transport more accessible to all customers. This is particularly important in lower-density areas, where it is both expensive and challenging to provide frequent bus services and ensure access to transport for the elderly or people with a disability.

The NSW Government has committed to the provision of up to an additional 250 commuter car spaces at Warwick Farm. TfNSW and FutureRail have investigated a long-list of site alternatives by utilising a Site Evaluation Framework to develop, evaluate and identify preferred CCP sites. TfNSW investigated two alternate sites at Warwick Farm, and this was carried forward to the Multi-criteria Analysis (MCA). The preferred site at Warwick Farm is the existing multi-storey commuter car park to the west of the station.

The Proposal is to construct an additional two floors over the existing MSCP building within the Warwick Farm Station precinct to provide an additional 250 commuter car parking spaces with the total of 732 car park spaces.

This noise and vibration impact assessment forms part of the Review of Environmental Factors (REF) which assesses the potential impacts of the Proposal on the environment. Relevant guidelines and assessment procedures have been followed to ensure all applicable State requirements have been considered.

A survey has been undertaken of the existing conditions in the Proposal area. Background noise levels have been monitored at a representative location to identify the existing noise environment in the Proposal area. The existing noise environment allows this assessment to establish appropriate noise criteria.

A construction noise impact assessment has been conducted with consideration to the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) and *Construction Noise and Vibration Strategy* (CNVS) (TfNSW, 2018). Reasonable worst-case construction scenarios have been assessed. Construction of the Proposal is expected to occur during standard construction hours. However out of hours scenarios have also been assessed.

The assessment of noise associated with the construction of the Proposal indicates some exceedances of the ICNG noise management levels at the most affected sensitive receivers. Exceedances of the noise management levels occur during the day and night at the most affected sensitive receivers during certain activities. The magnitude of these impacts is consistent with similar construction projects and highlights the need for effective noise mitigation and management planning.

Measures have been recommended to mitigate the construction noise impacts at adjacent sensitive receivers. Specific noise management and mitigation measures would be detailed in the contractor's Construction Noise and Vibration Management Plan.

Minimum working distances for vibration intensive construction works have been presented. Equipment size would be selected by the contractor taking into account the minimum working distances and the distance between the construction works and the most affected sensitive receiver. If works need to be undertaken within minimum working distances, vibration monitoring would be undertaken.

An assessment of the likely construction and operational traffic indicated that the noise increases along construction and operational traffic routes are predicted to be well below the 2 dB(A) increase screening criteria. Therefore, no further assessment is required with consideration to the Environment Protection Authority's *NSW Road Noise Policy* (RNP) (DECCW 2011).

An operational noise assessment for the car park facility has been completed with consideration to The Environment Protection Authority's *NSW Noise Policy for Industry* (NPfI), 2017. The results of the assessment indicated compliance with established project noise trigger levels.

2. Introduction

2.1 Background

RAPT Consulting has been engaged to undertake a construction and operational noise and vibration assessment (NVIA) for NGH as part of a Review of Environmental Factors for the proposed Multi Storey Car Park (MSCP) at Warwick Farm.

2.2 Purpose

The purpose of this NVIA is to assess potential noise and vibration from the proposal and to recommend mitigation measures where required.

The outcomes of this assessment include recommendations for potential noise and vibration mitigation and management measures designed to achieve an acceptable noise amenity for residential (dwelling) occupants and other sensitive receivers surrounding the proposal site.

2.3 Scope

The NVIA scope of work included:

- Initial desk top review to identify key environmental noise catchment areas and noise sensitive receptors from aerial photography;
- Undertake noise measurements for to determine ambient and background noise levels.
- Establish project specific noise goals for the construction and operation of the proposed project.
- Identify the likely principal noise sources during construction and operation, and their potential impacts on noise receptors;
- undertake noise modelling to predict noise levels that may occur as a result of the construction of the proposal at the closest and/or potentially most affected receivers;
- providing a comparison of predicted noise levels (and likely vibration events) to the construction NMLs and construction vibration objectives;
- assessment of potential impacts associated with construction noise and vibration; operational noise and sleep disturbance aspects of the proposal; and
- provide recommendations (to be implemented by TfNSW to manage impacts) for feasible and reasonable noise and vibration mitigation and management measures, where NMLs or vibration objectives may be exceeded.

2.4 Proposal Description

The Proposal is to construct an additional two floors over the existing MSCP building within the Warwick Farm Station precinct to provide an additional 250 commuter car parking spaces with the total of 732 car park spaces. Warwick Farm Station is located approximately 25 kilometres (km) south-west of Sydney Central Business District (CBD) and within the

Liverpool City Council local government area (LGA). The car park is located adjacent to the Main South Line which is an active railway corridor.

The Proposal site is located immediately adjacent to an existing operational rail corridor and approximately 80m south of the Hume Highway. Residential areas are located to the west of the Proposal site, with the nearest residents approximately 30 m away. There are several schools in the area however the closest school is approximately 240m south of the site (Liverpool Girls and Liverpool Boys High School).

The project site and surrounding area is shown in Figure 1.



Figure 1 Site and Surrounding Area

This assessment has been undertaken with consideration to:

- TfNSW *Construction Noise and Vibration Strategy*, v4 (TfNSW, 2018)
- TfNSW *Construction Noise and Vibration Strategy*, v4 Addendum Nov 2019 (TfNSW, 2019)
- *Road Noise Policy* (RNP, DECCW, 2011);

- *Noise Policy for Industry (NPfI)* (NSW EPA, 2017)
- *Interim Construction Noise Guideline (ICNG)* (NSW DECC, 2009)
- *Noise Criteria Guideline / Noise Mitigation Guideline (NMG, RMS, 2015);*
- *Environmental Noise Management Manual (ENMM, RTA, 2001);*
- *German Standard DIN 4150, Part 3: Structural Vibration in Buildings: Effects on Structures;*
- *British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings*
- *Assessing Vibration: A Technical Guideline (DECC, 2006);*

2.5 Limitations

The purpose of the report is to provide an independent noise assessment for the proposal.

It is not the intention of the assessment to cover every element of the acoustic environment, but rather to conduct the assessment with consideration to the prescribed work scope.

The findings of the noise assessment represent the findings apparent at the date and time of the assessment undertaken. It is the nature of environmental assessments that all variations in environmental conditions cannot be assessed and all uncertainty concerning the conditions of the ambient environment cannot be eliminated. Professional judgement must be exercised in the investigation and interpretation of observations.

In conducting this assessment and preparing the report, current guidelines for noise and vibration were referred to. This work has been conducted in good faith with RAPT Consulting's understanding of the client's brief and the generally accepted consulting practice.

No other warranty, expressed or implied, is made as to the information and professional advice included in this report. It is not intended for other parties or other uses.

3. Existing Environment

3.1 Ambient Noise Environment

Unattended week long noise monitoring was unable to be undertaken as secure locations could not be established. The units on Hart Street are exposed on the ground floor and were considered insecure locations presenting a high risk of theft or vandalism to monitoring equipment. RAPT consulting was also unable to enter residences residing on the first floor of the apartment blocks due to Covid 19 safety concerns as Liverpool was considered a Covid 19 hotspot at the time of the assessment. RAPT Consulting additionally approached Liverpool Boys High School about placing noise monitoring equipment on their grounds. However, Liverpool Boys High School refused RAPT Consulting access due to Covid 19 concerns. Therefore, to establish background and ambient noise levels operator attended measurements were conducted on 21 July, 2020 at Hart Park in the vicinity of the proposal and nearest residences to quantify the acoustic environment. This location was selected as it was representative of the ambient noise environment particularly for the potentially nearest affected residences on Hart Street and to the east of the east of the proposal on Manning Street. Other residential locations to the north of the proposal were exposed to Hume Highway noise and considered not appropriate for attended monitoring. Measurements were conducted using a RION NL-42 Sound Level Meter with Type 2 Precision. Three 15-minute measurements were undertaken. The measurements were undertaken with consideration to AS 1055-1997, "Acoustics – Description and measurement of Environmental Noise." The acoustic instrumentation employed during the monitoring complies with the requirements of AS 1259.2 – 1990, "Sound Level Metres" and is within current calibration. Calibration was checked before and after the measurements with no significant drift.

During site visits it was noted that existing road traffic, rail, light aircraft, wildlife (birds) and an underlying urban "hum" primarily described the ambient noise environment and is indicative of an urban area.

The monitoring location is shown in Figures 2 and 3..



Figure 2 Hart Park Monitoring Location

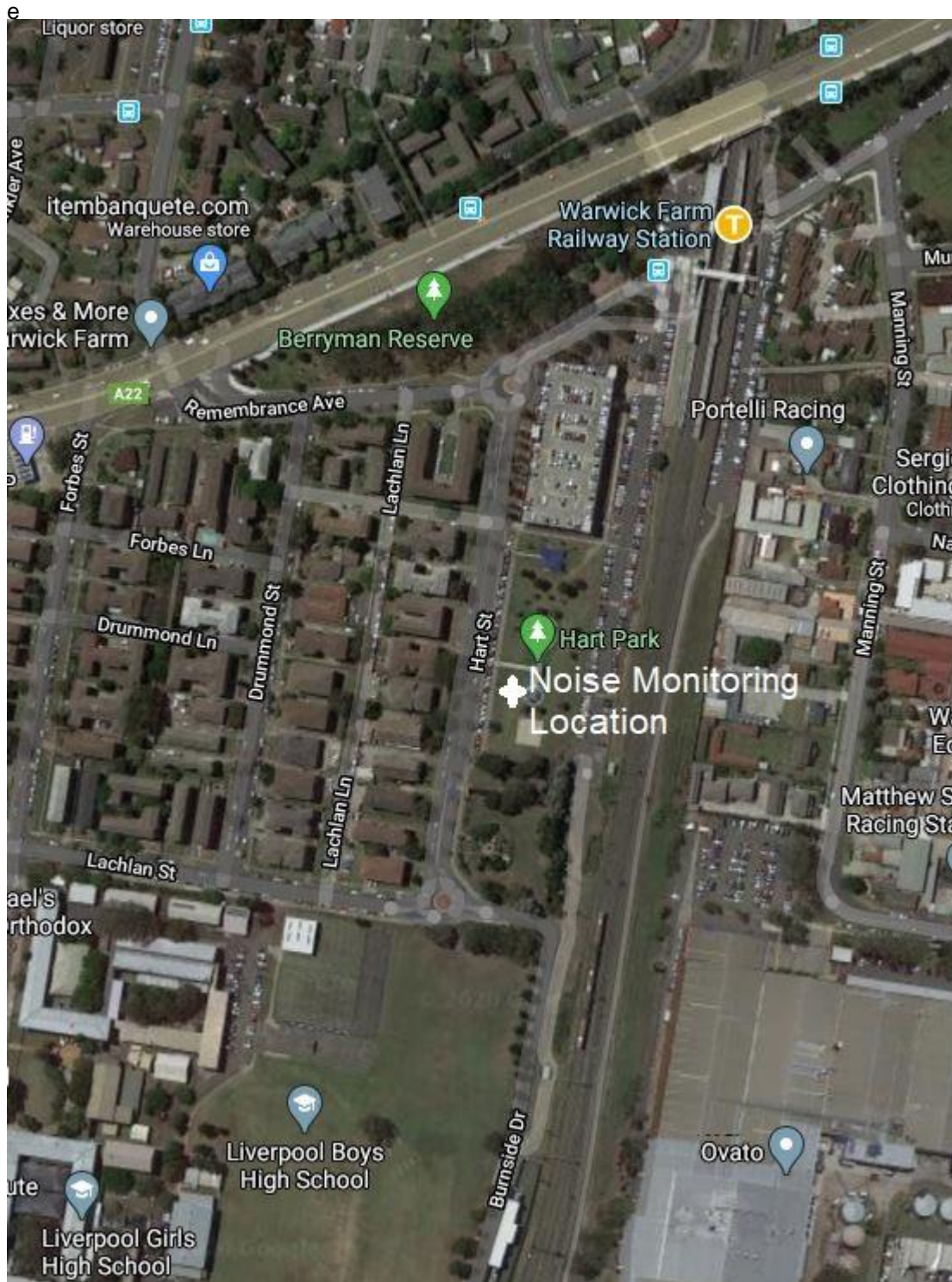


Figure 3 Noise Monitoring Location

Logged data was reviewed and filtered to exclude extraneous data during the monitoring period. The cumulative background and ambient noise results are provided in Table 1 below.

Table 1 Summary of Measured Noise Levels 21 July 2020

Location	Noise Period	Noise Level dB(A)		Noise Sources SPL dB(A)
		L _{Aeq} (15min)	L _{A90} (15min)	
Hart Park	11:20am – 12:10pm			Car Pass-by 54 -58
		55	47	Passenger Rail 56 – 62
		57	47	Cargo Rail 72
		57	47	Light Aircraft 65 – 75
				Birds 47 - 50

While unattended monitoring for 1 week is usually undertaken for proposals such as this, extenuating circumstances dictated this to not be possible in the instance. However, the results of the attended monitoring indicate a consistent background and ambient noise environment due to its highly urban location. While background and ambient noise levels can fluctuate over the course of days, it is expected that this particular noise environment is consistent over time and representative of the ambient noise environment. Therefore, it is considered these measurement are acceptable for this assessment.

Section B1.1 from the TFNSW Construction Noise and Vibration Strategy (CNVS) states assumed background noise levels based on Australian Standard AS1055 may be used as an estimate for simple noise assessments. In this circumstance AS1055 for urban environments has been utilised for evening and night time background noise levels.

4. Noise Criteria

4.1 Operational Noise

The New South Wales Noise Policy for Industry (NPfI) provides guidance on the assessment of operational noise impacts. The guidelines include both intrusive and amenity criteria that are designed to protect receivers from noise significantly louder than the background level and to limit the total noise level from all sources near a receiver.

Intrusive noise levels set by the NPfI control the relative audibility of operational noise compared to the background level. Amenity criteria limit the total level of extraneous noise. Both sets of criteria are calculated and the lower of the two in each time period normally apply. Intrusive criteria are simply 5 decibels above the measured (or adopted) background level with a minimum of 40 dB(A) for daytime and 35 dB(A) for evening and night time.

Amenity noise levels are determined based on the overall acoustic characteristics of the receiver area and the existing level of noise excluding other noises such as traffic and insects. Residential receiver areas are characterised into 'urban', 'suburban', 'rural' or other categories based on land uses, the existing level of noise from industry, commerce, and road traffic. Project amenity noise levels (ANL) are the ANL (Table 2.1 of the NPfI) minus 5 dB(A) and plus 3 dB(A) to convert from a period level to a 15-minute level. The project noise trigger level is the lower value between the intrusive and the amenity noise levels.

The NPfI noise criteria are planning levels and are not mandatory limits required by legislation however the noise criteria assist the regulatory authorities to establish licensing conditions. Where noise criteria are predicted to be exceeded, feasible and reasonable noise mitigation strategies should be considered. In circumstances where noise criteria cannot be achieved negotiation is required to evaluate the economic, social and environmental costs and benefits of the development against the noise impacts. The regulatory authority then sets statutory compliance levels that reflect the achievable and agreed noise limits from the development.

The NPfI is generally intended for large and complex industrial sources and recommends considerable monitoring and assessment measures that may not always be applicable to certain situations. However, the NPfI will be referred to for determining operational noise goals for this project.

Nearest residential receptors are considered urban. Target noise levels are provided for residences and commercial premises in Table 2.

Table 2 Project Noise Trigger Levels

	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am
Rating Background Level $L_{A90}(\text{Period})$	47	45*	40*
Project Intrusive Noise Level, $L_{Aeq}(15\text{min})$	52	50	45
Project Amenity Noise Level (Sub-Urban), $L_{Aeq}(\text{Period})$	55	45	40

	Day 7 am to 6 pm	Evening 6 pm to 10 pm	Night 10 pm to 7 am
Project Amenity Noise Level $L_{Aeq}(15min)$	58	48	43
Project Trigger Level Residential $L_{Aeq}(15min)$	52	48	43
Commercial Premises (When in use) $L_{Aeq}(15min)$	63	63	63
School Classroom – Internal (Noisiest 1 hr period when in use)	35	35	35
Active Recreation (When in use) $L_{Aeq}(15min)$	53	53	53

Note 1 *Taken from AS 1055

4.2 Maximum noise level assessment

The NPfI requires the potential for sleep disturbance to be assessed by considering maximum noise levels events during the night-time period.

Where the subject development/premises night-time noise levels at a residential location exceed the following screening levels a detailed maximum noise level event assessment should be undertaken:

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

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.

Based on the measured background noise levels during the night, the sleep disturbance criteria for the nearest noise sensitive residential receivers are presented in Table 3

Table 3 Night-Time Sleep Disturbance Screening Levels

Type of receiver	night-time RBL, $L_{A90,15min}$, dB(A)	Sleep disturbance screening levels	
		$L_{Aeq,15min}$	L_{AFmax}
Residential	40*	45	55

Note 2 *Taken from AS 1055

4.3 Road Noise Criteria

The NSW *Road Noise Policy* (RNP) recommends various criteria for different road and residential developments and uses. Although it is not mandatory to achieve the noise assessment criteria in the RNP, proponents will need to provide justification if it is not considered feasible or reasonable to achieve them. Based on the definitions in the RNP, the

Hume Highway is an Arterial Road and Remembrance Avenue is a Local Road. The following noise goals provided in Table 4 Below.

Table 4 Road Noise Policy Goals

Road Category	Day	Night
Freeway/ arterial/ sub-arterial roads: Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments.	60 L _{Aeq} (15hr) (External)	55 L _{Aeq} (9hr) (External)
Local roads: Existing residences affected by additional traffic on existing local roads generated by land use developments	55 L _{Aeq} (1 hour) (External)	50 L _{Aeq} (1 hour) (External)
School Classrooms	40 L _{Aeq} , (1 hour) (internal) when in use	-
Hospital Wards	35 L _{Aeq} , (1 hour) (internal)	35 L _{Aeq} , (1 hour) (internal)
Places of Worship	40 L _{Aeq} , (1 hour) (internal)	40 L _{Aeq} , (1 hour) (internal)
Open space (active use)	60 L _{Aeq} , (15 hour) (external) when in use	--
Open space (passive use)	55 L _{Aeq} , (15 hour) (external) when in use	--

For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.

4.4 Construction Noise

Construction noise is assessed with consideration to DECCW Interim Construction Noise Guidelines (ICNG) (July 2009). The ICNG is a non-mandatory guideline that is usually referred to by local councils and other NSW government entities when construction / demolition works require development approval. The ICNG recommend standard hours for construction activity as detailed in Table 5.

Table 5 ICNG Recommended Construction Hours

Work type	Recommended standard hours of work
Normal construction	Monday to Friday: 7 am to 6 pm. Saturday: 8 am to 1 pm. No work on Sundays or Public Holidays.

The ICNG provides noise management levels for construction noise at residential and other potentially sensitive receivers. These management levels are to be calculated based on the adopted rating background level (RBL) at nearby locations, as shown in Table 6.

Table 6 Recommended Construction Noise Management Levels

Period	Management Level $L_{Aeq}(15 \text{ min})$
Residential Recommended standard hours	Noise affected level: RBL + 10 Highly noise affected level: 75 dB(A)
Residential Outside recommended standard hours	Noise affected level: RBL + 5
Classrooms at schools and other educational institutions	Internal Noise Level 45 dB(A) (applies when properties are being used)
Hospital wards and operating theatres	Internal Noise Level 45 dB(A) (applies when properties are being used)
Places of worship	Internal Noise Level 45 dB(A) (applies when properties are being used)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dB(A)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dB(A)
Offices, retail outlets	70 dB(A)

The above levels apply at the boundary of the most affected residences / offices or within 30 m from the residence where the property boundary is more than 30 m from the residence.

The *noise affected level* represents the point above which there may be some community reaction to noise. Where the *noise affected level* is exceeded all feasible and reasonable work practices to minimise noise should be applied and all potentially impacted residents

should be informed of the nature of the works, expected noise levels, duration of works and a method of contact. The *noise affected level* is the background noise level plus 10 dB(A) during recommended standard hours and the background noise level plus 5 dB(A) outside of recommended standard hours.

The *highly noise affected level* represents the point above which there may be strong community reaction to noise and is set at 75 dB(A). Where noise is above this level, the relevant authority may require respite periods by restricting the hours when the subject noisy activities can occur, considering:

- Times identified by the community when they are less sensitive to noise (such as mid-morning or mid-afternoon for works near residences).
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

It is understood most works required for the proposal would be undertaken during standard construction hours. Based on the above and the RBL in this case being the background noise level of 47 dB(A) in Table 1 for daytime and AS 1055 for evening and night-time determined from site monitoring, construction noise management levels for residential receivers have been derived, as shown in Table 5. 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*.

Table 7 Construction Noise Management Levels dB(A) Leq(15min)

Period	RBL L _{A90} , dB(A)	Standard hours noise management levels, L _{Aeq,15min} , dB(A)	Out-of-hours noise management levels, L _{Aeq,15min} , dB(A)
Day	47	57	52
Evening	45	-	50
Night	40	-	45

4.5 Construction Sleep Disturbance

The ICNG requires a sleep disturbance assessment to be undertaken where construction works are planned to extend over more than two consecutive nights. The ICNG makes reference to the EPA's NSW *Environment Criteria for Road Traffic Noise* (ECRTN), now superseded by the NSW RNP, for the assessment of sleep disturbance. The RNP references the recommendations in the ECRTN as providing the most appropriate assessment guidance.

The guidance provided in the RNP for assessing the potential for sleep disturbance recommends that to minimise the risk of sleep disturbance during the night-time period (10pm to 7am), the LA1(1 min) noise level outside a bedroom window should not exceed the LA90(15 min) background noise level by more than 15 dB(A). The EPA considers it appropriate to use this metric as a screening criterion to assess the likelihood of sleep disturbance. If this screening criterion is found to be exceeded then a more detailed analysis must be undertaken that should include the extent that the maximum noise level exceeds the background noise level and the number of times this is likely to happen during the night-time period.

The RNP contains a review of research into sleep disturbance which represents NSW EPA advice on the subject of sleep disturbance due to noise events. It concludes that having considered the results of research to date that, 'Maximum internal noise levels below 50-55

dB(A) are unlikely to cause awakening reactions'. Therefore, given that an open window provides around 10 dB(A) in noise attenuation from outside to inside, external noise levels of 60-65 dB(A) are unlikely to result in awakening reactions. While construction is expected to take place during standard hours, sleep disturbance is not expected to be an issue. However for the operation of the proposal, based on the above an external noise level of 60 dB(A) $L_{A1(1min)}$ has been conservatively adopted for this proposal.

4.6 Vibration Guidelines

Vibration during construction and operational activity is expected to primarily originate from trucks and machinery during stages of construction and activities. RAPT Consulting also understand that blasting and heavy ground impact activities is not expected to occur during the construction works.

4.6.1 Human Exposure

Vibration goals during the were sourced from the DECCW's *Assessing Vibration: a technical guideline*, which is based on guidelines contained in British Standard (BS) 6472–1992, *Evaluation of human exposure to vibration in buildings (1–80 Hz)*.

Intermittent vibration is assessed using the vibration dose value (VDV), fully described in BS 6472 – 1992. Acceptable values of vibration dose are presented in Table 8.

Table 8 Acceptable Vibration Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime ¹		Night-time ¹	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas ²	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

4.7 Building Damage

Currently, there is no Australian Standard that sets the criteria for the assessment of building damage caused by vibration. Guidance of limiting vibration values is attained from reference to the following International Standards and Guidelines:

- British Standard BS7385.2 - 1993 *Evaluation and Measurement for Vibration in Buildings*, Part 2 - Guide to damage levels from ground borne vibration; and
- German Standard DIN 4150-3: 1999-02 Structural Vibration – Part 3: *Effects of vibration on structures*.

DIN 4150-3: 1999-02 is utilised in this case in the assessment of potential building damage resulting from ground borne vibration produced by the proposed activity.

The recommended Peak Particle Velocity (PPV) guidelines for the possibility of vibration induced building damage are derived from the minimum vibration levels above which any damage has previously been encountered and are presented in Table 9.

Table 9 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on structures

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz*	
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20-40	40-50	40
Dwellings and buildings of similar design and/or occupancy	5	5-15	15-20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 of table 5-7 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Ground Vibration – Minimum Working Distances from Sensitive Receivers

The Transport for NSW *Construction Noise and Vibration Strategy* (CNVS) provides guidance for minimum working distances. As a guide, minimum working distances from sensitive receivers for typical items of vibration intensive plant are listed in Table 10. The minimum distances are quoted for both “cosmetic” damage (refer BS 7385) and human comfort (refer OH&E’s *Assessing Vibration - a technical guideline*). DIN 4150 has criteria of particular reference for heritage structures.

Table 10 Recommended Minimum Safe Working Distances for Vibration Intensive Plant from Sensitive Receiver

Plant Item	Rating / Description	Minimum Distance Cosmetic Damage		Minimum Distance Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1-2 tonne)	5m	11m	15m to 20m
	<100 kN (2-4 tonne)	6m	13m	20m
	<200 kN (4-6 tonne)	12m	15m	40m
	<300kN (7-13 tonne)	15m	31m	100m
	>300kN (13-18 tonne)	20m	40m	100m
	>300kN (>18 tonne)	25m	50m	100m
Small Hydraulic Hammer	300kg (5 to 12 t excavator)	2m	5m	7m
Medium Hydraulic Hammer	900kg (12 to 18 t excavator)	7m	15m	23m
Large Hydraulic Hammer	1600kg (18 to 34 t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet Piles	2m to 20m	5m to 40m	20m
Pile Boring	≤ 800mm	2m (nominal)	5m	4m
Jack Hammer	Hand Held	1m (nominal)	3m	2m

Unlike noise which travels through air, the transmission of vibration is highly dependent on substratum conditions between the source/s and receiver. Also dissimilar to noise travelling through air, vibration levels diminish quickly over distance, thus an adverse impact from vibration on the broader community is not typically expected. Vibration during works is considered an intermittent source associated with two main types of impact; disturbance at receivers and potential architectural/structural damage to buildings. Generally, if disturbance issues are controlled, there is limited potential for structural damage to buildings.

5. Assessment of Potential Impacts

5.1 Operational Noise

For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'. Data obtained from the Futurerail publication, *Commuter Car Park Program – Traffic, Transport and Access Impact Assessment Warwick Farm Commuter Car Park (Futurerail 2020)* indicates the proposed Warwick Farm MSCP is anticipated to generate an approximate additional 99 vehicle movements during the AM peak hour and 81 vehicle movements during the PM peak hour.

Based on information provided in the abovementioned assessment this would result in an approximate traffic increase of 15% during AM peak hour and 18% during PM peak hour. An LAeq noise level increase of more than 2 dB(A) is equivalent to approximately a 60 percent increase in total road traffic. As such, it is unlikely the proposal would increase road noise levels by 2dB(A).

Additionally, the key intersections of the Hume Highway/Remembrance Avenue and Hume Highway/Governor Macquarie Drive intersections suggest the proposed additional 250 car park spaces would contribute less than 3% of the total traffic at these two intersections. Therefore, compliance with operational road traffic noise levels outlined in Table 2 is expected.

5.2 Car Park Operational Noise

To assess the potential noise impacts associated with the operation of the proposal, two key scenarios were assessed:

- general operational noise from normal car park usage within the carpark; and
- transient noise events such as car door slams, boot slams or horn emissions.

For the assessment of operational noise, a sound power for general car usage (i.e. car movement and engine noise) of 75dB(A) $L_{eq(15min)}$ was adopted. Wheel squeal from vehicles manoeuvring in the CCP has not been assessed as the proposal can be designed to minimise or eliminate this type of noise emission. To assess the impact transient noise events such as door or boot slams a sound power level of 85dB(A) L_{max} was adopted.

Predicted noise levels from the general operation of the car park are less than 42dB(A) $L_{eq(15min)}$ at all existing identified residential receivers, satisfying the minimum applicable night time NPfI trigger level of 43dB(A) $L_{eq(15min)}$. Predicted maximum noise level events are less than 52dB(A) L_{max} at all existing identified residential receivers, which would also satisfy the operational maximum noise trigger levels.

5.3 Construction Noise

Construction can occur in the vicinity of residences or other sensitive land uses and be variable in times of occurrence. These aspects of construction can exacerbate noise levels and their effects. Construction noise by its nature is temporary, may not be amenable to purpose-built noise control measures applied to industrial processes, and may move as

construction progresses. With these constraints in mind, The ICNG was developed to focus on applying a range of work practices most suited to minimise construction noise impacts, rather than focusing only on achieving numeric noise levels. While some noise from construction sites is inevitable, the aim of the Guideline is to protect much of residences and other sensitive land uses from noise pollution most of the time.

This section provides a summary of the likely methodology, staging, work hours, plant and equipment that would be used to complete the proposed work. For the purposes of the REF, indicative construction staging, and options are provided. Detailed methods and staging would be established by the construction contractor. Construction sequencing and methods are understood to generally be as follows:

Table 11 Indicative Construction Staging

Stage	Activities	Duration (Weeks)	Maximum daily Deliveries (Trucks)	Maximum Daily Workforce
Site Preparation	<ul style="list-style-type: none"> Secure site boundary with temporary fencing and hoarding Provide traffic and pedestrian controls in the vicinity of the Site in accordance with Liverpool 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. 	4	32	25

Stage	Activities	Duration (Weeks)	Maximum daily Deliveries (Trucks)	Maximum Daily Workforce
Superstructure	<ul style="list-style-type: none"> 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 Install electrical, hydraulic and mechanical services infrastructure. 	19	48	80
Demobilisation	<ul style="list-style-type: none"> Landscaping Other associated works 			

The construction methodology would be further developed during the detailed design of the proposal by the selected construction contractor in consultation with Transport for NSW.

This staging is indicative, based on the current concept design and may change once the detailed design methodology is finalised. The staging is also dependent on the selected construction contractor's preferred methodology, program and sequencing of work.

5.3.1 Construction Hours and Duration

The proposed work would be undertaken during standard work hours

- Monday to Friday, 7am to 6pm
- Saturday, 8am to 1pm
- No works on public holidays.

Certain works may need to occur outside standard hours to minimise disruption to customers, pedestrians, road users and nearby sensitive receivers. 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*.

5.3.2 Construction Equipment Source Noise Levels

An indicative list of plant and equipment that may be used for the construction of this proposal includes:

- Tower and Mobile Cranes
- Water trucks
- Road Saws
- Rollers
- Trench Compactors
- Concrete trucks
- Semi-trailers
- Spoil trucks (truck and dog)
- Welding equipment
- Air compressors
- Concrete saws,
- Generators
- Concrete vibrators
- Concrete pumps
- Jack hammers
- Elevated work platforms

The individual sound power levels (SWL) for the anticipated type of construction plant have been referenced from RAPT Consulting's database of noise sources and the RMS Construction Noise Estimator.

Table 12 Construction Plant and Equipment Sound Power Levels

Activities	Anticipated type of plant and equipment	SWL L_{Aeq} dB(A)	Estimated Usage % during 15-minute period
Site Preparation	Road Truck / Light Vehicle	108	50
	Trucks medium rigid	103	50
	Dump Truck	110	50
	Power Generator	103	100
	Mobile Crane	98	50
Superstructure	Tower / Mobile Crane	98	50
	Water Truck	107	25
	Road (concrete) Saw	118	50
	Roller	109	50
	Trench Compactor	106	50
	Concrete Truck	109	50
	Road Truck	108	50
	Truck and Dog	110	50
	Welding equipment	105	50
	Air compressor	109	50

Activities	Anticipated type of plant and equipment	SWL L_{Aeq} dB(A)	Estimated Usage % during 15-minute period
	Power generator	103	100
	Concrete vibrator	113	50
	Concrete pump	109	50
	Jack Hammer	113	50
	Elevated work platform	98	50
Demobilisation	Trucks / Light Vehicle	108	50
	Trucks Medium Rigid	103	50
	Power Generator	103	100
	Mobile Crane	98	50

Note 3 The sound power levels for the individual plant items are worst-case levels representative of the equipment operating at maximum capacity. In practice, not all plant items would operate at maximum capacity at the same time and therefore the estimated usage has been adjusted to reflect this. This adjustment is consistent with RAPT Consulting experience on similar projects.

5.3.3 Construction Noise Assessment

Acoustic modelling was undertaken using Bruel and Kjaer's "Predictor" to predict the effects of site noise. Predictor is a computer program for the calculation, assessment and prognosis of noise propagation. Predictor calculates environmental noise propagation according to ISO 9613-2, "Acoustics – Attenuation of sound during propagation outdoors". Terrain topography, ground absorption, atmospheric absorption and relevant shielding objects are taken into account in the calculations.

The calculated noise levels would inevitably depend on the number and type of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. In practice, the noise levels would vary due to the fact that plant and equipment would move about the worksites and would not all be operating concurrently. In some cases,

reductions in noise levels would occur when plant are located behind obstacles or even other items of equipment. Predicted noise levels have been assessed from each of the work scenarios outlined above with the site establishment and compound to the south in Hart Park.

Results of the predicted construction noise levels are provided in Tables 13 – 16 and are compared against operating hours. The noise levels are representative of the worst-case impact, for a given receiver type and are intended to give an indication of the possible noise levels from construction work when work is at their closest. For most construction activities, it is expected that construction noise levels would frequently be lower than predicted at the most exposed receiver. A general description of NML exceedance groups are provided below. The impact of these potential exceedances depends on the period in which they were to occur (generally night-time is more sensitive than daytime or evening for most people).

- Noise levels 1 – 10 dB(A) above NML – Impact generally marginal to minor
- Noise Levels 11 – 20 dB(A) above NML – Impact generally moderate
- Noise Levels > 20 dB(A) above NML – Impact generally high

Locations predicted to exceed construction NML's are shown in red.

Receivers assessed are shown in Figure 4.

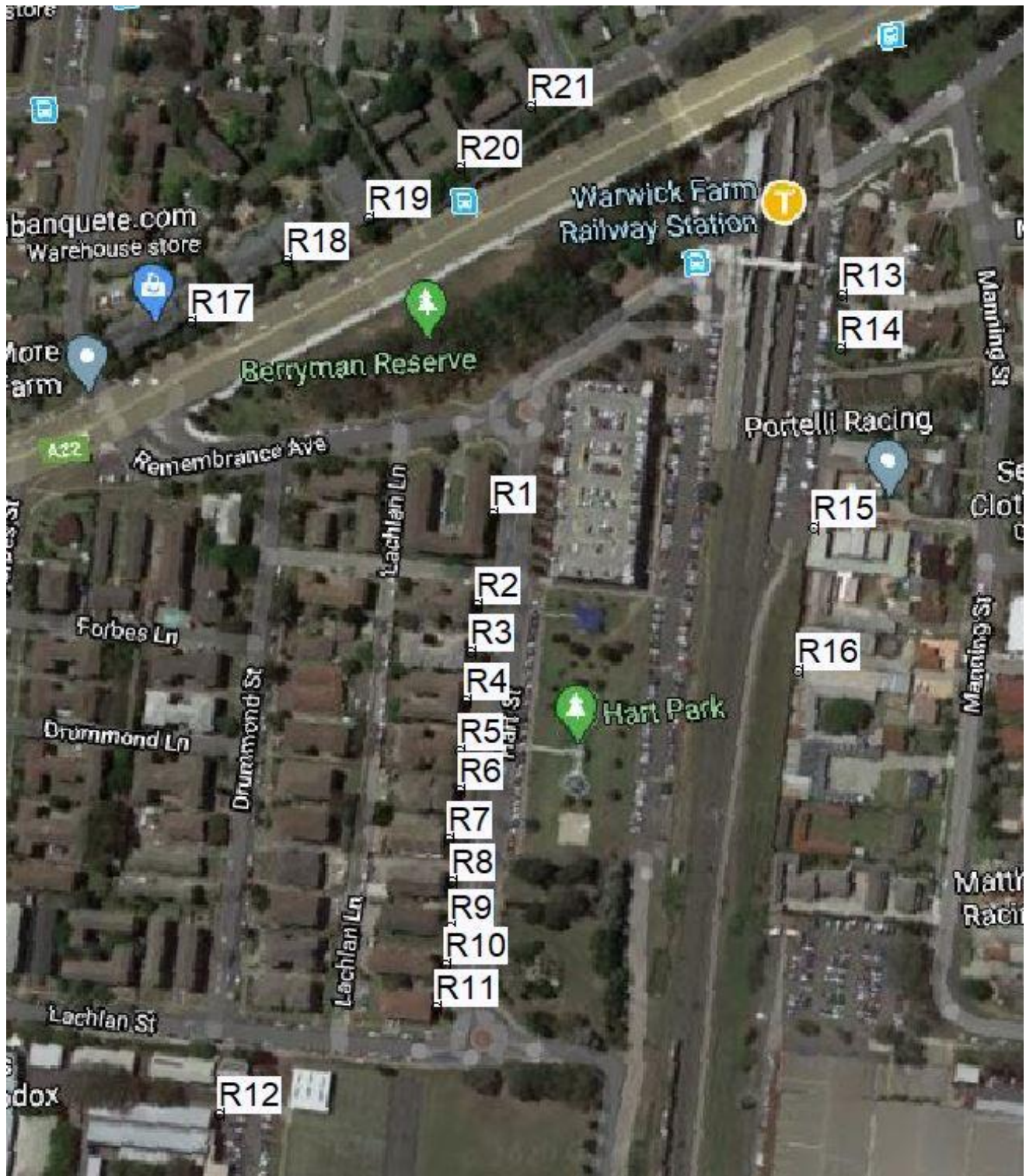


Figure 4 Assessed Locations

Table 13 Predicted Construction Noise Levels SPL dB(A) Leq(15min)

Receiver	Site Establishment	Superstructure	Demobilisation	Standard Daytime NML 57 dB(A) $L_{Aeq,15min}$	Highly Affected Noise Level 75 dB(A)	Exceed Highly Affected Noise Level
R1 (24 Remembrance Ave)	49	65	46	57	75	No
R2 (1 Lachlan Ln)	70	72	67	57	75	No
R3 (3 Lachlan Ln)	68	70	65	57	75	No
R4 (5 Lachlan Ln)	66	68	63	57	75	No
R5 (7 Lachlan Ln)	64	66	61	57	75	No
R6 (9 Lachlan Ln)	63	65	60	57	75	No
R7 (11 Lachlan Ln)	61	64	58	57	75	No
R8 (13 Lachlan Ln)	60	63	57	57	75	No
R9 (15 Lachlan Ln)	59	62	56	57	75	No
R10 (17 Lachlan Ln)	59	61	56	57	75	No

Receiver	Site Establishment	Superstructure	Demobilisation	Standard Daytime NML 57 dB(A) L _{Aeq,15min}	Highly Affected Noise Level 75 dB(A)	Exceed Highly Affected Noise Level
R11 (19 Lachlan Ln)	58	61	55	57	75	No
R12 (Liverpool Boys High School)	36	39	33	57	75	No
R13 (1 Manning Street)	34	55	31	57	75	No
R14 (3 Manning Street)	34	55	31	57	75	No
R15 (5 Manning Street)	46	52	43	57	75	No
R16(9 Manning Street)	55	58	52	57	75	No
R17 (33 Mannix Parade)	44	53	41	57	75	No
R18 (21-29 Hume Hwy)	32	57	29	57	75	No
R19 (19 Hume Hwy)	32	57	29	57	75	No

Receiver	Site Establishment	Superstructure	Demobilisation	Standard Daytime NML 57 dB(A) L _{Aeq,15min}	Highly Affected Noise Level 75 dB(A)	Exceed Highly Affected Noise Level
R20 (33 Freeman Street)	33	55	30	57	75	No
R21 (31 Freeman Street)	32	54	29	57	75	No

Table 14 Predicted Construction Noise Levels SPL dB(A) Leq(15min)

Receiver	Site Establishment	Superstructure	Demobilisation	Out of hours daytime NML 52 dB(A) L _{Aeq,15min}	Highly Affected Noise Level 75 dB(A)	Exceed Highly Affected Noise Level
R1 (24 Remembrance Ave)	49	65	46	52	75	No
R2 (1 Lachlan Ln)	70	72	67	52	75	No
R3 (3 Lachlan Ln)	68	70	65	52	75	No
R4 (5 Lachlan Ln)	66	68	63	52	75	No
R5 (7 Lachlan Ln)	64	66	61	52	75	No

Receiver	Site Establishment	Superstructure	Demobilisation	Out of hours daytime NML 52 dB(A) L _{Aeq,15} min	Highly Affected Noise Level 75 dB(A)	Exceeded Highly Affected Noise Level
R6 (9 Lachlan Ln)	63	65	60	52	75	No
R7 (11 Lachlan Ln)	61	64	58	52	75	No
R8 (13 Lachlan Ln)	60	63	57	52	75	No
R9 (15 Lachlan Ln)	59	62	56	52	75	No
R10 (17 Lachlan Ln)	59	61	56	52	75	No
R11 (19 Lachlan Ln)	58	61	55	52	75	No
R12 (Liverpool Boys High School)	36	39	33	52	75	No
R13 (1 Manning Street)	34	55	31	52	75	No
R14 (3 Manning Street)	34	55	31	52	75	No

Receiver	Site Establishment	Superstructure	Demobilisation	Out of hours daytime NML 52 dB(A) L _{Aeq,15} min	Highly Affected Noise Level 75 dB(A)	Exceeded Highly Affected Noise Level
R15 (5 Manning Street)	46	52	43	52	75	No
R16(9 Manning Street)	55	58	52	52	75	No
R17 (33 Mannix Parade)	44	53	41	52	75	No
R18 (21-29 Hume Hwy)	32	57	29	52	75	No
R19 (19 Hume Hwy)	32	57	29	52	75	No
R20 (33 Freeman Street)	33	55	30	52	75	No
R21 (31 Freeman Street)	32	54	29	52	75	No

Table 15 Predicted Construction Noise Levels SPL dB(A) Leq(15min)

Receiver	Site Establishme nt	Superstruct ure	Demobilisati on	Out of hours evenin g NML 50 dB(A) L _{Aeq,15} min	Highly Affecte d Noise Level 75 dB(A)	Excee d Highly Affecte d Noise Level
R1 (24 Remembran ce Ave)	49	65	46	50	75	No
R2 (1 Lachlan Ln)	70	72	67	50	75	No
R3 (3 Lachlan Ln)	68	70	65	50	75	No
R4 (5 Lachlan Ln)	66	68	63	50	75	No
R5 (7 Lachlan Ln)	64	66	61	50	75	No
R6 (9 Lachlan Ln)	63	65	60	50	75	No
R7 (11 Lachlan Ln)	61	64	58	50	75	No
R8 (13 Lachlan Ln)	60	63	57	50	75	No
R9 (15 Lachlan Ln)	59	62	56	50	75	No
R10 (17 Lachlan Ln)	59	61	56	50	75	No

R11 (19 Lachlan Ln)	58	61	55	50	75	No
R12 (Liverpool Boys High School)	36	39	33	50	75	No
R13 (1 Manning Street)	34	55	31	50	75	No
R14 (3 Manning Street)	34	55	31	50	75	No
R15 (5 Manning Street)	46	52	43	50	75	No
R16(9 Manning Street)	55	58	52	50	75	No
R17 (33 Mannix Parade)	44	53	41	50	75	No
R18 (21-29 Hume Hwy)	32	57	29	50	75	No
R19 (19 Hume Hwy)	32	57	29	50	75	No
R20 (33 Freeman Street)	33	55	30	50	75	No
R21 (31 Freeman Street)	32	54	29	50	75	No

Table 16 Predicted Construction Noise Levels SPL dB(A) Leq(15min)

Receiver	Site Establishme nt	Superstruct ure	Demobilisati on	Out of hours night NML 45 dB(A) L _{Aeq,15} min	Highly Affecte d Noise Level 75 dB(A)	Excee d Highly Affecte d Noise Level
R1 (24 Remembran ce Ave)	49	65	46	45	75	No
R2 (1 Lachlan Ln)	70	72	67	45	75	No
R3 (3 Lachlan Ln)	68	70	65	45	75	No
R4 (5 Lachlan Ln)	66	68	63	45	75	No
R5 (7 Lachlan Ln)	64	66	61	45	75	No
R6 (9 Lachlan Ln)	63	65	60	45	75	No
R7 (11 Lachlan Ln)	61	64	58	45	75	No
R8 (13 Lachlan Ln)	60	63	57	45	75	No
R9 (15 Lachlan Ln)	59	62	56	45	75	No
R10 (17 Lachlan Ln)	59	61	56	45	75	No

Receiver	Site Establishment	Superstructure	Demobilisation	Out of hours night NML 45 dB(A) $L_{Aeq,15\text{ min}}$	Highly Affected Noise Level 75 dB(A)	Exceeded Highly Affected Noise Level
R11 (19 Lachlan Ln)	58	61	55	45	75	No
R12 (Liverpool Boys High School)	36	39	33	45	75	No
R13 (1 Manning Street)	34	55	31	45	75	No
R14 (3 Manning Street)	34	55	31	45	75	No
R15 (5 Manning Street)	46	52	43	45	75	No
R16(9 Manning Street)	55	58	52	45	75	No
R17 (33 Mannix Parade)	44	53	41	45	75	No
R18 (21-29 Hume Hwy)	32	57	29	45	75	No
R19 (19 Hume Hwy)	32	57	29	45	75	No

Receiver	Site Establishment	Superstructure	Demobilisation	Out of hours night NML 45 dB(A) $L_{Aeq,15}$ min	Highly Affected Noise Level 75 dB(A)	Exceeded Highly Affected Noise Level
R20 (33 Freeman Street)	33	55	30	45	75	No
R21 (31 Freeman Street)	32	54	29	45	75	No

Noise results present the worst-case scenario if all items of plant outlined in Table 12 were operating at their maximum sound power levels simultaneously. In reality, this is unlikely to occur and actual received sound levels due to construction are expected to be lower than is reported in Table 12.

Highly affected noise levels are also predicted to be complied with at all assessed locations. While actual noise levels are not expected to be of this magnitude, it is recommended a construction noise and vibration management plan (CNVMP) be implemented as part of this proposal to manage and minimise construction noise and vibration.

Deliveries to/from the site would peak at 48 trucks per day during the concrete pours and would be spread evenly throughout the day (six trucks per hour). This peak impact would occur for the duration of construction of the CCP superstructure, over a 19-week period. This is not expected to impact existing road network noise conditions.

5.4 Construction Vibration

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (e.g. dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of vibration, are all important aspects in both the annoyances caused and the strains induced in structures.

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 (i.e. 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.

Due to the above factors, there is inherent variability in ground vibration predictions without site-specific measurement data.

Generally, piling is not expected to be used in this proposal but is included for informational purposes. Based on distances from the proposal to nearest receivers which are approximately 30 metres away and items of plant to be used, vibration goals are expected to be met. However, if hammering is to occur, it is recommended this activity does not exceed the medium hydraulic hammer specification. Additionally vibratory rolling is recommended to not exceed the <100 kN (2-4 tonne) specification.

Ground Vibration – Minimum Working Distances from Sensitive Receivers

The Transport for NSW *Construction Noise and Vibration Strategy* (CNVS) provides guidance for minimum working distances. As a guide, minimum working distances from sensitive receivers for typical items of vibration intensive plant are listed in Table 17. The minimum distances are quoted for both “cosmetic” damage (refer BS 7385) and human comfort (refer OH&E’s *Assessing Vibration* - a technical guideline). DIN 4150 has criteria of particular reference for heritage structures. The minimum working distances are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

Table 17 Recommended Minimum Safe Working Distances for Vibration Intensive Plant from Sensitive Receiver

Plant Item	Rating / Description	Minimum Distance Cosmetic Damage		Minimum Distance Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1-2 tonne)	5m	11m	15m to 20m
	<100 kN (2-4 tonne)	6m	13m	20m
	<200 kN (4-6 tonne)	12m	15m	40m
	<300kN (7-13 tonne)	15m	31m	100m
	>300kN (13-18 tonne)	20m	40m	100m

Plant Item	Rating / Description	Minimum Distance Cosmetic Damage		Minimum Distance Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
	>300kN (>18 tonne)	25m	50m	100m
Small Hydraulic Hammer	300kg (5 to 12 t excavator)	2m	5m	7m
Medium Hydraulic Hammer	900kg (12 to 18 t excavator)	7m	15m	23m
Large Hydraulic Hammer	1600kg (18 to 34 t excavator)	22m	44m	73m
Vibratory Pile Driver	Sheet Piles	2m to 20m	5m to 40m	20m
Pile Boring	≤ 800mm	2m (nominal)	5m	4m
Jack Hammer	Hand Held	1m (nominal)	3m	2m

Given the nearest residential receptors are approximately 30 metres from the project, where vibratory rollers are proposed it is recommended <100 kN (2-4 tonne) be utilised. Additionally if hydraulic hammering were to occur, it is recommended no larger than medium 900kg (12 to 18 t excavator) be utilised.

6. Noise and Vibration Mitigation Measures

6.1 Construction Noise and Vibration Mitigation Measures

6.1.1 Noise Mitigation Measures

Construction noise levels are predicted to exceed noise management levels at the residences outlined in Tables 13 - 16. Where exceedances are anticipated after implementing standard mitigation measures, additional mitigation measures can be applied where feasible and reasonable. The TfNSW Construction Noise and Vibration Strategy(CNVS) provides guidance for additional mitigation measures and may be used to minimise the impacts on the community from noise and vibration. The provision of additional mitigation is based on predicted exceedances above RBLs and when the exceedances occur. Table 18 provides how to implement additional airborne noise management levels.

Table 18 How to implement additional airborne noise management levels

Construction hours	Receiver perception	dB(A) above RBL	dB(A) above NML	Additional management measures
Standard hours Monday-Friday (7am-6pm) Saturday (8am-1pm)	Noticeable	5 to 10	0	-
	Clearly audible	> 10 to 20	< 10	-
	Moderately intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly intrusive	> 30	> 20	PN, V
	75 dB(A) or greater	N/A	N/A	PN, V, SN
OOHW Period 1 Monday-Friday (6pm-10pm) Saturday (7am-8am, 1pm-10pm) Sunday/PH (8am-6pm)	Noticeable	5 to 10	< 5	-
	Clearly audible	> 10 to 20	5 to 15	PN
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP#, DR#
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/PH (12am-8am, 6pm-12am)	Noticeable	5 to 10	< 5	PN
	Clearly audible	> 10 to 20	5 to 15	PN, V
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RP, DR
	Highly intrusive	> 30	> 25	PN, V, SN, AA, RP, DR

Note 4 PN = Project notification SN = Specific notification, individual briefings, or phone call V = Verification monitoring DR = Duration respite RP = Respite period RO = Project specific respite order AA = Alternative accommodation

** SWLs used for the purpose of estimating noise impact shall be increased by 5 dB(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. # Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (i.e. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6am)

Table 19 outlines the additional mitigation measures, as outlined in the CNVS.

Table 19 Description of Additional Mitigation Measures

Measure	Description	Abbreviation
Periodic Notification	<p>For each project, a notification entitled 'Project Update' or 'Construction Update' is produced and distributed to stakeholders via letterbox drop and distributed to the project postal and/or email mailing lists. The same information will be published on the TfNSW website (www.transport.nsw.gov.au). Periodic notifications provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage, inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. 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 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 Community Engagement Team will determine the community engagement strategy on a case-by-case basis.</p>	PN
Verification Monitoring	<p>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 (i.e. for vibration provided there is an immediate feedback mechanism such as SMS capabilities) or operator attended surveys (i.e. for specific periods of construction noise).</p> <p>The purpose of monitoring is to confirm that:</p>	V

Measure	Description	Abbreviation
	<ul style="list-style-type: none"> construction noise and vibration from the project 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 <p>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. Refer to Section 8.4 for more details.</p>	
Specific Notification	<p>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.</p> <ul style="list-style-type: none"> 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 project <p>Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.</p>	SN
Respite Offer	<p>The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact. The offer could comprise pre-purchased 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 projects.</p>	RO

Measure	Description	Abbreviation
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 Levels (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 consecutive evening and/or night works. Strong justification must be provided where it is not reasonable and feasible to implement these period restrictions (e.g. to minimise impacts to rail operations), and approval must be given by TfNSW through the OOHWS Approval Protocol (Section 6). Note; this management measure does not apply to OOHWS Period 1 – Days (See Table 1).	RP
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 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 Community Engagement Representatives.	DR

6.1.2 Vibration Mitigation Measures

While vibration generated by the proposal is expected to comply with established vibration goals, Table 20 provides further guidance for triggers for additional vibration mitigation measures taken from Table 11 of the CNVS.

Construction Hours	Receiver Perception	Above VML	Additional Management Measures
Standard Hours Monday – Friday (7am-6pm) Saturday (8am-1pm)	Human Disturbance	>HVML	P, V, RO
	Building Damage	>DVML	V, AC
OOHW Period 1 Monday – Friday (6pm-10pm) Saturday (7am-8am, 1pm-10pm) Sunday/Public Holiday (8am-6pm)	Human Disturbance	>HVML	PN, V, SN, RO, RP, DR
	Building Damage	>DVML	V, AC
OOHW Period 2 Monday-Saturday (12am-7am, 10pm-12am) Sunday/Public Holiday (12am-8am, 6pm-12am)	Human Disturbance	>HVML	PN, V, SN, RO, AA, RP, DR
	Building Damage	>DVML	V, AC

Note 5 PN=Project Notification; SN=Specific Notification, Individual Briefings, or Phone Call; V=Verification of Monitoring; AA=Alternative Accommodation; DR=Duration Reduction; RO=Project Specific Respite Offer; RP=Respite Period; AC=Alternative Construction Methodology

7. Conclusion

RAPT Consulting has undertaken a construction and operational noise and vibration assessment (NVIA) for NGH as part of a Review of Environmental Factors for the proposed Multi Storey Car Park (MSCP) at Warwick Farm.

Operation

The results of the assessment indicate the proposal is predicted to increase traffic noise levels by less than 2dB(A). Additionally, predicted noise levels from the general operation of the car park are less than 42dB(A) $L_{eq(15min)}$ at all existing identified residential receivers, satisfying the minimum applicable night time NPfI trigger level of 43dB(A) $L_{eq(15min)}$. Predicted maximum noise level events are less than 52dB(A) L_{max} at all existing identified residential receivers, which would also satisfy the operational maximum noise trigger levels.

Therefore compliance with operational noise levels is expected.

Construction

The assessment outlined in this report indicates that construction noise management levels may be exceeded for some receivers assessed. However, the highly noise affected level of 75dB(A) $L_{Aeq(15min)}$ is expected to be complied with. A set of standard mitigation measures for construction noise and vibration have been provided based on anticipated requirements of the proposal. It is believed construction noise can be minimised and managed acceptable to the local community through the implementation of a CNVMP similar to what has been recommended in this report.