Normanhurst Station Upgrade

Noise and Vibration Impact Assessment

Prepared for Transport for New South Wales
February 2021

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This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of the client and no responsibility will be taken for its use by other parties. The client may, at its discretion, use the report to inform regulators and the public.

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1 Introduction

Transport for NSW is proposing to undertake the Normanhurst Station Upgrade (the Proposal) to improve access to the train station. Transport for NSW is the government agency responsible for the delivery of major transport infrastructure projects in NSW and is the proponent for the Proposal.

The Proposal forms part of the Transport Access Program. The NSW Government is committed to delivering accessible public transport infrastructure, which is why Transport for NSW is providing a better experience for public transport customers by delivering accessible, modern, secure and integrated transport infrastructure across the state. As part of the program, the Normanhurst Station Upgrade aims to provide a station precinct that is accessible to those with a disability, limited mobility, parents/carers with prams and customers with luggage.

1.1 Overview

As part of this program, the Proposal would provide accessibility upgrades to Normanhurst Station to achieve Disability Standards Accessible Public Transport (DSAPT) compliance. The current layout of Normanhurst Station does not achieve compliance.

The Proposal would include the following key features:

- two new lifts to provide access to the station platforms;
- new weather protection canopies at lift entries;
- improved accessibility to the waiting rooms;
- a new FAT, and male and female ambulant toilets;
- new accessible pedestrian pathways throughout the station and entrances;
- new accessible entrance to Platform 1;
- new canopy coverage over Boarding Assistance Zones;
- new bike hoops located near Denman Parade;
- new kiss and ride bay on Denman Parade;
- modification to the bus stops on Malsbury Road and Denman Parade;
- improvements to CCTV, lighting and wayfinding signage; and
- electrical upgrades to accommodate new infrastructure.

Subject to approval, construction is expected to commence in mid-2021 and is expected to be completed in mid-2023. The project is expected to employ approximately 15 people throughout the duration of the works (ie on a daily basis), with staffing increased to approximately 80 people per rail shutdown event.

The majority of the work required for the Proposal would be undertaken during NSW EPAs recommended standard construction hours. Certain work may need to occur outside recommended standard hours and would include night work and work during routine rail shutdowns, which are scheduled closures that would occur regardless of the Proposal when part of the rail network is temporarily closed for maintenance and trains are not operating.

There will be no additional traffic resulting from the operation of the Proposal. As such, road traffic noise from operations of the proposal has not been assessed further.

There will be minimal construction road traffic associated with the Proposal, which will consist of mostly light vehicles from the construction workforce, which will be parked at the proposed lay down area off Malsbury Road. There will be infrequent heavy vehicle movements during the construction phase, which will likely be attributed to the delivery and installation of the lifts, and the delivery of concrete. Any local traffic impacts associated with heavy vehicles will be temporary and localised to Denman Parade or Malsbury Road.

1.2 Scope

The scope of this assessment is to:

- establish the existing background noise levels in the vicinity of the works;
- establish construction noise management levels and vibration limits which would apply to the works;
- predict construction noise and vibration levels at nearby residential and other sensitive assessment locations due to the works;
- recommend mitigation measures where necessary to reduce and manage noise and vibration impacts from the construction;
- predict noise impacts from additional construction road traffic generated by the upgrade; and
- recommend mitigation measures where necessary to reduce and manage noise impacts from the station upgrade works.

As operational noise levels are expected to remain mostly unchanged and the specific mechanical systems to be installed for the Proposal are not yet finalised, no quantitative modelling of operational noise impacts was undertaken.

1.3 Guidelines

The following guidelines apply to construction noise and vibration and operational noise from the proposal:

- *NSW Interim Construction Noise Guideline* (ICNG) 2009, Department of Environment and Climate Change;
- *Construction Noise and Vibration Strategy* (CNVS) v4.2 2019, Transport for NSW;
- *NSW Assessing Vibration – a technical guideline* (AVTG) 2006, Department of Environment and Conservation;
- Australian Standard AS/NZS 2107:2016 *'Acoustics - Recommended design sound levels and reverberation times for building interiors'*;
- Australian Standard AS 2187.2:2006 *'Explosives - Storage and use - Part 2 Use of explosives'*;

- Australian Standard AS2436-1981 *'Guide to Noise Control on Construction, Maintenance and Demolition Sites'*;
- British Standard BS 6472-2008, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*;
- British Standard 7385: Part 2-1993 *'Evaluation and measurement of vibration in buildings'*;
- German Standard DIN4150-2016 *'Structural vibration Part 3: Effects of vibration on Structures'*;
- *Noise Policy for Industry* (NPfI) 2017, NSW Environment Protection Authority (EPA); and
- *Road Noise Policy* (RNP) 2011, NSW Environment Protection Authority (EPA).

2 Project Description

The Proposal is located in the suburb of Normanhurst, NSW, approximately 20 kilometres north-west of the Sydney Central Business District (CBD) within the Hornsby local government area (LGA). The current location of Normanhurst Station was established in 1895 and is serviced by the T9 Northern Line of the Sydney Trains network.

The Proposal is located within the existing footprint of Normanhurst Station (refer to Figure 2.1). Access to the site of the Proposal would be via the existing Station Access locations on Denman Parade and Malsbury Road. Commuter and pedestrian access to the station will be maintained at all times, except for during scheduled rail line shutdown periods.

The existing ambient noise environment is dominated by road traffic on Malsbury Road/Milson Parade. Adjacent to the south of the site is a strip mall, encompassing numerous commercial/retail operations. The nearest residences are located to the north (across Malsbury Road/Milson Parade), east and south-west of the site.

2.1 Proposed works

Details of the proposed work to take place at the station to improve accessibility are provided below:

- construction and installation of two new passenger lifts and lift landings connecting to the existing footbridge. This work would include:
    - installation of a lift at the station entrance on Malsbury Road;
    - installation of a lift at the station entrance on Denman Parade;
    - installation of protection screens to the lifts and stairs; and
    - lift landings with canopies for weather protection at the waiting areas.
- minor alterations to the existing stairs, providing compliant stair height, new handrails and tactile ground surface indicators (TGSIs);
- forecourt regrading work to create a larger forecourt at the Malsbury Road entrance by removing fencing and groundcover and a level forecourt at the Denman Parade entrance;
- vehicular and pedestrian wayfinding signage;
- new fencing (where required). New site perimeter fencing would be required at the Malsbury Road site boundary. Adjustment work would be completed on existing fencing where affected by construction activities;
- new pedestrian paved areas between kiss and ride bays and existing path, including upgrades to pavement;
- modifications to existing station buildings to undertake the following:
    - demolition of the existing bathroom and storeroom in the main station building;

- installation of a FAT, a female ambulant toilet, male ambulant toilet and storeroom in the main station building The new amenities fit out would include construction of level access, new wall and floor tiles, equipment, fixtures and doors. Level access for the FAT will be via a new ramp located to the west of the existing building.

- modifications to waiting rooms in both station buildings for DSAPT compliance including provision of ramp access to the main buildings waiting room and lowering the floor to provide level access to the Platform 2 waiting room; and

- upgrades to station distribution boards to accommodate new work.

- installation of new bicycle hoops at the Denman Parade entry;
- installation of free-standing canopy shelters at the BAZ on Platform 1 and 2;
- temporary site compounds and laydown areas for storage of materials and equipment;
- temporary work (where required) during construction in order to maintain existing pedestrian 'level of service', such as access provisions;
- ancillary work as required including services relocation and/or adjustments, including lighting and communications systems (e.g. CCTV), stormwater drainage, retaining walls, PA system upgrades, new hearing loops and adjustments to seating and rubbish bins as required;
- soft landscaping, including revegetation work in existing planting boxes, adjustments to existing landscaping features (such as bench seating and bike racks) and creation of new green zones as a part of revegetation of disturbance areas;
- localised platform regrading work including new TGSIs for the entire length of platforms;
- electrical upgrades to accommodate new infrastructure; and
- accessibility modifications to bus stops on Denman Parade and Malsbury Road to include TGSIs and compliant seating.

The main operational features of the Project with respect to noise include the PA system upgrades and the two passenger lifts. It is anticipated that the noise levels emanating from the upgraded PA system will not change from those experienced from the existing PA system. Conventional passenger lifts and their associated infrastructure operate in such a manner such that they are likely to be inaudible at the nearest residences. Given these, it is unlikely that operational noise emanating from the Project would increase operational noise levels at any surrounding receivers.

KEY

- Main construction area
- Noise catchment area
- Cadastral boundary
- Monitoring location
- Train station
- Rail line

Assessment location

- Commercial
- Residential

Indicative site work areas

- Site office
- Material laydown

Source: EMM (2021); Nearmap (2020); DFSI (2017); ASGC (2006)

0 50 100 m

GDA 1994 MGA Zone 56

N

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Noise monitoring and assessment locations

Transport for New South Wales
Normanhurst Station access upgrades
Noise and vibration impact assessment
Figure 2.1

EMM
creating opportunities

2.2 Work methodology

Subject to approval, construction is expected to commence in mid-2021 and is expected to be completed in 2023. The construction methodology would be further developed during the detailed design of the Proposal by the nominated Construction Contractor in consultation with Transport for NSW.

The proposed construction activities for the Proposal are identified in Table 2.1. This staging is indicative and is based on the current concept design and may change once the detailed design methodology is finalised.

Table 2.1 Indicative construction staging for key activities

Stage	Activities
Site establishment and enabling work	• secure site perimeter boundary with temporary fencing • undertake survey to identify site boundary and mark out existing services • establish site office, amenities and plant/material laydown areas • provide temporary power supply to site compound • establish temporary facilities as required (eg temporary pedestrian access to station, construction lights, etc.) • erect hoarding around work areas where required • establish other environmental controls, such as erosion and sediment controls and Tree Protection Zones (TPZs)
Relocation of services and preparation of substructure	• identification of services for protection or relocation • relocation or protection of services (as required)
Civil and Interchange Works	• modifications to the Malsbury Road and Denman Parade station entrances to create forecourt area • concrete removal and earthworks for regrading to construct/upgrade pedestrian access paths • construction of regular kiss and ride spaces on Denman Parade • modifications to bus stops on Denman Parade and Malsbury Road to comply with DDA/DSAPT requirements • mark out and remove vegetation as required • installation of wayfinding signage and other statutory/regulatory signage • fencing adjustments as required • line marking, installation of lighting and soft and hard landscaping work • Installation of new bike hoops
Lift work	• excavation for lift pits and foundations, including piling work to geotechnical and structural specifications • waterproofing (as required), installation of reinforcement, formwork and concrete to form the lift pits • installation of lift shaft and lift structures inclusive of cantilevered upper landing, glazing, louvres, roof, motor, air conditioning, and other auxiliary equipment • install canopies and anti-throw screens (where applicable) at lift landings to match existing • install lift cars • architectural fit-out around lift shaft including new awning over the lift.

Stage	Activities
Stairs and Footbridge	• demolition of existing balustrades and other existing footbridge components to accommodate lifts, where required • stair modifications including new nosings, handrails and TGSIs to meet DSAPT standards • regrading/resurfacing of stair landing surfaces and footbridge, where applicable
Station building modifications and power supply works	• modify the existing internal walls and upgrade the fittings of the existing male / female toilet facilities to provide a new family accessible toilet and male and female ambulant toilets • adjustments to the doorways and access provisions including modifications to walls and steps as required • provision of level access from platform to the family accessible toilet including remote access control • Modifications to station waiting rooms to provide level access from platform, including adjustments to waiting room seating • install new fittings, fixtures, finishes, services connections • Installation of a new isolation transformer power supply, submain connections and upgrades to the station distribution board and circuit breakers to provide a new fire rated enclosure • upgrades to general station infrastructure including wayfinding signage, PA, AFILS and CCTV as required.
Platform modification work	• platform regrading/resurfacing work as required for accessible path and combined services route • installation of new TGSIs • installation of new canopy sheltered areas at boarding assistance zones • modifications to platform furniture and fencing, including boarding ramps, lighting, payphones and drinking fountains where required • adjustments to existing Opal Card readers and provision of new opal card readers where required
• Testing and commissioning	• various activities to test and commission power supply and lighting
Decommissioning of temporary facilities and site demobilisation	• decommissioning of temporary construction facilities and site demobilisation, including removal of hoardings • removal of footpath/pedestrian management and traffic controls • removal of environmental control measures • site clean-up and tidying work

3 Existing Environment

This section describes the assessment locations identified for this study and the background noise survey to quantify the existing ambient noise environment.

3.1 Assessment locations

The nearest representative noise sensitive locations to the proposed station upgrade works have been identified for the purpose of assessing potential noise and vibration impacts. These locations were selected to represent the range and extent of noise impacts from the site. Details are provided in

Table 3.1 and their locations are shown in Figure 2.1. They are referred to in this report as assessment locations.

Table 3.1 Noise assessment locations

ID	Classification	Address	Distance to site (m)	Representative catchment area
R1	Residential	4 Eaton Avenue, Normanhurst	30	Residences to north west
R2	Residential	74 Malsbury Road, Normanhurst	36	Residences to north east (on western side of Rail line)
R3	Residential	11 Denman Parade, Normanhurst	55	Residences to north east (on eastern side of Rail line)
R4	Residential	60 Denman Parade, Normanhurst	35	Residences to south east
R5	Commercial/Retail	58 Denman Parade, Normanhurst	33	Commercial to south
R6	Commercial/Retail	52-56 Denman Parade, Normanhurst	15	Commercial to south
R7	Commercial/Retail	32-36 Denman Parade, Normanhurst	45	Commercial to south
R8	Residential	30 Denman Parade, Normanhurst	90	Residences to south west
R9	Residential	2A Milson Parade, Normanhurst	35	Residences to west

3.2 Background noise survey

In order to establish the existing ambient noise environment of the area, an unattended noise survey and operator-attended measurements were conducted at monitoring locations as guided by the procedures described in the NPfI and Australian Standard AS 1055-2018 - *Acoustics - Description and Measurement of Environmental Noise*.

Noise monitoring was conducted at one location (R1: 4 Eaton Avenue, Normanhurst), considered to be representative of the range of noise levels likely to be experienced by residential assessment locations in the vicinity of the site. The logger location was selected after inspection of the site and its surrounds, giving due consideration to other noise sources which may influence the readings (eg domestic air-conditioners), the proximity of assessment locations to the site, security issues for the noise monitoring device and gaining permission for access from the residents or landowners.

The monitoring location selected is presented in Table 3.2 and shown in Figure 2.1.

Table 3.2 Noise monitoring locations

ID	Address	Instrumentation
NM1	4 Eaton Avenue, Normanhurst	ARL NGARA (S/N 878127)

The noise logger was programmed to record statistical noise level indices continuously in 15-minute intervals, including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and the L_{Aeq}. Calibration of all instrumentation was checked prior to and following monitoring. All equipment carried appropriate and current National Association of Testing Authorities (NATA) (or manufacturer) calibration certificates.

A summary of existing background and ambient noise levels is given in Table 3.3, as derived in accordance with the NPfI. Results are provided for each day in Annexure A. The measured background noise levels are consistent with the 'Urban' area type as outlined in Appendix B from the RMS CNVS.

Table 3.3 Summary of existing background and ambient noise

Monitoring location[4]	Date	Period[1]	Rating background level (RBL)[2], dBA	Measured $L_{Aeq, period}$ noise level[3], dBA
NM1 4 Eaton Avenue, Normanhurst	11/11/2020 - 21/11/2020	Day	50	65
		Evening	44	65
		Night	35	55

1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: 10 pm to 7 am, Sunday to Friday and 10 pm to 8 am Saturday and public holidays.
2. The RBL is an NPfI term and is used to represent the background noise level. In accordance with the NPfI, minimum thresholds were adopted given measured values were lower.
3. The energy averaged noise level over the measurement period and representative of general ambient noise.
4. The noise logger was located in the rear yard of the property, which is the most exposed location to the proposed construction works.

4 Assessment criteria

4.1 Construction noise

The ICNG (DECC 2009) has been jointly developed by NSW Government agencies, including the NSW Environment Protection Authority (EPA) and Department of Planning, Industry and Environment (DPIE). The objectives of the guideline relevant to the planning process are to promote a clear understanding of ways to identify and minimise noise from construction and to identify 'feasible' and 'reasonable' work practices. The guideline recommends standard construction hours where noise from construction activities is audible at residential premises (ie assessment locations), as follows:

- Monday to Friday 7 am to 6 pm;
- Saturday 8 am to 1 pm; and
- no construction work is to take place on Sundays or public holidays.

The ICNG acknowledges that works outside standard hours may be necessary, however, justification should be provided to the relevant authorities.

The ICNG provides two methodologies to assess construction noise emissions. The first is a quantitative approach, which is suited to major construction projects with typical durations of more than three weeks. This method requires noise emission predictions from construction activities at the nearest assessment locations and assessment against ICNG recommended noise levels.

The second is a qualitative approach, which is a simplified assessment process that relies more on noise management strategies. This method is suited to short-term infrastructure and maintenance projects of less than three weeks.

This assessment has adopted a quantitative approach as the Proposal will require over three weeks of construction activities. The qualitative aspects of the assessment include identification of assessment locations, description of works involved including predicted noise levels and proposed management measures that include a complaint's handling procedure.

4.1.1 Construction noise management levels

Table 4.1 provides ICNG noise management levels (NMLs) which apply to residential assessment locations.

Table 4.1 ICNG construction noise management levels for residences

Time of day	NML $L_{Aeq,15min}$	Application
Recommended standard hours: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm, No work on Sundays or public holidays	Noise-affected RBL + 10 dB	The noise-affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{eq(15\text{-}min)}$ 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.

Time of day	NML $L_{Aeq,15min}$	Application
	Highly noise affected 75 dBA	The highly noise-affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences); 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise-affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise-affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Source: ICNG (EPA, 2009).

Table 4.2 summarises the ICNG recommendations and provides NML for other land uses.

Table 4.2 ICNG noise levels at other land use

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

Source: ICNG (DECC, 2009).

The project construction NMLs for recommended standard and out of hour periods are presented in Table 4.3 for all assessment locations. However, it is acknowledged that construction works would be during daytime hours only.

Table 4.3 Construction noise management levels

Assessment location	Period	Adopted RBL[1]	NML $L_{Aeq,15min}$, dB
Residential	Day (standard ICNG hours)	50	60
	Evening (out of hours)	44	49
	Night (out of hours)	35	40
Commercial	When in use	-	70

Note: 1. The RBLs adopted from Table 3.3.

4.2 Maximum noise level event assessment

In accordance with the NPfI methodology, the potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered.

The NPfI suggests that a detailed maximum noise level event assessment should be undertaken where the development/premises night-time noise levels at a residential location exceed:

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

Guidance regarding potential for sleep disturbance is also provided in the RNP. The RNP calls upon a number of studies that have been conducted into the effect of maximum noise levels on sleep. The RNP acknowledges that, at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance. However, the RNP provides the following conclusions from the research on sleep disturbance:

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

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade including a partially open window will reduce external noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB calculated at the facade of a residence is unlikely to cause awakening affects.

4.3 Construction vibration

4.3.1 Human perception of vibration

Humans can detect vibration levels which are well below those causing any risk of damage to a building or its contents.

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

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2 1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4.4.

Table 4.4 suggests that people will just be able to feel floor vibration at levels of approximately 0.15 millimetres per second (mm/s) and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

Table 4.4 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable

Approximate vibration level	Degree of perception
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Source: German Standard DIN 4150 Part 2 (1975).
Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hertz (Hz) to 80 Hz.

4.3.2 Assessing vibration - a technical guideline

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

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

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.5.

Table 4.5 Examples of types of vibration

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

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

Intermittent vibration is representative of heavy vehicle pass-bys and construction activities such as impact hammering, rolling or general excavation work.

Section 2.4 of the guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz.

To calculate VDV the following formula is used (refer to Section 2.4.1 of the guideline):

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

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

The acceptable VDV for intermittent vibration are reproduced in Table 4.6.

Table 4.6 Acceptable vibration dose values for intermittent vibration

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

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

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

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

4.3.3 Structural vibration

i Australian Standard AS 2187.2 – 2006

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 *Explosives - Storage and Use - Use of Explosives* recommends that the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

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

The recommended limits (guide values) for transient vibration to manage minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.7 and graphically in Figure 4.1.

Table 4.7 Transient vibration guide values - minimal risk of cosmetic damage

Line[1]	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Notes: Refers to the "Line" in Figure 4.1

The standard notes that the guide values in Table 4.7 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4.7 may need to be reduced by up to 50%.

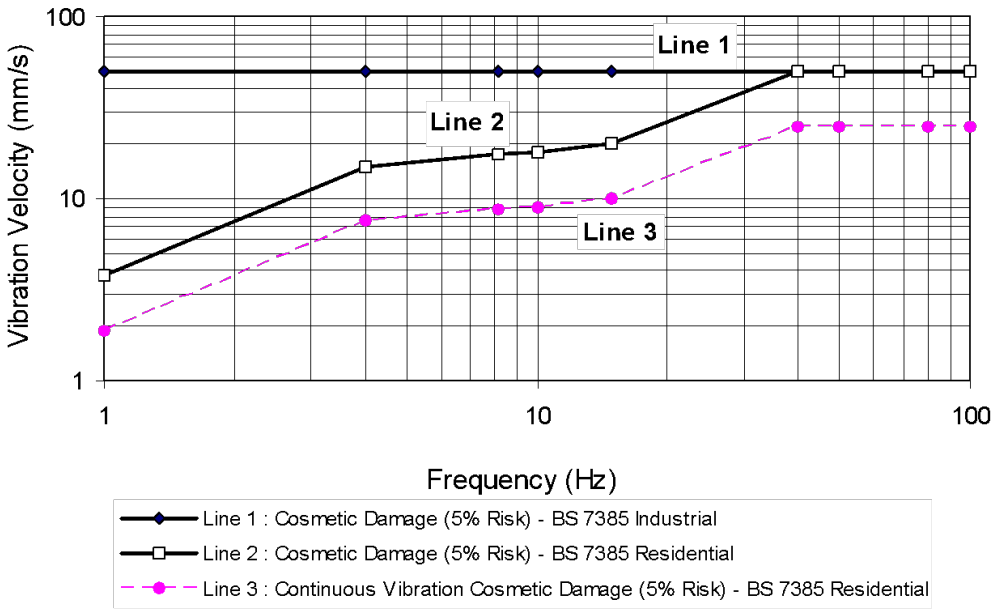


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz (as shown in Figure 4.1**Error! Reference source not found.**).

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.7 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.7.

It is noteworthy that in addition to the guide values nominated in Table 4.7 the standard states that:

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

ii German Standard DIN 4150-3:1999

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

The DIN 4150 values (maximum levels measured in any direction at the foundation, or maximum levels measured in (x) or (y) horizontal directions, in the plane of the uppermost floor), are summarised in Table 4.8 and shown graphically in Figure 4.2.

For residential and commercial type structures, the standard recommends safe limits as low as 5 mm/s and 20 mm/s respectively. These limits increase with frequency values above 10 Hz. The operational frequency of construction plant typically ranges between 10 Hz to 30 Hz, and hence according to DIN 4150, the safe vibration guide limit range for dwellings is 5 to 15 mm/s. For reinforced commercial type buildings, the limit is as low as 20 mm/s, while for heritage or sensitive structures the lower limit is 3 mm/s.

Table 4.8 Structural damage guideline values of vibration velocity – DIN4150

Line*	Type of structure	Vibration Velocity in mm/s			
		At foundation at a frequency of			Plane of floor of uppermost storey
		1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	5 to 20	15
3	Structures that because of their particular sensitivity to vibration do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Notes: 1. "Line*" refers to curves in Figure 1 of DIN4150.
2. For frequencies above 100 Hz the higher values in the 50 Hz to 100 Hz column should be used.

These levels are "safe limits", for which damage due to vibration effects is unlikely to occur. "Damage" is defined in DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

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

As indicated by the guide levels from DIN 4150 in Table 4.8, high frequency vibration has less potential to cause damage than lower frequencies. Furthermore, the "point source" nature of vibration from plant causes the vibratory disturbances to arrive at different parts of nearby large structures in an out-of-phase manner, thereby reducing its potential to excite in-phase motion of the low order modes of vibration in such structures.

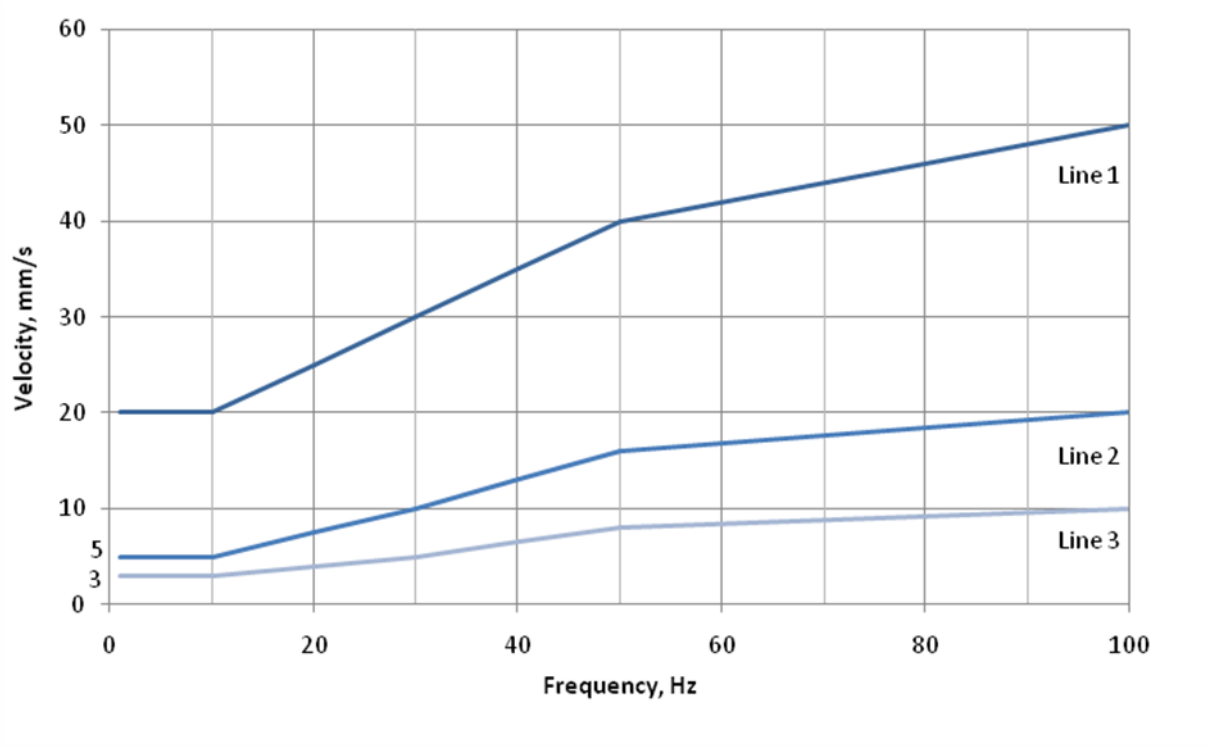


Figure 4.2 DIN4150 structural damage guideline values of vibration velocity

The potential effect of vibration on particular structures can vary depending on many factors including their existing structural integrity and use.

4.3.4 Project specific assessment criteria

Assessment of potential for cosmetic damage associated with construction activities of residential and commercial buildings, heritage structures, infrastructure items and transmission lines has adopted the criteria established in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* be used as they are "applicable to Australian conditions".

4.3.5 Construction Noise and Vibration Strategy

In many instances, impacts from construction noise and vibration are unavoidable where works are undertaken in relatively close proximity to surrounding receivers. The Construction Noise and Vibration Strategy (CNVS) includes a list of additional mitigation measures which aim to manage the potential noise impacts. Additional mitigation measures outlined in the CNVS are summarised in Table 4.9. Predicted noise levels are outlined in Section 6.1 and the mitigation requirements are discussed in Section 7 of this report.

Table 4.9 CNVS additional noise mitigation measures

ID	Name	Description
PN	Periodic Notification	For each IP 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 IP 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 IP Community Engagement Team will determine the community engagement strategy on a case-by-case basis.
V	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 (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). The purpose of monitoring is to confirm that: • 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 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 CNVIS amended.
SN	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. • 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 Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.

ID	Name	Description
RO	Respite Offer	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 IP projects.
AA	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.
AC	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 VMLs for building damage. For example, replace large rock breaker with smaller rock breakers or rock saws.
RP	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 OOHW Approval Protocol. Note; this management measure does not apply to OOHW Period 1 – Days.
DR	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 IP 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 IP Community Engagement Representatives.

For airborne noise, the level of additional mitigation is then assigned based on the impact classification (ie predicted noise level above NML) and the list of measures in Table 4.10.

Table 4.10 Additional mitigation measures matrix – airborne construction noise

Construction Hours	Perception	dBA above RBL	dBA above NML	Additional mitigation measures
Standard hours: Monday - Friday (7 am – 6 pm), Saturday (8 am – 1 pm)	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
	75dBA or greater	N/A	N/A	PN, V, SN
OOHW Period 1: Monday – Friday (6 pm – 10 pm) Saturday (7 am – 8 am & 1 pm – 10 pm) Sunday/PH (8 am – 6 pm)	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*

Construction Hours	Perception	dBA above RBL	dBA above NML	Additional mitigation measures
OOHW period 2: Monday - Friday (10 pm – 7 am) Saturday (10 pm – 8 am) Sunday/PH (6 pm – 7 am)	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: 1. The following abbreviations are used: Project Notification (PN), Verification of monitoring (V), Respite Period (RP), Alternative Accommodation (AA), Specific Notification (SN), Duration Reduction (DR), Project specific respite offer (RO).
* 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-6pm)

For vibration, the level of additional mitigation is then assigned based on the impact classification (ie predicted noise level above NML) and the list of measures in Table 4.10.

Table 4.11 Additional mitigation measures matrix – construction vibration

Construction Hours	Perception	Above VML	Additional mitigation measures
Standard hours: Monday - Friday (7 am – 6 pm), Saturday (8 am – 1 pm)	Human disturbance	>HVML	PN, V, RO
	Building damage	>DVML	V, AC
OOHW Period 1: Monday – Friday (6 pm – 10 pm) Saturday (7 am – 8 am & 1 pm – 10 pm) Sunday/PH (8 am – 6 pm)	Human disturbance	>HVML	PN, V, SN, RO, RP, DR
	Building damage	>DVML	V, AC
OOHW period 2: Monday - Friday (10 pm – 7 am) Saturday (10 pm – 8 am) Sunday/PH (6 pm – 7 am)	Human disturbance	>HVML	PN, V, SN, RO, AA, RP, DR
	Building damage	>DVML	V, AC

Note: 1. The following abbreviations are used: Project Notification (PN), Verification of monitoring (V), Duration Reduction (DR), Respite Period (RP), Specific Notification (SN), Alternative Accommodation (AA), Project specific respite offer (RO), Alternative construction methodology (AC).

4.4 Road traffic noise

Construction and operational road traffic require assessment for potential noise impacts where there is a likely increase in road traffic volumes as a result of a development. The Proposal is not expected to generate any new operation noise, as such this section considers construction road traffic noise only. The principle guidance to assess the impact of the road traffic noise on assessment locations is in the NSW Road Noise Policy (RNP). Table 4.12 presents the road noise assessment criteria for residential land uses (ie assessment locations), reproduced from Table 3 of the RNP for road categories relevant to the proposed station upgrade.

Table 4.12 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria – dBA	
		Day (7 am to 10 pm)	Night (10 pm to 7 am)
Freeway/arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{eq,15hr}$ 60 (external)	$L_{eq,9hr}$ 55 (external)

Section 2.2 of the RNP outlines the different road categories based on functionality. Considering the procedures of the RNP, for the routes proposed, this assessment has adopted arterial/sub-arterial type for Milson Parade/Malsbury Road and Denman Road.

The RNP states that where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to an increase of up to 2 dB.

In addition to meeting the assessment criteria in Table 4.12 any significant increase in total traffic noise at the relevant residential assessment locations must be considered. Residential assessment locations experiencing increases in total traffic noise levels above those presented in Table 4.13 should be considered for mitigation.

Table 4.13 Road traffic relative increase criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase – dBA	
		Day (7 am to 10 pm)	Night (10 pm to 7 am)
Freeway/arterial/sub-arterial roads and transit ways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{eq(15\text{-}hr)}$+12 dB (external)	Existing traffic $L_{eq(9\text{-}hr)}$+ 12 dB (external)

Appendix B of the RNP, states that noise levels shall be rounded to the nearest integer, whilst difference between two noise levels are to be rounded to a single decimal place.

4.5 Operational noise

Once the Project has been completed, noise generated from the operation of Normanhurst station is expected to remain the same as that currently experienced by the nearest assessment locations. The proposal is not expected to generate any additional noise and as such, operational noise impacts stemming from the proposal are considered unlikely and have not been assessed further.

Road traffic volumes associated with the operation of the Proposal are not expected to change from current volumes. As such, road traffic noise impacts as a result of the Proposal are considered unlikely.

5 Assessment method

5.1 Noise modelling

This section presents the methods and base parameters used to model operational and construction noise and vibration emissions from the proposed station upgrade.

Operational and construction noise levels were predicted using a computer-generated model using DGMR Software proprietary modelling software, iNoise. The model utilised international standard ISO 9613-2:1996 'Acoustics – Attenuation of sound during propagation outdoors'. As per Section 1 of the standard:

> The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.
>
> These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The model calculates total noise levels at assessment locations from concurrent operation of multiple noise sources. It considers factors that influence noise propagation such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the site and surrounding area and applicable meteorological conditions.

The model was populated with 3-D topography of the Proposal site and surrounding area, extending out past nearest assessment locations. Plant and equipment representing the range of proposed construction and operation scenarios was placed at locations which would represent worst case noise levels throughout the construction and operational scenarios.

5.2 Construction noise

The construction noise impact assessment has adopted sound power levels from the Department of Environment, Food and Rural Affairs (DEFRA) and EMM noise database for plant and equipment items used on similar projects. Plant and equipment items, sound power levels and quantities adopted in the noise modelling are summarised in Table 5.1.

Subject to approval, construction is expected to commence in mid-2021 and is expected to be completed in 2023. The construction methodology would be further developed during the detailed design of the Proposal by the nominated Construction Contractor in consultation with Transport for NSW.

The station upgrade will include five key phases. These include:

- site establishment and enabling work;
- relocation of services and preparation of substructure;
- construction of station upgrade work (incorporating civil and interchange works, lift works, stair and footbridge works, station building modifications, power supply works and platform modification works);
- testing and commissioning; and
- decommissioning of temporary facilities and site demobilisation.

Table 5.1 Typical construction plant and equipment

Description	Equipment	Quantity	Item $L_{Aeq,15min}$	Overall $L_{Aeq,15min}$
Site establishment	Heavy vehicle	1	105	108
	Generator	1	101	
	Hand tools	2	94	
	Backhoe	1	102	
Service relocation	Backhoe	1	102	111
	Heavy vehicle	1	105	
	Hand tools	1	94	
	30T excavator	1	104	
	Bogie tipper	1	107	
Upgrade works	Heavy vehicle	1	105	113
	Concrete pump	1	106	
	Concrete agitator	1	106	
	30T excavator	1	104	
	Elevated work platform (EWP)	1	105	
	Franna Crane	1	106	
	Hand tools	1	94	
Site demobilisation	Heavy vehicle	1	105	108
	Generator	1	101	
	Hand tools	2	94	
	Backhoe	1	102	

1. Standard hours: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm and no construction work on Sundays or public holidays.
2. Plant and equipment items have been assumed to operate continuously in any 15-minute period unless otherwise specified.

It is of note that the testing and commissioning phase is unlikely to incorporate major noise generating equipment and, as such, has not been assessed. To assess a potential worst-case construction scenario (ie upgrade works), the assessment has considered source noise levels outlined in Table 5.1. Construction noise levels were predicted to the assessment locations listed in

Table 3.1 and identified in Figure 2.1.

It is of note that while the majority of the work required for the project would be undertaken during NSW EPA's recommended standard construction hours, certain works may need to occur outside of recommended standard hours including night work and or works during routine rail shutdowns.

5.3 Road traffic noise

Assumed traffic volumes were provided by Transport for NSW to represent generation of construction vehicles associated with the Proposal. The expected traffic generated during the construction of the proposal are shown in Table 5.2.

Table 5.2 Construction traffic

Period	Construction works		
	Total Vehicles	Light Vehicles	Heavy Vehicles
Weekly	15	10	5
Daily	3	2	1
Rail Possession	35	20	15

6 Impact assessment

6.1 Construction noise

In accordance with procedures outlined in Section 5.2, prediction of construction noise levels are provided in Table 6.1 for standard day periods under ISO9613 weather conditions. The level presented for each assessment location represents the energy-average noise level over a 15-minute period and assumes all plant operating concurrently. The predicted exceedance of the ICNG noise affected NML at each assessment location is also provided.

The proponent will manage construction noise levels where exceedances of NMLs have been identified. The construction noise management methods will be detailed in a construction noise management plan as discussed further in Section 7.

The ICNG recommends the following where NMLs are predicted to be exceeded:

- application of feasible and reasonable work practices to minimise noise; and
- inform potentially impacted residents of the nature of the works to be carried out, expected noise levels and duration and relevant contact details.

Table 6.1 Predicted construction noise levels

Assessment location	Classification	Predicted construction noise level, dB $L_{Aeq,15min}$	NML, dB			
			Standard hours		OOHW Period 1	OOHW Period 2
			Noise affected NML	Highly noise affected NML		
R1	Residential	64	60	75	49	40
R2	Residential	62	60	75	49	40
R3	Residential	57	60	75	49	40
R4	Residential	63	60	75	49	40
R5	Commercial	63	70	n/a	70	70
R6	Commercial	65	70	n/a	70	70
R7	Commercial	60	70	n/a	70	70
R8	Residential	54	60	75	49	40
R9	Residential	63	60	75	49	40

Notes: Standard hours are 7am to 6pm Monday to Friday, 8am to 1pm Saturday and no work on Sunday or public holidays.
OOHW Period 1 are 6pm to 10pm Monday to Friday, 7am to 8am and 1pm to 10pm Saturday and 8am to 6pm Sundays or public holidays.
OOHW Period 2 are 10pm to 7am Monday to Friday, 10pm to 8am Saturday and 6pm to 8am Sundays or public holidays.

Construction noise levels are predicted to marginally exceed the NMLs by up to 4 dB at a number of assessment locations during standard construction hours. It is noted that the highly noise affected NML of 75 dB is predicted to not be exceeded at any locations.

The characterisation of the noise impacts (as outlined in the NPfI) are generally based on human perception to changes in noise levels as explained in the glossary of the acoustic terms in this report. For example, a change in noise level of 3 dB is considered marginal, as a change of 3 dB is only just perceptible to the human ear.

There is limited opportunity to provide at source or mitigation in the form of construction hoardings given the locations and space limitations of construction works areas along with maintaining the requirement for commuter access. In accordance with the ICNG, residents will be notified prior to works commencing and which will inform them of the duration, the noise level of the works and any proposed respite periods.

It is of note that while the majority of the work required for the project would be undertaken during NSW EPA's recommended standard construction hours, certain works may need to occur outside of recommended standard hours including night work and or works during routine rail shutdowns.

While the nature of the proposed out of hours works is not known at this stage, it is expected that noise levels during these works could be similar to the predictions above during any 15-minute period, which assume all construction plant and equipment operating concurrently during a worst-case 15-minute period. The required CNVS mitigation measures as outlined in Table 7.1 reflect this assumption. Notwithstanding, it is likely that construction noise levels would be significantly less than the standard hours predictions for the majority of the out of hours works period.

6.2 Construction Traffic

Given the construction traffic volumes outlined in Section 5.3, it is anticipated that these would be less than 2% of the existing road traffic volumes on both Denman Parade and Malsbury Road/Milson Parade. An increase of 2% of existing road traffic noise volumes would equate to a road traffic noise increase of <0.5 dB. Further, and as outlined in Table G.2, a change of less than 2 dB is not typically perceptible by the human ear.

As a result, any increases in road traffic noise on Denman Parade and Malsbury Road/Milson Parade due to construction traffic are considered to have a negligible impact and, as such, road traffic noise impacts stemming from the construction of the proposal are considered unlikely.

6.3 Construction vibration

Table 6.2 provides an indication of potential offset distances required from sensitive receivers in order to comply with relevant vibration criteria. This information should be used by relevant personnel when planning their work to identify when other forms of construction methodology or vibration mitigation and/or management measures may need to be investigated or implemented. This information is based on publicly available data for other large infrastructure projects.

The safe working distances provided are indicative and will vary depending on the item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

Table 6.2 Recommended safe working distances for vibration intensive plant

Plant item[1]	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Vibratory Roller	<50 kN (typically 1–2 tonnes)	5 m	15 to 20 m
	<100 kN (typically 2–4 tonnes)	6 m	20 m
	<200 kN (typically 4–6 tonnes)	12 m	40 m
	<300 kN (typically 7–13 tonnes)	15 m	100 m
	>300 kN (typically 13–18 tonnes)	20 m	100 m
	>300 kN (>18 tonnes)	25 m	100 m
Small hydraulic hammer	(300 kg - 5 to 12 tonne excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg - 12 to 18 tonne excavator)	7 m	23 m

Plant item[1]	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Large hydraulic hammer	(1,600 kg - 18 to 34 tonne excavator)	22 m	73 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Source: Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects) (2007).
Notes: 1. Plant and equipment items are indicative to illustrate safe working distances, not all plant items will be used during the proposed works.

In relation to human comfort response, the safe working distances in Table 6.2 relate to continuous vibration and apply at residential receivers. For the proposed works, vibration emissions are intermittent and therefore higher vibration levels occurring over shorter periods are allowed, in accordance with BS 6472.

The nearest residential facades (on Malsbury Road) are located approximately 30 m or greater from the proposed construction works. The nearest commercial façades (on Denman Parade) are located approximately 15 m or greater from the proposed construction works, however it is unlikely that significant vibration generating activities will occur within 30 m of the structure. Based on the assumed construction equipment list, the most vibration intensive item of plant to be utilised close to residences will be a small to medium sized excavator. Hence, the risk of vibration impacts is low given the relevant safe-working distances of greater than 23 m.

The state significant 'Gilligaloola', Davidson Park, Roadside trees and bushland (all of which are heritage items) are located in close proximity to Normanhurst Station, however there would be no impact to these items as part of the Proposal.

In the first instance the guide values presented in Table 6.2 should be followed. Allowing for the known separation distances between construction activity and nearest receptors, it is unlikely that the project will cause vibration impacts at any surrounding receivers. No additional mitigation is therefore required.

6.4 Maximum noise level event assessment

Noise levels from the project during the night period with the potential to cause sleep disturbance at nearby residences have been assessed in accordance with the NPfI. Predicted $L_{Aeq,15\ minute}$ noise levels for the night period were taken from Table 6.1 and compared against the relevant sleep disturbance trigger levels.

Maximum noise levels from operations during the night period have also been assessed. Typical maximum noise events are likely to include reversing alarms and impacts associated with unloading. A typical conservative sound power level of L_{Amax} 121 dB has been used to predict potential sleep disturbance impacts at residential assessment locations.

Noise modelling results for the assessment of sleep disturbance are shown in Table 6.3 for noise-enhancing meteorological conditions. The assessment of sleep disturbance only applies to residential assessment locations.

Table 6.3 Predicted maximum noise event levels

Residential assessment location	Predicted $L_{Aeq,15\ minute}$ noise level, dB	Predicted L_{Amax} noise level, dB	Maximum noise screening criteria, dB	
	Noise-enhancing	Noise-enhancing	$L_{Aeq,15\ minute}$	L_{Amax}
R1	64	78	40	52
R2	62	79	40	52

Residential assessment location	Predicted $L_{Aeq,15\ minute}$ noise level, dB	Predicted L_{Amax} noise level, dB	Maximum noise screening criteria, dB	
	Noise-enhancing	Noise-enhancing	$L_{Aeq,15\ minute}$	L_{Amax}
R3	57	75	40	52
R4	63	76	40	52
R8	54	68	40	52
R9	63	78	40	52

Results of noise modelling demonstrate that maximum noise level events are predicted to exceed the relevant maximum noise level event screening criteria at all representative residential assessment locations under noise-enhancing meteorological conditions.

This is not an uncommon finding for construction works occurring during out-of-hours periods in residential areas. Out of hours works should be avoided, where possible, and the relevant mitigation measures outlined in the CNVS should be applied to minimise impacts.

6.5 Cumulative noise

Cumulative impacts occur when two or more projects are carried out concurrently and in close proximity to one another. The impacts may be caused by both construction and operational activities and can result in a greater impact to the surrounding area than would be expected if each project was undertaken in isolation. Multiple projects undertaken at a similar time/similar location may also lead to construction fatigue, particularly around noise impacts, if not appropriately managed.

A search of the Department of Planning, Industry and Environment's (DPIE) Major Projects Register, North Sydney Planning Panel Development and Planning Register, and Hornsby Shire Council's Development Application Register in December 2020 identified two major development applications are listed near Normanhurst.

The Loreto Normanhurst School Redevelopment project is currently awaiting approval from DPIE. The redevelopment involves an increase in the student cap to 2,000 students and a new boarding house. This redevelopment could result in more patrons for Normanhurst station, and therefore adds to the need for increased accessibility to the station. The redevelopment is unlikely to cause cumulative noise impacts with the proposal given the separation distances between the sites (Loreto Normanhurst School is over 500 m to the south of the site and is located across Pennant Hills Road).

The Wahroonga Estate Redevelopment is located approximately three kilometres south of the Proposal and consists of expansions to the existing Sydney Adventist Hospital and Wahroonga Adventist School (stages of which have already been completed) and the construction of a new residential development. These redevelopments increase patronage to the region and are likely to increase patrons to Normanhurst Station, but are unlikely to cause cumulative noise impacts with the proposal given the large separation distances between the sites.

Previous major projects in the region such as NorthConnex tunnel and Sydney Metro Stage 1 Northwest have been recently completed and therefore potential cumulative impacts associated with these projects are obsolete.

Based on the above, it is anticipated that the cumulative impacts would be negligible. The potential cumulative impacts associated with the Proposal would be further considered as the design develops and as further information regarding the location and timing of potential developments is released. Environmental management measures would be developed and implemented as appropriate.

7 Noise and vibration mitigation and management

The NSW EPA's ICNG requires that construction noise levels be assessed against NMLs. It is not uncommon for construction projects to exceed NMLs. For this reason, they are not considered as noise criteria, but as a trigger for all feasible and reasonable noise mitigation and management to be considered, once exceeded.

7.1 Construction Noise and Vibration Strategy

Given the predicted noise levels in Section 6.1, the relevant CNVS mitigation requirements for airborne construction noise are outlined in Table 7.1. The relevant mitigation measures have been sourced from Table 9 of the RMS CNVS.

Table 7.1 Required CNVS mitigation – airborne construction noise

Assessment location	Predicted noise level, dB	Level above NML, dB			Mitigation required		
		Standard hours	OOHW Period 1	OOHW Period 2	Standard hours	OOHW Period 1	OOHW Period 2
R1	64	+4	+15	+24	Nil	PN	PN, V, SN, RP, DR
R2	62	+2	+13	+22	Nil	PN	PN, V, SN, RP, DR
R3	57	Nil	+8	+17	Nil	PN	PN, V, SN, RP, DR
R4	63	+3	+14	+23	Nil	PN	PN, V, SN, RP, DR
R5	63	Nil	Nil	Nil	Nil	Nil	Nil
R6	65	Nil	Nil	Nil	Nil	Nil	Nil
R7	60	Nil	Nil	Nil	Nil	Nil	Nil
R8	54	Nil	+5	+14	Nil	Nil	PN, V
R9	63	+3	+14	+23	Nil	PN	PN, V, SN, RP, DR

Notes: 1. The following abbreviations are used: Project Notification (PN), Verification of monitoring (V), Respite Period (RP), Alternative Accommodation (AA), Specific Notification (SN), Duration Reduction (DR), Project specific respite offer (RO).

As no assessment locations are expected to exceed the relevant construction vibration criteria, no mitigation is required as per the CNVS.

As mentioned previously, the nature, timing and extent of the proposed out of hours works is not known at this stage and a review of the applicable AMM should be undertaken once the extent of the proposed out of hours works is determined.

In addition to the outcomes from the CNVS, a number of standard mitigation measures will be adopted by the project. Examples of these measures are listed in the following sections.

7.2 Construction Noise and Vibration Management Plan (CNVMP)

It is recommended that a CNVMP be prepared for the construction works, outlining how Transport for NSW will manage construction noise and vibration during the construction works, including as a minimum,

- identification of nearby residences and sensitive land uses;

- description of approved hours of work and what work will be undertaken;
- description of what work practices will be applied to minimise noise;
- description of the complaints handling process;
- description of monitoring that is required; and
- notification process for nearby properties.

7.3 Work practices

There are a number of work practices that may be implemented to mitigate and minimise noise and vibration. These include:

- avoiding the use of public address systems or other methods of site communication that may unnecessarily impact upon neighbouring residents;
- where possible, avoid the use of equipment that generates impulsive noise;
- minimise the movement of materials and plant and unnecessary metal-on-metal contact; and
- Use two way radio rather than horns for signalling between plant and work groups.

7.3.1 Work scheduling

There are a number of good practice work scheduling methods that may be implemented to mitigate and minimise noise and vibration. These include:

- where possible, schedule activities to minimise impacts by undertaking all possible work during hours that will least adversely affect sensitive receivers and by avoiding conflicts with other scheduled events;
- where possible, scheduling concurrent noisy activities separately to reduce the overall noise generated; and
- where possible, planning deliveries and access to the site to occur quietly and efficiently and organising parking only within designated areas located away from the sensitive receivers.

7.4 Community consultation

Community consultation includes:

- periodic notification (such as monthly letterbox drop) detailing upcoming construction activities delivered to sensitive receivers at least seven days prior to commencement of works; and
- register of most affected noise and vibration sensitive receivers (NVSRs) including address, category (residential, commercial, etc), contact name and phone number.

7.5 Feasible and reasonable noise mitigation

A noise mitigation measure is considered feasible if it can be engineered and is practical to build and/or implement, given project constraints such as safety, maintenance and reliability requirements.

Reasonableness relates to the application of judgement in arriving at a decision, considering if the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the mitigation measure.

The following factors have been considered when evaluating the available noise mitigation options:

- Noise impacts:
  - existing and future noise levels, and projected changes in noise levels;
  - the amount by which the RNP triggers are exceeded;
- Noise mitigation benefits:
  - amount of noise reduction expected;
  - number of people likely to benefit;
- Cost-effectiveness of noise mitigation:
  - total cost of mitigation measures (including capital and maintenance);
  - ongoing operational and maintenance cost borne by the community (eg running air conditioners if closing dwelling windows is required to improve noise);
- Community views:
  - aesthetic considerations; and
  - views of all potentially affected areas determined through community consultation.

Consideration of the feasibility and reasonableness of additional noise mitigation measures has been undertaken considering the residential properties exposed to exceedances of the predicted construction noise levels above the relevant NMLs of the ICNG.

Mitigation options have been considered as provided in Table 7.2. Mitigation strategies have been considered in the following hierarchical approach:

1. control of noise at the source;
2. once the feasible and reasonable controls at the source are exhausted, controlling the transmission of noise; and
3. once source and transmission feasible and reasonable controls are exhausted, considering mitigation measures at the noise-sensitive receivers.

Table 7.2 Mitigation decision-making matrix

Mitigation option	Feasible?	Reasonable?	Justification for adopting / disregarding and expected noise benefit
At-source controls			
Option 1 Reduction in noise from construction equipment	No	No	Rejected on basis of requirement for relatively expensive engineering treatment to contractor equipment which would only be utilised at the site for the duration of construction. Benefits: Compliance with ICNG criteria for nearest residences.
Control transmission of noise			
Option 2 Provision of construction hoardings on the construction works/site boundaries	Yes	Yes/No	Possibly feasible and reasonable for some areas of the construction works. Not feasible for other areas on the basis of works location, space limitations and the requirement for commuter access. Benefits: Possible compliance with ICNG criteria for nearest residences.
Mitigation at the receptor			
Receptor mitigation	Yes	No	Rejected on the basis of the temporary and marginal nature of potential exceedances. Cost can be high for receptor mitigation (mechanical ventilation, building upgrades, etc.). Does not address external amenity.

8 Noise and vibration monitoring

To maximise the effectiveness of management strategies to minimise noise emissions, a monitoring program has been developed to guide, manage, quantify and control emissions from construction activities. Where monitoring results indicate exceedances of the relevant noise and vibration goals, additional feasible and reasonable mitigation measures and controls should be considered to minimise impacts to nearby sensitive receivers.

It should be noted that while there are no specific requirements to undertake noise and/or vibration monitoring throughout construction works, monitoring should be considered if noise/vibration levels are predicted to be significantly above recommended criteria or validated complaints are received from nearby sensitive receivers.

8.1 Objectives

Upon commencement of acoustically significant activities or where valid complaints are received, monitoring could be conducted to quantify construction noise and vibration levels and to verify these levels within the community.

The objectives of the monitoring program would be as follows:

- specify appropriate intervals for monitoring to evaluate, assess and report the relative contribution due to construction activity;
- outline the methodologies to be adopted for monitoring construction noise and vibration, including justification for monitoring intervals or triggers, weather conditions, monitoring location selection and timing;
- assess construction noise and vibration levels against relevant goals, with consideration given to non-site related ambient and background noise and vibration at the time of measurements;
- identify potential noise and vibratory sources and their relative contribution to impacts from construction activity; and
- incorporate noise and vibration management and mitigation strategies outlined in this plan.

8.2 General noise measurement procedures

The noise measurement procedures should be in general accordance with AS 1055-2018 *Acoustics - Description and Measurement of Environmental Noise* and the ICNG.

All acoustic instrumentation used in the monitoring of construction should comply with the requirements of IEC 61672.1-2013 and carry current NATA or manufacturer calibration certificates. All instrumentation should be programmed to record statistical noise level indices in 15-minute intervals which include the L_{Amax}, L_{A1}, L_{A10}, L_{A90}, L_{Amin} and the L_{Aeq}.

Instrument calibration shall be checked before and after each measurement survey.

8.3 Noise monitoring

Noise monitoring should be undertaken by a suitably qualified acoustic specialist or suitably qualified and trained environment officer.

Noise monitoring should be carried out at the complainant and/or nearest sensitive receivers.

Where ambient noise is a significant feature of the noise environment at the monitoring location, and the relative construction noise contribution cannot be directly quantified, intermediate monitoring locations may be selected so that the construction noise is clearly audible above the background noise level. Using this methodology, $L_{Aeq,15\ minute}$ noise levels can be estimated to the receiver using distance attenuation calculations[1], and compared with relevant construction noise goals.

8.4 Operator attended noise surveys

Operator attended noise measurements should be conducted at the potentially most affected receiver locations or representative thereof, relevant to the construction activities at the time of monitoring. Attended noise measurements are conducted to quantify noise emissions and estimate the $L_{Aeq,15\ minute}$ noise contribution from construction activities with respect to the overall level of ambient noise. Importantly, the background and ambient noise levels at that time and in the absence of site contribution must also be quantified.

The operator shall quantify and characterise noise levels from both extraneous (non-site) and construction noise sources over a period of 15 minutes for representative potentially affected receivers.

For each 15 minute attended noise monitoring period, the following information should be recorded:

- name of monitoring personnel;
- monitoring location;
- dates and times that monitoring began and ended at each location;
- height of the microphone above the ground and, if relevant, distances to building facades or property boundaries;
- quantitative meteorological data such as wind speed (including the height above ground at which the measurement was taken), wind direction, temperature and humidity;
- qualitative meteorological information such as cloud cover, fog or rainfall;
- instrument type and calibration details before and after the monitoring period;
- statistical noise level descriptors over the 15 minute interval: $L_{Aeq,15\ minute}$, L_{Amin}, L_{A90}, L_{A10}, L_{A1} and L_{Amax};
- notes that identify the noise source that contribute to the maximum noise levels (L_{A1} or L_{Amax}) and noise sources that contribute to the overall noise environment or for periods of time when a specific noise source is audible presented on a run-chart of the recorded noise levels;
- an estimate of the noise contribution from the construction or from other identifiable noise sources;

[1] Distance attenuation can be calculated by using the following equation: $distance\ attenuation = -20log\left(\frac{distance_{new}}{distance_{old}}\right)$ where $distance_{old}$ is the distance between the measurement location and the source and $distance_{new}$ is the distance between the location of interest (e.g. residence) and the source. As a rule of thumb, if the distance between a noise source and a receiver is doubled then a reduction of 6 dB can be expected.

- measurements in one-third octave bands from 10 Hz to 8 kHz inclusive (or a broader range of bands) for the 15 minute interval;
- any other data suitable for assessing the relative contribution of site-generated noise to the overall noise being measured;
- notes that identify the noise source that contributed to the overall noise environment; and
- recommendations or comments (where considered appropriate).

8.5 General vibration monitoring procedures

The level of vibration produced by construction activities depends on a number of factors, many of which are site specific. However, given the proposed activities and the relative distance to nearest buildings, the risk of cosmetic damage is low.

Notwithstanding, it is recommended, prior to significant vibration-generating activities and where operation is required within the safe working distance for cosmetic damage, such as excavation or vibratory compaction, that a series of trials be carried out to determine likely vibration levels from typical plant at the nearest potentially affected receiver(s). The likelihood of vibration levels exceeding the criteria will be able to be determined from these results.

Continuous vibration monitoring may also be required during significant vibration generating activities if the risk of damage or annoyance, as determined from trial monitoring results, is high. If initial vibration measurement trials conclusively demonstrate negligible vibration levels within close working distances, then additional monitoring may not be required, unless otherwise warranted for risk management purposes.

Supplementary vibration monitoring may also be carried out in response to complaints received.

8.6 Vibration monitoring

Vibration monitoring should be undertaken by a suitably qualified specialist or suitably qualified and trained environment officer.

The vibration monitor should be installed at the nearest foundation point of the sensitive structure to the vibration generating works. In the event of a complaint, the monitoring shall also be carried out at the complainant location.

The monitoring equipment should be capable of recording the appropriate parameters to provide assessment against the relevant vibration goals (i.e. peak particle velocity (PPV) in three orthogonal axes). The monitor's geo-phone should be mounted on the foundation or in the ground, on a primary transmission path between construction activity and the relevant building/structure (refer to AS 2187 for further information).

The monitoring system should also be fitted with an auditory or visual alarm system (or similar) which will trigger when vibration levels approach and/or reach the nominated structural vibration criteria. This will also indicate when alternate work practices should be adopted (such as decrease vibratory intensity, alternate equipment selection, etc.).

8.7 Training

All personnel involved in noise and vibration monitoring should be adequately trained and up to date with relevant measurement standards, methodologies and product technology with respect to noise and vibration measurements.

9 Conclusion

This NVIA has been prepared to support the Review of Environmental Factors (REF) for the Transport Access Program (TAP) station upgrades at Normanhurst. It has documented the methods and results, the initiatives built into the project design to avoid and minimise associated impacts, and the mitigation and management measures proposed to address any residual impacts not able to be feasibly and reasonably avoided.

The assessment considered the potential for noise and vibration impacts of the proposed works and has been prepared in accordance with the methodology outlined in the NPfI, ICNG, as well as other relevant guidelines and standards.

Noise goals for operation and construction of the project have been established based on the results of ambient noise monitoring and methodology provided in the NPfI and ICNG.

Findings of the assessment are summarised as follows:

- Construction noise levels from the project are predicted to marginally exceed the ICNG NMLs at a number of residential assessment locations. Accordingly, it is recommended that works be conducted during standard hours only, where possible. Furthermore, residents will be notified prior to works commencing and informed of the duration and noise level of the works and any proposed respite periods.

- Maximum noise level events occurring during the night-time period are expected to exceed the screening criteria at all residential assessment locations under noise-enhancing meteorological conditions. This is not an uncommon finding for construction works occurring during out-of-hours periods in residential areas. Out of hours works should be avoided, where possible, and the relevant mitigation measures outlined in the CNVS should be applied to minimise impacts.

- The potential for vibration impacts on residents and vibration sensitive structures near construction has been assessed. The nearest off-site structures are approximately 30 m away from vibration generating construction activities. The assessment locations are well outside of the safe working distances required to maintain acceptable human response and structural vibration levels for the proposed plant and equipment. Vibration impacts from construction at the nearest assessment locations are therefore considered unlikely.

- Operational noise associated with the proposal is unlikely to change from the existing levels experienced at surrounding assessment locations and, as such, noise impacts are considered unlikely.

- Road traffic volumes associated with the construction of the proposal are negligible when compared to the existing road traffic volumes. As such, road traffic noise impacts from the construction of the proposal are considered unlikely.

- Road traffic volumes associated with the operation of the proposal are not expected to change from current volumes. As such, road traffic noise impacts as a result of the proposal are considered unlikely.

- With effective management and consideration of mitigation measures listed in Section 7, including those required by the CNVS, noise and vibration emissions from the project are expected to be well controlled and at most locations within relevant guidelines, standards and policies.

Glossary

Table G.1 Project and technical terms

Term	Meaning
ABL	The assessment background level (ABL) is defined in the INP as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
Amenity noise criteria	The amenity noise criteria relate to existing industrial noise. Where industrial noise approaches base amenity noise criteria, then noise levels from new industries need to demonstrate that they will not be an additional contributor to existing industrial noise.
Day period	Monday-Saturday: 7 am to 6 pm, on Sundays and public holidays: 8 am to 6 pm.
dBA	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
Evening period	Monday-Sunday: 6 pm to 10 pm.
ICNG	Interim Construction Noise Guideline – for the assessment of construction noise from the project
Intrusive noise criteria	The intrusive noise criteria refers to noise that intrudes above the background level by more than 5 dB.
L1	The noise level exceeded for 1% of the time.
L10	The noise level which is exceeded 10% of the time. It is roughly equivalent to the average of maximum noise level.
L90	The noise level that is exceeded 90% of the time. Commonly referred to as the background noise level.
Leq	The energy average noise from a source. This is the equivalent continuous sound pressure level over a given period. The Leq(15min) descriptor refers to a Leq noise level measured over a 15-minute period.
Lmax	The maximum sound pressure level received during a measuring interval.
Night period	Monday-Saturday: 10 pm to 7 am, on Sundays and public holidays: 10 pm to 8 am.
NPfI	Noise Policy for Industry NVIA
NVIA	Noise and vibration impact assessment.
PNTL	The project-noise trigger level (PNTL) is criteria for a particular industrial noise source or industry. The PSNL is the lower of either the intrusive noise criteria or amenity noise criteria.
RBL	The rating background level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the average background levels.
Sound power level (Lw)	A measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.

The table below gives an indication as to what an average person perceives about changes in noise levels. Examples of common noise levels encountered on a daily basis are provided in the figure below.

Table G.2 Perceived change in noise

Change in sound level (dB)	Perceived change in noise
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud.

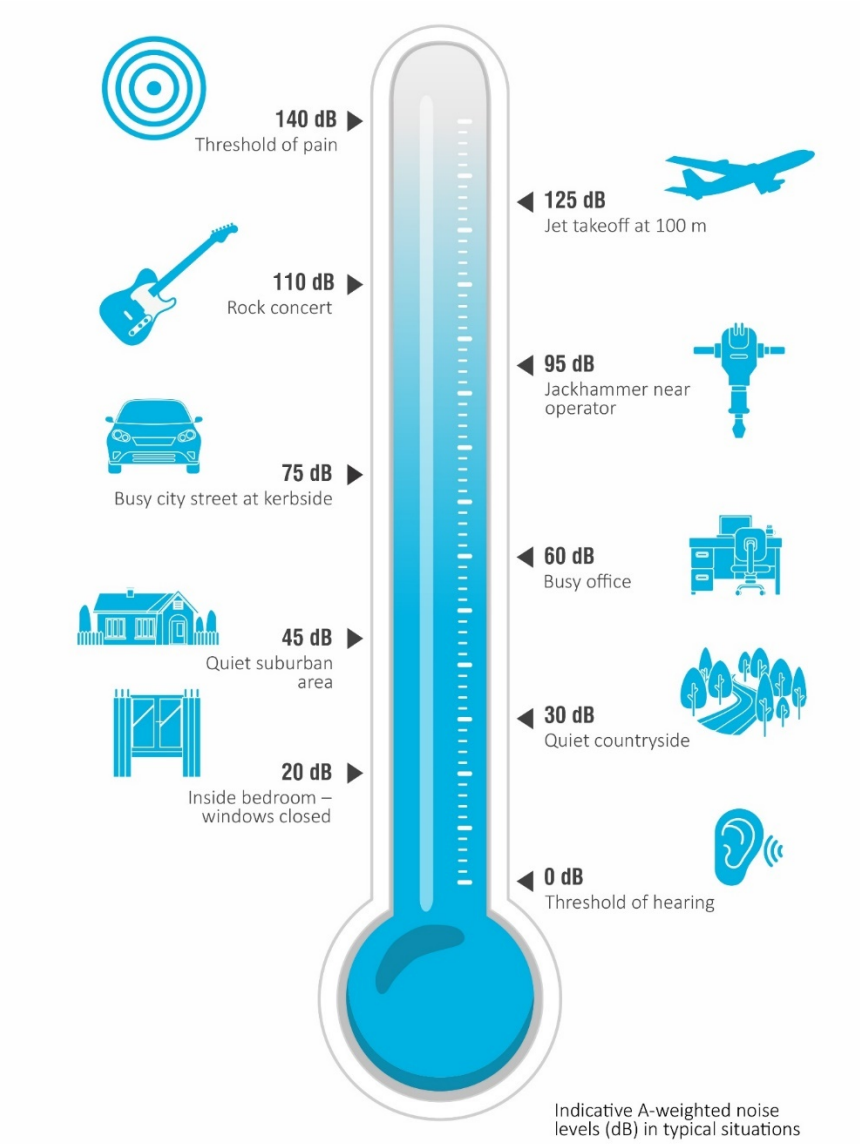


Figure G.1 Common sources of noise with levels

References

NSW Interim Construction Noise Guideline (ICNG) 2009, Department of Environment and Climate Change;

Construction Noise and Vibration Strategy (CNVS) v4.2 2019, Transport for NSW;

NSW Assessing Vibration – a technical guideline (AVTG) 2006, Department of Environment and Conservation;

Australian Standard AS/NZS 2107:2016 *'Acoustics - Recommended design sound levels and reverberation times for building interiors'*;

Australian Standard AS 2187.2:2006 *'Explosives - Storage and use - Part 2 Use of explosives'*;

Australian Standard AS2436-1981 *'Guide to Noise Control on Construction, Maintenance and Demolition Sites'*;

British Standard BS 6472-2008, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*;

British Standard 7385: Part 2-1993 *'Evaluation and measurement of vibration in buildings'*;

German Standard DIN4150-2016 *'Structural vibration Part 3: Effects of vibration on Structures'*;

Noise Policy for Industry (NPfI) 2017, NSW Environment Protection Authority (EPA); and

Road Noise Policy (RNP) 2011, NSW Environment Protection Authority (EPA).

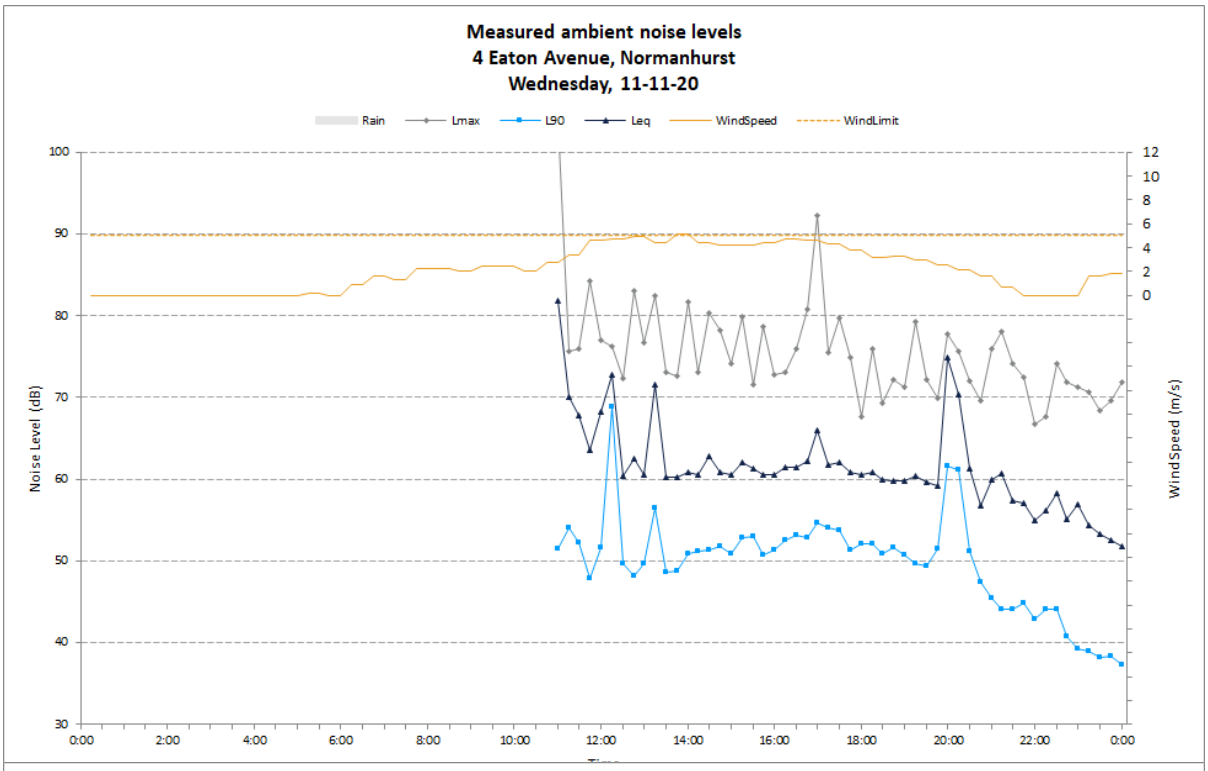
Appendix A

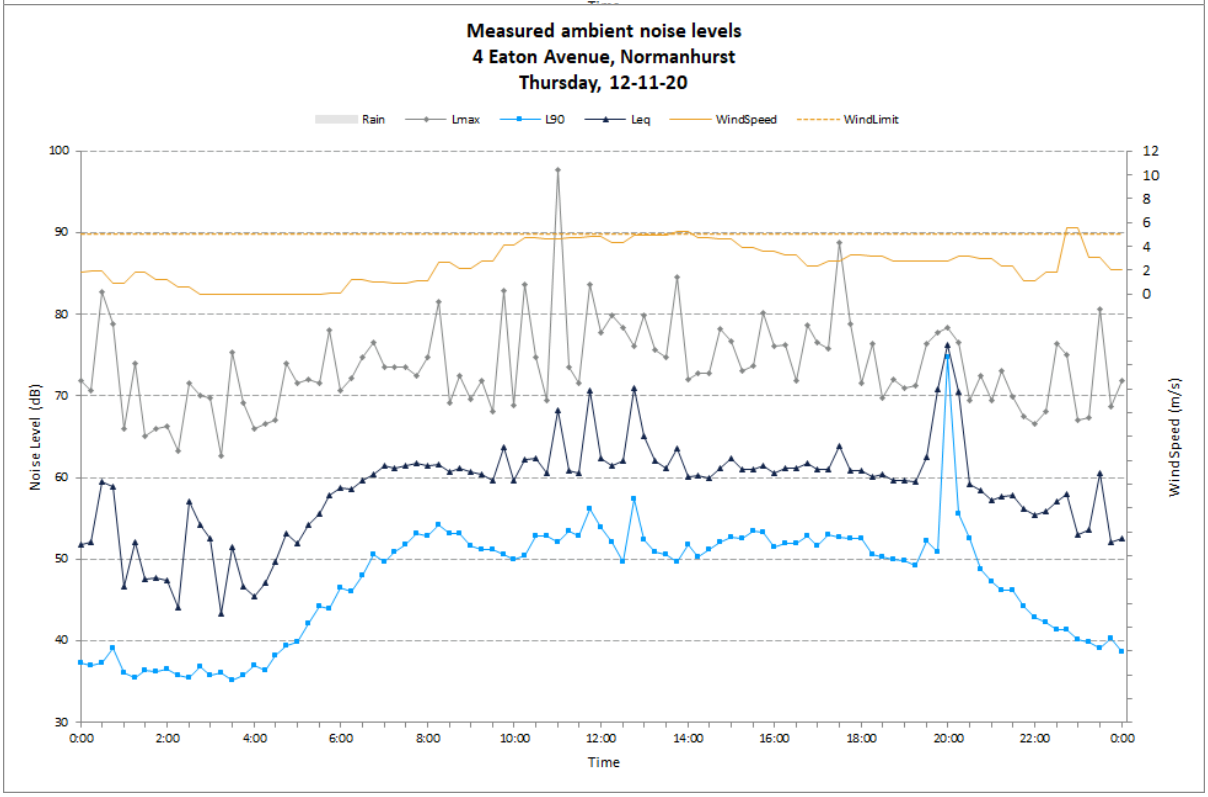
Unattended noise monitoring results

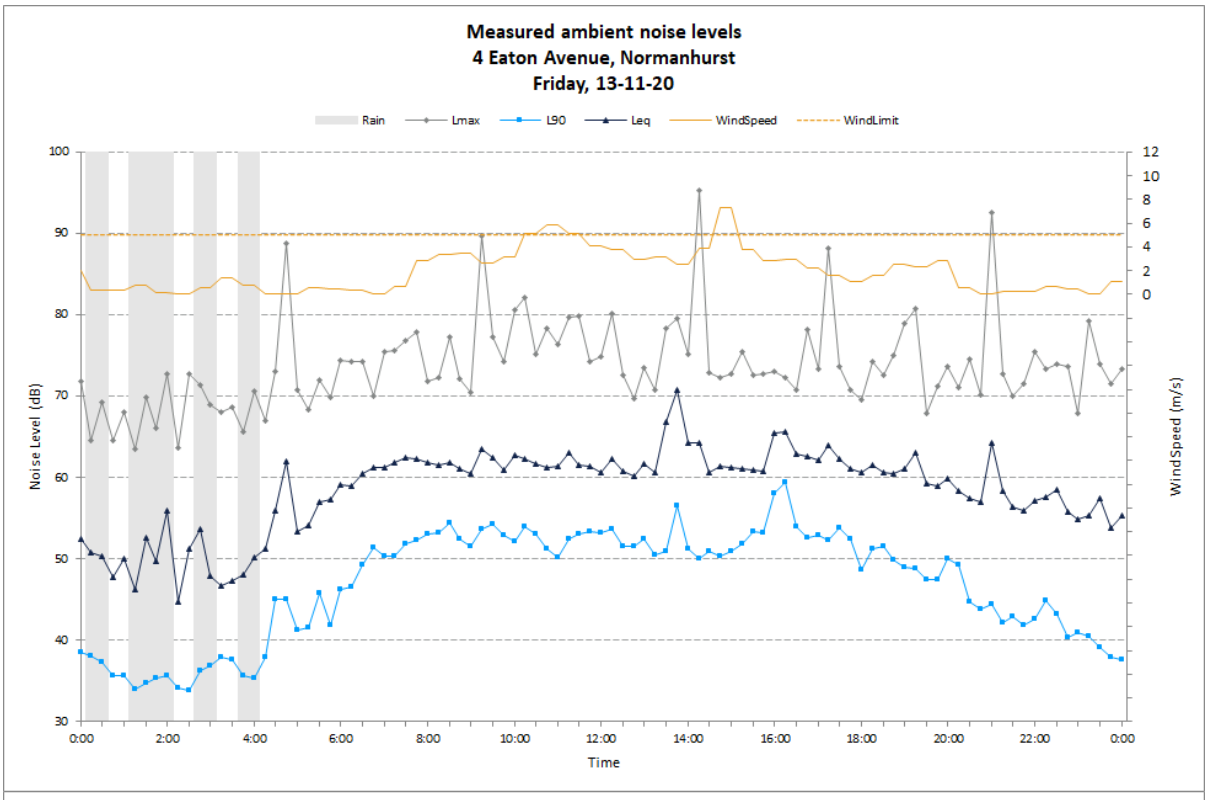
Table A.1 Summary of daily noise logging results – NM1 (4 Eaton Avenue, Normanhurst)

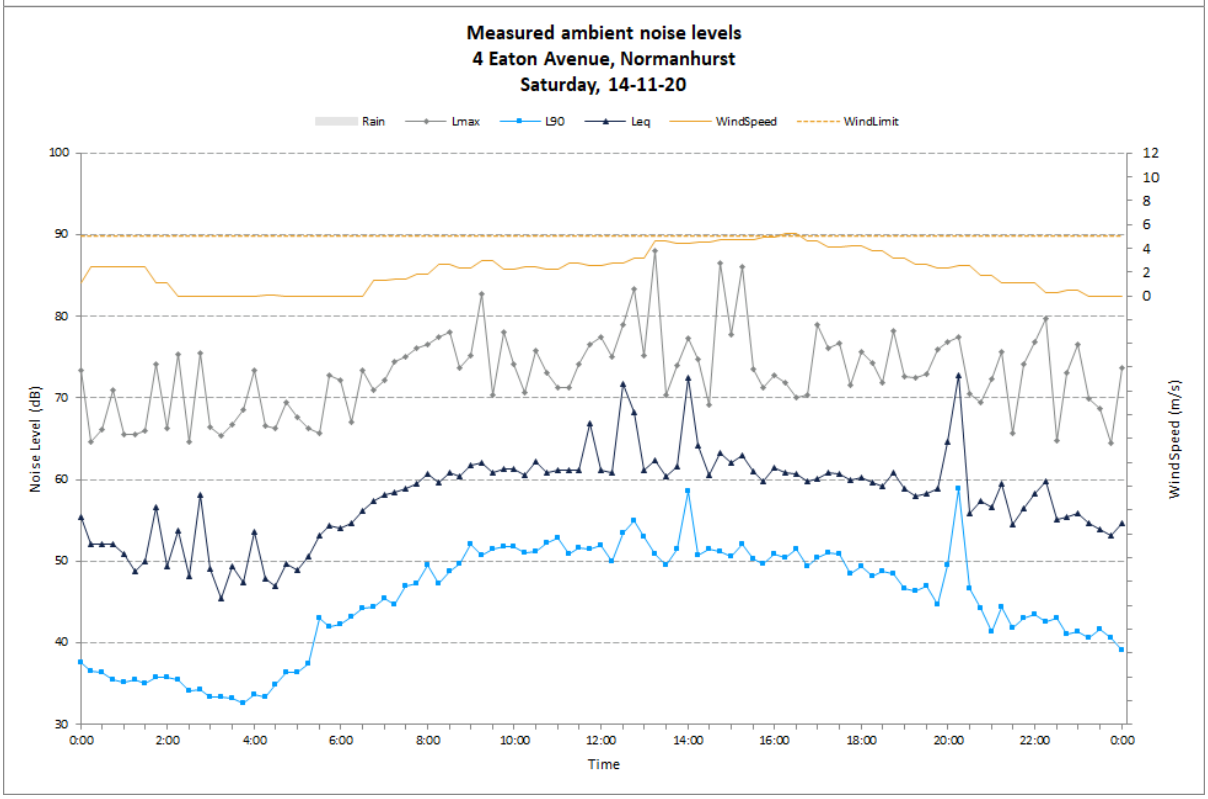
Date	RBL (Day)	RBL (Evening)	RBL (Night)	$L_{Aeq,15\ hour}$, dB (Day)	$L_{Aeq,4\ hour}$, dB (Evening)	$L_{Aeq,9\ hour}$, dB (Night)
Wednesday, 11-11-20	0	44	36	0	65	56
Thursday, 12-11-20	51	44	0	63	67	0
Friday, 13-11-20	51	42	33	63	60	54
Saturday, 14-11-20	48	42	33	63	63	53
Sunday, 15-11-20	42	44	35	64	67	55
Monday, 16-11-20	0	47	0	0	71	0
Tuesday, 17-11-20	0	41	33	0	60	55
Wednesday, 18-11-20	49	44	35	62	59	56
Thursday, 19-11-20	50	44	35	67	64	56
Friday, 20-11-20	51	49	36	67	65	55
Saturday, 21-11-20	0	0	0	0	0	0
Overall	50	44	35	65	65	55

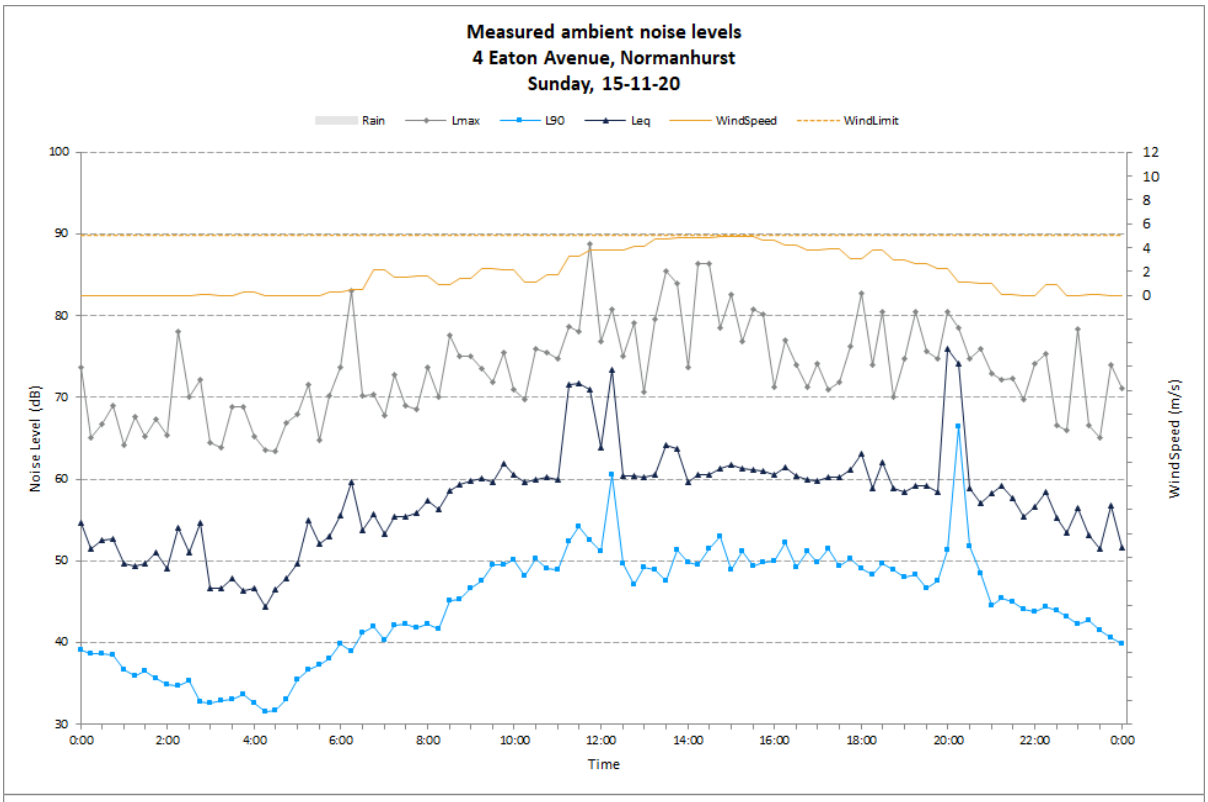
Notes: 1. 0 indicates periods with too few valid samples due to weather or logger operation
2. Leq24hr encompasses the period 7am to 7am

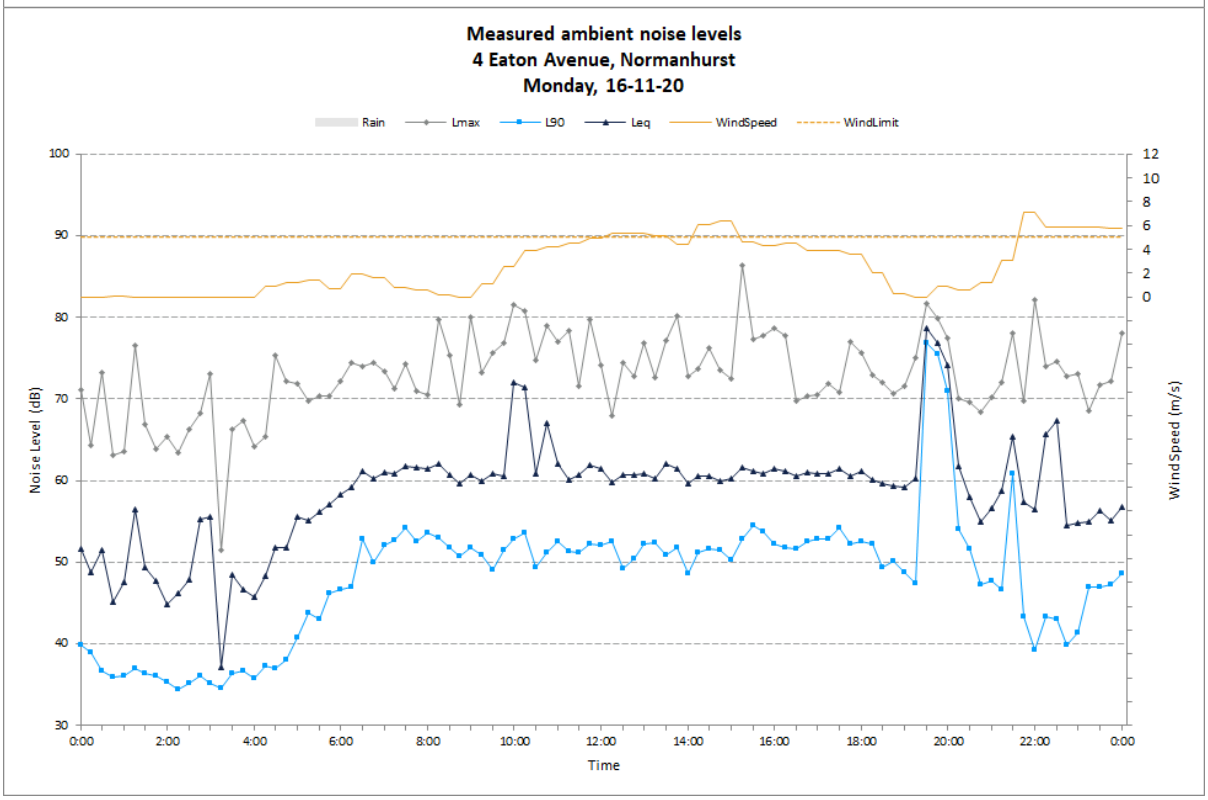

Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Wednesday, 11-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
100
90
80
70
60
50
40
30
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

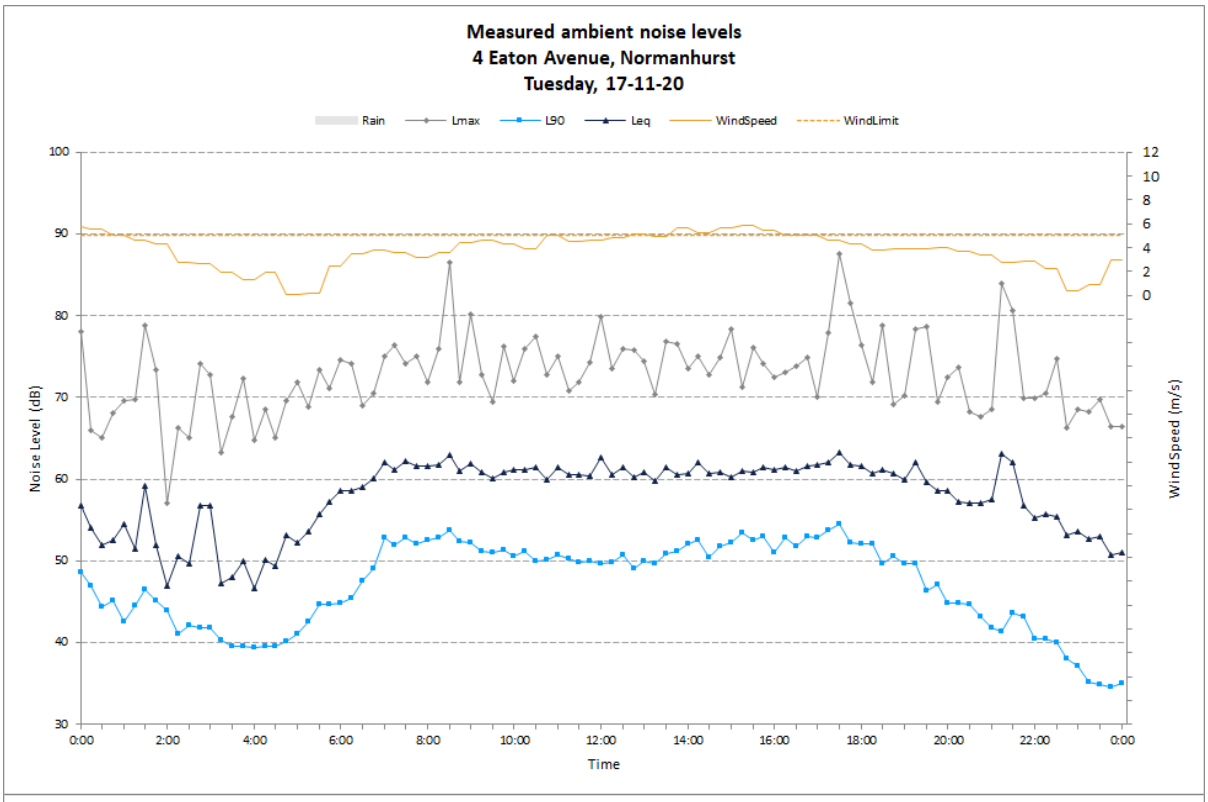

Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Thursday, 12-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
100
90
80
70
60
50
40
30
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Time


Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Friday, 13-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Saturday, 14-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Sunday, 15-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Monday, 16-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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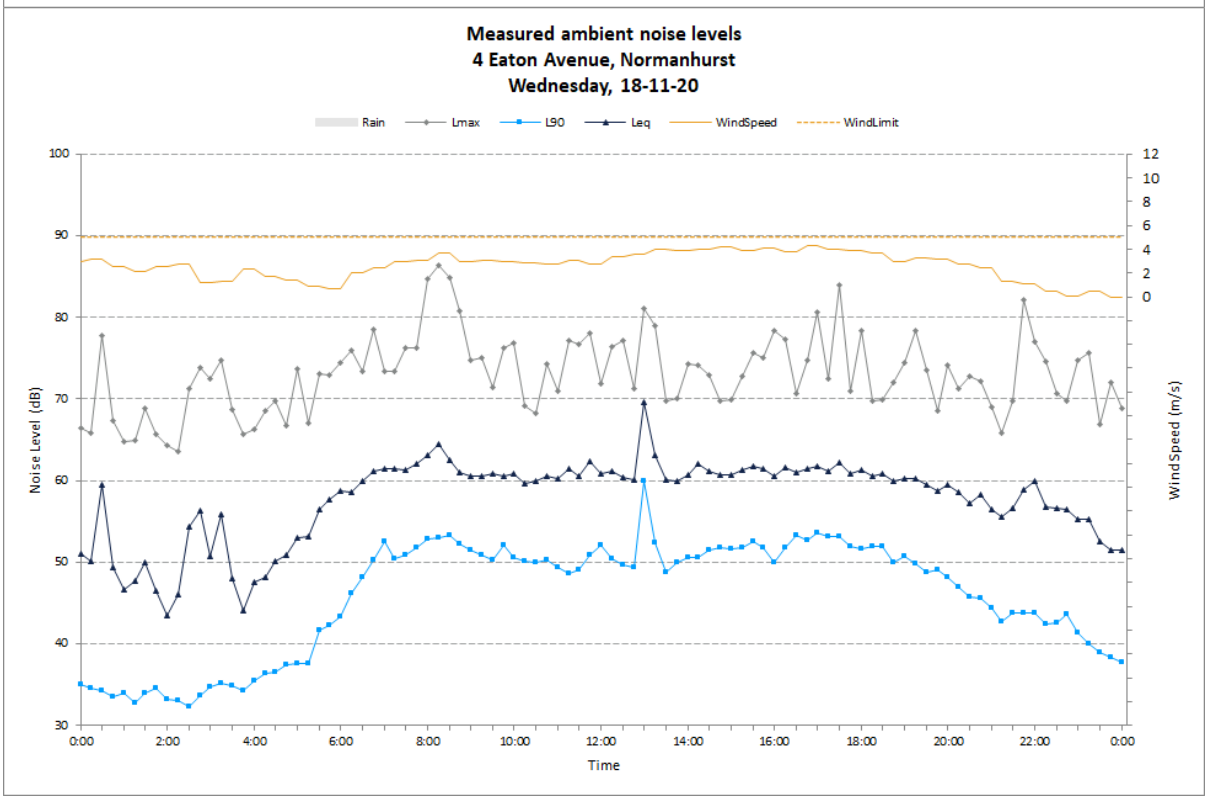
Tuesday, 17-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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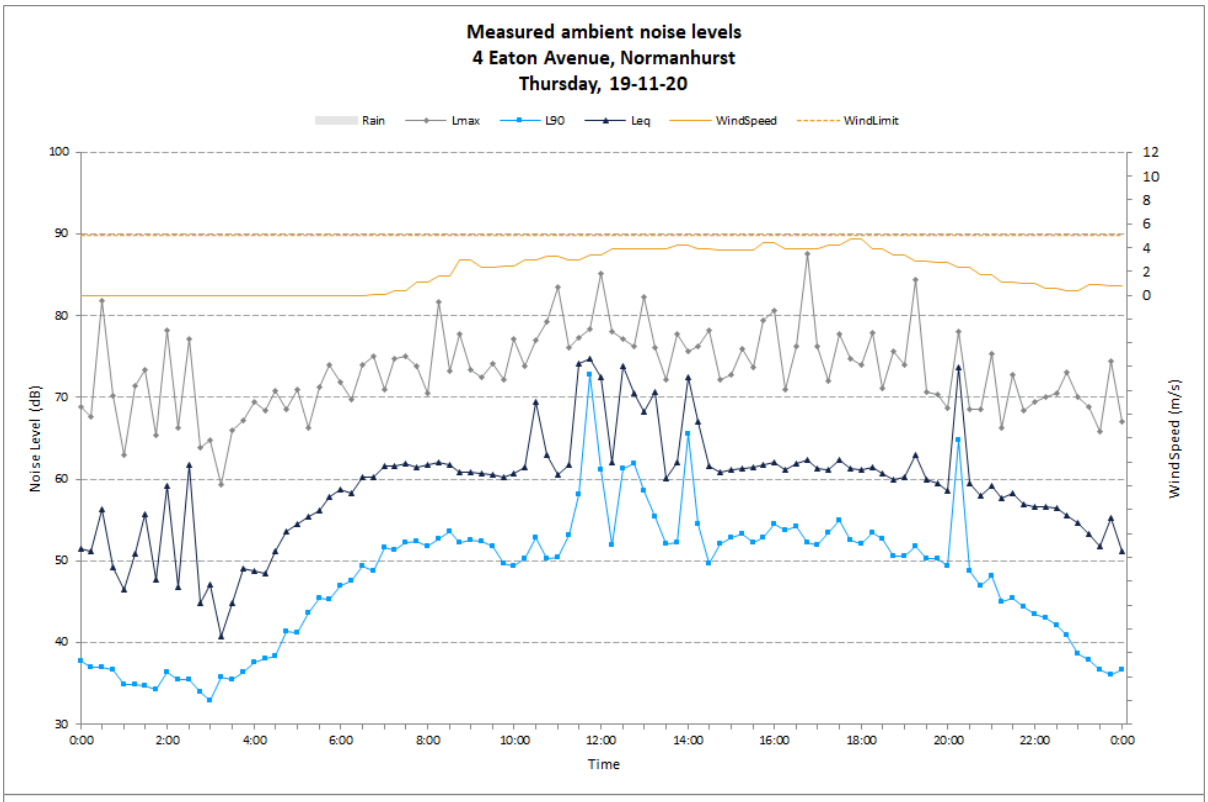
Wednesday, 18-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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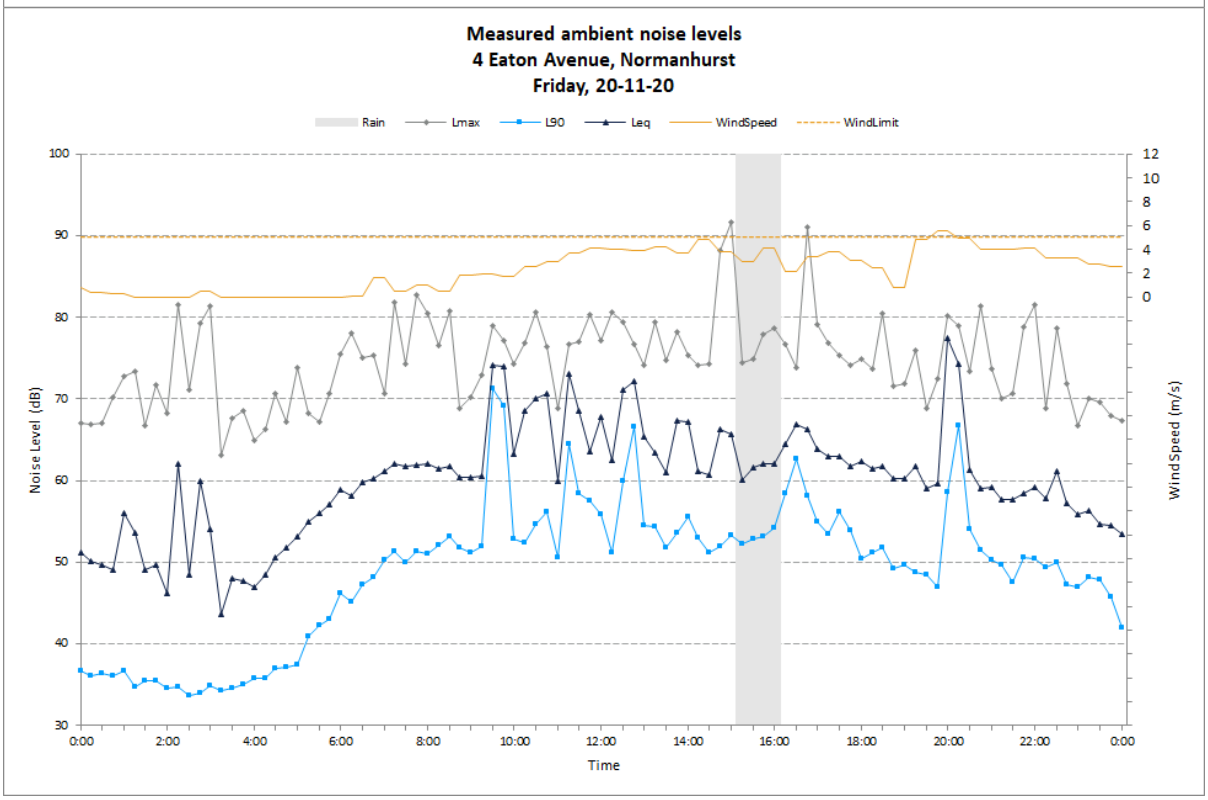
Thursday, 19-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time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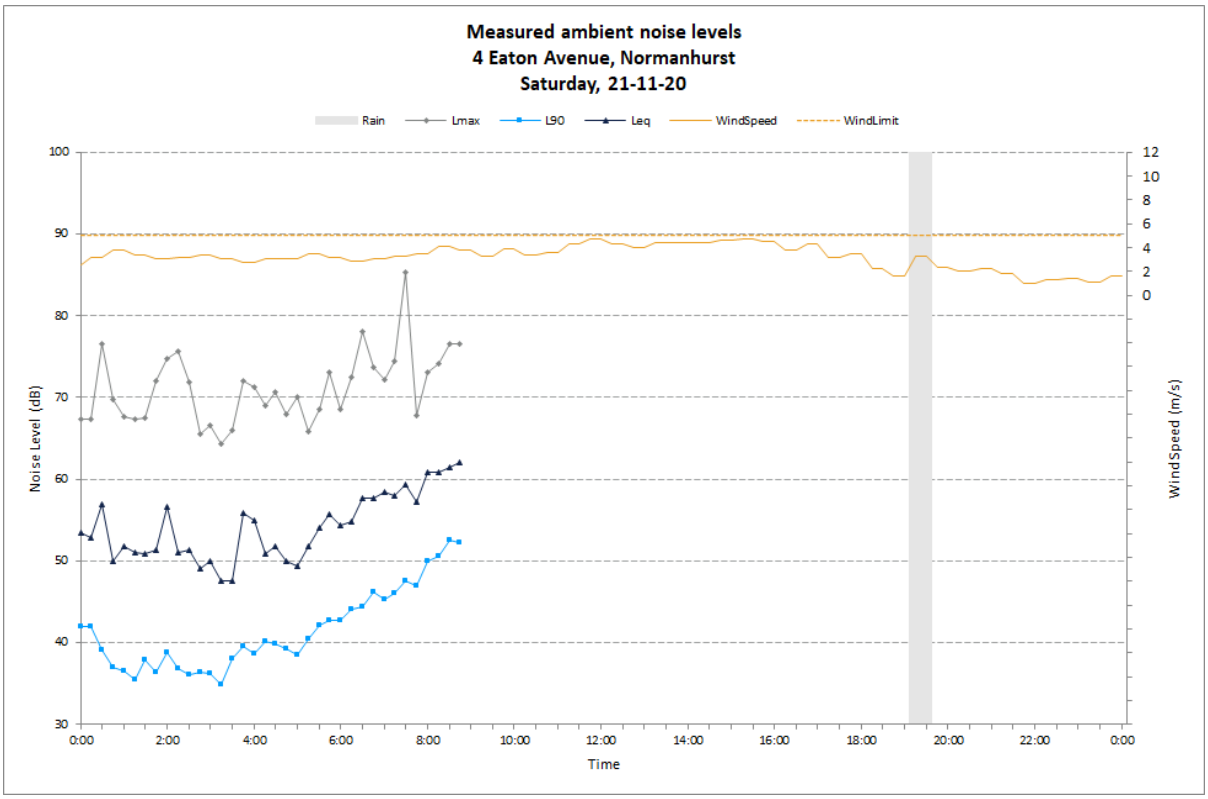
Friday, 20-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time


Measured ambient noise levels
4 Eaton Avenue, Normanhurst
Saturday, 21-11-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
WindSpeed (m/s)
Time
100
90
80
70
60
50
40
30
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00