Vibration Monitoring Assessment Report

771 Cudgen Road, Cudgen NSW

Prepared for: Lendlease Building Pty Ltd

Job Number: A101021.0286.00 VIB41.Rev0 **| Date:** 07/02/2023

ADE CONSULTING GROUP

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For and on behalf of

ADE Consulting Group Pty Ltd

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Contents

Executive Summary

ADE Consulting Group Pty Ltd (ADE) was commissioned by Lendlease Group (Lendlease) to assess the levels of construction related vibration during the construction of the Tweed Valley Hospital Project, located at 771 Cudgen Road, Cudgen NSW.

This report summarises vibration data collected at three (3) locations during the monitoring period of December 2022; ~~,~~ each device positioned along the south and southwest of Cudgen Road. At the time of preparing this report and the monitoring period in which it covers (December 2022), CD Civil are on site undertaking planned road work activities on Cudgen Road, and, Lendlease are completing superstructure works.

The road works underway are in close proximity to the vibration loggers, each of which is positioned in close proximity to residential receivers. These receivers are anticipated to experience some increased levels of perceptible vibration at~~in~~ which the occupants' comfort may be impacted during vibration intensive works. December did not have high levels of vibration.~~,~~ Nonetheless,~~however~~ some works may have impacts at the receivers which may induce a reaction from the occupants, however did not.

Measurement data during operation show vibration dose value guidelines exceeded over three (3) days, and five (5) nights at one location impacted by higher than usual extraneous influences. Conservatively, the data is likely due to the works occurring near the logger and is considered representative of the works having some expected impact to the nearby residential sensitive receiver.

While the impact at the loggers would be higher than at the facade or foundation of the receiver, the data presented in this report shows the potential for the impact which may induce a community response to the works.

ADE prepared a Construction Noise and Vibration Impact Statement to CD Civil which presents mitigation measures and management practices for impacted receiversd (where feasible and reasonable). To date, n~~N~~o comment or complaint has been received from the receivers.

1 Introduction

1.1 Introduction

ADE Consulting Group Pty Ltd (ADE) was commissioned by Lendlease Group (Lendlease) to assess the levels of construction related vibration during the construction of the Tweed Valley Hospital Project, located at 771 Cudgen Road, Cudgen NSW (hereinafter referred to as 'the Site').

No one section or part of a section of this report should be taken as giving an overall idea of this report. Each section must be read in conjunction with the entire report, including its appendices and attachments.

At the time of vibration monitoring, Lendlease is continuing superstructure works on site which includes the construction of columns and suspended slabs. CD Civil has begun works on Cudgen Road which includes construction of permanent footpaths, road construction and widening which includes the use of large 10T vibratory rollers, multi-tyred rollers, generators, excavators, graders and asphalt machines.

The purpose of environmental monitoring is to:

- aAssess construction related ground borne vibration levels against regulatory requirements, development consent conditions, Australian guidelines, and international standards for construction vibration management and control on construction sites
- mMManage and mitigate potentially excessive vibration generation through site planning and the adoption of appropriate work methods and practices where feasible and reasonable
- mMMonitor and assess construction impacts likely to cause adverse comment by the community or impact surrounding sensitive receivers/structures, and provide feasible and reasonable recommendations to manage the impacts
- eEEstablish and maintain positive relationships with project stakeholders.

The purpose of the Vibration Monitoring Assessment (NVA) report is to assess the impacts construction activities from the Tweed Valley Hospital Project have had on vibration levels on site and comply with the Tweed Valley Hospital Management Plan – Noise and Vibration, and conditions **C18** – **C20** and **B16** from the development consent below as well as the relevant criteria in **Section 2**.

This report uses specific terminology. A general acoustic glossary is provided in **Appendix I – Glossary**.

1.2 Project background

On 13 June 2017, the NSW Government announced an allocation of approximately $534M for the development of a new hospital on a greenfield site in the Tweed. The new Tweed Valley Hospital (the Project) is located on a portion of 771 Cudgen Road.

An Environmental Impact Statement (EIS) was prepared to accompany a State Significant Development Application for the Project which was assessed under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

An overview of the project specific information is provided in **Table 1** below.

Table 1 Project Specific Information

Site Details	
Client Name:	Lendlease
ADE Project Number:	A101021.0286.00
Site Address:	771 Cudgen Road, Cudgen NSW (Lot 11 DP 1246853)
Date of Report:	07/02/2023
Development Consent	SSD-10353, Health Administration Corporation. Authorized by the Minister for Planning and Public Spaces on 9 March 2020. Consent approved on 12 June 2020.
Objectives:	• Comply with DIN 4150-3:2016 guidelines and conditions **C18** - **C20** of the SSD-10353 consent • Manage potential vibration impacts from construction activities which have the potential to affect the nearby buildings (Kingscliff TAFE and residential properties) • To manage the generation of vibration which could affect the neighbours of the Site, workers on the Site, associated buildings, and other members of the public • Establish and maintain good relationships with the neighbours and wider community.
Key Legislation:	Protection of the Environment Operations Act 1997 (NSW) (POEO Act). The POEO Act is a key piece of environmental protection legislation and regulates activities via: • Environmental protection licensing, as per schedule 1 • Regulation of scheduled and non-scheduled activities • Environmental protection offences and penalties • Establishment of a general duty of care to notify environment harm.

1.2.1 Development consent SSD-10353

The consent of approval conditions regarding vibration are summarised below in **Table 2**.

Table 2 Development consent conditions

Condition of Approval number	Condition requirement
C18	Vibration caused by construction at any residences or structure outside the site must be limited to: a) For structural damage, the latest version of DIN 4150-3 (1992-02) Structural Vibration- Effects of vibration on structures (German Institute for Standardisation, 1999) b) For human exposure, the acceptable vibration values set out in the Environmental Noise Management Assessing Vibration: A Technical Guideline (DEC, 2006) (as may be updated or replaced from time to time)
C19	Vibratory compactors must not be used closer than 30 m from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified in condition C18
C20	The limits in conditions **C18** and **C19** apply unless otherwise outlined in the CNVMSP, approved as part of the CEMP required by condition **B16** of this consent

Note: CoA B16 refers to the Lendlease's Construction Noise and Vibration Management Sub-Plan (CNVMSP)

1.2.2 Monitoring Locations

M~~The m~~onitor~~s were relocated due to~~location was altered in November 2022 to assess the potential impact from scheduled road upgrade works, being undertaken by CD Civil along Cudgen Road. The monitoring locations were moved to the boundary of the nearest sensitive receivers to ensure the roadworks are compliant with the Tweed Valley Hospital Management Plan – Noise and Vibration.

Aerial imaging and monitoring location overview is presented in **Appendix II – Aerial Photograph**.

2 Vibration guidelines summary

Vibration criteria and guidelines values for sensitive structures and human comfort are derived from Australian guidelines and International Standards for the purpose of assessment.

2.1 Guideline vibration values

International standards from Germany and the United Kingdom are used in conjunction with the NSW guideline *Assessing Vibration: A Technical Guideline* (DEC, 2006) for assessment of measurement data.

The DEC guideline is an informal guideline for assessment of vibration under Australian conditions. The document outlines, summarizes, and provides guidance for the assessment of vibration.

These standards and guidelines offer guidance for the assessment of:

- Human perception to vibration
- Structures sensitive to vibration
  - Residential buildings
  - Commercial
  - Heritage or other sensitive
  - Buried pipework or other utility services including concrete and masonry.

For assessment of the potential for vibration induced damage (structural or cosmetic) of buildings, the German Standard DIN 4150 is used.

2.1.1 Structural/Cosmetic damage

Structural or cosmetic damage can be caused by transient or impulsive vibration, as well as long term intermittent vibration.

The German Standard DIN 4150:2016 is used to evaluate construction vibration on structures surrounding construction works.

Table 3 provides guideline values for evaluation of long-term vibration on buildings.

Table 3 Guideline values for evaluating the long-term vibration effects on buildings

Type of building	Guideline values for $v_{i, max}$ mm/s (PPV)	
	Topmost floor, horizontal direction, all frequencies	Floor slab, vertical direction, all frequencies
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	10	10
Residential buildings and buildings of similar design and/or occupancy	**5**	**10**
Structures that, because of their particular sensitivity to vibration, cannot be classified as above and are of great intrinsic value (e.g. listed buildings)	3	10

Note: Bold represents proejct-specific vibration guidelines

Short term vibration which includes works such as impact pile driving, excavation, and rock breaking which would cause impulsive or intermittent vibration impacts on the surrounding receivers is assessed as transient PPV vibration, guidance is taken from the DIN 4150 standard.

Table 4 below provides guidance for values for Peak Particle Velocity (PPV) at the foundation of the structure and at the plane of the topmost floor. This table illustrates particle velocity and damage (cosmetic or structural) is frequency dependent, ie that the lower the frequency the more sensitive the structure may be to vibration.

Table 4 Guideline Values for Vibration Velocity (Evaluating Effects of Short-Term Vibration on Structures)

Line	Type of Structure	Peak Particle Velocity, mm/s				
		At foundation at a frequency of			Highest floor, horizontal direction	Floor Slabs, vertical direction
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All Frequencies	All Frequencies
1	**Buildings used for commercial purposes, industrial buildings and buildings of similar design**	**20**	**20 to 40**	**40 to 50**	**40**	**20**
2	**Dwellings and buildings of similar design and/or occupancy**	**5**	**5 to 15**	**15 to 20**	**15**	**20**
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed buildings under preservation order)	3	3 to 8	8 to 10	8	20

Note: Bold represents proejct-specific vibration guidelines

A graphical representation of **Table 4** is shown below in **Figure 1**.

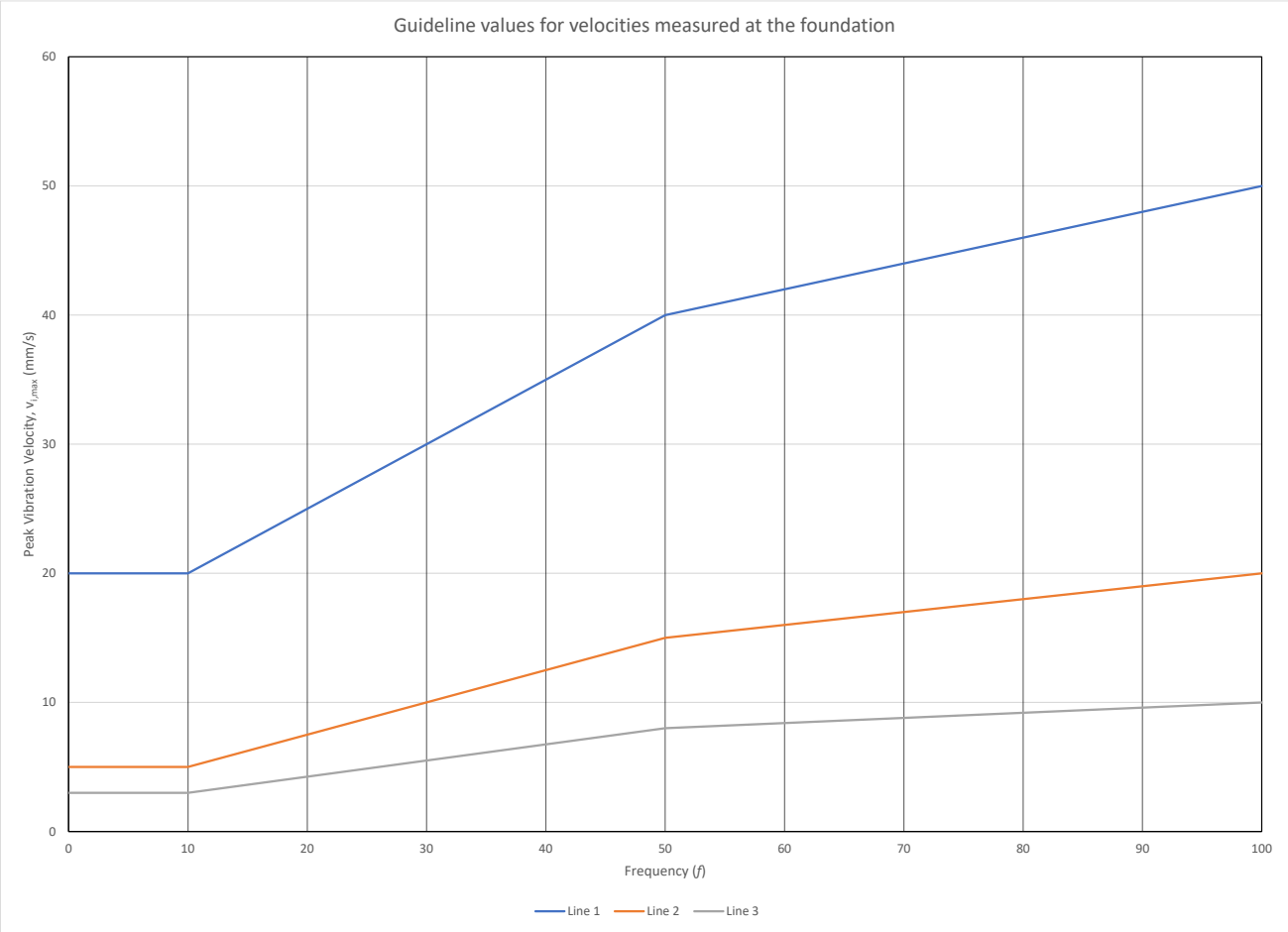

Figure 1 Illustration of the DIN4150 guideline. Structural sensitive to vibration is a function of frequency and velocity

2.1.2 Safe working distances

The Construction Noise and Vibration Strategy (CNVS, TfNSW 2019) outlines the minimum safe working distances for vibration intensive plant for surrounding vibration sensitive receivers.

As a guide, the minimum working distances for typical vibration intensive plant are listed in **Table 5**. These minimum working distances are summarised for both cosmetic damage (BS 7385 and DIN 4150) and human comfort (*Assessing Vibration: A Technical Guideline*).

Table 5 Recommended minimum working distances from vibration intensive plant (TfNSW CNS)

Plant Item	Approximate Size / Weight / Model	Minimum Distance for Cosmetic Damage (BS7385)	Minimum Distance for Human Response (DEC Assessing Vibration)	Heritage (DIN4150)
Vibratory Roller	1-2 tonne	5 m	15 – 20 m	11 m
	2-4 tonne	6 m	20 m	14 m
	4-6 tonne	12 m	40 m	27 m
	7-13 tonne	15 m	100 m	33 m
	13-18 tonne	20 m	100 m	44 m
	>18 tonne	25 m	100 m	55 m
Small Hydraulic Hammer	300 kg (5 to 12texcavator)	2 m	7 m	5 m
Medium Hydraulic Hammer	900 kg (12 to 18t excavator)	7 m	23 m	16 m
Large Hydraulic Hammer	1600 kg (18 to 34t excavator)	22 m	73 m	49 m
Pile Driver – Vibratory	Sheet piles	2 to 20 m	20 m	15 m[B]
Piling Rig - Bored	≤ 800 mm	2 m (nominal)	n/a	6 m[A]
Piling Rig – Hammer	12 t down force	15 m	50 m	45 m[A]
Jackhammer	Hand held	1 m	Avoid contact with structure	3 m

Note: Where works occur closest to a sensitive receiver which is designated as a heritage structure, more stringent conditions may apply. For this, a conservative minimum cosmetic damage distance multiplied by 2.2 is used as a guide only
Note A: Data taken from BS5228-2:2009
Note B: Conservative estimate

2.1.3 Human comfort

Construction activities which have the potential to create ground-borne vibrations may impact sensitive receivers near the project works. Humans are responsive to vibration and some discomfort may arise due to various activities, their intensity and duration.

Structural or cosmetic damage to buildings due to vibration only occur at extreme levels, relative to what humans find tolerable.

For human comfort and exposure to vibration, the NSW document *Assessing Vibration: A Technical Guideline* (DEC, 2006) provides the relevant guidance's derived from British Standard BS6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings. Part 2: Vibration sources other than blasting*.

Table 6 below tabulates the Vibration Dose Values for human comfort. These values represent a guideline for the total accumulation of vibration energy during a 15 hour day-time period where the vibration would be experienced. VDV is the total accumulated energy over time.

Table 6 Vibration Dose Values (VDV) for Intermittent Vibration

Location	Period	Preferred value, VDV $m/s^{1.75}$	Maximum value VDV $m/s^{1.75}$
Critical areas	Day or Night	0.1	0.2
Residences	**Day**	**0.2**	**0.4**
	Night	**0.13**	**0.26**
Offices, schools, educational institutions and places of worship	Day or Night	0.4	0.8
Workshops	Day or Night	0.8	1.6

Note: Daytime is 07:00 am to 22:00 pm
A 16 hour dosage is used for daytime to assess the dosage of vibration for a whole-day
Note: **Bold** indicates project-specific relevance

Table 7 below tabulates guideline VDV ranges in residential buildings at which a human response or adverse comment to construction vibration would be likely. These levels are derived from BS6472-2 and provide a subjective judgement for which vibration onsite may result in adverse comment by those who experience it, and to which this monitoring report is assessed against.

Table 7 Vibration Dose Value ranges which might result in various probabilities of adverse comment within residential buildings

Place and time	Low probability of adverse comment [1] $m/s^{1.75}$	Adverse comment possible $m/s^{1.75}$	Adverse comment probable [2] $m/s^{1.75}$
Residential buildings 16 hr day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Note 1: Below these ranges adverse comment is not expected
Note 2: Above these ranges adverse comment is likely
Note 3: For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the above vibration dose ranges for 15h day.

At levels within the ranges tabulated above, the probability for which a comment may be made from the community increases with increased vibration energy from the site. The degree of the dosage would determine the nature of the vibration perceived which may be experienced by occupants of near by vibration sensitive receivers.

3 Results overview

3.1 Survey instrumentation and methodology

The vibration measurements at three (3) locations from 1 December to 31 December 2022 at all monitoring locations were measured using Class 1 four-channel Svantek SVAN 958A Sound & Vibration Analysers.

These vibration monitors are enclosed in a weather resistant environmental case which is placed on the ground and covered with a tarp to aid in keeping temperatures below 60°C to prevent and avoid temperature related failures., and moisture intrusion Images relating to the installation of the loggers is provided in **Appendix II – Aerial Photograph** and **Appendix IV – Site Photographs**.

The tri-axial accelerometer is placed firmly against the soil surface and covered with a sandbag to minimize external interference. The monitors are positioned external the Site along the boundary adjacent Cudgen Road to the south and southeast.

A summary of the vibration monitoring equipment is provided in **Table 8** below.

Table 8 Vibration equipment deployed

Make	Model	Location	Serial Number	Calibrated on	Calibration Due
Svantek	SVAN958A	005	92832	1/02/2022	1/02/2024
Svantek	SVAN958A	006	92835	18/02/2022	18/02/2024
Svantek	SVAN958A	007	92834	9/03/2022	9/03/2024

Lendlease has established a daily check list on site to ensure all monitors are operating in the field correctly, have adequate sunlight to power the units and that they are reporting consistently. Lendlease will report any issues immediately to ADE.

Furthermore, ADE conduct regular checks throughout the week via telemetry to ensure the monitors are operating and recording correctly. ADE are to advise Lendlease of any issues immediately. Monitors will not be removed unless consultation with Lendlease, TSA and HI have occurred and alternative locations are agreed upon.

3.2 Results

3.2.1 Velocity

An increase in vibration intensive activities occurring along Cudgen Road during the road's upgrade works has increased the energy recorded and measured at the ground sensors location. Peak events infrequently exceed the recommended velocity levels *at the sensor* and may be likely to exceed at the receiver in some minor instances, however no impact is likely based on data analysis.

The increased in construction activities utilizing heavy plant equipment is origin of the measured energy, however ADE acknowledge that Logger L.006 is positioned near a farm field with irrigation which may influence both noise and vibration readings.

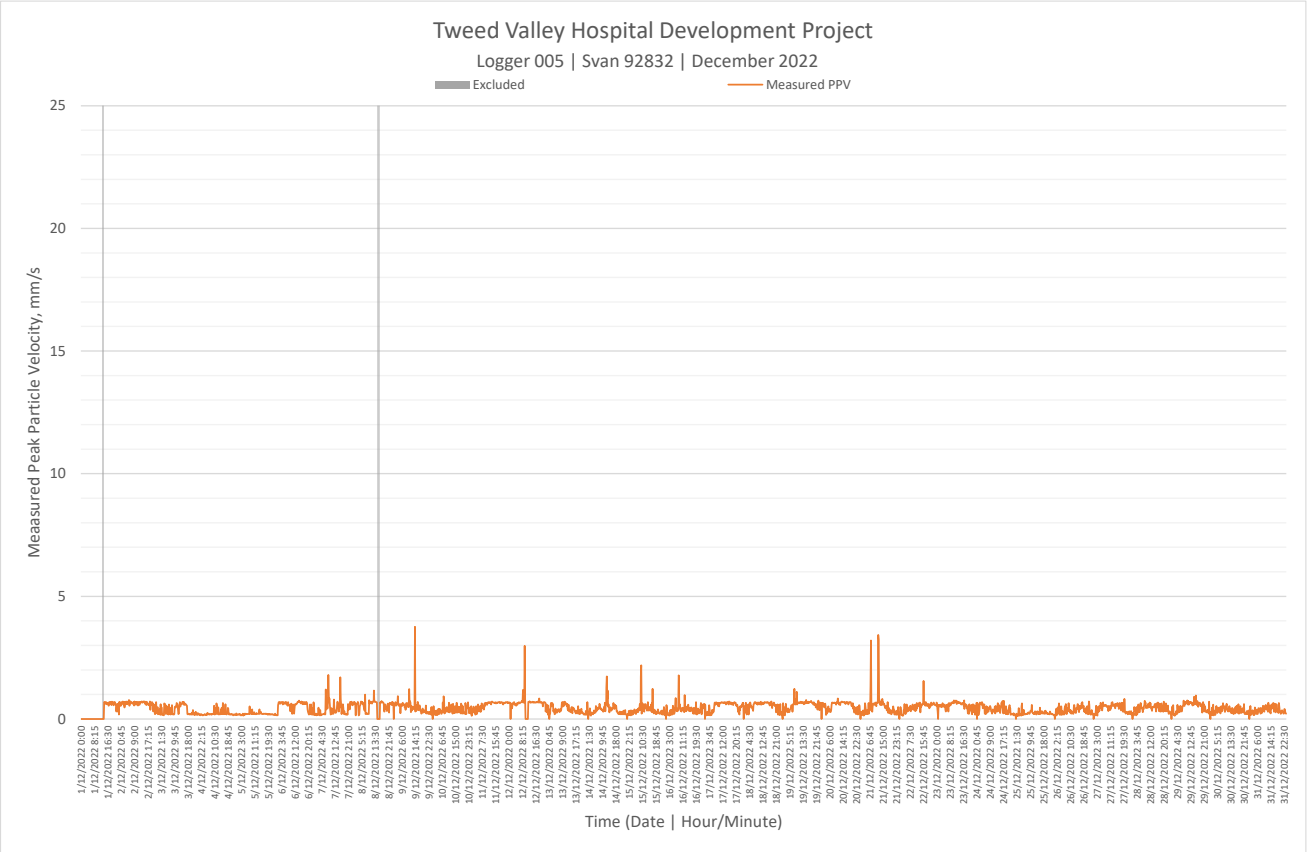

Figure 2 Velocity over time (Logger 005 - Residential/Commercial)

Figure 3 presents velocity measurement data at the Mate and Matts commercial/residential premises. ADE site visits are noted on some days and the data is excluded from analysis.

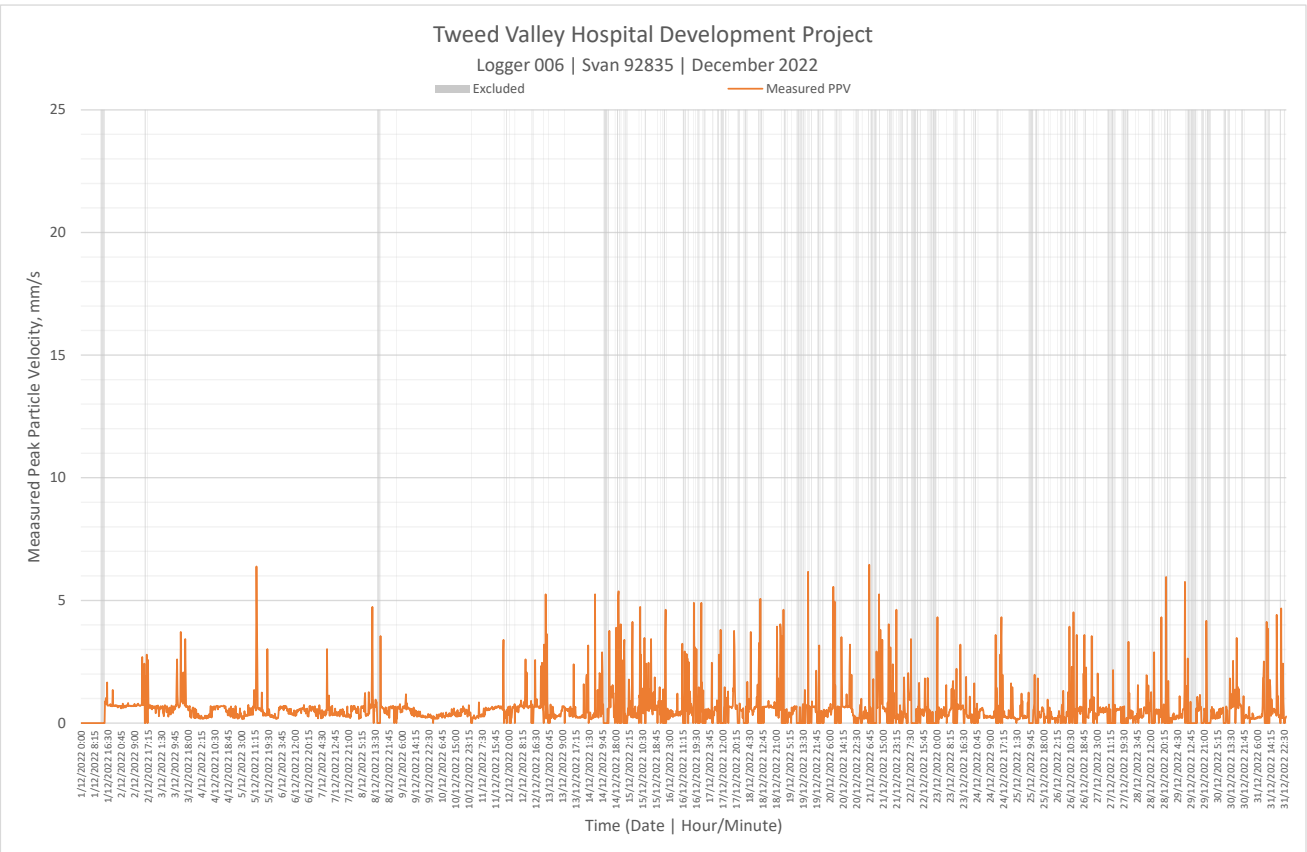

Figure 3 Velocity over time (Logger 006 – Residential/Commercial)

Figure 4 below presented velocity data for the logger located in close proximity to a residential premises.

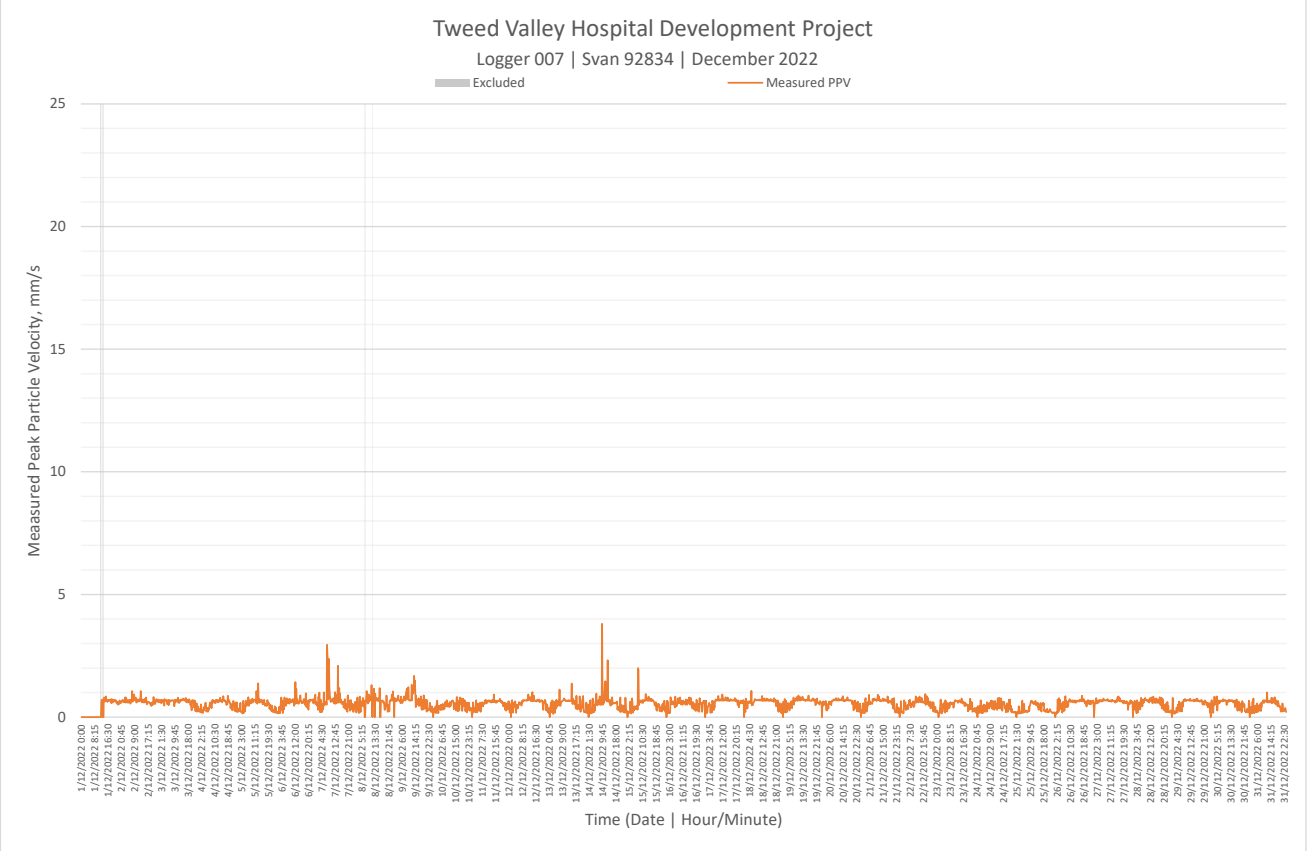

Figure 4 Velocity over time (Logger 007 – Residential)

3.2.2 Acceleration/VDV

During December 2022, road works along Cudgen Road were undertaken where large and heavy plant equipment operated along the anticipated alignment. Prior to these works, ADE undertook a Construction Noise and Vibration Impact Statement for the works. A screening assessment predicted a conservative estimated Vibration Dose Value (VDV) of 0.48 $^{m/s1.75}$ during a conservative scenario.

During the monitoring period, three (3) days measured dosages exceeding the recommended levels of ≤0.4 m/s$^{1.75}$ and five (5) night-time periods where the night-time recommended levels of ≤0.28 m/s$^{1.75}$ were exceeded.

The results were measured at Logger Location L.006 during periods of higher than usual extraneous influence and are judged conservatively as either works occurring in close proximity to the devices (relative to the other two vibration loggers), or, extraneous data not identified in the analysis process and incorrectly reported here as site impact.

At this location (L.006), the maximum measured VDV for the daytime period was 0.7 m/s$^{1.75}$ and the maximum measured VDV for the night-time period was 0.6 m/s. The results indicate that, at the residence near this vibration logger, an adverse comment is possible, as works along Cudgen Road proceed with heavy plant equipment.

Note, the vibration loggers are installed closer to the road carriageway than the facade of the nearest sensitive receiver, the results outlined here would be **higher** that what would be expected at the foundation of the residential building.

Figure 5 below presents VDV and weighted RMS Acceleration (α_{rms}) data measured at L.005. ADE site visit influence is removed from analysis.

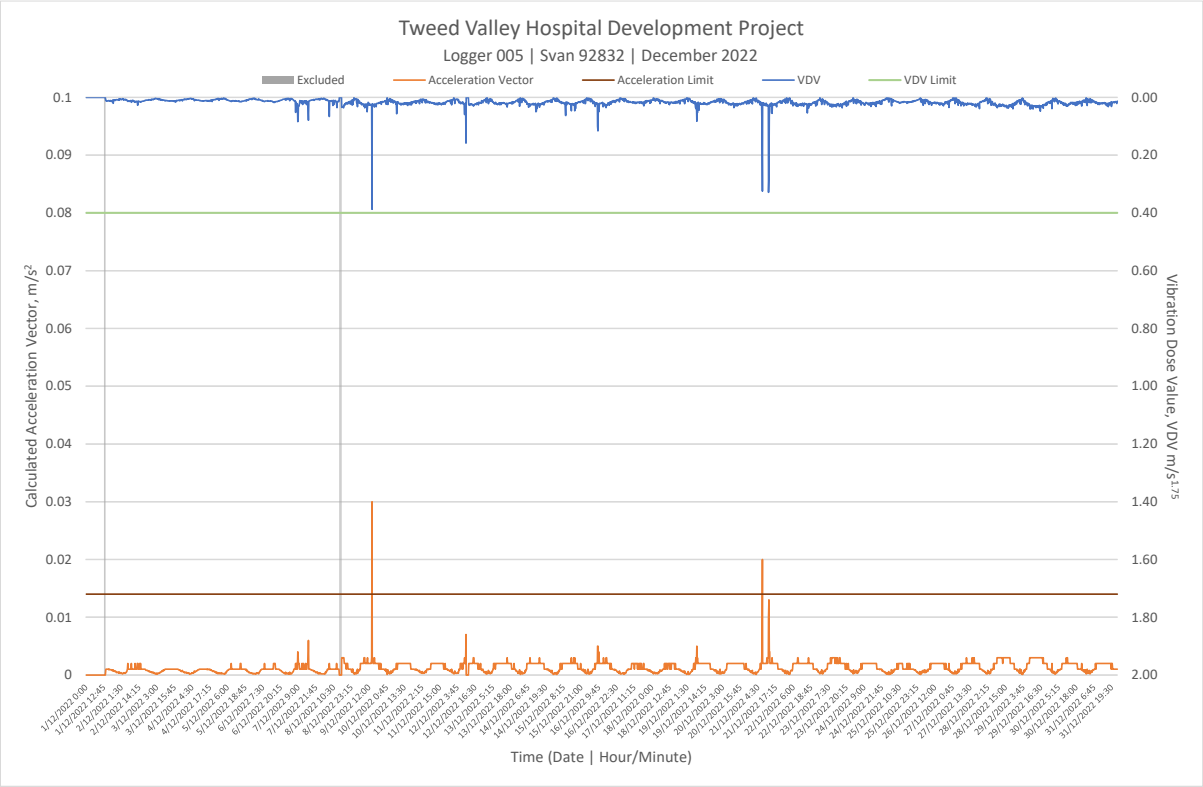

Figure 5 Acceleration and Vibration Dose Value over time (Logger 005)

The vibration impact at the commercial and residential premises is presented below in **Figure 6**. Data considered extraneous in nature (including ADE influence) has been removed from the data analysis and the graph.

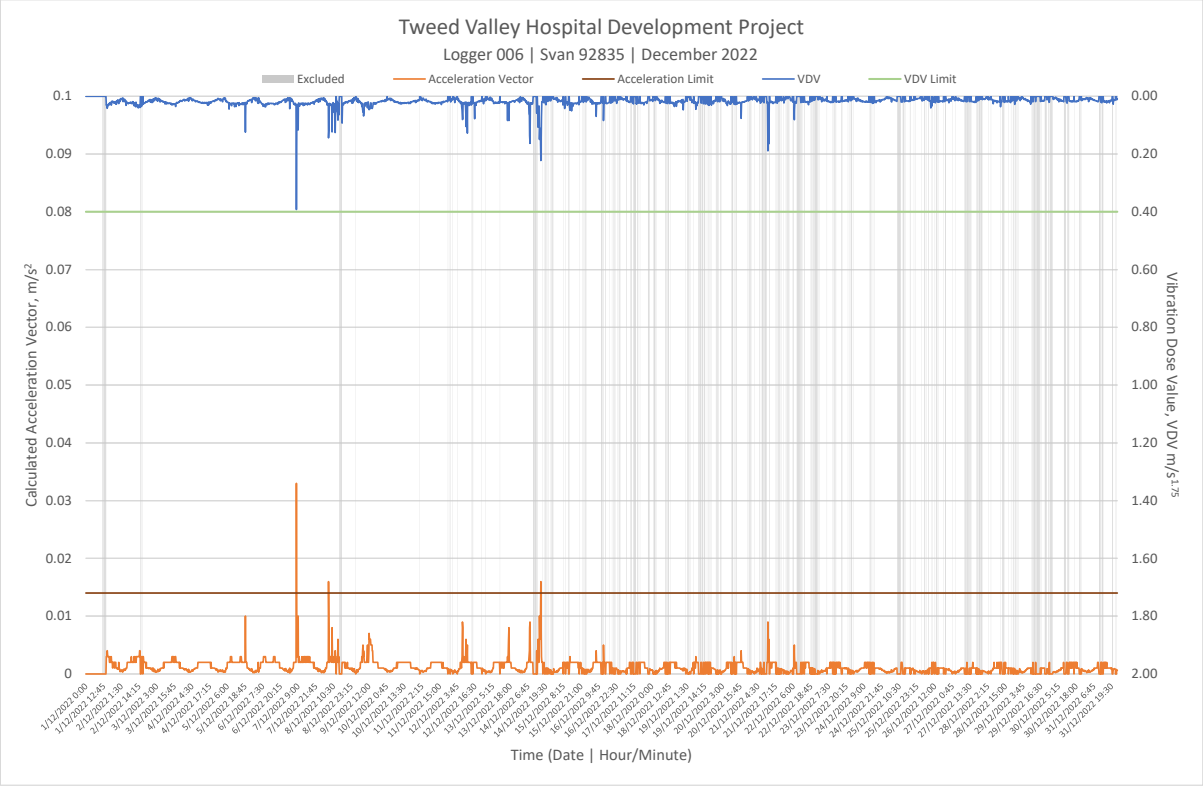

Figure 6 Acceleration and Vibration Dose Value over time (Logger 006 – Residential/Commercial)

Figure 7 which follows presents the increase in perceptible vibration at the southwestern residential receiver nominated as Location L.007.

The occupants at this location are likely to have experienced an increase of perceptible vibration during the days where heavy plant equipment where in use, and the likelihood of adverse comment is probable.

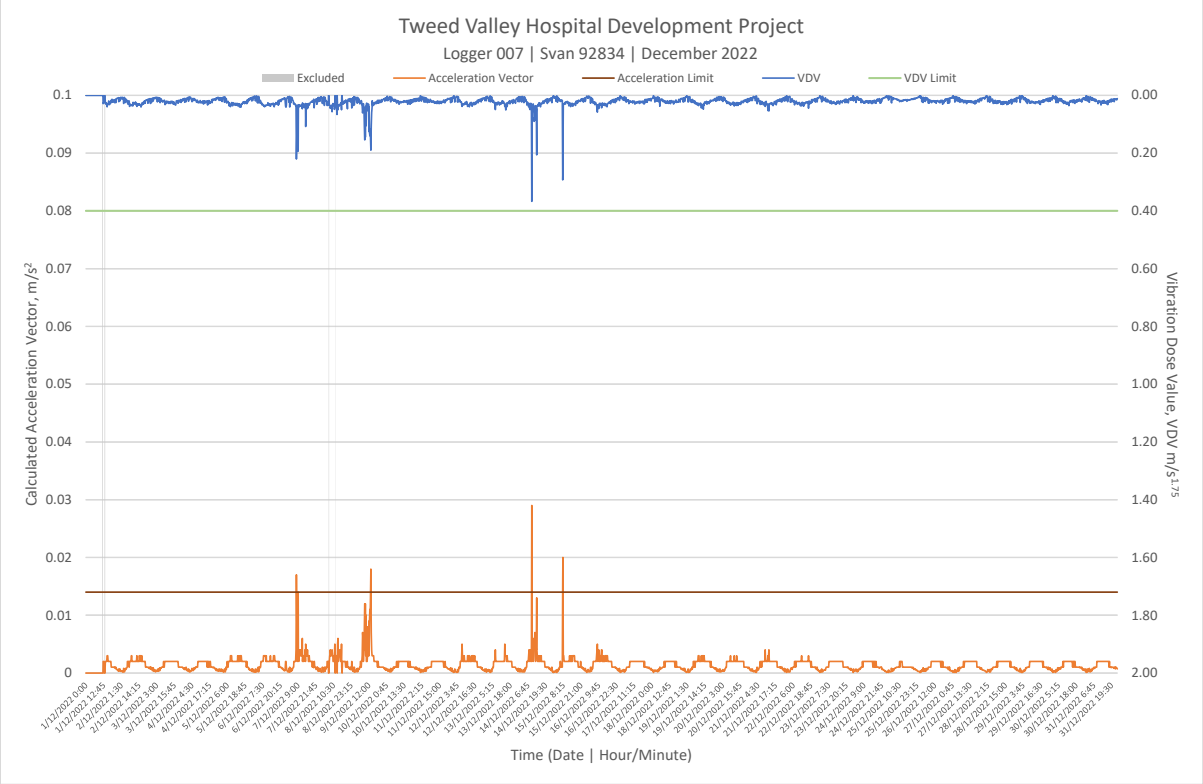

Figure 7 Acceleration and Vibration Dose Value over time (Logger 007 – Residential)

3.3 Discussion

Vibration data collected during December 2022 show a mild increase in energy collected at each of the three sites, however less than the measured levels from the previous month in November. The Cudgen Road Upgrade Works where graders, asphalt machines, large trucks, and multi-tyre/vibratory rollers are in active use in close proximity to each of the vibration loggers.

The impacts correlate with the data and known works of the site undertaken near the loggers, including:

- CD Civil open trench works to lay new watermain. Plant include 8T excavator, 9T Roller and Bobcat. Proximity to monitors is approximately 10 m
- Gosling Electrical drilling piles and erecting light poles. Proximity to monitors is approximately 10 – 50 m
- CD Civil excavating to full depth pavement on Cudgen Road. Plant include 8t excavator, Grader, 9T Roller and Bobcat. Proximity to monitors is approximately 15 m
- ADCO excavating/pouring concrete to Health Hub foundation, installing steel (this is not part of LLB scope, however, is within proximity to dust/noise monitors. Plant includes 14T excavator, 9T roller and Concrete boom pumps. Proximity to monitors is approximately 15 m)
- ABS installing facade on Main Hospital Building. Plant includes tower crane. Proximity to monitors is approximately 200 m
- Portable generators live throughout the day. Proximity to monitors is approximately 60 m
- Constant entrance/exit of trucks to site compound for spoil removal and material delivery through main entrance. Trucks involved are semi-trailers, 6-wheelers etc. Proximity to monitors is approximately 30 m

- Installing stormwater drainage on Northern side of Cudgen Road. Plant includes 8T excavator and plate compactors. Proximity to monitors is approximately 50 m
- Saw cutting of concrete footpath on Eastern End of Cudgen Road. Proximity to monitors is approximately 12 m.

Works operating at these distances would be anticipated to increase the degree of measured vibration at the location of ground sensors, which has the potential to impact the residential receivers near to the works, and increase the likelihood of adverse comments by the community.

No comment or complaint was received during the December monitoring period, as vibration decreased from the previous monitoring period (November 2022). Implementation of all feasible and reasonable mitigation measures, and adherence to management practices may have reduced the vibration impact from the site.

4 Conclusion

ADE Consulting Group Pty Ltd (ADE) was commissioned by Lendlease Group (Lendlease) to assess the levels of construction related vibration during the construction of the Tweed Valley Hospital Project, located at 771 Cudgen Road, Cudgen NSW (hereinafter referred to as 'the Site').

This report summarises vibration data collected at three locations, positioned along the south and southwest of Cudgen Road. At the time of preparing this report and the monitoring period in which it covers (December 2022), CD Civil are on site undertaking planned road work activities on Cudgen Road. These works include graders, excavators, asphalt works and vibratory compaction.

The road works onsite have produced vibration levels anticipated, and as such a review of the data has been undertaken. The results are as follows:

- Velocity
  - No impacts of any concern in which velocity values are exceeded
- Acceleration and Vibration Dose Values
  - Human comfort is anticipated to be potentially intermittently impacted by residential receivers to the southwest of the project where acceleration and VDV measurement data exceeds the recommended values outlined in **Section 2**
  - The perception of vibration is likely to be noticeable and cause some discomfort to residences occupying their premises during vibratory rolling/compaction works
  - The likelihood of adverse community comments has increased based on the dosages measured at the site
  - The measured dosages where during higher than normal extraneous data, conservative judgement places the data as works occurring on site near to the loggers ground sensor, although is not representative of the vibration which may be measurable or perceptible at the facade or foundation and is considered higher.

Appendix I – Glossary

1 Sound Pressure Level

Defined as:

$$L_p = 10log_{10}\left(\frac{p^2}{p_{ref}^2}\right) dB$$

In the above equation, p is the sound pressure fluctuation relative to atmospheric pressure, and *pref* is 20 microPascals (2 x 10-5 Pa), the approximate threshold of hearing.

Sound or noise is the sensation produced at the ear by small fluctuations in atmospheric pressure. Human ears are sensitive to changes to sound pressure over a wide range, from 20 microPascals to 60 Pascals, in lieu of using a linear scale to represent this range, a logarithmic scale is adopted to better handle

2 Sound Power Level

Sound power level cannot be directly measured using a microphone, it does not change with distance and is not influenced by atmospheric conditions. The sound power level refers to the total energy of the sound, and is reference to 1 Pico Watt.

3 Weighting and Loudness

The overall level of a sound is usually expressed as dB(A) and not dB. Weighting refers to the human ear's frequency response to sound. Typically, sound is measured with an A-weighted filter which reduces the significance of lower frequencies and very high frequencies, increasing the importance of mid-frequencies (500 Hz to 4 kHz), and being a good measure of the "loudness" of a sound.

A change of 1 to 2 dB(A) is difficult to detect, whilst a change of 3 to 5 dB(A) corresponds to a small but noticeable change. A 10 dB(A) change corresponds to a doubling or halving in apparent loudness.

4 Noise Metrics and Statistical Noise Levels

i) L_{Aeq} - The time averaged A-weighted sound pressure level for the interval, as defined in AS1055.1. It is generally described as the equivalent continuous A-weighted sound pressure level that has the same mean square pressure level as a sound that varies over time. It can be considered as the average sound pressure level over the measurement period.

ii) L_{Amin}/L_{Amax} - Minimum or Maximum A-weighted noise level detected during the measuring period. It refers to the minimum background noise detected or the maximum L*p* measured.

iii) L_{A90} - A-weighted noise level which is exceeded for 90% of the measuring period. It is usually used as the descriptor for background noise level during the measurement period.

iv) L_{A1} - Noise level which is exceeded for 1% of the measurement period.

v) L_{A10} - Noise level which is exceeded for 10% of the measurement period. The L_{A10} is often referred to as the average *maximum* noise level.

5 Background Noise

The underlying level of noise present in the ambient noise, excluding the noise source which is under investigation, when extraneous noise is removed.

6 Ambient Noise

Ambient noise of an environment: the all-encompassing sound associated with that environment, being a composite of sounds from many sources.

7 Vibration

The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related

8 Displacement

The change in position of an object, is a vector quantity. (Stress indicator).

9 Velocity

The rate of change of displacement, is a vector quantity. (Fatigue indicator).

10 Acceleration

The rate of change of velocity, is a vector quantity. (Indicator of force).

11 Frequency

The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.

12 Hertz

The unit of frequency or pitch of a sound. One hertz equals one cycle per second.

13 Peak Particle Velocity (PPV)

The greatest instantaneous particle velocity during a given time interval if measurements are made in 3-axis. The resultant Peak Particle Velocity (PPV) is the vector sum i.e. the square root of the summed squares of the maximum velocities, regardless of when in the time history those occur.

14 Root Mean Square rms

The rms value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.

15 Vibration Dose Value VDV

The Vibration Dose Value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when the structure is occupied.

16 Peak

The peak is the maximum amplitude during a measurement period.

17 Peak to Peak P-P

The peak-to-peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.

18 Logarithmic Scale

Comparing frequency with large amplitude differences be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale, however a logarithmic scale shows prominent vibration components equally well at any amplitude.

19 Zero Crossing Frequency

Determining the apparent dominate frequency of a given sample can be achieved by using the Zero Crossing Frequency.

20 Primary Waves P Waves

Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

21 Secondary Waves S Waves

Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.

22 Rayleigh Waves R Waves

Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.

23 Accelerometer

A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs'.

24 Geophone

Geophones measure velocity by means of a magnetic core surrounded by an electrical coil. When the surface vibrates, the geophone housing moves however the coil stays stationary, thus the movement of the magnet in the coil causes an electrical current which is calibrated to velocity of vibration.

25 Filter

A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.

26 Short-term vibration

Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.

27 Long-term vibration

All types of vibration not covered by the definition of 'short-term vibration

28 Impulsive vibration

Rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration. It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short (typically <2 seconds). Impulsive vibration (no more than 3 occurrences) in an assessment period is assessed on the basis of weighted rms acceleration, and peak particle velocity.

29 Continuous vibration

Continuous vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time). This type of vibration is assessed on the basis of weighted rms acceleration.

30 Intermittent vibration

Defined as interrupted periods of continuous (e.g., a drill) or repeated periods of impulsive vibration (e.g., a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g., pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce Continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose value.

Appendix II – Aerial Photograph

ADE Monitoring locations, site location (including CD Civil's Cudgen Road Upgrade works) are presented below.


555200
555600
556000
N
Tweed Valley Hospital Development Project
Northern Location
005 - SVAN 92832 | DustTrack 8533 181 801
Stockpile Locations
006 - SVAN 92835 | DustTrack 8533 184 203
Southern Works
007 - SVAN 92834 | DustTrack 8533 184 203
0
100
200 m
Tweed Valley Hospital Development Project
Environmental Noise, Vibration, and Dust Monitoring
Location Overview
Image: Nearmaps | Scale 1:4500 | GDA 1994 Zone 56
Legend
Roads
Cudgen Road Uprade Works Locations
Loggers
Tweed Valley Hospital Development Project
ADE GROUP
SOLUTIONS THROUGH INNOVATION

Appendix III – References

Standards, policies, and guidelines used for the assessment of vibration are as follows:

- ADE Group Consulting Pty Ltd – Cudgen Road Upgrade Construction Noise and Vibration Impact Statement, Prepared for CD Civil, Version 1.0, 6 September 2022 (ADE Reference A103022.1044.00)
- Assessing Vibration: A Technical Guideline (February 2006), Department of Environment and Conservation (DEC)
- British Standard BS 7385-2:1993 Evaluation and measurement for vibration in buildings – Part 2: guide to damage Levels from ground-borne vibration
- British Standard BS 6472:2008 Guide to evaluation of human exposure to vibration in buildings – Part 1: vibration sources other than blasting
- Construction Noise and Vibration Strategy (April 2019) Published by Transport for New South Wales (TfNSW)
- Development Consent SSD-10353, Department of Planning, Industry and Environment – Tweed Valley Hospital Stage 2 – 12 July 2020 (approval)
- German Standard DIN 4150-1:2001 Structural vibration Part 1: Prediction vibration parameters
- German Standard DIN 4150-3:2016 Vibrations in buildings – Part 3: Effects on structures
- Tweed Valley Hospital Management Plan – Noise and Vibration, Revision 7.0, Lendlease Building Pty Ltd, 11 June 2019
    - Tweed Valley Hospital – Noise and Vibration Impact Assessment for State Significant Development (SSD), SVM-2370, Revision: Issue 2, 17 October 2018 – Acoustic Studio

Appendix IV – Site Photographs

Photograph 1 Representative photograph of monitoring location 007 – Residential, as observed 08/12/2022

Photograph 2 Representative photograph of monitoring location 005 – Solar Industry, as observed 08/12/2022

Photograph 3 Representative photograph of monitoring location 006 – Mate and Matts, as observed 08/12/2022

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