Vibration Monitoring Assessment Report

771 Cudgen Road, Kingscliff NSW

Prepared for: Delta Group

DLT-01-Q1013 / VIB4 / v1.1f
9th December 2019

ADE CONSULTING GROUP
SOLUTIONS THROUGH INNOVATION

Prepared for:

Delta Group

Vibration Monitoring Assessment Report

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Written By:

[redacted]

[redacted]

Occupational Hygienist

Reviewed By:

[redacted]

[redacted]

Principal Occupational Hygienist

[redacted]

[redacted])

VIBRATION MONITORING ASSESSMENT REPORT
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Sydney Office:
ADE Consulting Group Pty Ltd
Unit 6 / 7 Millennium Court
Silverwater, NSW 2128

Melbourne Office:
ADE Consulting Group Pty Ltd
Unit 4 / 95 Salmon Street
Port Melbourne, VIC 3207

Newcastle Office:
ADE Consulting Group Pty Ltd
Unit 9 / 103 Glenwood Drive
Thornton, NSW 2322

Brisbane Office:
ADE Consulting Group Pty Ltd
Unit 3 / 22 Palmer Place
Murarrie QLD 4172

Contact Us:
Site: www.ADE.Group
Email: info@ade.group
Phone: 1300 976 922

DEFINITIONS

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.
Displacement:	The change in position of an object, is a vector quantity (Stress indicator).
Velocity:	The rate of change of displacement, is a vector quantity (Fatigue indicator).
Acceleration:	The rate of change of velocity, is a vector quantity. (Indicator of force).
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.
Hertz (Hz):	The unit of frequency or pitch of a sound. One hertz equals one cycle per second.
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.
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.
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 structure is occupied.
Peak:	The peak is the maximum amplitude during a measurement period.
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.
Logarithmic Scale:	Comparing frequency with large amplitude differences can 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. But a logarithmic scale shows prominent vibration components equally well at any amplitude.
Zero Crossing Frequency:	Determining the apparent dominate frequency of a given sample can be achieved by using the Zero Crossing Frequency.

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.
Secondary Waves (S Waves):	Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.
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.
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'.
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.
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.
Long-term vibration	All types of vibration not covered by the definition of ‘short-term’ vibration.

1 INTRODUCTION

1.1 Project Background

Kingscliff is located in the Northern Rivers region of New South Wales. The Site is bounded by the Tweed Coast Road to the west, Cudgen Road to the south and Turnock Street to the east.

Delta Group are undertaking Earthworks for the Tweed Valley Hospital Project located at 771 Cudgen Road, Kingscliff NSW, hereafter referred to as 'the Site'. The Site was previously agricultural land and excavation works were on going during November 2019.

The purpose of the Vibration Monitoring Assessment (VMA) report is to assess the impacts of piling, excavation and general construction works from the Tweed Valley Hospital Project upon the surrounding community.

Table 1. Project Specific Information.

Project Specific Information	
Scope:	This vibration report provides detailed real time vibration monitoring results at three locations within the site.
Objectives:	• Comply with DIN 4150-3:2016 guidelines and conditions C21 - C24 of the consent. • Avoid or minimise vibration impacts from activities which could affect the nearby buildings (Kingscliff Tafe and residential properties). • To minimise the generation of vibration which could affect the neighbours of the site, workers on the site and associated building and other members of the public. • Establish and maintain good relationships with the neighbours and wider community.
Key Issues and Risks:	While using mobile plant and conducting piling operations, nearby residential and commercial buildings and their occupants may be affected by vibration. A pre-work vibration assessment was carried out and compared to the DIN 4150-3:2016 Vibration Standards for Buildings, this information will determine possible impacts of other sensitive premises identified in the area. Vibration generating activities that has likely contributed to the level of current vibration are listed in Appendix 2 and 3 of the Lendlease Noise and Vibration Management Plan.
Key Legislation/ Standards/ Guidance:	*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; and • Establishment of a general duty of care to notify environment harm.

Table 1. Continued...

Project Specific Information	
Key Legislation/ Standards/ Guidance:	*Vibrations in buildings Part 3: Effects on structures DIN4150-3 February 2016.* This standard specifies a method of measuring and evaluating the effects of vibration on structures designed primarily for static loading. It applies to structures which do not need to be designed to specific standards or codes of practice as regards dynamic loading. This standard also gives guideline values which, when compiled with, will not result in damage that will have an adverse effect on the structure's serviceability. In some cases, guideline values for a simplified evaluation are also given.

1.2 Previous Report

Refer to the previous report (DLT-01-Q1013 / VIB3 / v2f) for details from earlier monitoring periods.

1.3 Monitoring locations

The three (3) vibration monitors are located within the confines of the site adjacent to Cudgen Road and were supplied by the client *(refer to Figure 1 – Aerial Photograph)*.

Vibrations were recorded at the above-mentioned locations throughout the preparation works of the Tweed Valley Hospital Project.

The vibration monitors are operational from 6.45am to 7pm daily, commencing Friday 1st November 2019.

1.4 Limits for vibration

The Peak Vibration Velocity (PVV) limits for the duration of work have been adopted from *Vibrations in buildings Part 3: Effects on structures DIN4150-3 February 2016.* Lines 1 and 2 in Table 2 below apply to the surrounding structures of the Tweed Valley Hospital project, including the Kingscliff TAFE and nearby residences. Given that the monitoring being undertaken is ground monitoring on-site and not structural monitoring at a receiver, ADE is confident that an exposure level of 20mm/s is suitable as the maximum short-term velocity at all frequencies for the duration of the project.

Additionally, as per the Department of Environment and Conservation, Environmental Noise Management, Assessing Vibration: a technical guideline Table 2.2 a human exposure vibration limit of 5.3mm/s has been adopted. This value has been chosen as the worksite has been considered as a 'workshop' under the guideline and the lowest value across all frequencies was adopted as no large vibrations are expected during normal construction.

Table 2. Guideline Values for Vibration Velocity to Evaluate the Effects of Short-Term Vibration on Structures.

Line	Type of Structure	Peak Vibration 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

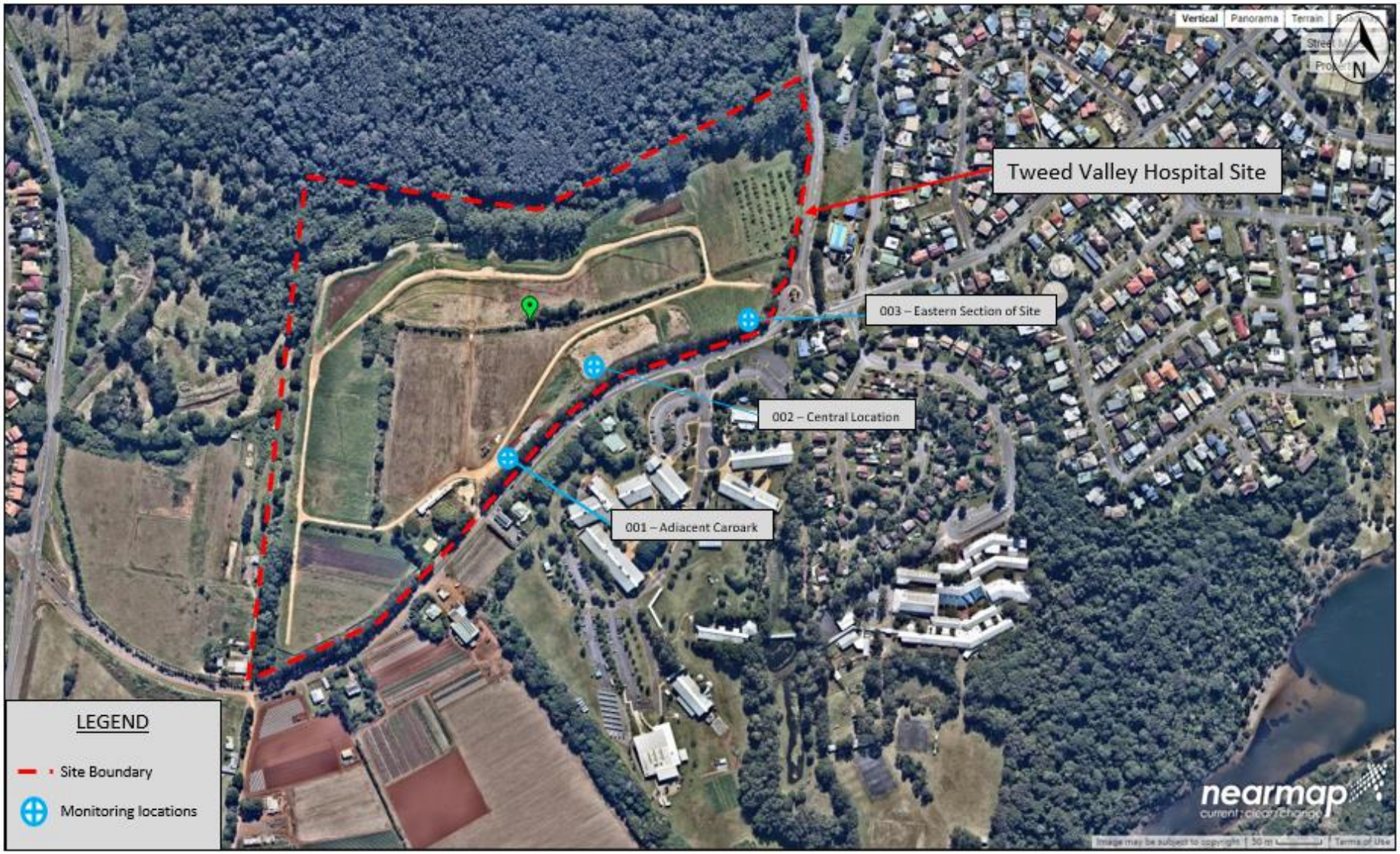

Figure 1. Aerial photograph of the site at Kingscliff NSW.

1.5 Monitoring Frequency

Vibration monitoring was carried out for a period from Friday 1st November 2019 to Saturday 30th November 2019 to determine the level of ground vibration that is experienced on the boundary of the site before travelling off-site as per the German Vibration Standard DIN4150. Vibration monitoring was completed during the hours 6.45am – 7pm everyday Friday 1st November 2019 to Saturday 30th November 2019.

1.6 Survey Instrumentation and Methodology

The vibration monitors were enclosed in a tough case with the noise monitors which initially placed on the ground.

Due to extreme temperatures the case was placed on a step and covered with a tarp on the 4th of December 2019 to aid in keeping temperatures below 60°C and to ensure continuous monitoring. The accelerometer was placed firmly against the soil surface with sandbags over top to minimize external interference. The monitors were positioned within the site along the boundary adjacent Cudgen Road.

The vibration measurements were recorded using Profound Vibra+ vibration monitors.

1.7 Existing Vibration Environment

The main on-going vibration source in the area prior to site establishment was:

- Car and Trucks passing by on nearby Cudgen Road.

The main cause for vibration throughout this monitoring period (in addition to cars and trucks from nearby Cudgen Road) is:

- Earthworks and excavations works being undertaken by Delta Group (i.e. the use of excavators, bulldozers, piling machines, trucks).

An alarm beacon was set-up with the vibration monitors in order to alert Delta and the Site Supervisor in the case of an exceedance in real-time. If the alarm was triggered, Delta and the Site Supervisor would receive a text SMS and need to note the date and time, document the activity and consider implementing controls and work practices reviewed before re-commencing works.

2 Results

The results of the vibration monitoring for the dates 1st November 2019 to 30th November 2019 are summarised in Figure 2, 3, 4 and 5, below.

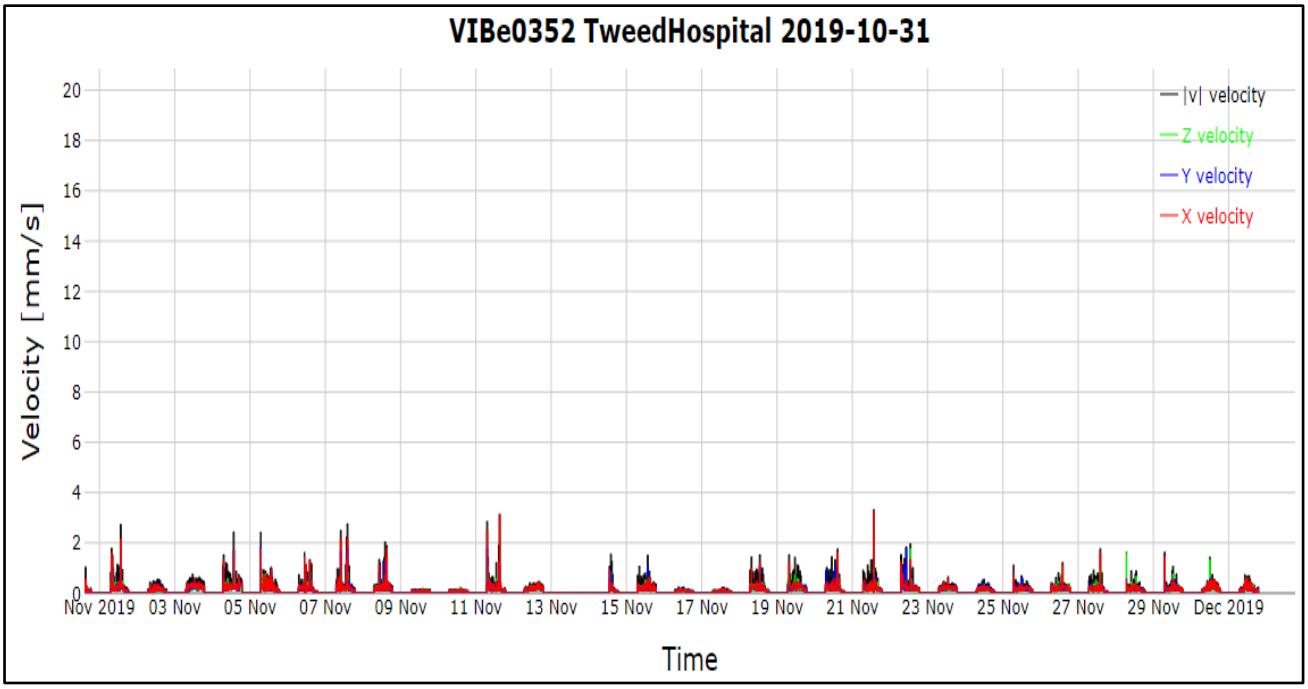

Figure 2. Results of the vibration monitoring from 1st November 2019 to 30th November 2019 at monitoring location 001 – Adjacent carpark.

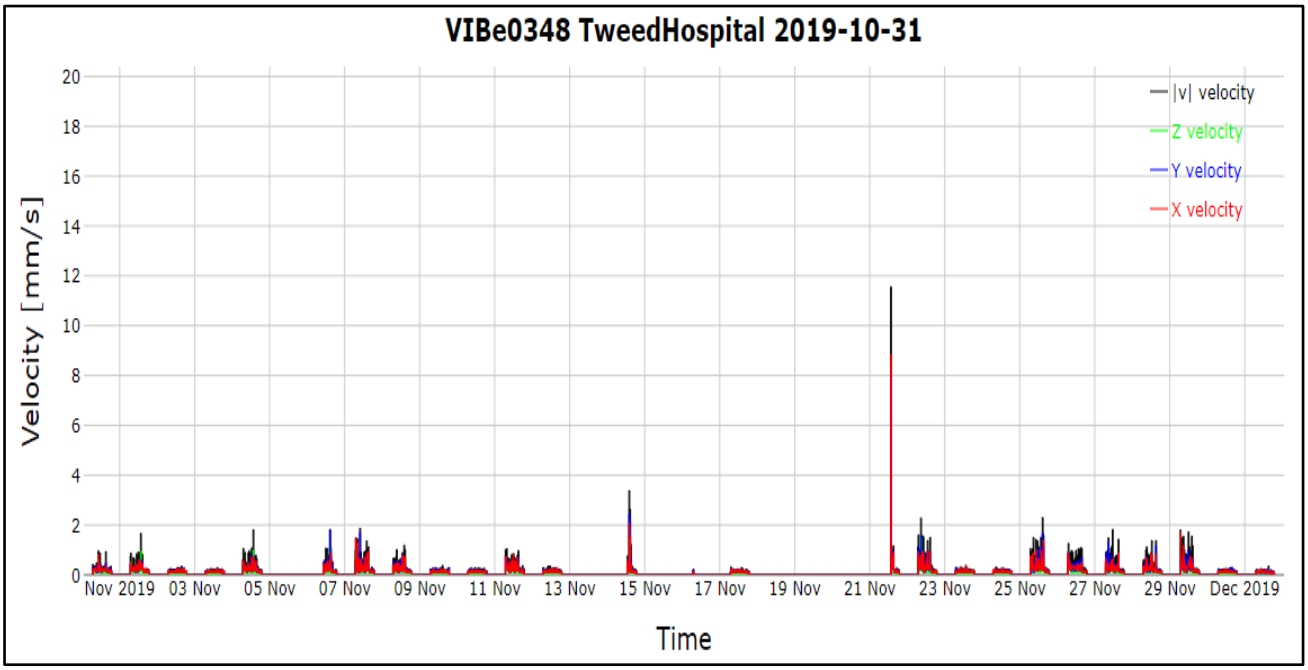

Figure 3. Results of the vibration monitoring from 1st November 2019 to 30th November 2019 at monitoring location 002 – Central monitor.

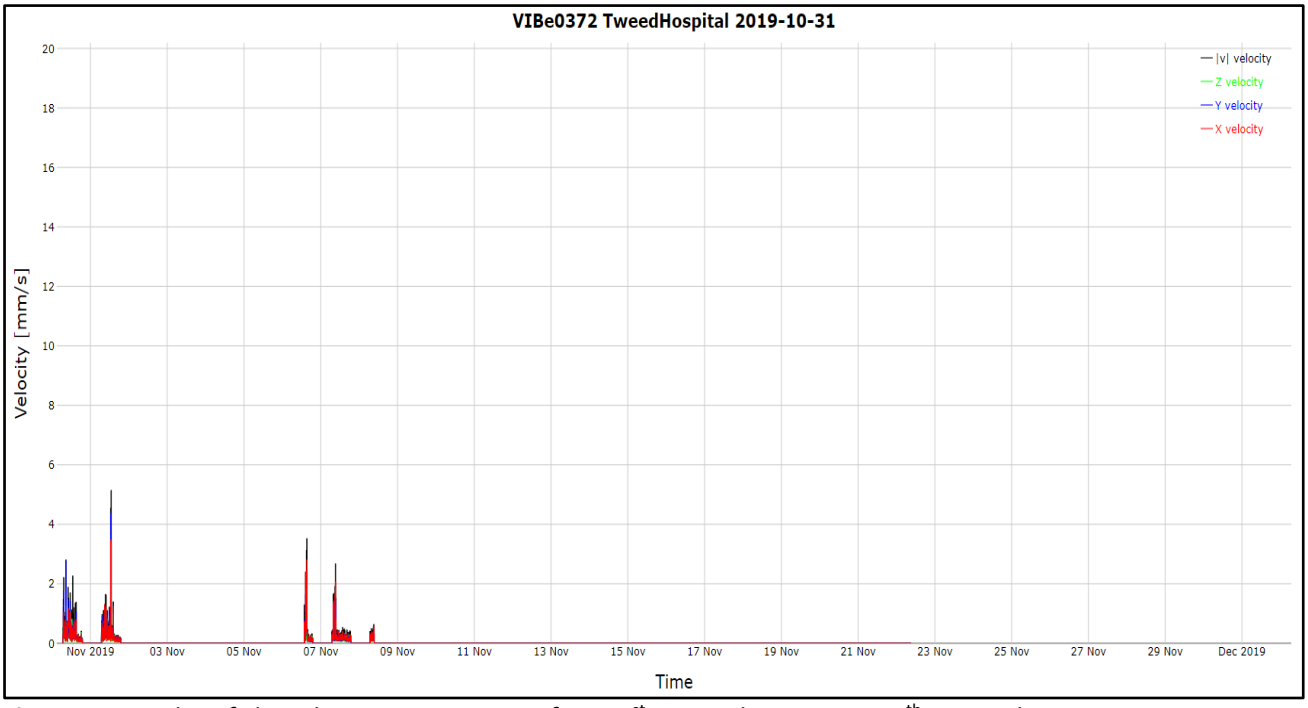

Figure 4. Results of the vibration monitoring from 1st November 2019 to 7th November 2019 at monitoring location 003 – Eastern section of site.

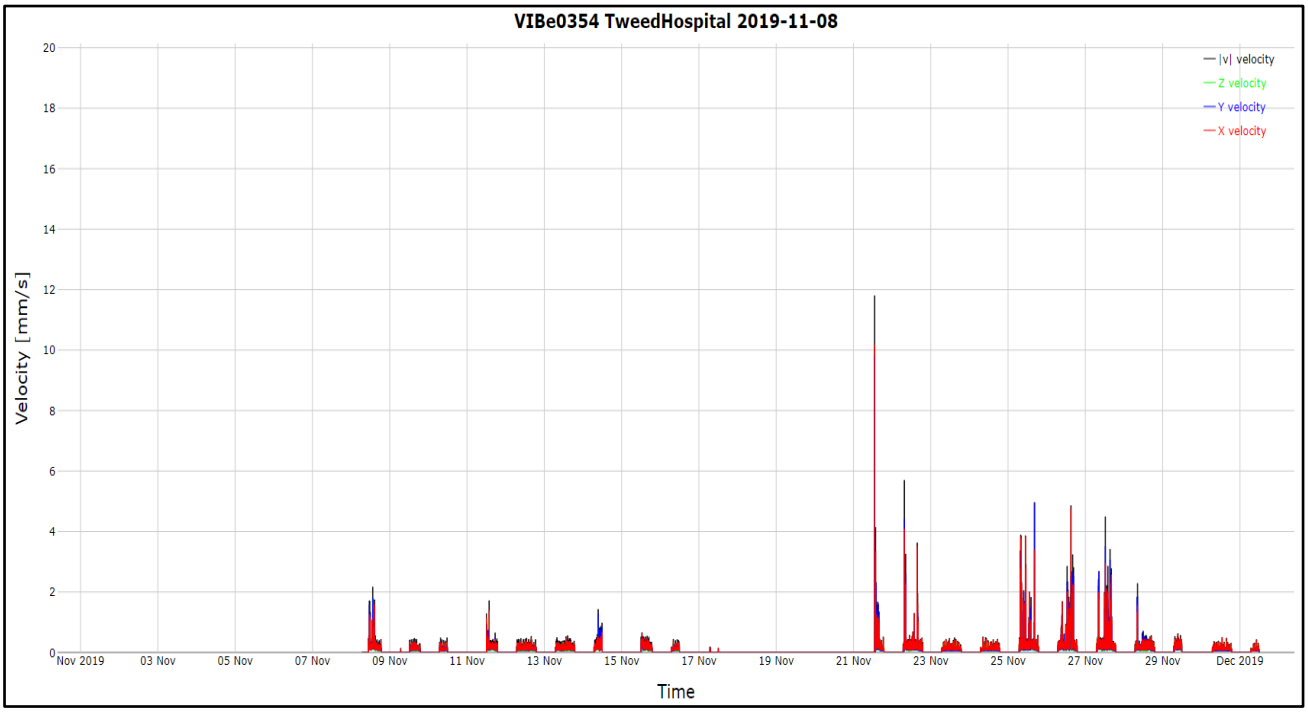

Figure 5. Results of the vibration monitoring from 8th November 2019 to 30th November 2019 at monitoring location 003 – Eastern section of site.

*Note: No Data periods from the 3rd- 7th and 17th – 21st for the Eastern monitoring location are believed to be due to temperatures >60°C.

60°C is the maximum operating temperature of the vibration monitors (refer to *Appendix C – Vibra Technical Specifications)*

3 Discussion

ADE has installed a new Vibration monitor at the eastern monitoring location on Friday the 8th of November 2019 due to a fault in the previous monitor believed to be caused by high temperatures. Figures 4 and 5 represent the two vibration monitors and the applicable monitoring period.

Table 2 outlines acceptable Peak Vibration Velocity (PVV) across different frequencies based on the type of structure. The 'Kingscliff Tafe' has been determined to be a Line 1 building, the Residential properties to the east of the site have been determined as line 2 buildings and A PVV value of 20 mm/s was adopted based on this assessment (refer to previous report *DLT-01-Q1013 / VIB3 / v2f*).

ADE site visits on the 21st of November 2019 had results >5mm/s as can be seen in Figures 3 and 5 of this report. The activities undertaken by ADE included manoeuvring within close proximity to the vibration sensors in the enclosure and replacing the vibration sensor in the eastern monitoring location. These values can be correlated with the peaks on these particular days (refer to *Appendix B – ADE Site Time Summary)*.

A human exposure limit of 5.3mm/s was also adopted from the Department of Environment and Conservation, Environmental Noise Management, Assessing Vibration: a technical guideline Table 2.2. Values remained below these criteria.

During ADEs site visit on the 4th of December, the cases that contain the vibration monitors were raised above the ground and covered with a tarp to aid in keeping temperatures below 60°C and ensure continuous monitoring.

4 Conclusion

- Results from vibration monitoring undertaken during the monitoring periods were **below** the threshold PVV value determined by DIN 4150 for the duration of this monitoring period;
- The peak vibration results were below the adopted threshold of 20 mm/s; and
- The effects of vibration at the levels seen through November would have little to no effect on the neighbouring properties.

5 References

- Vibrations in buildings Part 3: Effects on structures DIN4150-3 February 2016.

- Department of Environment and Conservation, Environmental Noise Management, Assessing Vibration: a technical guideline.

Appendix A – Photographs

Photograph 1. Representative photo of the monitoring location 001 – adjacent carpark, as observed on the 04.12.2019

Photograph 2. Representative photo of the monitoring location 002 – central location, as observed on the 04.12.2019

Photograph 3. Representative photo of the monitoring location 003 – eastern section of site, as observed on the 04.12.2019.

Appendix B – ADE Site Time Summary

Date of site visit
Wednesday 06.11.2019
Thursday 14.11.2019
Thursday 21.11.2019
Wednesday 04.12.2019

Appendix C – Vibra Technical Specifications

VIBRA-series:
VIBRA, *VIBRA*+

Profound *VIBRA*-series

Vibrations from pile driving, construction, road or rail traffic, demolition work and blasting can create nuisance or cause damage to buildings and sensitive equipment. These vibrations are accurately quantified with a system of the Profound *VIBRA*-series.

The *VIBRA*'s robust aluminium housing is IP65 watertight. The system is easily portable, lightweight and battery-operated which allows for up to 4 weeks of continuous and unmanned operation.

Depending on the chosen model *VIBRA* or *VIBRA*+, the system complies with national and international standards and is according to DIN 45669-1:2010. The specific characteristics of each model are further outlined in the *VIBRA* features overview.

Setting up the system on site is easy: attach the 3-dimensional sensor to the structure to be monitored, switch on the system and start measuring. While measuring the *VIBRA* displays date, time, time interval and the current peak vibration values including frequency in all 3 directions. In advance an alarm level can be set.

Peak values including dominant frequencies, are directly stored in memory. For full interpretation measurement signals are transferred via USB to a computer for further analysis. The *VIBRA* pc software automatically generates tables and graphs of peak values and signals for use in reports. The data can also be easily exported as a csv-file.

The *VIBRA*+ can be set up for wireless automatic data transfer including sms alerts via the integrated 3G modem. Data can also be continuously uploaded to any FTP server for real-time online monitoring. As an alternative Profound offers a turnkey online monitoring service.

Technical specifications *VIBRA*-series	
Velocity (PPV), frequency and acceleration (PPA)	In x, y, z-direction per time interval
Displacement (*VIBRA*+ only)	In x, y, z-direction per time interval
Sensor type	3-channel geophone
Geophone correction	Digital IR filter
Velocity range	0 – 100 mm/s
Resolution display	0.01 mm/s
Resolution AD-converter	0.001 mm/s (24 bits ADC)
Frequency range and accuracy	DIN 45669-1:2010-09 or SBR – part A, B 2002
Storage capacity	4 MB. Fixed or ring memory incl. buffer
Storage interval	1, 2, 5, 10, 20, 30, 60 s
Data save level	Adjustable between 0.01-100.00 mm/s (or always)
Alarm level	Adjustable between 0.01-100.00 mm/s (or none)
Data retention	10 years (minimum) at 25 °C
Clock stability	Within 5 minutes/year at 25 °C
Temperature range (operating)	- 20 °C to + 60 °C
Housing	Robust hard anodized aluminium case
Protection rating	IP65 according to DIN 40 050/IEC 529
Dimensions (l x w x h)	216 x 160 x 50 mm
Weight	2 kg
Display	≥ 4 Lines; display backlight; anti-reflex coating; anti-scratch
Batteries	3 x 1.5 V Alkaline D-size batteries
Battery life	≈ 28 days (continuous operation)
I/O functionality	Geophone, mini-USB
PC operating system	WIN10/WIN8/WIN7
Accessories	VIB.00320 Cable reel (50m) VIB.00407 Alarm beacon VIB.00420 USB adapter. External power via USB adapter: V_{mains} 100 ↔ 240 V, 47 ↔ 63 Hz