WOOD & GRIEVE ENGINEERS

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Bowral and District Hospital Redevelopment

Acoustic Report

Construction Noise & Vibration Monitoring

1/7/2019-31/7/2019

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Revision

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1. Introduction

Wood & Grieve Engineers (WGE) have been engaged by ADCO Constructions to conduct construction noise and vibration monitoring for the construction works of the Bowral and District Hospital Redevelopment. The site is located at 97-103 Bowral St, Bowral.

This report addresses the monitoring requirements established by the NSW Government Department of Planning and Environment for the grant of the construction certificate allowing the work on site to commence. Monitoring results will be presented to confirm the requirements have been met during the period from 1 July 2019 to 31 July 2019.

The project involves the construction of a 4-storey new hospital building along Bowral St, with various medical departments on three levels and central mechanical plant within a Level 3 plant room. Additionally, the existing hospital carpark will be relocated

The works as described below are expected to occur across approximately 12 months of work. The works are to be split into three periods which are:

1. Excavation
   - Shoring
   - Bulk excavation
   - Piling
   - Detailed excavation
2. Structure
   - Basement slab and walls
3. Fitout
   - Internal structures and finishes
   - External façade elements

Currently, WGE have been engaged to conduct noise and vibration monitoring during the excavation and construction stages, which are estimated to occur during the first 16-20 weeks of the works. The monitoring is based on the criteria and discussion within the Construction Noise and Vibration Management Plan (CNVMP, ref. AC-RE-005CNVMP_003), a previous report by WGE. The CNVMP provided the following:

- Criteria for the noise and vibration generated during the early works phases.
- A quantitative assessment of the airborne and ground-borne noise generated by the works for the proposed development and its impact on nearby receivers.
- Strategies to mitigate the noise and vibration generated during the construction works phases.

This monitoring report discusses the criteria and the monitoring results for the monitoring period 1 July 2019 to 31 July 2019. The impact of the construction noise on the nearest noise-affected receivers during this period is analysed and discussed.

This report has been prepared with the following references:

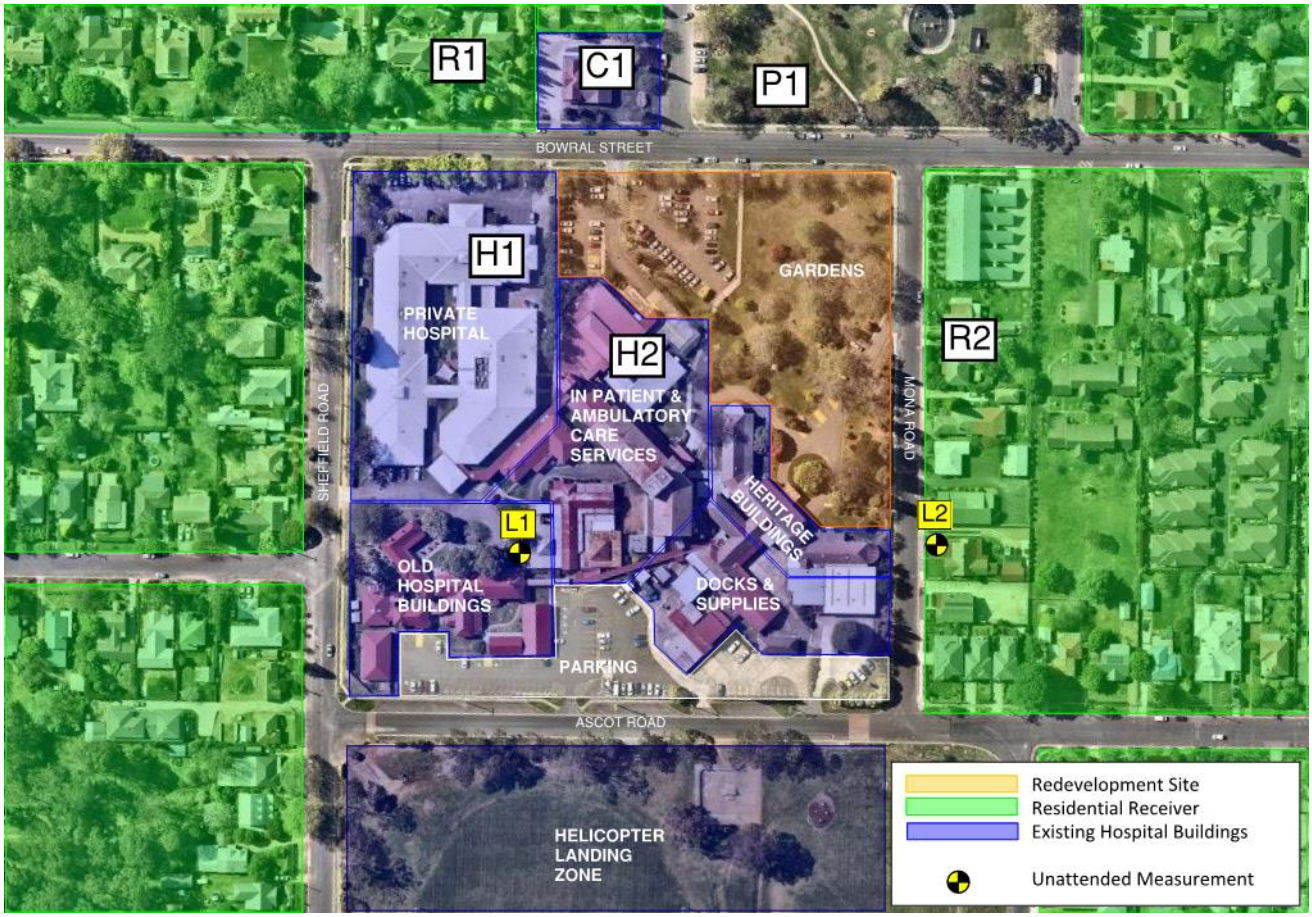
- Interim Construction Noise Guideline (ICNG), NSW DECC, 2009
- Construction Noise Strategy, Transport for NSW, 2013
- Noise Policy for Industry (NPI), NSW EPA, 2017
- Assessing Vibration: A Technical Guideline, NSW DEC, 2006
- AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*
- British Standard BS 5228: Part 1:1997 *Noise and Vibration Control on Construction and Open Sites*
- British Standard BS 7358:1993 *Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground-borne Vibration*
- German Standard DIN 4150-Part 3 *Structural vibration in buildings – Effects on structures*
- Construction Noise and Vibration Management plan, AC-RE-005CNVMP_003, WGE, 16/4/2019

2. Project Overview

2.1 Site Description and Noise & Vibration Sensitive Receivers

The construction works are located at 97-103 Bowral St, Bowral, in the north-eastern corner of the block occupied by Bowral and District Hospital and Southern Highlands Private Hospital. The part to be developed was formerly a parking lot and a garden area. The site is bounded by Bowral St to the north, Mona Rd to the east and various public and private hospital facilities to the west and south.

The nearest noise and vibration sensitive receivers are the existing hospital buildings adjacent to the site. The facilities include various hospital departments and patient units, some of which operate within heritage buildings. There is also one specialist clinic across Bowral St. The nearest residential properties can be found along Mona Rd and Bowral St. The site location, background noise measurement positions and surrounding receivers are shown in Figure 1. The receivers are further identified in Table 1.



Source: nearmap.com

Figure 1: Site Map and Background Noise Measurement Locations.

Table 1: Nearest Noise Sensitive Receivers.

ID	Type	Address	Approximate Distance to Construction Works, m
R1	Residential	104 Bowral St	80
		106 Bowral St	**60**
		19 St Jude St	68
R2	Residential	**107 Bowral St**	**45**
		2 Mona Rd	**45**
		6 Mona Rd	50
		8 Mona Rd	75
C1	Health	St Jude Street Specialist Centre 21 St Jude St	32
H1	Hospital	Southern Highlands Private Hospital 99 Bowral St	30
H2	Hospital	Bowral and District Hospital 97-103 Bowral St	5

2.2 Existing Noise & Vibration Environment

The existing noise environment around the site is dominated by suburban road traffic noise on Bowral St and Mona Rd. Other nearby roads include Sheffield Rd to the west of the hospital block and Ascot Rd to the south. Mechanical equipment and other operational noise from the hospital facilities also form a part of the typical noise environment, including ambulance movements and occasional helicopter landings in Loseby Park across Ascot Rd.

In the CNVMP, existing noise data from two noise monitors was used to establish the noise targets at the nearby sensitive receivers. This data was originally collected for the SSDA acoustic report (ref. AC-RE-003_SSDA_009, WGE, dated 7/1/2019) to measure background noise in the area. The loggers were on site for the duration of 9 days in December 2018. The results from the noise monitoring are summarised in Table 2, having any rain-affected data excluded. The noise data for each monitor has been illustrated in Figure 2 and Figure 3.

Table 2: Summary of Unattended Noise Measurements.

Location	Rating Background Noise (RBL) Level, dB(A)			Equivalent Continuous Noise Level, L_{Aeq}, dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	44	43	41	49	50	45
L2	42	33	30*	58	53	49

Note: The time periods are defined as: day 7am-6pm, evening 6pm-10pm, night 10pm-7am.
* Adjusted from a level of 29 dB(A) to 30 dB(A) as per Section 2.3 of the NPI.

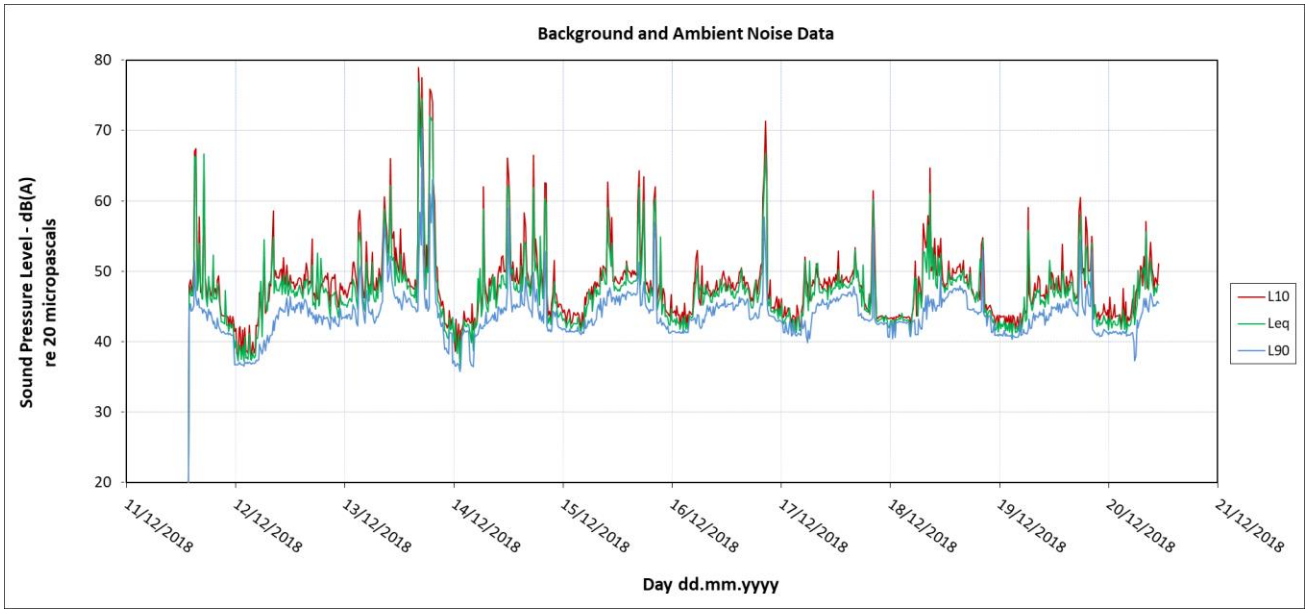


Figure 2: Unattended Noise Monitor Data at Location L1 – Existing Noise Environment within Hospital Area.

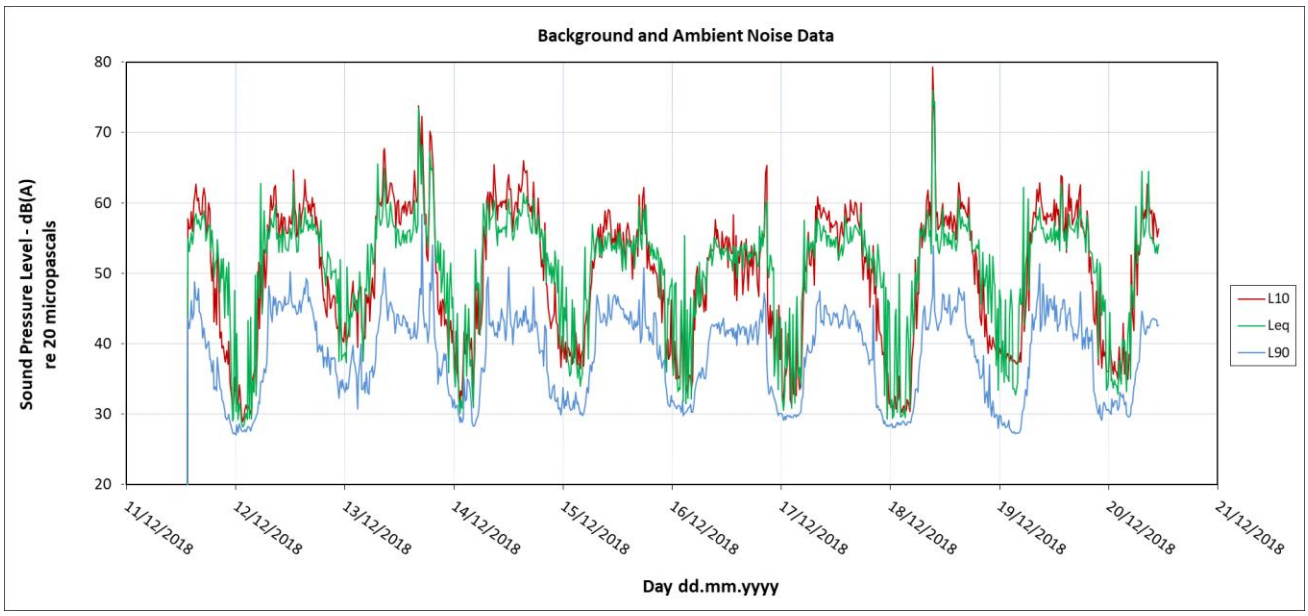


Figure 3: Unattended Noise Monitor Data at Location L2 – Existing Noise Environment at Nearest Residences.

3. Acoustic Criteria

3.1 Construction Noise Criteria

The *Interim Construction Noise Guideline* (ICNG) by NSW DECC has a few key components that have been incorporated into this monitoring report. These components are as follows:

1. **Use of L_{Aeq} as the noise metric for measuring and assessing construction noise**
   In recent years, NSW policies including the Noise Policy for Industry and NSW Environmental Criteria for Road Traffic Noise have selected the L_{Aeq} to be the primary noise metric when measuring and assessing construction noise. Consistent with the ICNG, the use of the L_{Aeq} as a key descriptor for measuring and assessing construction noise may follow a 'best practice' approach.

2. **Application of feasible and reasonable noise mitigation measures**
   As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints. Selecting reasonable mitigation measures from those that are feasible requires one to determine whether the overall noise benefit of applying the measure outweighs the overall social, economic and environmental effects, including the cost of the measure.

3. **Quantitative and qualitative assessment**
   The ICNG provides two methods for assessment of construction noise, being either quantitative or qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels and assessment against set criteria.

   A qualitative assessment is recommended for small projects with a short-term duration, where works are not likely to affect an individual or a sensitive land use for more than three weeks in total. It focuses on minimising noise disturbance through the implementation of feasible and reasonable work practices and community notification.

   Given the scale of the construction works for this project, a quantitative assessment was carried out in the CNVMP, and the monitoring results will consequently be assessed accordingly.

4. **Management levels**
   The ICNG sets out noise management levels and describes the conditions, where they should be applied. The guidelines intend to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

   The rating background level (RBL) is used when determining the management levels. The RBL is the overall single-figure background noise level measured in each assessment period over the day.

In order to establish noise criteria for the quantitative assessment, the ICNG recommends the following standard hours of construction:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sunday and public holidays: no work

It is understood that extended hours are proposed for Saturday works, **from 7am to 3pm**. This was taken into account in the construction noise assessment in the CNVMP.

The noise criteria associated with construction and its related activities are shown in Table 3, as presented in Section 4.1.1 Table 2 of the ICNG.

Table 3: Construction Noise Criteria at Residences.

Time of Day	Management Level $L_{Aeq,15min}$	How to Apply
Recommended Standard Hours:	Noise Affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15min}$ 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 residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, 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 + 5dB	• 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 dB(A) 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

Note: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30m away from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 4 below (Section 4.1.3 of the ICNG) sets out the noise management levels for other land uses, including commercial premises. The external noise levels should be assessed at the most affected occupied point for commercial and industrial uses, and at the most affected point within 50 metres of the area boundary for parks.

Table 4: Construction Noise Criteria for Other Land Uses.

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilized
Hospital wards and operating theatres	Internal noise level 45dB(A)
Passive recreation, parks	External noise level 60dB(A)

Based on the criteria in the tables above, the following noise management levels in Table 5 should be applied to the health premises and residential receivers. For the hospital buildings, the façade is assumed to provide minimum 15 dB attenuation from outside to inside. Criteria for both standard hours and outside standard hours are given for residential receivers based on the proposed construction hours, limited to daytime only.

Table 5: Project Specific Construction Noise Management Levels.

Land Use	Time	Management Level, $L_{Aeq,15min}$
Hospital wards and operating theatres	At all times	External noise level **60dB(A)**
Passive recreation, parks	At all times	External noise level **60dB(A)**
Residential	Standard hours	42dB(A) + 10dB = **52dB(A)**
	Outside standard hours	42dB(A) + 5dB = **47dB(A)**

3.2 Construction Vibration Criteria

3.2.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day. The vibration emitted from construction works should be such that it does not exceed the maximum limits set out in the criteria presented in Table 6 to Table 9. The guide on preferred values for human comfort have been extracted from the NSW DEC *Assessing Vibration: A Technical Guideline* (2006). The criteria for continuous and impulsive vibration are summarized in Table 6.

Table 6: Criteria for Exposure to Continuous and Impulsive Vibration.

Place	Time	Vibration Acceleration (m/s^2)			
		Preferred		Maximum	
Continuous Vibration		**z axis**	**x and y axis**	**z axis**	**x and y axis**
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime Night time	0.010 0.007	0.0071 0.005	0.020 0.014	0.014 0.010
Offices	Day or night time	0.020	0.014	0.040	0.028
Workshops	Day or night time	0.040	0.029	0.080	0.058
Impulsive Vibration		**z axis**	**x and y axis**	**z axis**	**x and y axis**
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime Night time	0.30 0.10	0.21 0.071	0.60 0.20	0.42 0.14
Offices	Day or night time	0.64	0.46	1.28	0.92
Workshops	Day or night time	0.64	0.46	1.28	0.92

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. The criteria applicable when considering periods of intermittent vibration are presented in Table 7.

Table 7: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$).

Location	Daytime		Night time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
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

3.2.2 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from construction activities that will not damage surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity. The human comfort criteria are also often exceeded before a risk of structural damage.

Structural damage criteria are presented in German Standard DIN 4150-Part 3 *Structural vibration in buildings – Effects on structures* and British Standard BS 7385-2:1993 *Evaluation and Measurement for Vibration in Buildings*. The British Standard BS 7385-2:1993 establishes vibration values for buildings based on the lowest vibration levels above which damage has been credibly demonstrated. These values are evaluated to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as 95% probability of no effect. The aforementioned values are summarised in Table 8.

Table 8: Transient Vibration Guide Values for Cosmetic Damage – BS 7385-2:1993.

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial or light commercial type buildings	50mm/s	N/A
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s	20mm/s (50mm/s at 40Hz and above)

Table 9 indicates the vibration limits presented in DIN 4150-Part 3 to ensure structural damage does not occur.

Table 9: Guideline Value of Vibration Velocity (v_i) for Evaluating the Effects of Short-Term Vibration – DIN 4150-Part 3.

Line	Type of Structure	Vibration velocity, v_i, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100Hz *	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	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied.					

4. Proposed Construction Activities

The proposed construction activities, assumptions and the related equipment and their noise levels have been discussed in the CNVMP (ref. AC-RE-005CNVMP_003). Please refer to this report for these details.

The construction hours have been extracted from the CNVMP and are as follows:

- Monday to Friday: 7am to 6pm, standard hours
- Saturday: 7am to 3pm, out of which 8am to 1pm standard hours
- Sunday and public holidays: no work

5. Noise & Vibration Monitoring Program

5.1 General Methodology

Noise levels should be monitored at various points of construction to ensure that noise generated as a result of remediation and construction activities does not disturb local businesses and residents.

Monitoring may be in the form of regular checks by the builder or indirectly by an acoustic consultant engaged by the builder and in response to any noise complaints. Where noise criteria are being exceeded or in response to valid complaints, noise monitoring should be undertaken. This would be performed inside the premises of the affected property and on site adjacent to the affected receivers.

Monitoring is to be undertaken by an experienced noise monitoring professional or an acoustic consultant. The results of any noise monitoring are to be provided to the relevant party or person in a timely manner allowing the builder to address the issue and respond to the complaints.

Noise monitoring can take two forms:

1. Short term monitoring
2. Long-term monitoring

Short-Term Monitoring

Short-term monitoring consists of attended monitoring when critical stages of the construction are occurring. This normally provides real-time assistance and guidance to the subcontractor on site, telling them when the noise and vibration criteria are exceeded. Thus, the selection of alternative method on construction or equipment selection is allowed in order to minimise noise and vibration impacts.

Long-Term Monitoring

Similar to short-term monitoring, long-term monitoring provides real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded. Instead of someone being on site measuring, noise and vibration loggers are used.

Typically, the noise and vibration loggers stay on site for a period of several months for the critical construction stages of the project. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities through the DA conditions.

Both methodologies are complementary and normally used simultaneously providing a significant amount of data via the long-term monitoring, but also providing information on the sources of noise and vibration generating exceedances via the short-term or attended monitoring.

5.2 Monitoring Locations

During the monitoring period discussed in this report, one noise monitor and one vibration monitor were installed on site from 1 to 29 July, after which the number of noise monitors was increased to two units. The locations of the monitors have been illustrated in Figure 4.

When only one noise monitor was on site, it was installed within the fenced construction area at N1, in the corner closest to the most sensitive receivers. This location was chosen due to pending arrangements to install two noise monitors within the premises of the most sensitive receivers along Bowral St and Mona Rd. Once access was granted and a suitable external placement of the two monitors decided, they were installed on site on 29 July at N2 and N3. The monitor at N1 was removed on the same day.

Figure 4: Monitoring Locations – July.

5.3 Construction Noise & Vibration Goals

As per the construction noise modelling undertaken for the CNVMP, the noise impact from the works are likely to exceed the management levels listed in Section 3.1 after implementing the reasonable and feasible noise mitigation methods. The measured ambient noise levels without the presence of construction works were also higher than the residential management levels, rendering them unusable as criteria at the residences.

Instead of using the ICNG management levels as criteria, noise targets were established at the locations of the noise monitors N1 to N3 for the approved construction hours. The targets were based on the modelling results and the noise contour maps in the CNVMP. These targets are presented in Table 10.

Table 10: Construction Noise Target Levels During Approved Construction Hours.

ID	Receiver Type	Address/Location	Noise Level Target $L_{Aeq,15min}$, dB(A)
N1	N/A	Northeastern corner of fenced construction site	69
N2	Health	21 St Jude St	68
N3	Residential	107 Bowral St	60

The vibration monitor V1 is placed on a concrete surface next to an existing hospital building. As completely avoiding vibration impact on the sensitive health care spaces is not possible, the monitoring will focus on avoiding damage to the heritage buildings. The limit values for the peak component velocity have been outlined in Table 11, giving a value for a warning level and the maximum levels allowed.

Table 11: Construction Vibration Target Levels.

ID	Receiver Type	Address/Location	Condition	Vibration Limit v, mm/s
V1	Heritage building	Next to an existing hospital building near southern end of construction site	Warning level	2.5
			Maximum level	3.0 to 10.0*

Note: * Maximum velocity limit depends on frequency. Monitoring device is programmed to take this into account. See Table 9.

6. Noise Monitoring Results

Noise monitoring was conducted from 1 July to 31 July 2019 at the locations shown in Figure 4. The noise monitor N1 was located within the fenced construction site in the northeastern corner from 1 to 29 July, whereas the monitors at N2 and N3 were installed on 29 July in the yards of the marked premises.

The target levels for the noise monitors are listed in Table 10, and they were established based on the assessments conducted for the construction works in the CNVMP by WGE. In the sections below, the data from the monitors is shown in weekly graphics and potential exceedances of the limits are discussed. It is understood that the construction hours nominated in Section 4 were adhered to.

6.1 Noise Monitor N1

The noise monitoring results at N1 have been illustrated in Figure 5 to Figure 8, including the noise level target for reference. Where exceedances have occurred, the date and time together with the measured level have been marked. It should be noted that the system uses 24h time notation.

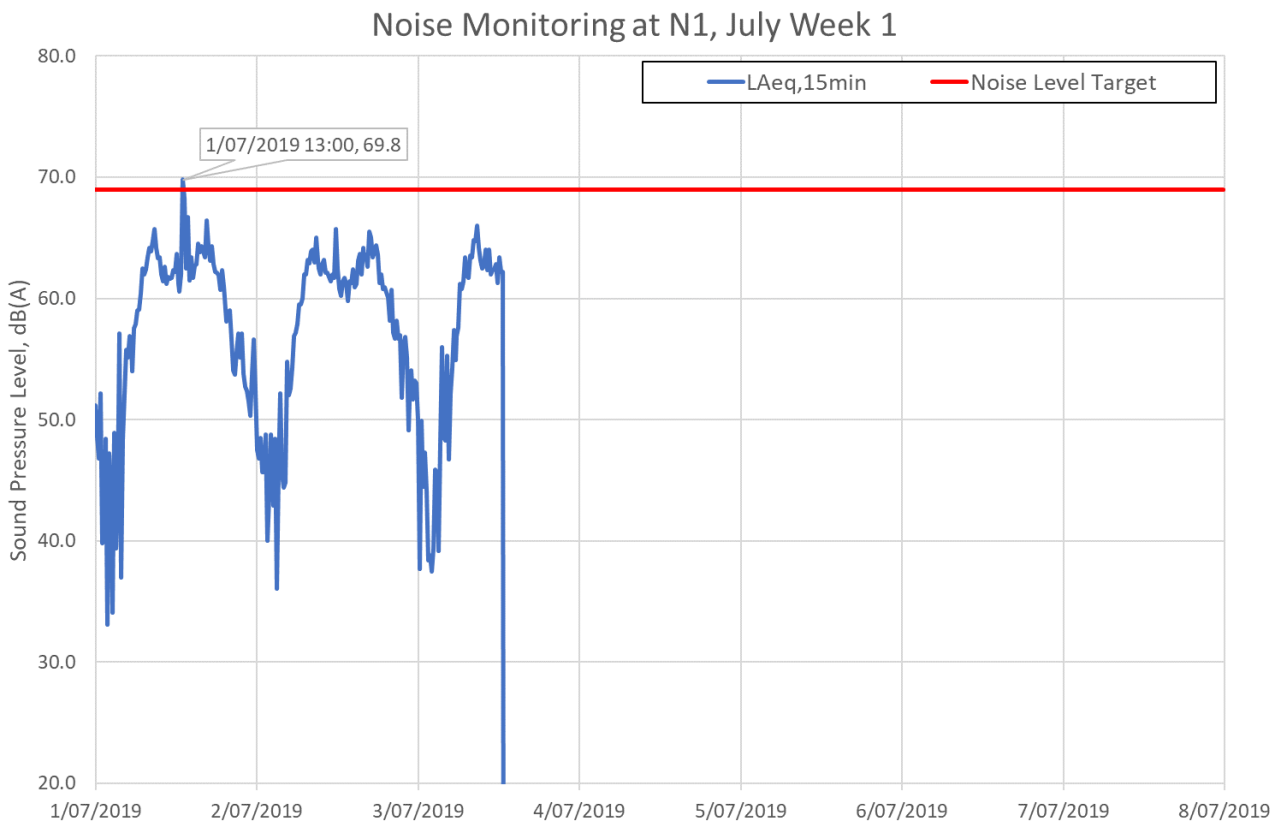


Figure 5: Noise Monitoring at N1 – July 2019, Week 1.

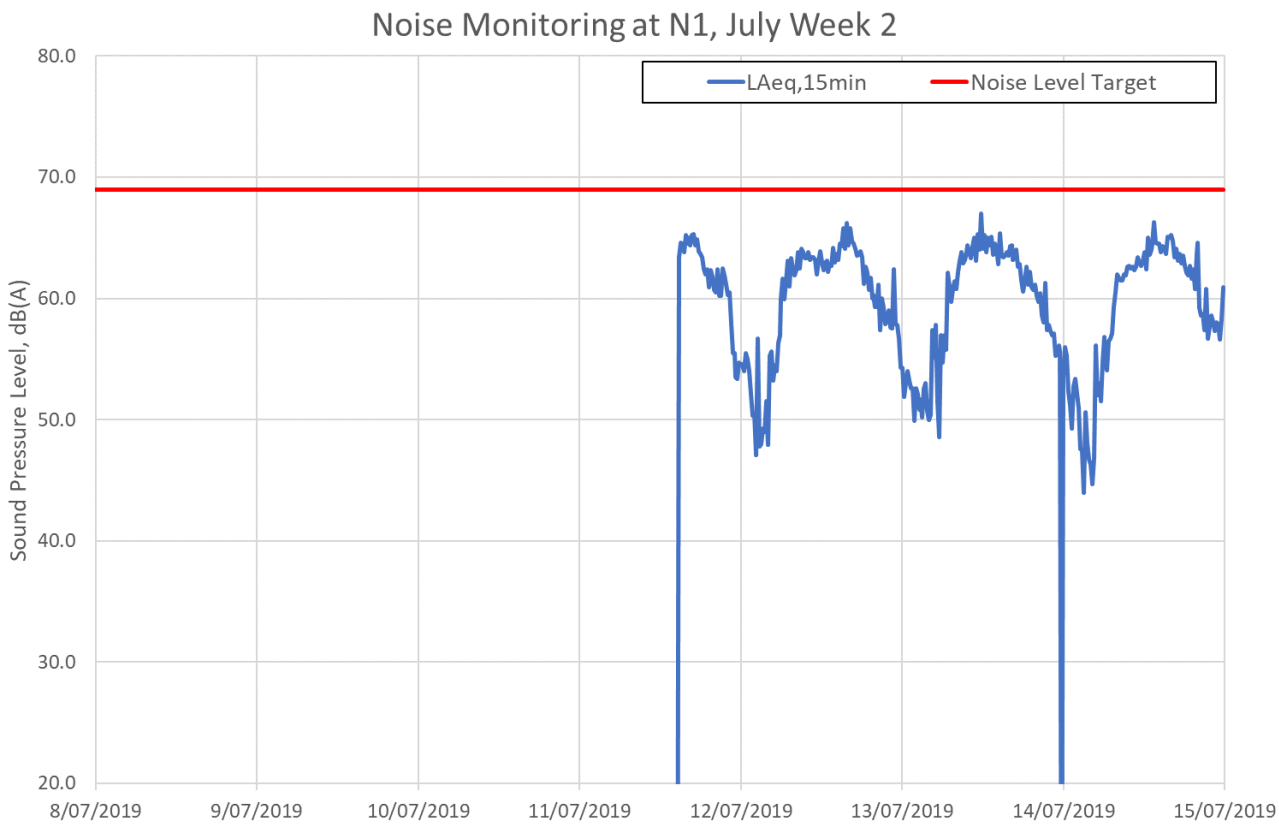


Figure 6: Noise Monitoring at N1 – July 2019, Week 2.

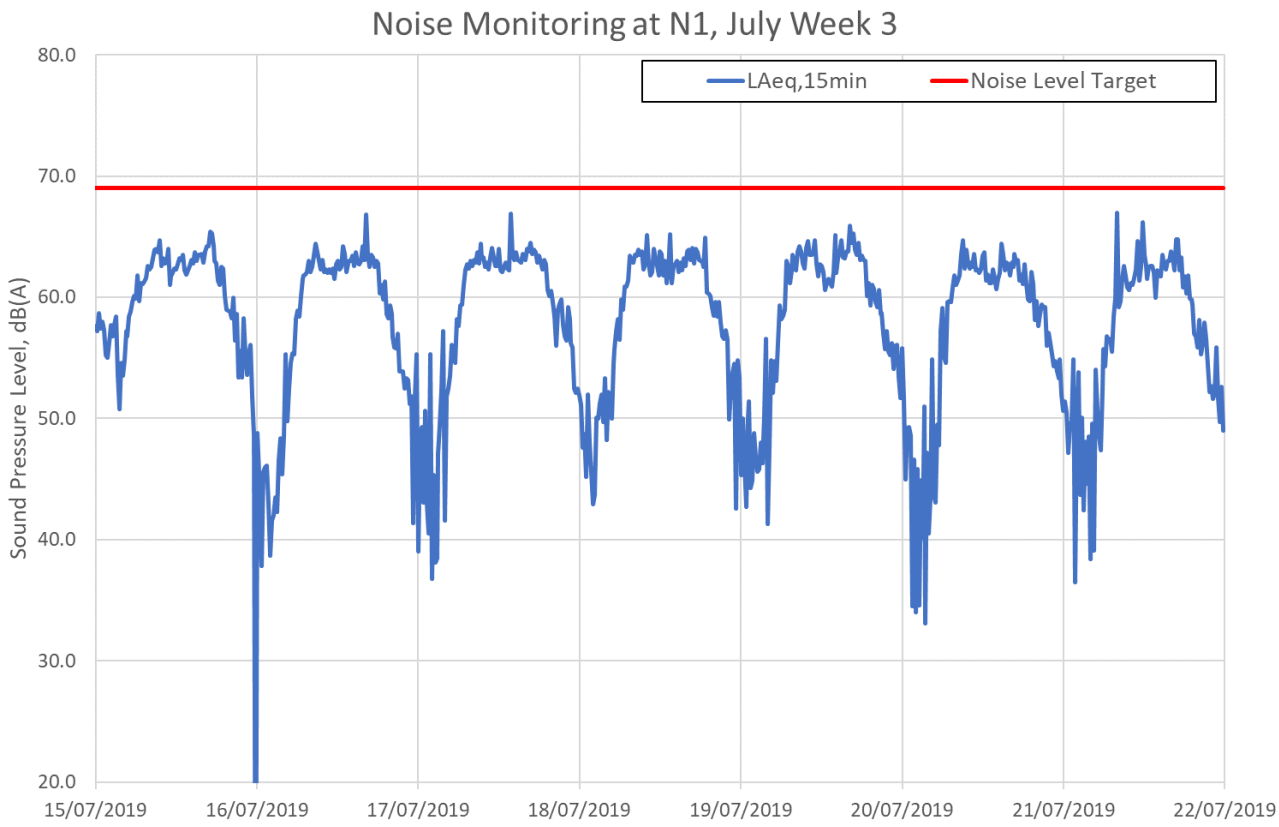


Figure 7: Noise Monitoring at N1 – July 2019, Week 3.

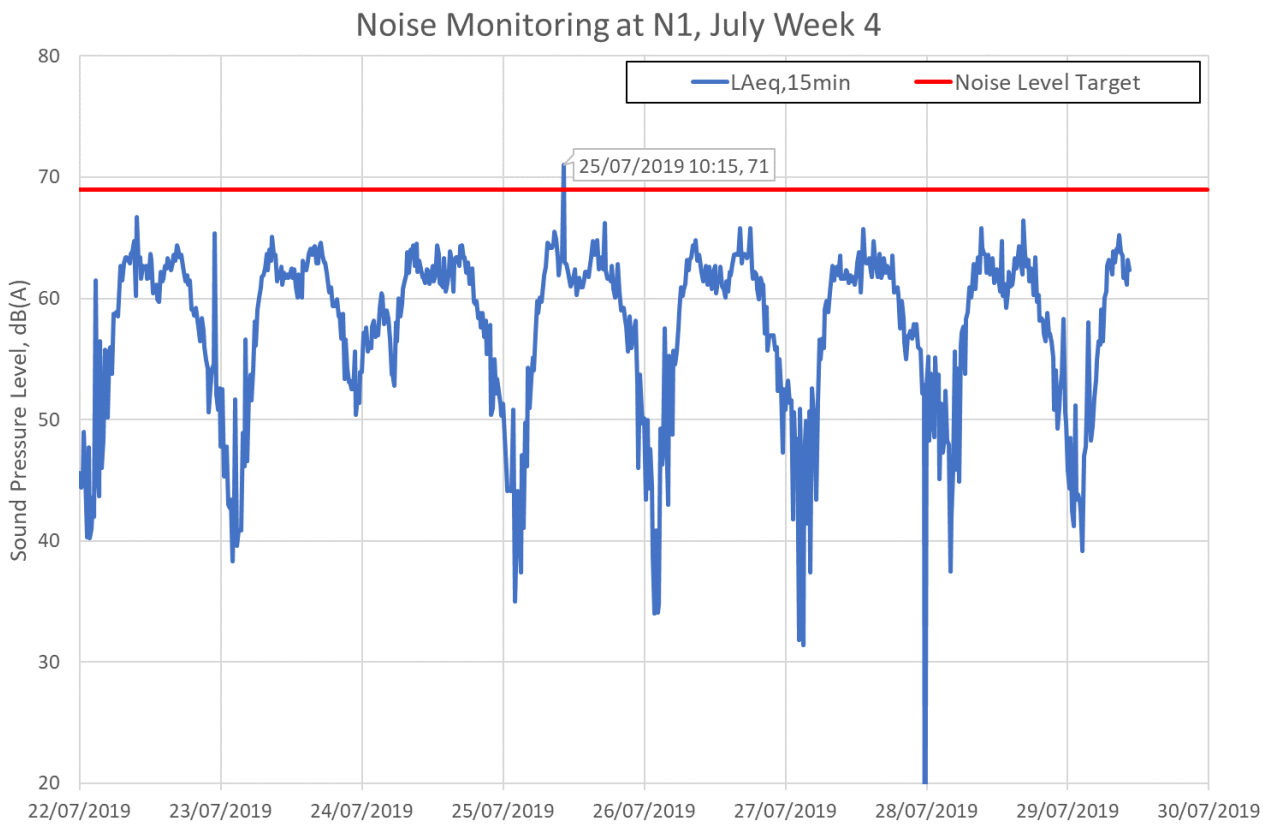


Figure 8: Noise Monitoring at N1 – July 2019, Week 4.

6.2 Noise Monitor N2

The noise monitoring results at N2 have been illustrated in Figure 9, including the noise level target and the ICNG criterion for reference. The criterion for health care has been applied. Where exceedances of the target level have occurred, the date and time together with the measured level have been marked. It should be noted that the system uses 24h time notation.

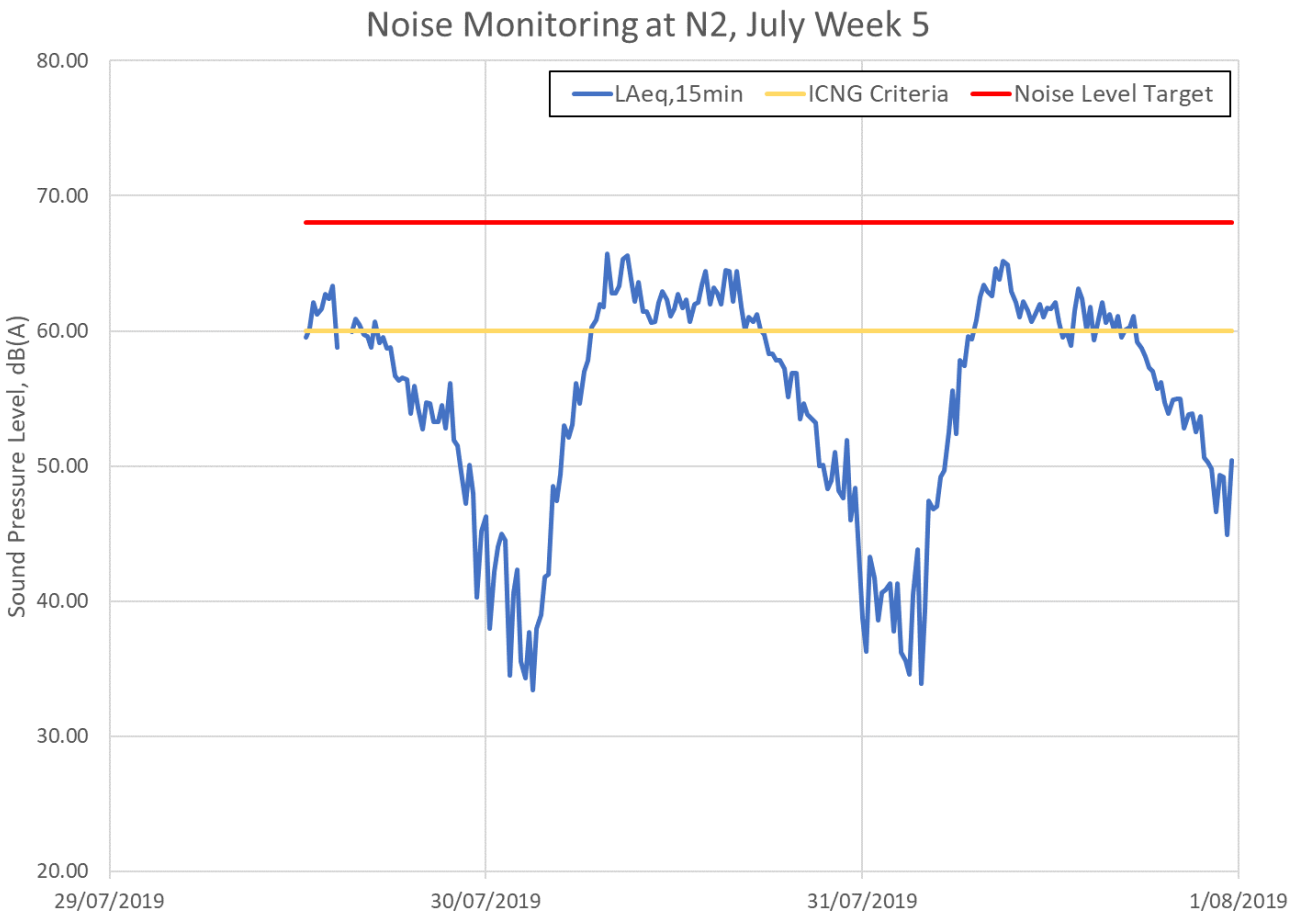


Figure 9: Noise Monitoring at N2 – July 2019, Week 5.

6.3 Noise Monitor N3

The noise monitoring results at N3 have been illustrated in Figure 10, including the noise level target for reference and the ICNG residential criteria for information, see the discussion in Section 5.3. Where exceedances of the target level have occurred, the date and time together with the measured level have been marked. It should be noted that the system uses 24h time notation.

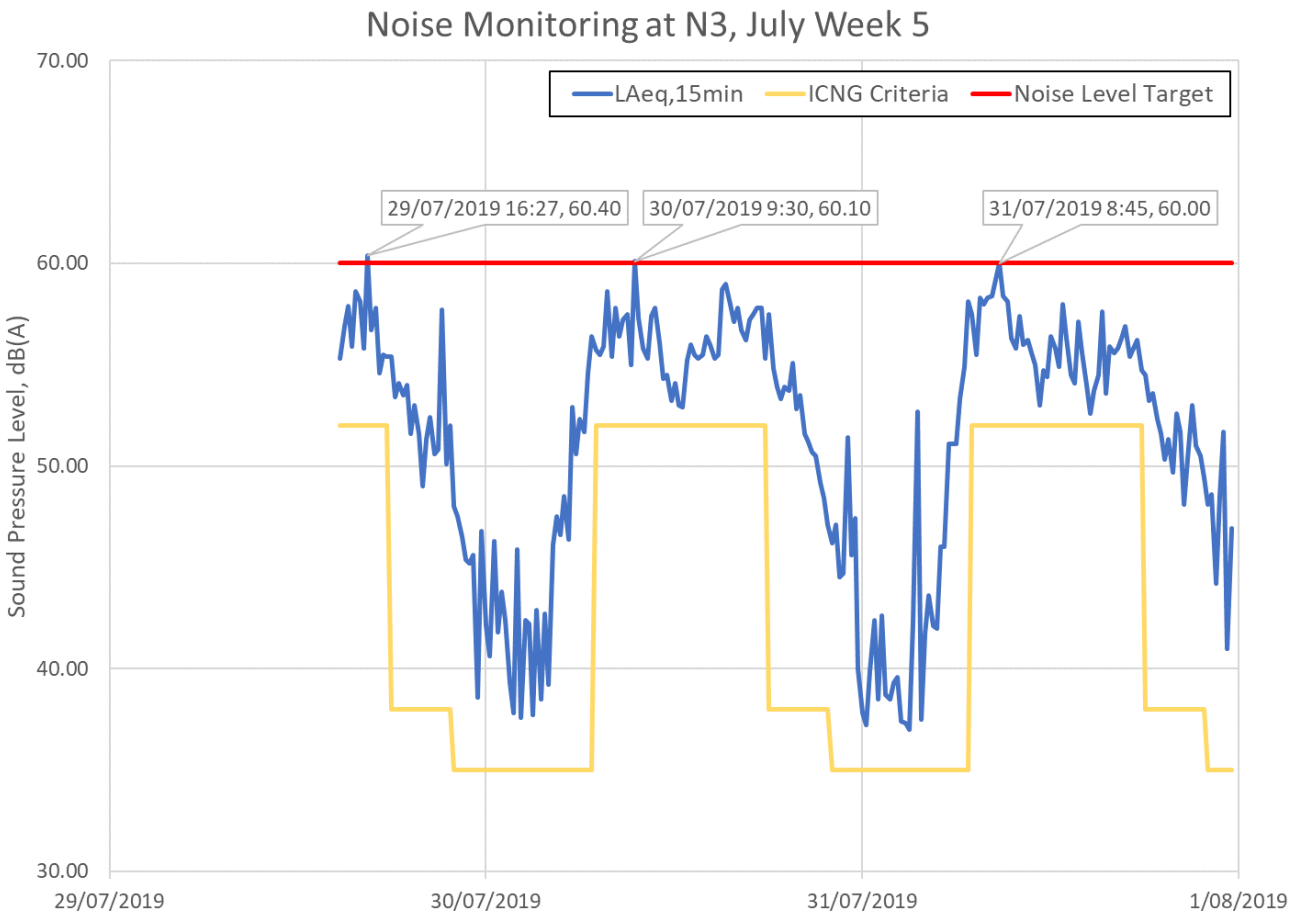


Figure 10: Noise Monitoring at N3 – July 2019, Week 5.

6.4 Discussion

It is noted that approximately eight days of monitoring data is missing between 3 and 11 July at noise monitor N1. A potential reason for the interruption in the monitoring is that the device became accidentally disconnected from external power and the internal battery ran out. As the daily noise levels in general seem to be relatively similar from day to day, it is likely that the missing days were not an exception.

The figures in the sections above show that the noise level targets were exceeded five times during the 31 days of monitoring presented in this report. At other times during the construction hours, the noise levels typically varied between 63-65dB(A) at N1, between 60-63dB(A) at N2 and between 53-57dB(A) at N3. Figure 10 demonstrates that the noise levels at the residential receiver at N3 are generally very similar to the ambient levels measured along Mona Rd in the absence of construction noise, see Figure 3.

All the exceedances were minor and were only reported for a single 15-minute measuring period at a time. As such, the events that produced these noise levels were short in duration and are not considered to have significantly affected the nearby sensitive receivers.

Potential causes for the exceedances are:

- Accidental but uncontrolled events
- Construction activities
- Background noises, such as surrounding traffic
- Rain noise

7. Vibration Monitoring Results

Vibration monitoring was conducted from 1 July to 31 July 2019 at the location V1 shown in Figure 4. The monitor was installed on a concrete platform at an existing hospital building near a vending machine.

The target levels for the vibration logger are listed in Table 11, and they were established based on the assessments conducted for the construction works in the CNVMP by WGE. In the sections below, the data from the monitor is shown in weekly graphics and potential exceedances of the limits are discussed. It is understood that the construction hours nominated in Section 4 were adhered to.

7.1 Vibration Monitor V1

The vibration monitoring results at V1 have been illustrated in Figure 11 to Figure 15, including the warning and maximum vibration levels for reference. The lowest value in the maximum level range (3.0 mm/s) has been presented. Where exceedances have occurred, the date and time together with the measured level have been marked. It should be noted that the system uses 24h time notation.

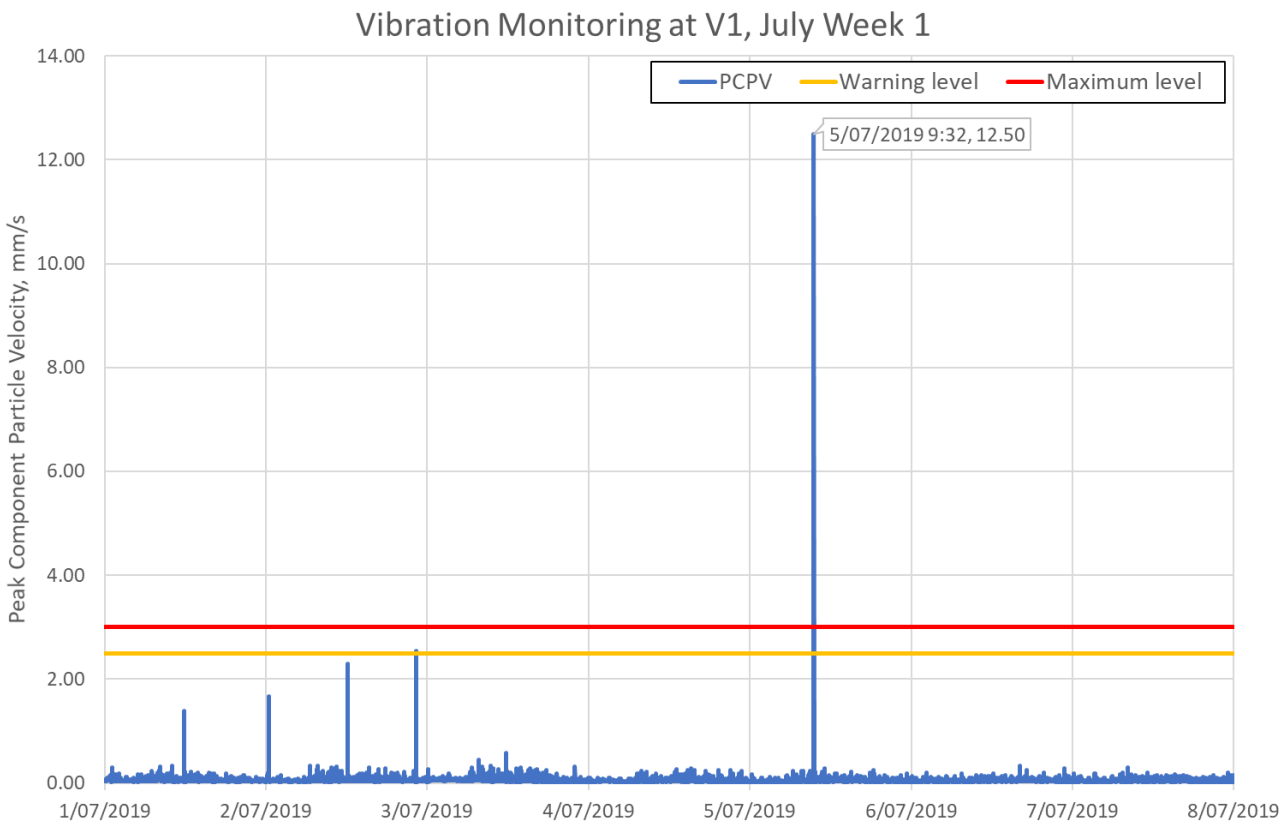


Figure 11: Vibration Monitoring at V1 – July 2019, Week 1.

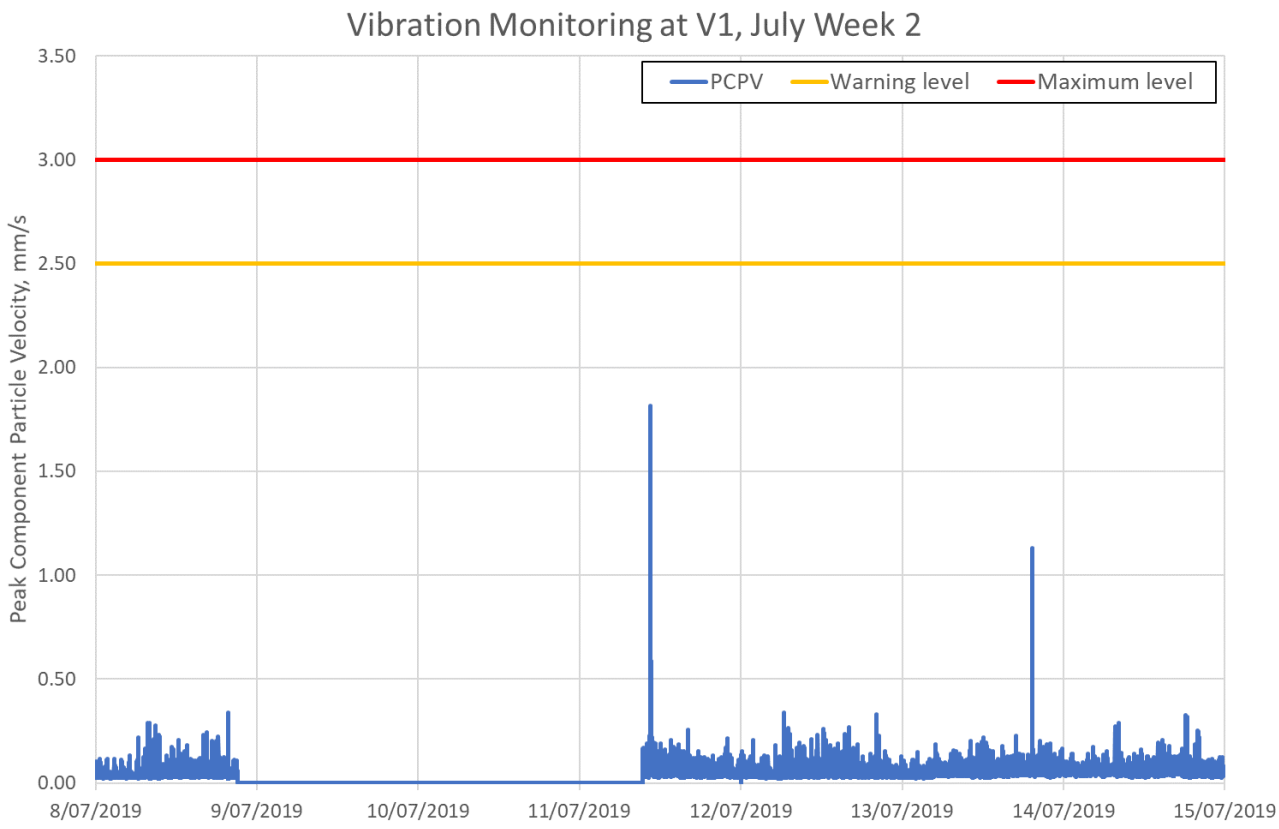


Figure 12: Vibration Monitoring at V1 – July 2019, Week 2.

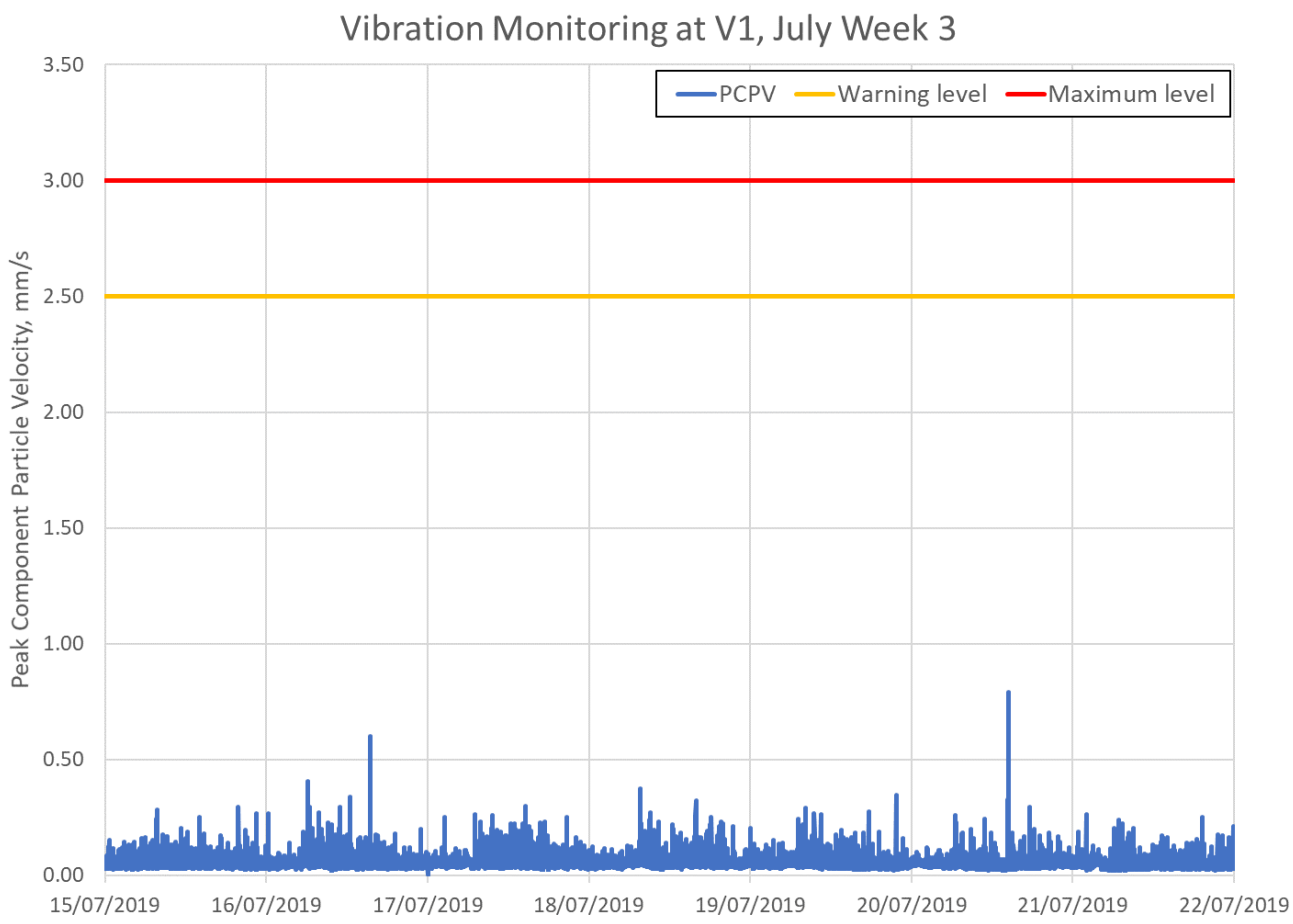


Figure 13: Vibration Monitoring at V1 – July 2019, Week 3.

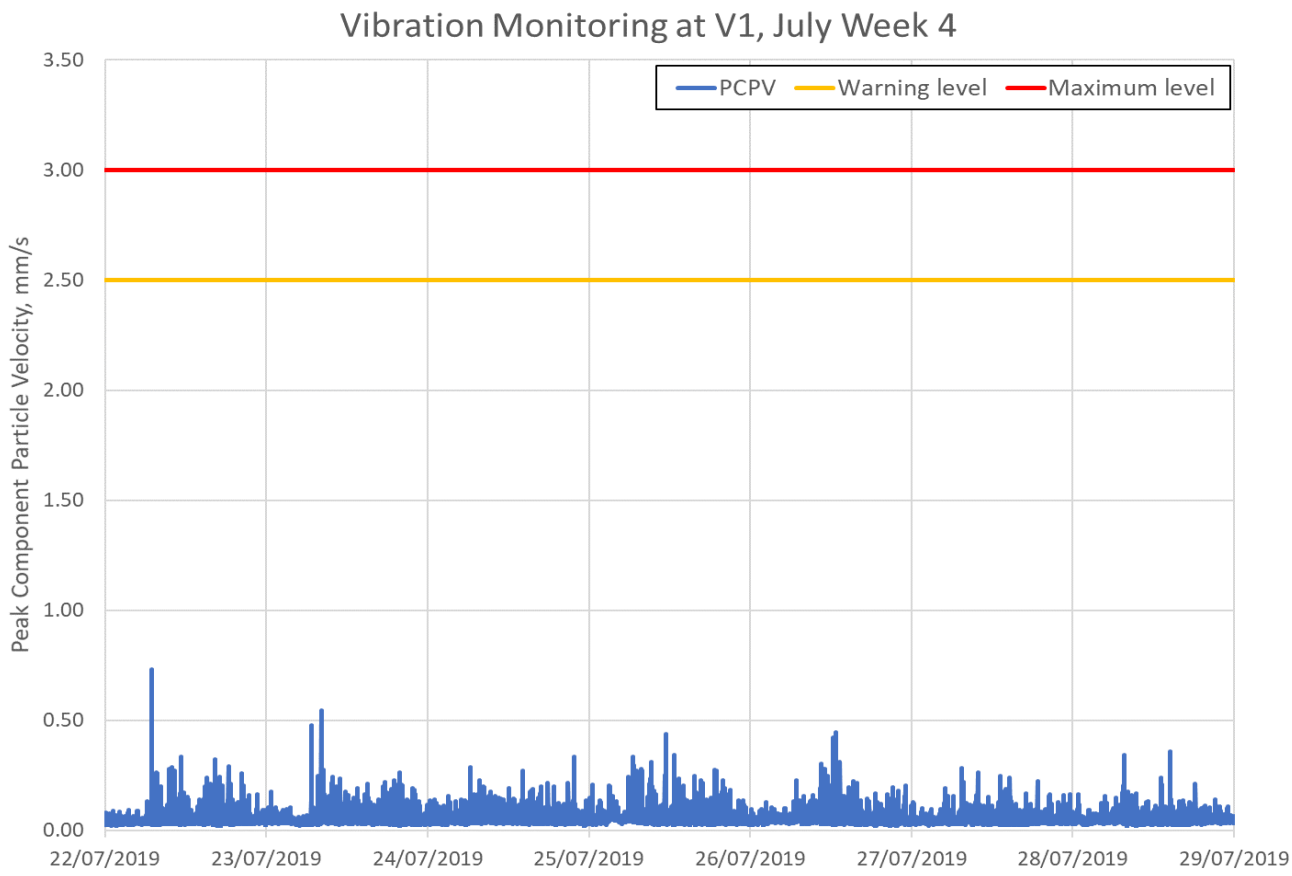


Figure 14: Vibration Monitoring at V1 – July 2019, Week 4.

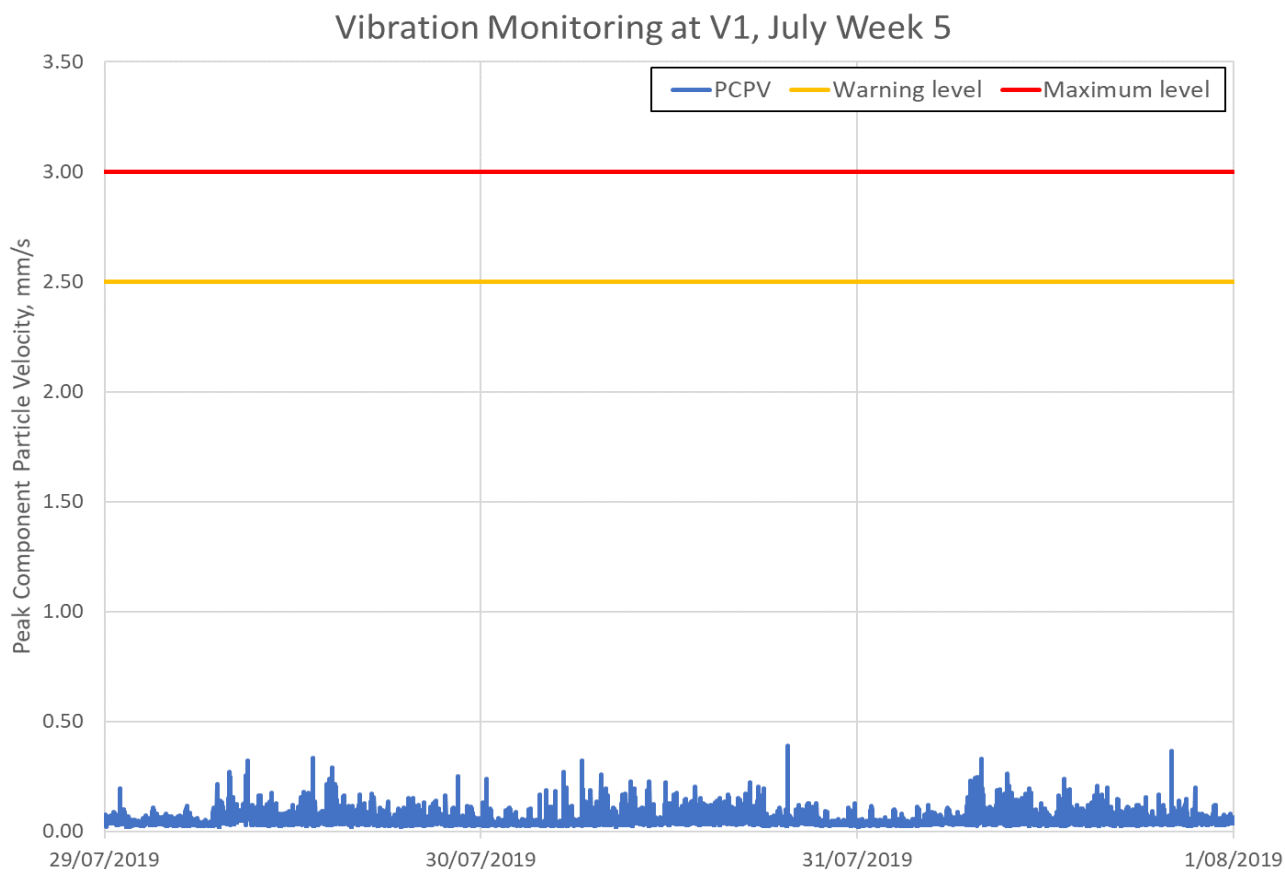


Figure 15: Vibration Monitoring at V1 – July 2019, Week 5.

7.2 Discussion

It is noted that approximately two days of monitoring data is missing between 9 and 11 July. This was potentially due to technical issues with the device. As the vibration levels in general seem to remain below 0.5mm/s, it is likely that the missing days were not an exception.

The figures above show that the lowest maximum level criterion was exceeded once during the 31-day monitoring period presented in this report. As the actual maximum level varies over the frequency scale, the dominant frequency of the event must be assessed to determine if this limit was exceeded as well, refer to Table 9.

The vibration event potentially exceeding the relevant maximum level occurred in the morning on Friday 5 July. The frequency analysis of the event showed that the spike was focused around 0.8 Hz, and the relevant maximum level of 3.0mm/s was clearly exceeded.

The maximum level exceedance event occurred during the nominated construction hours and might be related to the construction activities. However, the event was isolated and of short duration, and it is not considered to have significantly affected the nearby sensitive receivers or the existing buildings. Possible other causes for the spike could include:

- Accidental but uncontrolled events
- Human interference in the vicinity of the device

8. Conclusion

Construction noise and vibration monitoring was undertaken from 1 July to 31 July 2019 for the construction works of the new Bowral and District Hospital building at 97-103 Bowral St. As can be seen from the monitoring data presented in Sections 6 and 7 of this report, it is our opinion that the construction noise and vibration levels have been complying with the design criteria the majority of the time.

Appropriate measures have been taken where possible by ADCO, following the noise mitigation measures outlined in the Construction Noise and Vibration Management Plan of the project. However, occasional noisy work is unavoidable. ADCO was notified when the noise target or vibration levels were exceeded so that action could be taken if similar works were to be continued.

The noise and vibration monitoring conducted through the period showed that the established criteria were not exceeded during considerable periods of time. Only a few isolated noise target and vibration maximum level exceedances were measured during the construction hours. Thus, the acoustic amenity of those that surround the construction site are concluded to be satisfactory.

After evaluating the measured data of the period, accounting for all the criteria, the sensitiveness of the project and the validity of the data, it is the conclusion of this assessment that the noise and vibration generated from the construction works have not exceeded the limits set and approved for the works at the surrounding receivers. Thus, no further action needs to be taken.

APPENDIX A Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable L_{Aeq} noise level from industrial sources, recommended by the EPA (Table 2.2, NPI). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L_{A90} noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A-filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.

L_{Amax}	The maximum A-weighted sound pressure level measured over a period.
L_{Amin}	The minimum A-weighted sound pressure level measured over a period.
L_{A1}	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
L_{A10}	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
L_{A90}	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{A90} noise level expressed in units of dB(A).
L_{Aeq}	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
$L_{Aeq,T}$	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R_w:	The Sound Insulation Rating R_w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{eq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.