NOISE AND VIBRATION MANAGEMENT PLAN

LIVERPOOL HOSPITAL & ACADEMIC PRECINCT (LHAP)

LENDLEASE BUILDING PTY LTD

PROPERTY RISK AUSTRALIA

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1. INTRODUCTION

This Noise and Vibration Management Plan (NVMP) has been prepared in accordance with Planning Approvals SSD 10388 (Condition B14) and SSD 10389 (Condition B13) for the upcoming Liverpool Hospital & Academic Precinct (LHAP), Integrated Services Building (ISB) redevelopment and refurbishment works at Liverpool Hospital – Elizabeth and Goulburn St, Liverpool NSW 2170 (the site). The works are to be completed across three stages. A detailed summary of the project scope is provided in **Section 1.3** below.

The site and redevelopment locations are provided in **Appendix A** – *Figure 1*.

1.1 Mission Statement

Lendlease Building is committed to managing the noise and vibration associated with the works to protect the environment, local community and worker safety.

1.2 NVMP Objectives and Scope

The objective of this NVMP is to provide guidance, mitigation measures and reactive management strategies to control the generation of noise and vibrations on site to minimise their effect on the surrounding environment during the redevelopment works.

The objectives of the NVMP will be to:

- Ensure that construction works do not significantly impact background noise levels around the hospital precinct, and that applicable guidelines and regulations are met;
- Ensure all equipment operates within the applicable noise levels;
- Vibration does not affect occupiers or sensitive equipment of the hospital; and
- Ensure all feasible and reasonable work practices are implemented during construction to minimise the impact of noise and vibration.

1.3 Project Scope

The LHAP - ISB works are separated into three stages. This includes the following:

<u>Stage 1 & 2:</u>

- Demolition and site preparation;
- Construction and operation of a new 6 storey ISB to provide:
  - Expanded Emergency Department;
  - New women's and paediatric services;
  - New cancer treatment centre;
  - New support services including pathology, satellite medical imaging and pharmacy;
  - New education and teaching spaces;
  - New retail facilities; and
  - New basement loading dock.
- Refurbishment of existing buildings to provide:
  - Expansion and reconfiguration of the existing Emergency Department;
  - Expansion of the Intensive Care Unit;
  - Reconfiguration of existing operating theatres and same day surgery; and
  - Repurpose Caroline Chisholm Building for office accommodation.

- New hospital entry and drop off;
- Construction of a skybridge link over Campbell Street to the Ingham Institute;
- Construction of new internal access roads and links;
- Expansion of Ambulance bays on Elizabeth Street;
- Creation of a shared zone on Campbell Street;
- Tree removal;
- Landscape works;
- Utilities services and amplification works; and
- Site preparation civil works.

Stage 3:

Refurbishment works of the following buildings:

- Oncology Bunker;
- Caroline Chisholm; and
- CSB Including ED.

Refurbishment works will generally involve the soft stripping of internal fit out and reconfiguration into a new department. Access to the buildings during refurbishment will be via existing corridors and works will be completed in and around the existing operational departments.

2. MANAGEMENT PLAN COMMUNICATION STRATEGY

The NVMP will be supplied to each Sub-contractor as part of the procurement process (including tendering and contract award).

The NVMP will be made available to, and understood by, all persons involved in the management and operation of the site.

3. CONTINUOUS IMPROVEMENT

The NVMP should be referred to regularly and updated/maintained by the Management Plan Controller when major project changes could produce additional noise and vibration.

Where appropriate, additional controls identified while rectifying incidents associated with noise and vibration will be incorporated into the next revision of the Management Plan.

4. REGULATORY COMPLIANCE

Key Legislation relevant to noise and vibration management includes, but is not limited to the following:

- *Environmental Planning and Assessment Act 1979* (EP&A Act);
- *Protection of the Environment Operations Act 1997* (POEO Act);
- Protection of the Environment Operations, Noise Regulation Controls (NRC) 2008;

4.1 Guidelines and Standards

The primary guidelines, specifications, and policy documents relevant to this NVMP include, but are not limited to the following:

Construction noise and vibration:

- NSW DECCW Interim Construction Noise Guideline (ICNG) 2009;
- NSW DECC Assessing Vibration: A Technical Guideline 2006;
- NSW EPA Noise Policy for Industry (NPI) 2017.
- Australian Standard AS 2436:2010 *'Acoustics – Guide to Noise Control on Construction, Maintenance and Demolition Sites'*;
- British Standard 6472: *Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*;
- British Standard 7385: Part 2 – *Evaluation and measurement of vibration in buildings*; and
- German Standard *DIN 4150: Structural Vibration in Buildings - Effects on Structures.*
- German Standard *DIN 4150-3: Effects of Vibration on Structures (1999).*

5. ENVIRONMENTAL ASPECTS AND IMPACTS

5.1 Factors Affecting Construction - Noise and Vibration Generators

Noise and vibration are expected to be influenced by the following factors:

- The type of activities being undertaken;
- The duration of the activity being undertaken;
- The size of the subject site;
- The ambient noise and vibration;
- The number, duration and type of plant equipment being used; and
- The condition (maintenance) and operation of plant equipment – poorly balanced parts can cause structural vibrations.

5.2 Sensitive Receptors - Noise

Sensitive receptors likely to be impacted by redevelopment works are as follows:

- **People** – As the works are being undertaken within and adjacent to the hospital, there are high numbers of people within proximity to the site. Low (R2) density residential premises are situated along the western boundary of the redevelopment area along Goulburn Street. Educational facilities including Liverpool TAFE and Liverpool Girls High School are located to the south and north respectively – see **Appendix A** – *Figure 2*.
  Due to this, it can be expected for the surrounding demographics to encompass all manner of people from children through to the elderly.
- **Hospital & Facilities** –As the Ingham Institute/Animal Research Lab are located to the north-west of the redevelopment, research animals housed in these facilities may be impacted by noise.

5.3 Sensitive Receptors - Vibrations

The sensitive receptors likely to be impacted by redevelopment works are as follows:

- **People** – As the works are being undertaken within and adjacent to the hospital, there are high numbers of people within proximity to the site. Low (R2) density residential premises are situated along the western boundary of the redevelopment area along Goulburn Street. Educational facilities including Liverpool TAFE and Liverpool Girls High School are located to the south and north respectively – see **Appendix A** – *Figure 2*.

Due to this it can be expected for the surrounding demographics to encompass all manner of people from children through to the elderly.

- **Property** – Vibrations can be damaging to structures and annoying to people. It is therefore important that vibration criteria for buildings and comfort are adhered to during construction. High intensity activities such as rock breaking or piling (as is occurring at work area 4) may cause impulsive vibration (i.e. infrequent activities that cause up to three distinct vibration events within any given assessment period).
- **Hospital & Facilities** – As sensitive equipment such as X-ray machines and activities including surgery are conducted at the hospital, it can be expected that these may be impacted by vibrations. The Ingham Institute/Animal Research Lab are located to the north-west of the redevelopment, research animals housed in these facilities may be impacted by vibrations.

5.3.1 Impact on Receptors

The dominant noise and vibration impacts expected from the redevelopment works on site are as follows:

- Potential effects on receptors include nuisance, adverse health effects and damage to property;
- Complaints from both public and hospital staff regarding excessive noise and vibrations – this will usually occur during out of hours works.

6. RISK ASSESSMENT

The Environmental Assessment predicted the likely and vibration generated during the works. Rather than making further quantitative predictions of the noise and vibration generated throughout the project, a qualitative assessment has been undertaken of the noise and vibration risks associated with each stage of the works. The outcomes of this risk assessment have been used to assist the project to meet the noise and vibration goals of protecting the environment, local community and worker safety.

Effective environmental management should be proactive rather than reactive. In order to facilitate a proactive style of environmental management, a risk management style of assessment has been utilised to identify and assess noise and vibrations associated with the project, and to implement appropriate mitigation strategies to minimise the likelihood of environmental risks associated with each aspect. This process involves:

1. Identifying the risk/aspect.
2. Analysing the risk/aspect (determining likelihood and consequence).
3. Evaluating the risk/aspect.
4. Treating the risk.

All identified aspects are assessed based on the risk assessment defined in **Table 1** below. The risk assessment is based on (1) the consequences of the impact if the event occurred; and (2) the likelihood of an impact occurring as a result of the aspect.

Following this assessment, each impact is assigned a risk category which range from “Very Low” (very low likelihood and consequence) to “Very High” (very high likelihood and consequence).

A risk category identified as having an extreme or higher risk may be downgraded if appropriate environmental controls and measures are implemented and maintained. Proactive planning, installation and maintenance of appropriate environmental controls and ongoing monitoring will reduce the risks associated with each environmental impact identified for the project. **Table 2** details the noise and vibration aspects identified for the project, the initial risk category prior to appropriate management strategies and the residual risk once management strategies have been applied.

Table 1 - Risk matrix

RISK MATRIX	**CONSEQUENCE** *(how **severe** are the consequences?)*				
LIKELIHOOD *(how **likely** is it to occur?)*	**Very Large** Major irreversible environmental harm on-site and/or off-site damage	**Large** Major on-site and/or off-site impacts with clean up or remedy requires significant effort.	**Medium** Moderate on-site and/or off-site impacts (but no significant irreversible damage) with clean up or remedy work incurring a moderate level of effort	**Small** Treatable on-site impact with clean up or remedy work incurring a small level of effort.	**Very Small** Reversible and insignificant environmental impact.
Almost Certain Could happen in most circumstances	**Very High**	**Very High**	High	Medium	Medium
Likely Expected to happen occasionally	**Very High**	High	Medium	Medium	Low
Moderate Could happen sometime in a working life	High	Medium	Medium	Medium	Low
Unlikely Could happen only in unlikely circumstances	Medium	Medium	Medium	Low	Very Low
Rare Not expected to occur but could	Medium	Low	Low	Very Low	Very Low

Table 2 – Risk Assessment

Stage of Work	Source	Pathway	Receptor	Hazards	Likelihood	Consequence	Hazard Risk Level	Risk Control Measures Found in Table 10	Likelihood	Consequence	Residual Risk
Site Set-up	Noise	Noise generated during mobilising	Hospital Workers, patients, Ingham Institute/Animal Research Lab and adjacent residents	Stakeholder exposure to excessive noise	M	VS	Low	N1, N2, N3, N4, N6, N13, N14, N15 & N16	U	VS	Very Low
	Vibration	Structure and ground borne vibration	Hospital Workers and patients	Exposure to vibration causing annoyance	R	S	Very Low	V3	R	VS	Very Low
Demolition	Noise	Noise generated during demolition	Hospital Workers, patients, Ingham Institute/Animal Research Lab and adjacent residents	Stakeholder exposure to noise exceeding the NMLs	AC	M	High	N1, N2, N3, N4, N6, N7, N8, N9, N10, N11, N12, N13, N14, N15 & N16	U	M	Medium
	Vibration	Structure and ground borne vibration generated during demolition	Hospital equipment, Hospital Workers , Ingham Institute/Animal Research Lab and patients	Exposure to vibration causing annoyance or structural damage	L	L	High	V1, V2, V3	M	L	Medium

Stage of Work	Source	Pathway	Receptor	Hazards	Likelihood	Consequence	Hazard Risk Level	Risk Control Measures Found in Table 10	Likelihood	Consequence	Residual Risk
Civil/Piling	Noise	Noise generated during earthworks, piling and road/ service works	Hospital Workers, patients, adjacent residents, Ingham Institute/Animal Research Lab and educational facilities	Stakeholder exposure to noise exceeding the NMLs	AC	M	High	N1, N2, N3, N4, N6, N7, N8, N9, N10, N11, N12, N13, N14, N15 & N16	L	M	Medium
	Vibration	Ground borne vibration generated during earthworks, piling, rock breaking or compacting materials	Hospital equipment, Hospital Workers, patients, adjacent residents, Ingham Institute/Animal Research Lab and educational facilities	Exposure to vibration causing annoyance or structural damage	L	M	High	V1, V2, V3			Medium
Structure and Fit-out	Noise	Noise generated during structure works and fit-out	Hospital Workers, patients, adjacent residents	Exposure to excessive noise	M	M	Medium	N1, N2, N3, N4, N6, N10, N12, N14, N15 & N16	U	VS	Very Low
	Vibration	Structure and ground borne vibration during structure works and fit-out	Hospital equipment, Hospital Workers, patients	Exposure to vibration causing annoyance	M	S	Medium	V1, V2, V3	R	VS	Very Low

7. HOURS OF WORK

Lendlease and its subcontractors will undertake the works in accordance with the following approved hours of work. Where works are required to be undertaken outside these approved hours, Lendlease will follow a separately approved Out of Hours Work Approval Protocol.

7.1 Approved Hours

7.1.1 Condition C4

All work including demolition, excavation, building work and activities in the vicinity of the site generating noise associated with preparation for the commencement of work (e.g Loading and unloading of goods, transferring tools etc) in connection with the proposed development must only be carried out:

a) Between 7:00am and 6:00pm Monday to Friday
b) Between 8:00am and 1:00pm Saturday
c) No work to be undertaken on Sundays or public holidays

7.1.2 Condition C5

Construction activities may be undertaken outside of the hours if required:

a) by the Police or a public authority for the delivery of vehicles, plant or materials; or
b) in an emergency to avoid the loss of life, damage to property or to prevent environmental harm; or
c) where the works are inaudible at the nearest sensitive receivers; or
d) for the delivery, set-up and removal of construction cranes, where notice of the crane- related works is provided to the Planning Secretary and affected residents at least seven days prior to the works; or
e) where a variation is approved in advance in writing by the Planning Secretary or his nominee if appropriate justification is provided for the works.

7.1.3 Condition C6

Notification of such construction activities as referenced in condition C5 must be given to affected residents before undertaking the activities or as soon as is practicable afterwards.

7.1.4 Condition C7

Construction activities may be undertaken outside of hours in condition C4 for concrete finishing works (including the use of a helicopter float), unless directed otherwise by the planning secretary, with these activities restricted to the following time.

a) Friday: 6pm – 10pm
b) Saturday: 1pm – 10pm
c) Sunday: 8am – 10pm

7.1.5 Condition C9

Rock breaking, rock hammering, sheet piling, pile driving and similar activities may only be carried out between the following hours:

a) 9am to 12pm, Monday to Friday;
b) 2pm to 5pm Monday to Friday; and
c) 9am to 12pm, Saturday.

7.2 Out of Hours Work

7.2.1 Condition C8

The work permitted under condition C7 must only be undertaken where managed by an Out-of-Hours Work Protocol, prepared in consultation with the EPA and Council, and approved by the Planning Secretary. The Protocol must be prepared to identify a schedule for work to be undertaken outside the hours permitted under condition C4 and how they would be managed. The Protocol must provide:

a) a description of the proposed out-of-hours works;
b) predictions of LAeq (15 minute) noise levels at noise sensitive receivers from these works and activities, where noise levels are predicted to be greater than the construction noise management level (NML); and
c) a monitoring plan to validate the noise predictions, based on monitoring at the boundary of representative sensitive receivers during noise generating activities that are representative of the out-of-hours works;
d) identification of proposed mitigation and management measures;
e) consideration of out-of-hours work against the relevant NML and vibration criteria;
f) a process for consultation with the community at each affected location for identifying and implementing mitigation measures where the NML would be exceeded, including respite periods. The measures must take into account the predicted noise levels and the likely frequency and duration of the out-of-hours works that sensitive receivers would be exposed to; and
g) notification arrangements for affected receivers, the EPA and the Planning Secretary for out-of-hours works.

8. NOISE MANAGEMENT

In general, all plant and equipment used during the redevelopment works will remain within the maximum noise levels specified (at 7 meters) in **Appendix C** – Construction Equipment Noise Levels. All personnel will also be made aware of the risks associated with construction noise exposure during the site induction.

8.1 Interim Construction Noise Guideline

The EPAs *Interim Construction Noise Guideline* (ICNG) provides guidelines that assist in evaluating the impact of noise generating activities. These are as follows:

Table 3 – Interim Construction Noise Guidelines

Applicable Operating Hours	Classification	Management Level ($LA_{eq,\ 15\ min}$)*	Possible Actions
Standard Operating Hours	Noise affected	RBL + 10dBA	- There may be complaints from the local community. - In areas where $LA_{eq,15min}$ exceeds the "noise affected" classification action must be taken to reduce noise levels. - Residents should be forewarned about the nature of work to be carried out, the anticipated noise level, duration and contact details.
	Highly noise affected	75dBA	- The point above which strong community backlash may be anticipated. - Where areas are measured to be "highly noise affected" it should be very carefully considered whether the work can be performed in a different manner - If no quieter feasible or reasonable method can be considered the contractor should communicate clearly with residents explaining the anticipated duration, noise level and respite periods planned as well as provide their contact details.
Outside Standard Operating Hours	Noise affected	RBL + 5dBA	- Provide a strong reason to justify continuation of works outside of standard operating hours. - Apply all reasonable and feasible practices to reduce noise to meet the noise affect level. - If the noise affected (RBL + 5dB) is reached it is recommended for the proponent to negotiate with the community.

* 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 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

8.2 Noise Management Levels

The ICNG specifies Noise Management Levels (NMLs) that guide the need to apply work practices to minimise noise impacts.

Based on previous background noise monitoring, which formed part of the planning approval application, the NMLs listed in **Table 4** will apply to construction related noise for the project. The NMLs will be monitored and reported in accordance with **Section 10.2**. Where the project NMLs have been exceeded they will be managed in accordance with **Table 11**.

Due to the proximity of the Animal Research Laboratory, this Plan also provides a suitable NML to the minimise potential disturbance to lab animals. Many laboratories have found that noise and vibration

produced by construction corresponds to a reduction in breeding success and disturbance in their animals. Typical laboratory conditions generally do not exceed 60 dBA and rodents have been shown to be comfortable in laboratories beneath 50 dBA. The existing NMLs for critical structures listed in **Table 4** below are generally more conservative that the typical comfortable levels reported for lab animals. Therefore, it is recommended an internal $LA_{eq,\ 15min}$ of 45dBA is maintained to minimise disturbance to lab animals in the adjacent Ingham Institute/Animal Research Lab (~35-40 m away from the works).

Table 4 – Recommended Construction Noise Management Levels

Receiver / Area	Internal / External	Recommended Noise (LA_{eq} - 15 min)	
		Standard Hours	Outside Standard Hours
Goulburn Street Residential Suburban (R2) – Noise affected	External	52	47
Goulburn Street Residential Suburban (R2) – Highly Noise affected	External	75	N/A
Educational Receivers	Internal	45	N/A
Bedroom Wards			
Consulting Rooms			
Treatment Rooms			
Office Areas			
Operating Theatres			
X-Ray Areas	Internal	45	N/A
Ingham Institute/Animal Research Lab	Internal	45	N/A

The typical list of equipment that may be used during the project and their predicted noise outputs are outlined in **Appendix C**.

8.3 Activities Predicted to Exceed the Noise Management Levels

In accordance with Condition C17 of the Planning approval (SSD 10389), there are two stages of the works that are likely to generate noise that could exceed the construction NMLs. These stages were identified in the risk assessment above and include demolition, civil and piling. The activities associated with these stages will be managed in accordance with the measures identified in **Table 10**.

9. VIBRATION MANAGEMENT

When planning for activities anticipated to cause excessive vibrations all practical effort must be made to ensure that adequate protection is granted to vibration sensitive building and amenities. Guidelines for vibration criteria are specified within the EPA guidelines "*Assessing Vibration: A Technical Guideline (2006).*"

In accordance with Condition C20 of the Planning approval (SSD 10389), vibration caused by construction at any residence or structure outside the site must be limited to those outlined in the latest version of DIN 4150-3, these numbers are outlined in **Table 8**.

9.1 Managing Exposure to Vibration in Humans and Research Animals

Human exposure to continuous and impulsive vibration, such as drilling, is dependent upon the time of day and associated activity (such as workshop, office or residential). The criteria relevant to this

project are shown in **Table 5** below. Vibration is taken utilising the root mean square (RMS) of vibration.

Vibration can have detrimental effects in both humans and research animals, with nearby construction activity shown to impede breeding success and cause health problems in rodents. The closest distance from the Animal Research Lab to the demolition area is approximately 35-40m, across the intersection between Campbell Street and Goulbourn Street. Studies have utilised control groups 100m away that have shown to these research animals be unaffected by construction noise however, due to the sensitivity of these receptors we recommend the exposure guidelines for critical areas be adopted.

Table 5 – EPA Human Exposure Guidelines for Continuous Vibration

Place	Time	Peak Particle Velocity, mm/s [dB ref 10^{-6} mm/s]			
		Continuous Vibration		Impulsive Vibration	
		Preferred	Maximum	Preferred	Maximum
Critical Areas (Hospitals)	Day or Night	0.10 [100dB]	0.20 [106dB]	0.10 [100dB]	0.20 [106dB]
Residential – Daytime	Day	0.20 [106dB]	0.40 [112dB]	6.00 [136dB]	12.00 [142dB]
Residential – Night-time	Night	0.14 [103dB]	0.28 [109dB]	2.00 [126dB]	4.00 [132dB]
Offices, schools, education and worship	When in Operation	0.40 [112dB]	0.8 [118dB]	13.00 [142dB]	26.00 [148dB]
Ingham Institute/Animal Research Lab	Day or Night	0.10 [100dB]	0.20 [106dB]	0.10 [100dB]	0.20 [106dB]

Intermittent vibration is caused by equipment such as rock breakers and is characterised by several (usually around 3) sharp pulses of vibration. For intermittent vibration events it is recommended that vibration dose value (VDV) is used (**Table 6**). Acceptable dosages for intermittent vibration specific to this project are as follows:

Table 6 – Acceptable Dosages for Intermittent Vibrations (m/s1.75)

Place	Period	Preferred Value	Maximum Value
Critical Working Areas (e.g. hospitals, precision laboratories)	When in use	0.10	0.20
Residential – Daytime	Daytime	0.20	0.40
Residential – Night-time	Night-Time	0.13	0.26
Offices	When in use	0.40	0.8

9.2 Minimising Possibility of Damage to Surrounding Structures

The British Standard *BS7385: Evaluation and measurement of vibration in building* is used to assess the likelihood of vibration caused by construction activities damaging nearby structures.

Peak particle velocity (PPV) refers to the movement of subsurface particles with the displacement (in mm) referring to the movement of particles at the surface. *BS7385* uses PPV to specify damage criteria across frequencies varying from 4 – 250hz (**Table 7**).

Table 7 - BS7385 Structural Vibration Criteria

Type of Structure	Peak Component Particle Velocity (mm/s)		
	4 – 15Hz	15 – 40Hz	>40Hz
Reinforced or framed structures, industrial and heavy commercial buildings	50	50	50
Un-reinforced or light framed structures, residential or light commercial buildings	15 - 20	20 - 50	50

The German standard *DIN 4150: Structural Vibration in Buildings - Effects on Structures* provides recommendations for maximum vibration levels that reduce the likelihood of surrounding buildings experiencing structural damage caused by vibration.

These "safe limits" are degrees up to which no structural damage caused by vibration has been observed. Under *DIN4150* damage is considered to include minor, non-structural effects such as superficial cracking in cement render, the enlargement of pre-existing cracks and the separation of partitions or intermediate walls from load bearing structures. *DIN 4150* also explains that, even if these safe levels are exceeded, it does not necessarily follow that damage will occur. Safe levels are demonstrated in **Table 8** below:

Table 8 – DIN 4150-3 Structural Vibration Criteria

Category	Type of Structure	Peak Component Particle Velocity (mm/s)		
		<10Hz	10 – 50Hz	>50Hz
1	Commercial or industrial buildings and buildings of similar design	20	20 - 40	40 - 50
2	Residential structures and buildings of similar design	5	5 - 15	15 - 20
3	Structures that, due to their particular sensitivity to vibration, do not correspond to either of the above categories (e.g. heritage structures)	3	3 - 8	8 - 10

10. CONTROLS, MONITORING AND REACTIVE MANAGEMENT STRATEGIES

Responsibility for implementation, management and response belongs to Lendlease Building and the relevant sub-contractors.

10.1 Work Practices

Site specific work practices (controls), monitoring, reporting and performance measurements have been identified in this NVMP to minimise and where possible, prevent noise and vibration resulting from construction impacting the environment or the community. These feasible and reasonable work practices have been identified using the first two steps of the three-step approach to selecting work practices to minimise construction noise outlined in the ICNG. The steps include:

Step 1: Identify work practices likely to be major contributors to noise. (Refer to **Section 6** and **Section 8.3**)

Step 2: Select the applicable universal work practices, as well as the selected feasible and reasonable work practices. (Refer to **Table 10**)

All feasible and reasonable noise mitigation measures will be implemented and any activities that exceed the construction noise management levels will be managed in accordance with "Mitigation Measures" described in **Table 10** – Mitigation on the following page.

10.2 Monitoring & Reporting

Noise and vibration monitoring is comprised of two components – long-term and short-term monitoring. In short-term monitoring real-time assistance and guidance is delivered to the contractor to inform them where noise management levels or vibration criteria have been exceeded so that a new method or tool can be selected to minimise impacts. Long-term monitoring utilises noise loggers and vibration sensors to provide real-time alerts to the builder and site manager with remote sensing to inform them when criteria are exceeded.

The type and frequency of noise and vibration monitoring will be undertaken in accordance with **Table 9** below. The vibration sensors will be located as close as practical to the most sensitive hospital equipment adjacent to the works (e.g., Oncology Bunker and Animal Research Lab). This will provide the project team with the most conservative vibration data for the works to assist in protecting the vibration sensitive equipment.

Subject to construction requirements and consultation with Liverpool Hospital, the noise and vibration monitoring during the various stages of works will include:

Stage 1

- Demolition
  - Three (3) Noise Loggers - One (1) within the Oncology Bunker, one (1) within the Ingham Research Institute (Animal Research Lab) or alternatively in the Clinical Services Building (CSB), and one (1) located near an adjacent resident.
  - Two (2) Vibration Loggers - One (1) at the Oncology Bunker, and one (1) at the Ingham Research Institute (Animal Research Lab).
  - Attended Noise Monitoring - As required (e.g., identified potential intrusive noise generating activities or due to noise complaints).
- Piling
  - Three (3) Noise Loggers - One (1) at the Oncology Bunker, one (1) at the Ingham Research Institute (Animal Research Lab) or alternatively in the CSB, and one (1) located near an adjacent resident.
  - Two (2) Vibration Loggers - One (1) at the Oncology Bunker, and one (1) at the Ingham Research Institute (Animal Research Lab).
  - Attended Noise Monitoring - As required (e.g., identified potential intrusive noise generating activities or due to noise complaints)
- Remainder of Stage 1 works
  - Noise Loggers or Attended Monitoring - As required pending outcome of results determined during Demolition and Piling (e.g., identified potential intrusive noise generating activities or due to noise complaints)
  - Vibration Loggers – As required pending outcome of results determined during Demolition and Piling (e.g., identified potential vibration generating activities or due to vibration complaints)

Stage 2

- Demolition

- Three (3) Noise Loggers - One (1) at the Oncology Bunker, one (1) at the Ingham Research Institute (Animal Research Lab), and one (1) located near an adjacent resident.
- Three (3) Vibration Loggers - One (1) at the Oncology Bunker, one (1) at the Ingham Research Institute (Animal Research Lab), and 1 within the (newly constructed) ISB Building
- Attended Noise Monitoring - As required (e.g., identified potential intrusive noise generating activities or due to noise complaints)

o Piling

- Three (3) Noise Loggers - One (1) at the Oncology Bunker, one (1) at the Ingham Research Institute (Animal Research Lab), and one (1) located near an adjacent resident.
- Three (3) Vibration Loggers - One (1) at the Oncology Bunker, one (1) at the Ingham Research Institute (Animal Research Lab), and 1 within the (newly constructed) ISB Building
- Attended Noise Monitoring - As required (e.g., identified potential intrusive noise generating activities or due to noise complaints)

o Remainder of Stage 2 works

- Noise Loggers or Attended Monitoring - As required pending outcome of results determined during Demolition and Piling (e.g., identified potential intrusive noise generating activities or due to noise complaints)
- Vibration Loggers – As required (e.g., identified potential vibration generating activities or due to vibration complaints)

<u>Stage 3</u>

o Refurbishment works (Oncology Bunker, Caroline Chisholm, and CSB including ED)

- Noise Loggers or Attended Monitoring - As required pending outcome of results determined during Demolition and Piling (e.g., identified potential intrusive noise generating activities adjacent to sensitive internal hospital receivers, or due to noise complaints). Identified sensitive internal hospital receivers to be determined in consultation with Liverpool Hospital Representative.
- Vibration Loggers – As required (e.g., identified potential vibration generating activities adjacent to vibration sensitive hospital equipment, or due to vibration complaints). Identified sensitive hospital equipment to be determined in consultation with Liverpool Hospital Representative.

o Remainder of Stage 3 works

- Noise Loggers or Attended Monitoring - As required (e.g., identified potential intrusive noise generating activities or due to noise complaints Identified sensitive internal hospital receivers to be determined in consultation with Liverpool Hospital Representative.
- Vibration Loggers - As required (e.g., identified potential vibration generating activities adjacent to vibration sensitive hospital equipment, or due to vibration complaints). Identified sensitive hospital equipment to be determined in consultation with Liverpool Hospital Representative.

Table 9 – Summary of Noise & Vibration Monitoring & Reporting

Detail	Frequency	Standards	Reporting	Responsibility
Continuous unattended noise monitoring	Real-time monitoring. Continuous noise monitoring is to be reviewed periodically. Once consistent readings below the applicable criteria is achieved, continuous monitoring may be ceased while the same activity is taking place. Once a new phase of work begins, monitoring is to recommence. Indicative locations shown in **Appendix A** Note: Locations are indicative and subject to change throughout the project based on work areas, construction requirements and approval from stakeholders.	ICNG NMLs in **Table 4**.	Monthly report	Nominated Subcontractor EHS Coordinator Noise & Vibration Specialist
Attended noise monitoring	As required. in response to complaints. to differentiate between construction noise sources and other sources (e.g. road traffic or hospital operations). As needed during site establishment. Locations will vary depending on the works.	ICNG NMLs in **Table 4**.	Included in monthly report	Nominated Subcontractor EHS Coordinator Noise & Vibration Specialist
Continuous unattended vibration monitoring	Real-time monitoring. Continuous vibration monitoring is to be reviewed periodically. Once consistent readings below the applicable criteria is achieved, continuous monitoring may be ceased while the same activity is taking place. Once a new phase of work begins, monitoring is to recommence. Indicative locations shown in **Appendix A** Note: Locations are indicative and subject to change throughout the project based on work areas, construction requirements and approval from stakeholders.	EPA guidelines BS6472 DIN4150 Part 3 **Section 9**	Monthly report	Nominated Subcontractor EHS Coordinator Noise & Vibration Specialist

Table 10 – Controls, Monitoring and Reactive Management

Ref.	Mitigation Measure	Relevant Works				Responsibility	Monitoring and Reporting	Targets	Reactive Management Strategy
		Stage 1/2			Stage 3				
		Site Set-up	Demolition	Civil/Piling	Structure Fit-out				
N1.	Unattended noise monitoring with provision for alarms.		✓	✓	✓	Site Manager, Sub-contractors	See **Table 9** above.	See **Table 4** above.	See **Table 3** above.
N2.	Attended noise monitoring as required, in response to noise complaints or to verify noise output from plant and equipment.	✓	✓	✓	✓	Site Manager, Sub-contractors	See **Table 9** above.	See **Table 4** above.	See **Table 3** above.
N3.	Operate in accordance with the approved hours of work.	✓	✓	✓	✓	Site Manager, Sub-contractors	Daily surveillance. Weekly/monthly inspection checklist.	Operate in accordance with the approved hours of work.	Review work hours
N4.	Work outside current approve hours to be approved in accordance with the Out of Hours Works Protocol	✓	✓	✓	✓	Site Manager, Sub-contractors	Daily surveillance. Weekly/monthly inspection checklist.	Operate in accordance with the approved hours of work.	Review work hours
N5.	Provide respite periods between high noise activities.		✓			Site Manager, Sub-contractors	Daily surveillance. Weekly/monthly inspection checklist.	As per SSDA and EPA requirements, and to be agreed with the south-western Sydney Local Health District.	Review work practices, identify and implement additional reasonable and feasible noise controls.
N6.	Provide respite during bored piling. The respite will be based around shift breaks and movement of rigs. This will generally include two (2) thirty-minute breaks, and limited breaks between rig movements.			✓		Site Manager, Sub-contractors	Daily surveillance. Weekly/monthly inspection checklist	As per SSDA and EPA requirements, and to be agreed with the south-western Sydney	Review work practices, identify and implement additional reasonable and feasible noise controls.

Ref.	Mitigation Measure	Relevant Works				Responsibility	Monitoring and Reporting	Targets	Reactive Management Strategy
		Stage 1/2			Stage 3				
		Site Set-up	Demolition	Civil/Piling	Structure Fit-out				
								Local Health District.	
N7.	Reduce the volume of incoming deliveries by amalgamating loads when possible and facilitate efficient deliveries by organising parking within designated areas located away from sensitive receptors.	✓	✓	✓	✓	Site Manager, Sub-contractors	Daily surveillance.	No complaints about off-site trucks parking.	Reviewing logistics to site and implement controls as identified.
N8.	Utilise appropriate traffic management procedures to minimise the amount of congestion on site.		✓	✓		Site Manager, Sub-contractors	Daily surveillance.	Limited duration of on-site congestion.	Reviewing logistics to site and implement controls as identified.
N9.	Regularly maintain equipment, plant and machinery to minimise noise and vibrations that may be produced by damaged or faulty machinery.		✓	✓		Site Manager, Sub-contractors	Plant & Equipment Register	All plant and equipment to be managed through the plant and equipment register process.	Put all plant and equipment through the register process or remove from site
N10.	Turn engines off while parked or waiting to enter the site.		✓	✓		Site Manager, Sub-contractors	Daily surveillance – Site Diary Entries Weekly/monthly inspection checklist	Limited engine idling Complaints related to idling	Toolbox talk drivers regarding requirement
N11.	Use mains power where available and suitable.		✓	✓	✓	Site Manager, Sub-contractors	Daily surveillance – Site Diary Entries Weekly/monthly inspection checklist	Noise complaints related to generator use.	Convert generator to mains power or limit operation of the generator (where practical)

Ref.	Mitigation Measure	Relevant Works				Responsibility	Monitoring and Reporting	Targets	Reactive Management Strategy
		Stage 1/2			Stage 3				
		Site Set-up	Demolition	Civil/Piling	Structure Fit-out				
N12.	Employ quieter techniques for high noise activities such as piling, rock breaking, concrete sawing and using power or pneumatic tools.		✓	✓		Sub-contractors Site Supervisor EHS Manager/Coordinator	Daily surveillance – Site Diary Entries Weekly/monthly inspection checklist	No noise related complaints.	Review work practices, identify and implement additional reasonable and feasible noise controls.
N13.	Where practicable and without compromising the safety of construction staff or members of the public, non-tonal reversing beepers ('quackers') are to be used on plant and equipment to ensure noise impacts on surrounding noise sensitive receivers are minimised	✓	✓	✓	✓	Sub-contractors Site Supervisor EHS Manager/Coordinator	Plant & Equipment Register Daily surveillance – Site Diary Entries Weekly/monthly inspection checklist	All plant with quackers fitted.	Without compromising safety, change the reversing alarm to a quacker type.
N14.	Employ quieter plant and equipment when appropriate to quickly and efficiently complete required tasks.		✓	✓	✓	Sub-contractors Site Supervisor EHS Manager/Coordinator	Daily surveillance – Site Diary Entries Weekly/monthly inspection checklist	Noise complaints related to plant and equipment.	Identify noisy plant and equipment in use and replace with quieter alternative (where practical).
N15.	Install noise barriers to reduce or mitigate site noise. These can either be permanent fixtures (installed early on) or temporary (such as using temporary stockpiles or building materials to act as additional acoustic treatment).	✓	✓	✓		Sub-contractors Site Supervisor EHS Manager/Coordinator	Daily surveillance – Site Diary Entries Weekly/monthly inspection checklist	Noise barriers in place.	Install noise barriers as required.
N16.	Remain in contact with neighbouring receptors, project staff and the community both before and during construction.	✓	✓	✓	✓	Sub-contractors Site Supervisor	Daily surveillance – Site Diary Entries	No noise related complaints.	See **Table 11** below.

Ref.	Mitigation Measure	Relevant Works				Responsibility	Monitoring and Reporting	Targets	Reactive Management Strategy
		Stage 1/2			Stage 3				
		Site Set-up	Demolition	Civil/Piling	Structure Fit-out				
						EHS Manager/Coordinator	Weekly/monthly inspection checklist		
N17.	Acknowledge noise complaints and act to address them quickly.	✓	✓	✓	✓	Sub-contractors Site Supervisor EHS Manager/Coordinator Stakeholder Engagement Manager	24/7 Contact phone number. Consultation Manager	No noise related complaints.	See **Table 11** below
N17.	Installation of secondary glazing to the external façade of the Alex Grimson building to minimise noise transmission.		✓	✓		Site Manager, Sub-contractors	Work as constructed drawings	Installed prior to demolition	Ensure additional glazing installed.
V1.	Unattended vibration monitoring with provision for alarms.		✓	✓		Site Manager, Sub-contractors	See **Table 9**.	No exceedances of the vibration criteria.	Review vibration generating activities and implement additional controls as practical.
V2.	Vibratory compactors must not be used closer than 30 metres from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified in section 9.2		✓	✓		Site Manager, Sub-contractors	Unattended vibration monitoring and reporting	No exceedances of the vibration criteria.	Review vibration generating activities and implement additional controls as practical.
V3.	Any activities involving vibrating rollers will be performed in accordance with the safe operating distances outlined in **Appendix D.**		✓	✓		Site Manager, Sub-contractors	Unattended vibration monitoring and reporting	No exceedances of the vibration criteria.	Review vibration generating activities and

Ref.	Mitigation Measure	Relevant Works				Responsibility	Monitoring and Reporting	Targets	Reactive Management Strategy
		Stage 1/2			Stage 3				
		Site Set-up	Demolition	Civil/Piling	Structure Fit-out				
									implement additional controls as practical.
V4.	Acknowledge vibration complaints and act to address them quickly.	✓	✓	✓	✓	Sub-contractors Site Supervisor EHS Manager/Coordinator Stakeholder Engagement Manager	24/7 Contact phone number. Consultation Manager	No vibration related complaints.	See **Section 11.2** below

11. COMMUNITY CONSULTATION

The Liverpool Health and Academic Precinct (LHAP) redevelopment team has undertaken extensive consultation with potentially impacted stakeholders, including Liverpool Hospital staff, adjacent health providers and the local community. In addition to the original Planning Approval community consultation phase, LHAP have also provided project specific Information Sheets that outline the upcoming works and the associated environmental management. These Information Sheets were provided via newsletters and notices that were emailed, uploaded to the public project website, and also dropped in letter boxes to the adjacent community. The contact details of the project team were included in each notice, including phone number and email address to raise any concerns or questions.

Further to the LHAP communication, Lendlease Building have undertaken discussions with the Liverpool Hospital, adjacent health providers, and research centres to ensure noise and vibration concerns have been adequately addressed.

The outcomes of the consultation processes have been incorporated into the management and monitoring measures detailed in this Plan.

Consultation with potentially impacted stakeholders will continue throughout the project as part of the project team's ongoing programme of engagement. Stakeholder engagement and consultation for the project will be managed in accordance with the Lendlease LHAP Community and Stakeholder Engagement Strategy.

In accordance with Condition C1(d), a site notice will be displayed at the boundary of the site and will include a 24-hour contact phone number for any inquiries, including construction/noise complaints.

11.1 NML Exceedance & Noise Complaint Response

NML exceedances and noise related complaints will be managed in accordance with **Table 11** below.

Table 11 – NML & Noise Complaint Response

Scenario	Mitigation measures & Actions LAeq(15 minute) noise level above relevant NML	
	1 to 10 dBA (noticeable)	> 10 dBA (clearly audible, potentially intrusive)
Approved hours **No complaints received**	o No additional action.	o LL &/or SC to review noise data and current work practices. o LL &/or SC to identify and implement reasonable and feasible measures.
Approved hours **Complaint(s) received**	o Respond to complainant. o Undertake attended noise monitoring (if required) to verify the noise source. o LL &/or SC to identify and implement reasonable and feasible measures. o Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.	o Respond to complainant. o Undertake attended noise monitoring (if required) to verify the noise source. o LL &/or SC to identify and implement reasonable and feasible measures. o Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.

Scenario	Mitigation measures & Actions LAeq(15 minute) noise level above relevant NML	
	1 to 10 dBA (noticeable)	> 10 dBA (clearly audible, potentially intrusive)
Approved high noise generating activities **During approved hours** **No complaints received**	o Continue works.	o LL &/or SC to review noise data and current work practices. o LL &/or SC to identify and implement reasonable and feasible measures.
Approved high noise generating activities **During approved hours** **Complaint(s) received**	o Respond to complainant. o Undertake attended noise monitoring (if required) to verify the noise source. o LL &/or SC to identify and implement reasonable and feasible measures. o Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.	o Respond to complainant. o Undertake attended noise monitoring (if required) to verify the noise source. o LL &/or SC to identify and implement reasonable and feasible measures. o Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.
Approved out of normal hours activities **No complaints received**	o Letter box drops prior to works. o Inform relevant stakeholders/authorities prior to works.	o Letter box drops prior to works. o Inform relevant stakeholders/authorities prior to works. o LL &/or SC to review noise data and current work practices.
Approved out of normal hours activities **Complaint(s) received**	o Letter box drops prior to works. o Inform relevant stakeholders/authorities prior to works. o Respond to complainant. o Undertake attended noise monitoring (if required) to verify the noise source. o LL &/or SC to identify and implement reasonable and feasible measures. o Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.	o Letter box drops prior to works. o Inform relevant stakeholders/authorities prior to works. o Respond to complainant. o Undertake attended noise monitoring (if required) to verify the noise source. o LL &/or SC to identify and implement reasonable and feasible measures. o Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.

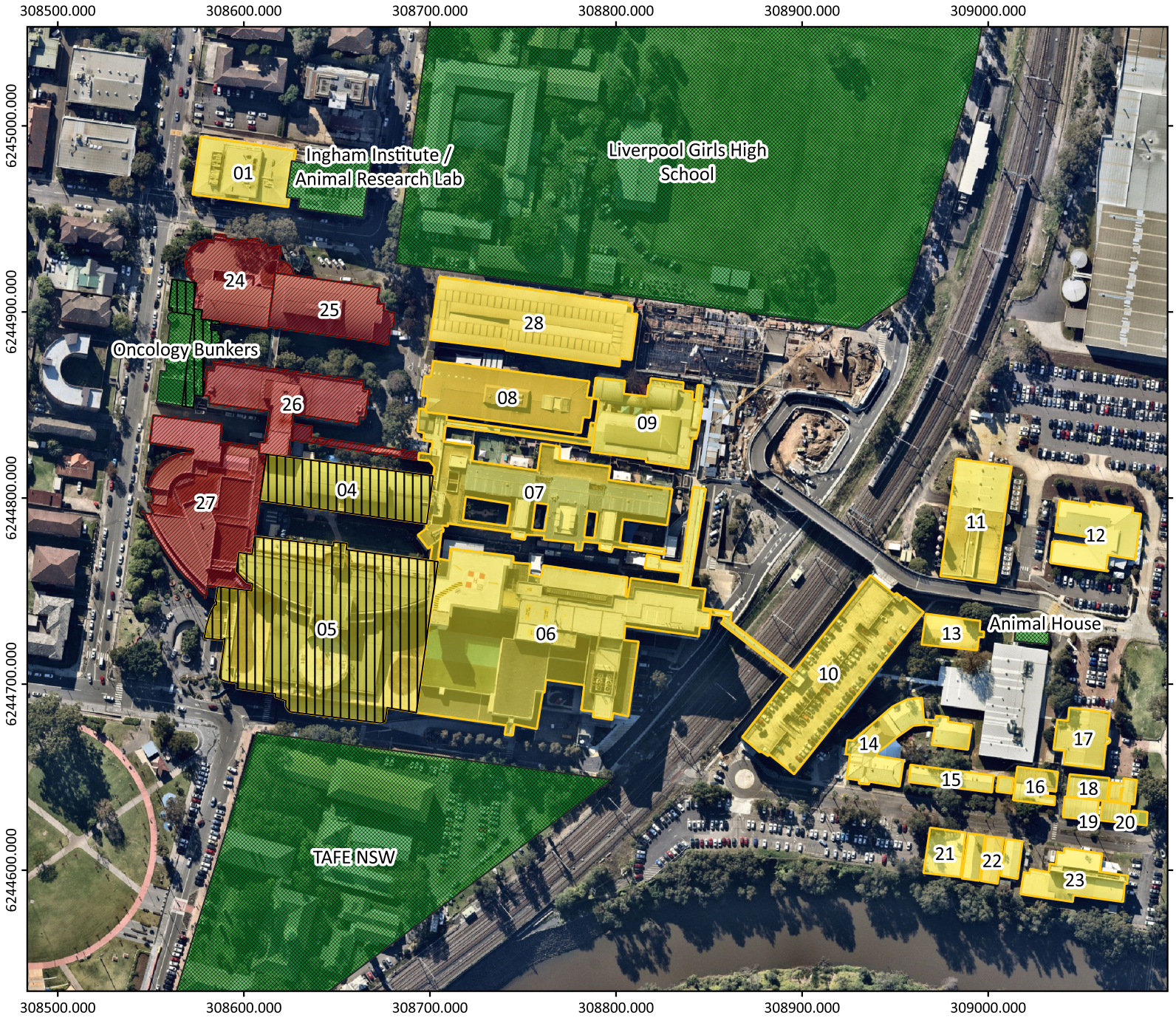
11.2 Vibration Complaint Response

Vibration related complaints will be managed on a case-by-case basis. The general response will include:

- Inform relevant stakeholders/authorities prior to works.
- Respond to complainant.
- Undertake additional vibration monitoring (if required) to verify the vibration source.

- LL &/or SC to identify and implement reasonable and feasible measures to minimise vibration.
- Consultation Manager entry capturing relevant complainant data and additional reasonable and feasible measures identified and implemented.

APPENDIX A FIGURES



PROPERTY RISK AUSTRALIA

Project Location:	**Elizabeth &, Goulburn St, Liverpool NSW 2170**
Figure Number:	**01**
Title:	**Liverpool Hospital**
Project ID:	**PRJ000719_Liverpool_Hospital**
Client Name:	**Lendlease**
Map Scale:	1:3,000
CRS:	GDA2020 / MGA zone 56
Source:	Source: Nearmaps 19/05/2021

Prepared:	Reviewed:	Date:
EW	WD	30/06/2021

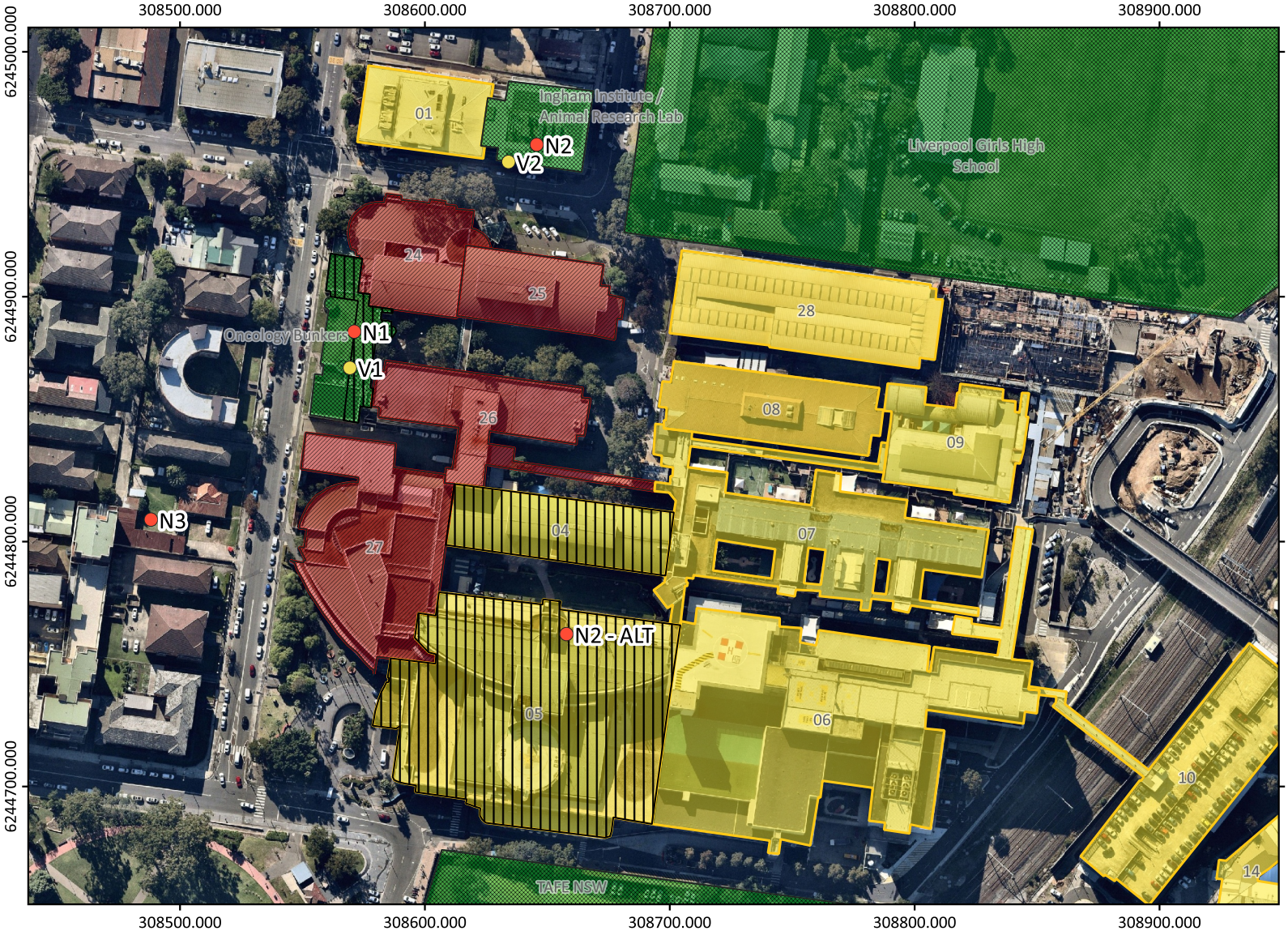
Legend

Area Type

- Scheduled for Demolition
- Hospital Structure
- Sensitive Receptor

N

0 70 140 m



PROPERTY RISK AUSTRALIA

Project Location:	**Elizabeth &, Goulburn St, Liverpool NSW 2170**
Figure Number:	**02**
Title:	**Liverpool Hospital**
Project ID:	**PRJ000719_Liverpool_Hospital**
Client Name:	**Lendlease**
Map Scale:	1:2,500
CRS:	GDA2020 / MGA zone 56
Description:	Potential environmental monitor locations at Liverpool Hospital.
Source:	Source: Nearmaps 19/05/2021

Prepared:	Reviewed:	Date:
EW	WD	09/07/2021

N

0 60 120 m

Legend

Area Type

- Scheduled for Demolition
- Hospital Structure
- Sensitive Receptor
- Critical Infection Control Zones

Indicative Environmental Monitors

- Ground Vibration Monitor
- Noise Logger

Note

Nominally vibration monitors will be placed at the lowest point on site (e.g. basements). The locations indicated for both noise and vibration monitors are subject to change depending on site conditions and direction from the Liverpool Hospital Representative.

APPENDIX B GLOSSARY OF ACOUSTIC TERMS

GLOSSARY OF ACOUSTIC TERMS

Majority of environments are subject to environmental noise that varies throughout the day – predominately as a function of traffic. To accommodate for this a variety of different sampling methods have been developed to describe the general noise environment, typically taken within a 15- minute period these include:

Maximum Noise Level (L_{Amax}) - This describes the maximum noise level reached over a given sample period over a fast response time.

L_{A1} - The L_{A1} is defined as the noise level that is exceeded for 1% of the sample period duration. Across the sampling period this level will only be reached 1% of the time.

L_{A10}: - The L_{A10} describes the noise level that is exceeded across 10% of the sample period duration. It is typically used as a descriptor for both environmental and traffic noise. It is reached across 10% of the total sampling period.

L_{A50}: - The L_{A50} describes the noise level that is exceeded across 50% of the sample period.

L_{A90}: - The L_{A90} describes the noise level that is exceeded across 90% of the sample period duration. This is colloquially referred to as the regions background noise level and is achieved for 90% of the sampling period.

L_{Aeq}: - The L_{Aeq} or equivalent continuous sound level describes the average energy of noise that is elicited across the sampling period and is equivalent to the level of persistent noise present in the environment across the sampling period. It is a common measure to describe environmental, road and traffic noise.

ABL - The Assessment Background Level encapsulates variations in background noise (L_{A90}) across the assessment period (typically daytime, evening and night-time) and is determined by calculating the lowest 10^{th} percentile (L_{A90}) across each period.

RBL – The Rating Background Level for each period is the median value of ABLs gathered across the sampling period (daytime, evening and night-time).

SWL – Sound Power Level (SWL) describes the amount of acoustic energy being released every second by an audio source. It is generally expressed in decibels (dB), relative to a reference of $1x10^{-12}W$.

APPENDIX C TYPICAL CONSTRUCTION EQUIPMENT NOISE LEVELS

CONSTRUCTION EQUIPMENT NOISE LEVELS

The following table details plant likely to be used throughout the works.

Table 11 – *Typical Construction Equipment Sound Power Levels*

Plant Type	Sound Power Level (dBA)
Bulldozer	114
Excavator	108
Rotary Hoe	109
Mobile Crane	104
Concrete Truck	109
Angle Grinder	109
Concrete Pump – 120 mm diameter / 50 bar	112
Concrete Saw	116
Crawler Cranes	98
Mobile Crane	98
Rotary Boring Drill Rig	107
Site Cranes	104
Dump Truck	108
Front End Loader	112
Excavator	107
Hammer Hydraulic	122
Auger Vibro Pile	110
Bored Pile Rig	112
Piling – Vibrating	108
Concrete Saw	113
Compressor	100
Bobcat	103
Hand Tools	90
Jackhammer	105

APPENDIX D VIBRATION PRODUCING PLANT DISTANCE REQUIREMENTS

CONSTRUCTION VIBRATION PRODUCTION

The following table details the required distance between vibration producing plant to prevent damage to buildings (A) and to maintain the volume of complaints to an acceptably low level (B). It should be noted that for complaints to stop completely further distance between source and residents is required.

Table 6 – *Plant Vibration Guidelines*

Roller Class	Weight Range (t)	Centrifugal Force (kN)	Distance from Buildings (m)	
			A	B
Very Light	< 1.25 tonnes	10 - 20kN	3m	-
Light	1 – 2 tonnes	20 - 50kN	5m	-
Medium	2 - 4 tonnes	50 - 100kN	6m	12m
Medium-Heavy	4 - 6 tonnes	100 - 200kN	12m	24m
Heavy	7 - 11 tonnes	200-300kN	15m	50m
Very Heavy	> 12 tonnes	>300kN	25m	50m

A – Prevent structural damage to nearby buildings. **B** – Reduced likelihood of vibration related complaints.