Liverpool Civic Place - Early Works DA Submission

Construction Noise & Vibration Management Plan

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Date: 16 Sep 2020

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Ref: 43144-1

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Revision

Revision	Date	Comment	Prepared By	Approved By
001	22/11/19	For Review	Nicolas Ramirez-Guevara	Brandon Notaras
002	29/11/19	For Development Application	Nicolas Ramirez-Guevara	Brandon Notaras
003	8/04/2020	Revised for Council Comments	Brandon Notaras	Brandon Notaras
004	16/09/2020	Revised for S4.55	Brandon Notaras	Brandon Notaras

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Contents

1. Introduction

This Construction Noise and Vibration Management Plan has been updated for Liverpool City Council (Council) in support of a Section 4.55(1A) Modification Application to Development Consent DA-906/2019 for site preparation and early works at 52 Scott Street, Liverpool (the site) also known as Liverpool Civic Place.

Development Application DA-906/2019 was approved by the Sydney Western City Planning Panel on 29 June 2020. The development consent relates to demolition of all structures, select tree removal and bulk earthworks including shoring through the use of piles.

The original DA relates to the broader Liverpool Civic Place site redevelopment plan which is detailed within the Concept DA (DA/485/2019) submitted to Council on 17 September 2019. Specifically, the Concept Proposal seeks approval for various uses within proposed building envelopes, including:

- A building envelope with a maximum height of RL 43.45 for the purpose of an information and education facility (public library) use.
- A building envelope with a maximum height of RL 84.25 for the purpose of a public administration building use, and either (or a combination of) commercial premises or child-care centre uses.
- A building envelope with a maximum height of RL 118.85 which will accommodate either (or a combination of) commercial premises, educational establishments, tourist and visitor accommodation or boarding house (student accommodation) uses.
- A landscaping and public domain concept including the provision of a public through-site link running north to south through the site, connecting Scott Street to the north through to Terminus Street to the south; and

A building envelope for a three-level shared basement car park across the entire site to accommodate parking for all future uses (approximately 413 spaces, to be determined as part of future detailed DAs) and accommodating a public car park to be owned by Council.

Following determination of DA-906/2019, development partners Built Development Group and Liverpool City Council recognised there was additional demand for public car parking within Liverpool Civic Place project. In addition, the original excavation works did not consider excavation to accommodate future pad footings. As such, this has necessitated a Section 4.55(1A) Modification Application to seek consent for deeper excavation and associated structure to accommodate an additional half level of basement.

The Modification Application also seeks consent for a minor extension of the demolition works to existing planters and ramps on the adjoining lot to the west (Lot 201 in DP 1224084 also owned by Liverpool City Council).

The detailed design including the basement of the Liverpool Civic Place will be subject of separate Stage 2 DA(s). The benefits of this approach would allow the expedited local assessment and determination of an application for these additional ‘early works’, which are key to ensuring the development can be delivered in a timely manner.

Figure 1: Indicative Photomontage of the Concept Proposal

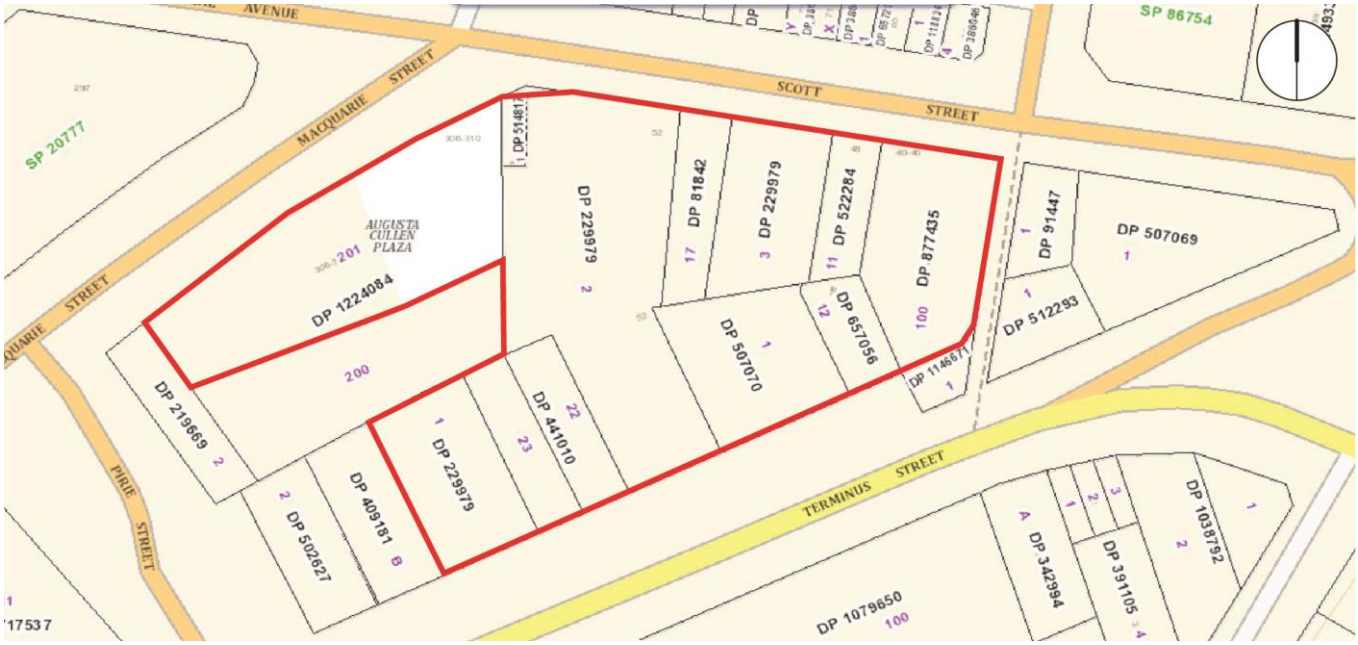


Figure 2: Site lot boundaries (site outlined red)

Source: Six Maps and Ethos Urban

Figure 3: Site aerial

Source: Nearmap and Ethos Urban

The early works as described below is expected to occur across approximately 10 months of work. The works are to be split into two periods which are:

- Demolition (3 months)
  - Existing office building demolition
  - Hardstand demolition
- Excavation and Shoring (7 months)
  - Bulk excavation
  - Piling
  - Detailed excavation

Certain tasks will be carried out concurrently with other tasks for particular time periods that are significant in duration. In a given combination of events, the noise emitted by performing the tasks simultaneously will be considered.

This Construction Noise and Vibration Management Plan provides:

- 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 work for the proposed development and its impact on nearby receivers

- Strategies to mitigate the noise and vibration generated during the construction works phases
- Complaints handling and community liaison procedures

This assessment discusses the predicted impact of the construction noise and vibration generated by the construction equipment on the nearest most-affected receivers.

This report has been prepared with the following references:

- Liverpool Development Control Plan (LDCP), 2008.
- Liverpool Local Environmental Plan (LLEP), 2008.
- 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*

The predicted noise levels are based on the proposed construction program and equipment lists provided in this report.

2. Project Description

2.1 Site Description and Noise & Vibration Sensitive Receivers

For the purposes of this construction noise and vibration management plan, the site location, measurement positions and surrounding noise and vibration sensitive receivers are shown in Figure 4.

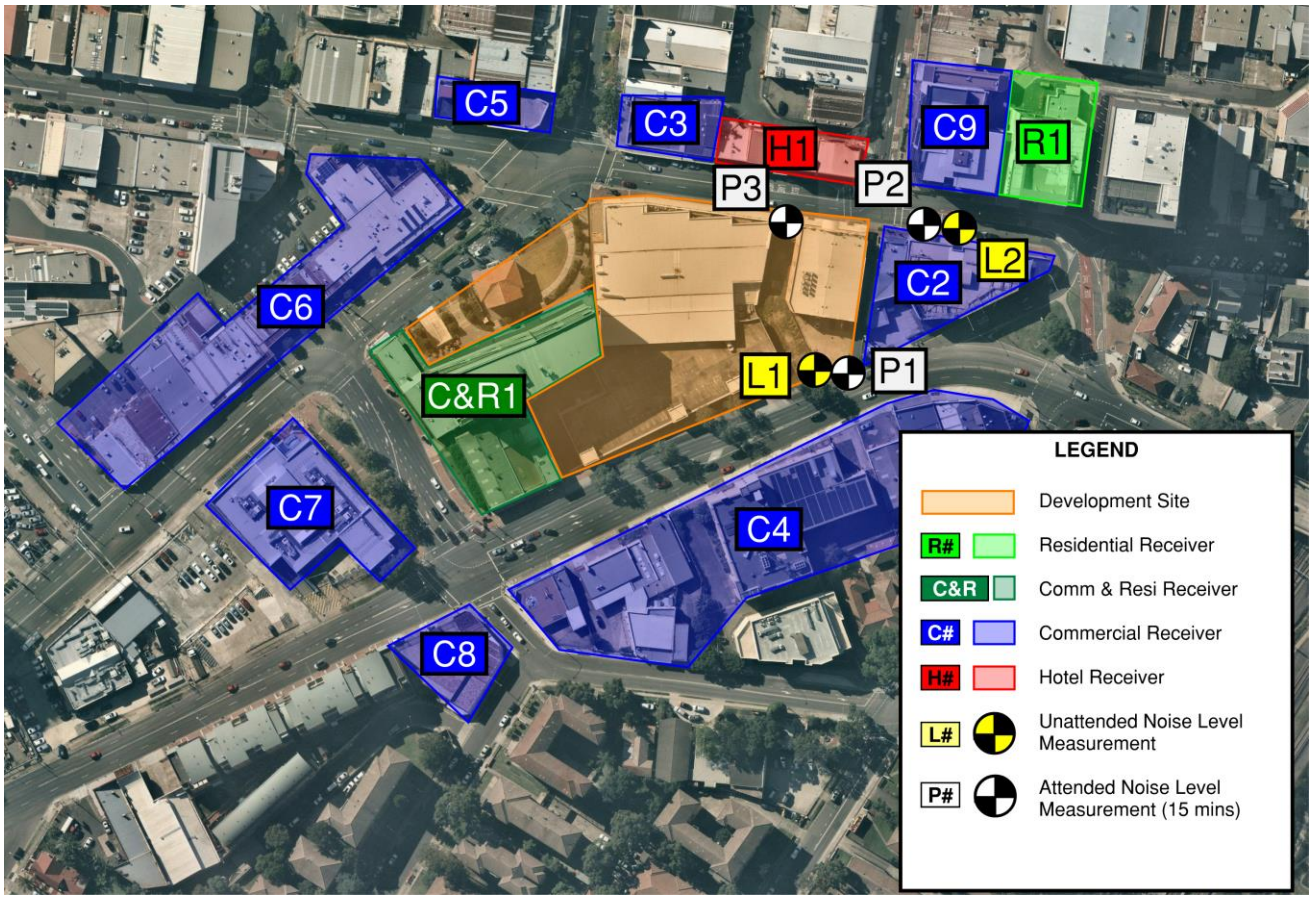


Figure 4: Overview of the site, measurement locations and surrounding sensitive receivers

2.2 Existing Noise & Vibration Environment

The existing noise environment is dominated by road traffic noise on the surrounding local roads. Typical to such an environment is for the daytime traffic volumes to increase at approximately 6:30am and to decrease at approximately 7:30pm in the evening. Additionally, the rooftop mechanical equipment on the surrounding buildings can contribute to the noise levels at higher elevations.

The existing background noise is typical of an urban area with continuous traffic flows and is within close proximity to commercial districts exuding a continuous “urban hum” as defined in the NSW Environment Protection Authority (EPA) Noise Policy for Industry, 2017 (NPI 2017). During the evening and night-time periods there is evidently a decrease in ambient noise levels due to reduced traffic volume and foot traffic around the site and within the nearing surroundings. The existing noise is assessed using three given time periods established in the NPI 2017.

3. Background and Ambient Noise Monitoring

3.1 Unattended Noise Survey

A noise monitor was placed at position L2 as shown in Figure 4 to measure the background and ambient noise that is representative of the surrounding noise and vibration sensitive receivers. Monitor L1 was installed to obtain ambient traffic noise levels (which is not relevant to this assessment), whilst monitor L2 was installed to measure the background noise for the surrounding residential receivers. Both monitors were installed from the 28th of June to the 4th of July 2019.

3.1.1 Background Noise & Traffic Noise

To ensure monitoring data obtained during adverse weather conditions does not affect the noise levels used to establish acoustic criteria, any rain-affected data during the period of logging has been excluded from the calculations. Where the amount of excluded data within a period exceeds a set limit, the whole period has been left out of the assessments.

The noise levels are relatively constant during the day and gradually decrease in the evening. The quietest period during the night typically lasts from midnight to approximately 6am. The difference between daytime and quietest night-time noise levels is approximately 10dB.

The resulting equivalent noise levels and RBL for each period have been outlined in Table 1 for both monitors L1 and L2. The noise data from monitor L2 is considered to represent the existing noise environment at the nearest receivers along Macquarie Street, and thus forms the basis for establishing the operational noise criteria at the residential receivers. Noise data from monitor L1 is considered to obtain the noise conditions from traffic movements along Terminus St. For the purposes of the construction noise assessment, the lower background noise levels at L2 have been used.

Table 1: Results of long-term background noise monitoring – L1 & L2

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$, dB(A)			Background Noise Level RBL, dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	71	72	67	59	58	48
L2	72	69	64	55	56	46

4. Acoustic Criteria

4.1 Construction Noise Criteria

The *Interim Construction Noise Guideline* (ICNG) by NSW DECC recommends the following standard hours of construction:

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

In this report, it is assumed that all works are performed during these standard hours. The noise criteria associated with construction and its related activities are shown in Table 2, extracted from Section 4.1.1 of the ICNG.

Table 2: 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 75 dB(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: - 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) - 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 3 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 3: Construction Noise Criteria for Other Land Uses

Land Use	Noise Management Level, $L_{Aeq,15min}$
Offices, retail outlets	External noise level 70 dB(A)

Based on the criteria in the tables above, the following noise management levels in Table 4 should be applied to the commercial and residential receivers when appropriate. Construction during standard hours has been assumed.

Table 4: Project Specific Construction Noise Management Levels

Land Use	Receiver	Noise Management Level, $L_{Aeq,15min}$	Highly Noise Affected Level $L_{Aeq,15min}$
Offices, retail outlets	C&R1, C2 – C9 / H1	External noise level **70 dB(A)**	75 dB(A)
Residential	C&R1	55 dB(A) + 10 dB = **65 dB(A)**	75 dB(A)

4.2 Construction Vibration Criteria

4.2.1 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 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 5 to Table 8. 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 5.

Table 5: Criteria for Exposure to Continuous and Impulsive Vibration

Place	Time	Vibration Acceleration (mm/s^2)			
		Preferred		Maximum	
Continuous Vibration		z axis	x and y axis	z axis	x and y axis
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices	Day or night time	0.020	0.014	0.040	0.028
Impulsive Vibration		z axis	x and y axis	z axis	x and y axis
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices	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 6.

Table 6: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

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

4.2.2 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 7.

Table 7: 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 8 indicates the vibration limits presented in DIN 4150-Part 3 to ensure structural damage does not occur.

Table 8: Guideline Value of Vibration Velocity (vi) for Evaluating the Effects of Short-Term Vibration – DIN 4150-Part 3

Line	Type of Structure	Vibration velocity, v_i, in mm/s			
		Foundation At a frequency of			Plane of floor of uppermost full storey
		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.					

5. Construction Noise Assessment

5.1 Proposed Construction Activities

In this assessment, the noise impact from the early construction works are considered. The proposed early construction will consist of the following stages, and is expected to occur over a period of 10 months:

- Demolition (3 months)
  - Existing office building demolition
  - Hardstand demolition
- Excavation and Shoring (7 months)
  - Bulk excavation
  - Piling
  - Detailed excavation

The hours of work are expected to occur during standard daytime hours, as follows:

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

5.2 Expected Construction Equipment

The noise sources likely to be associated with the works listed in the previous section of this report are presented in Table 9. The equipment noise levels have been extracted from AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites* and the *Construction Noise Strategy, Transport for NSW, 2013*. These equipment noise levels are provided as sound power levels (in-line with the documents referenced above) and are the estimated sound power emitted by the equipment, which differs to the sound pressure level rated for equipment at a particular distance.

Table 9: Construction Equipment Noise Levels

Stages	Equipment	Sound Power Level dB(A)
Demolition	Excavator 100t (shear)	117
	Excavator 40t (rock breaker)	115
	Excavator 18t (pulveriser)	105
	Bobcat	106
	Cherry Picker	105
	Dump Truck	117
	Jack Hammer	113

Stages	Equipment	Sound Power Level dB(A)
Excavation	Piling Rig	112
	Excavator 20t (saw, rock breaker)	105
	Excavator 48t	115
	Excavator 30t	110
	Dump Truck	117
	Jack Hammer	113

5.3 Noise Modelling & Assumptions

In order to assess the noise impact from the site during the various construction stages, a noise model was prepared using commercial software SoundPLAN v8.1, which is a comprehensive software package for conducting three-dimensional complex noise propagation modelling. Using the software, a 3D model of the site and its surroundings was constructed including the nearby buildings, and the construction plant and equipment were positioned as noise sources. Within the model, the effects of the environment (built and natural) on propagation of sound were considered to reliably estimate the resulting noise effects on the surrounding noise sensitive receivers.

The noise model represents the 'reasonable' worst case periods of construction activities, meaning that all the equipment of each stage is operating simultaneously during a 15-minute observation period.

The assumptions that were made within the assessment include the following:

- The predicted noise levels represent the worst-case scenario for each receiver, i.e. receiver R1 is most affected by works on the north-eastern boundary, C&R1 is most affected by works along the western site boundary
- The predicted noise levels at the receivers has been assessed at a height of 1.5m above ground level in accordance with the assessment procedures of the ICNG.
- The predicted noise levels at the nearby sensitive receivers have been assessed with the noise mitigation measures provided in Section 7.1 have been implemented.
- The noise levels have been assessed using neutral weather conditions

The noise levels at the surrounding sensitive receivers have been based on the assumptions and aforementioned sound power levels of the equipment provided in Table 9. The results of the predicted noise levels are presented in the following section.

5.4 Predicted Noise Levels

The predicted noise levels during the demolition and excavation phases for each receiver location have been presented in Table 10 and Table 11 respectively. The noise contour maps produced by the three-dimensional noise propagation modelling are provided in Appendix B.

Table 10: Predicted Noise Levels - Demolition

Demolition Phase					
ID	Receiver	Predicted Noise Level Range, Minimum - Maximum $L_{eq,15min}$ dB(A)	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level?
R1	Residential	51 – 70	65	0 – 5	No
C&R1	Commercial & Residential	75 – 84	65	10 – 19	Yes (See Note 1)
C2	Commercial	72 – 81	70	2 – 11	Yes (See Note 1)
C3	Commercial	71 – 79	70	1 – 9	Yes (See Note 1)
C4	Commercial	67 – 71	70	0 – 1	No
C5	Commercial	59 – 73	70	0 – 3	No
C6	Commercial	59 – 73	70	0 – 3	No
C7	Commercial	51 – 55	70	0	No
C8	Commercial	51 – 64	70	0	No
C9	Commercial	63 – 73	70	0 – 3	No
H1	Commercial	68 – 79	70	0 – 9	Yes (See Note 1)

Table 11: Predicted Noise Levels - Excavation

Excavation Phase					
ID	Receiver	Predicted Noise Level Range, Minimum - Maximum $L_{eq,15min}$ dB(A)	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level?
R1	Residential	53 – 70	65	5	No
C&R1	Commercial & Residential	76 – 84	65	11 – 19	Yes (See Note 1)
C2	Commercial	71 – 80	70	10	Yes (See Note 1)
C3	Commercial	67 – 79	70	9	Yes (See Note 1)
C4	Commercial	68 – 71	70	1	No
C5	Commercial	54 – 73	70	3	No
C6	Commercial	54 – 73	70	3	No
C7	Commercial	50 – 56	70	0	No
C8	Commercial	51 – 62	70	0	No
C9	Commercial	62 – 72	70	2	No
H1	Commercial	68 – 75	70	5	No

Note 1: There will be periods of time where the noise levels generated by construction works exceed the highly noise affected level. In these instances, the early works contractor is to implement the noise mitigation measures provided in Section 7 of this report, together with any other reasonable and feasible measures in order to reduce any potential adverse noise impact.

6. Construction Vibration Assessment

The vibration intensive plant that are assumed to be used in each of the construction stages are:

- Piling Rig
- Jack Hammer
- Excavator 40t (rock breaker)
- Excavator 20t (saw, rock breaker)

The Transport for NSW's *Construction Noise Strategy* (2013) provides safe working distances for vibration intensive plant and are quoted for both "cosmetic" damage (in accordance with BS 7385) and human comfort (in accordance with *Assessing Vibration – a technical guideline*). The recommended safe working distances for each of the plant listed above are provided in Table 12.

Table 12: Recommended safe working distances for vibration intensive plant

Plant Item	Safe Working Distance (metres)	
	Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Piling Rig	2m (nominal)	N/A
Jackhammer	1m (nominal)	Avoid contact with structure
Excavator 20t (saw, rock breaker)	22m	73m
Excavator 40t (rock breaker)	22m	73m

The nearest vibration sensitive receiver is the heritage commercial premises to the East of the site (partial C2). Similarly, the closes residential receiver is located along Scott Street at approximately 50m from the site boundary. As such, attended vibration monitoring shall be conducted at the commencement of work in order to verify the safe working distances. If the levels are compliant with the vibration limits as listed in Section 4.2, then work may proceed based on the implementation of the measures detailed in this report. If there are exceedances, reasonable and feasible mitigation measures and additional vibration monitoring should be conducted. Measures to prevent cosmetic damage to surrounding structures are provided in Section 7.

7. Noise & Vibration Management Strategies

7.1 Project Specific Recommendations

Project specific recommendations and required mitigation methods have been listed below within Section 7.1. For general noise and vibration mitigation and management measures, refer to Section 7.2 of this report.

7.1.1 Noise

The excavators with the rock breaker attachment are predicted to produce the highest noise levels during the early works phases at the surrounding most affected sensitive receivers, being the commercial and residential receiver C&R1, commercial receiver C2 and residential receiver R1.

The use of a standard A-class hoarding of the following materials and construction will suffice to mitigate the impact of the highest predicted noise levels, installed to the extent illustrated in Figure 5:

- The A-class hoarding should be impervious of gaps and cracks which would compromise its performance
- it should be comprised of acoustically suitable materials such as 17 mm plywood

The barrier shall reduce the noise levels experienced at the commercial premises directly across Scott Street. Locating site amenities towards the site boundaries further increases the shielding of construction noise.

In addition to the sound attenuating barrier, at least a one hour respite period, for example between 12:00pm – 1:00pm (or other period to coincide with construction workers lunch time(s)), should be offered per day during the most intensive periods of hammering and rock breaking. Frequent and proactive communication with the commercial tenants to is also encouraged, that being receivers C&R1, C2, C3 and H1. This will allow occupiers of adjacent premises to tune their work schedule to accommodate possible important business meetings. More details regarding communication with the community can be found in Section 7.3.

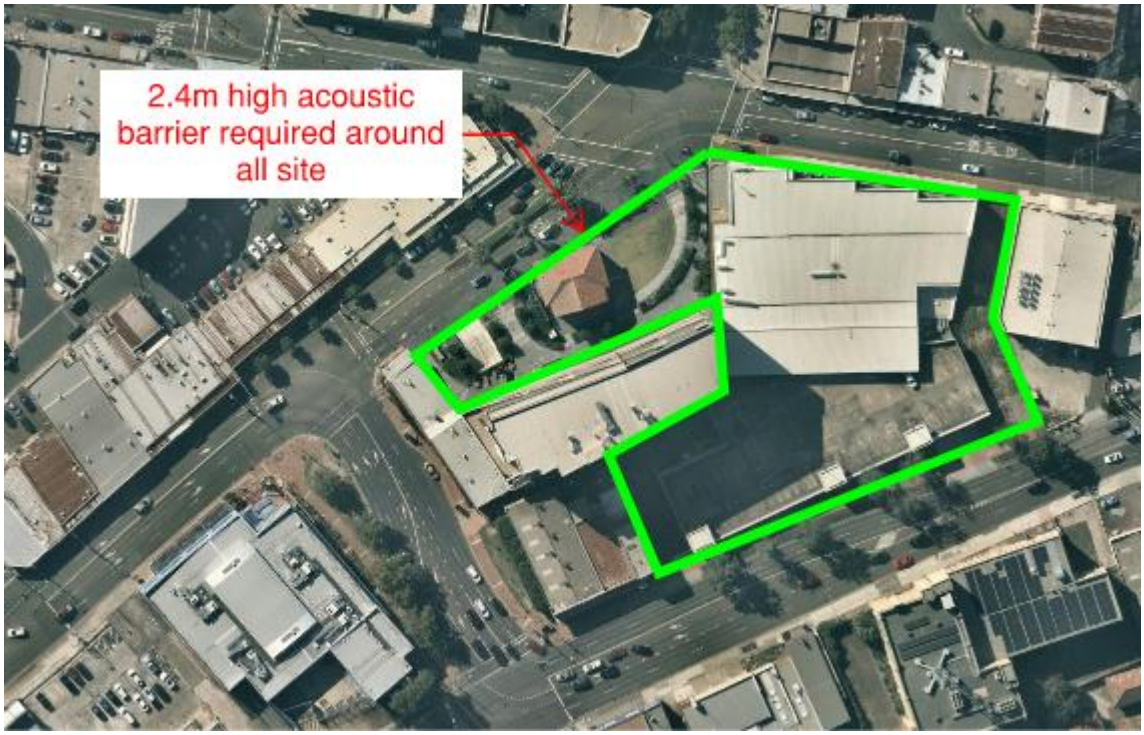


Figure 5: Acoustic Barrier

7.1.2 Vibration

Due to the proximity of demolition works to the commercial and residential receiver C&R1 and commercial receiver C2, there may be exceedances of the cosmetic damage and human comfort criteria. Prior to the use of the excavators with rock breakers on the western boundary during demolition, attended vibration measurements should be conducted to determine if there is an exceedance of the vibration limits set out in Section 4.2.

Upon any exceedances in vibration levels, reasonable and feasible measures should be considered to lessen the impact, such as an alternative means of demolition or reducing the capacity of the rock breaker to achieve the vibration levels required.

To further diminish the vibration impact, the one hour respite period, for example between 12:00pm – 1:00pm (or other period to coincide with construction workers lunch time(s)), recommended for noise mitigation shall also apply to vibration.

7.2 General Acoustic Recommendations for Construction

According to AS 2436 – 2010 *Guide to noise and vibration control on construction, demolition and maintenance sites* the following techniques could be applied to minimize the spread of noise and vibrations to the potential receivers.

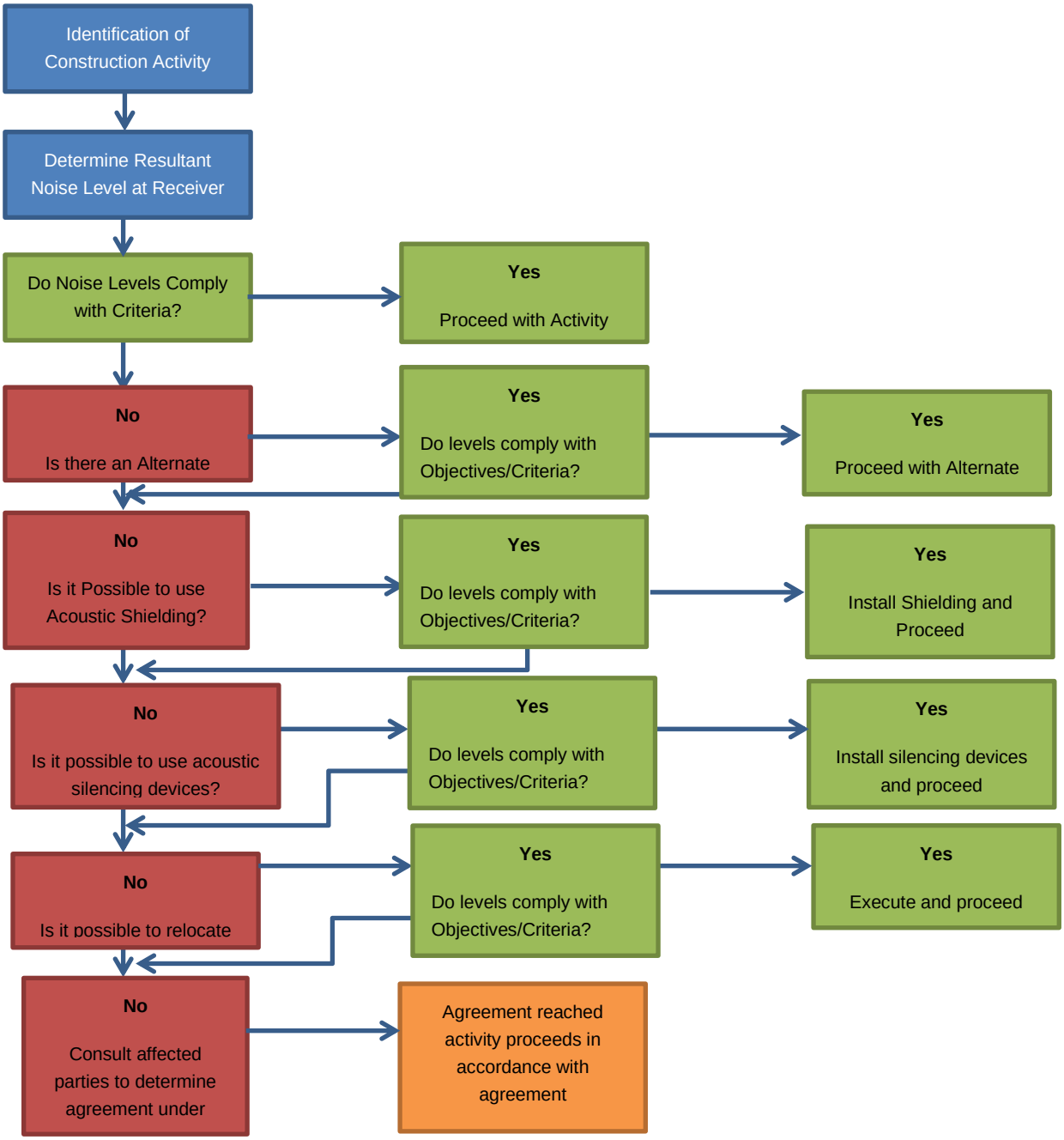
7.2.1 Noise

Figure 6 demonstrates the preferred order of actions taken to mitigate excessive construction noise emissions. If a process that generates significant noise levels cannot be avoided, the amount of noise reaching the receiver should be minimized. Two ways of achieving this are to either increase the distance between the noise source and the receiver or to introduce noise reduction measures such as screens. Practices that will reduce noise from the site include:

- Increasing the distance between noise sources and sensitive receivers.
- Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportables can be effective barriers).
- Constructing barriers that are part of the project design early in the project to introduce the mitigation of site noise.
- Installing purpose-built noise barriers, acoustic sheds and enclosures.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. A few of these methods have been introduced below.

Figure 6: Noise Mitigation Management Flow Chart



Screening

On sites where distance is limited, screening of noise may be beneficial or even the only way to reduce construction noise impacts on the nearby receivers. Below, screening options for various situations have been introduced. Constructing and utilising these screening methods should be taken into account already during the planning stages.

Temporary buildings: One option to introduce screening is to position structures such as stores, storage piles, site offices and other temporary buildings between the noisiest part of the site and the nearest dwellings. Due to shielding provided by these buildings, some of the noise emission from the site can be reduced. If the buildings are occupied, however, sound insulation measures may be necessary to protect site workers inside the buildings.

Hoarding: Another way of implementing screening is to build hoarding that includes a site office on an elevated structure. This option offers superior noise reduction when compared with a standard, simple hoarding. The acoustic performance is further enhanced when the hoarding is a continuous barrier.

Equipment operating 24h: When it comes to water pumps, fans and other plant equipment that operate on a 24-hour basis, they may not be an irritating source of noise during the day but can be problematic at night. They should therefore be effectively screened by either situating them behind a noise barrier or by being positioned in a trench or a hollow in the ground. Again, generated reverberant noise must be minimised and adequate ventilation should be ensured.

General remarks:

In many cases, it is not practical to screen earthmoving operations effectively, but it may be possible to partially shield a construction plant at the early stages of the project with protective features required to screen traffic noise.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and the receiver, and the material of which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected by at least ten times the shortest distance from the said property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend beyond the direct line of sight between the noise source and the receiver by a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are already predominantly located within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Cranes

For the early works construction phases, any cranage will be limited to mobile cranes where the engines are typically enclosed in an acoustically treated housing.

Reversing and warning alarms

Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternative warning alarms capable of providing a safe system of work that are equal to or better than the traditional “beeper”, while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

- Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal-frequency ‘beep’) are less intrusive when heard in the neighbourhood.
- Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
- Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.
- Spotters or observers.

The above methods should be combined, where appropriate.

7.2.2 Vibration

Vibration can be more difficult to control than noise, and there are few generalizations that can be made about its control. It should be kept in mind that vibration may cause disturbance by causing structures to vibrate and radiate noise in addition to perceptible movement. Impulsive vibration can, in some cases, provide a trigger mechanism that could result in the failure of building components that had previously been in a stable state.

During the demolition works and the erection of new structures, some vibrations (transmitted through the structure from the demolition sites) are expected, being more of a concern for the surrounding sensitive receivers. Vibrations can also trigger annoyance, which might get elevated into action by occupants of exposed buildings, and should therefore be included in the planning of communication with impacted communities.

It should be remembered that failures, sometimes catastrophic, can occur as a result of conditions not directly connected with the transmission of vibrations, e.g. the removal of supports from retaining structures to facilitate site access. BS 7385-2 provides more information on managing ground-borne vibration and its potential effects on buildings. Where site activities may affect existing structures, a thorough engineering appraisal should be made at the planning stage.

General principles of seeking minimal vibration at receiving structures should be followed in the first instance. Predictions of vibration levels likely to occur at sensitive receivers are recommended when they are relatively close, depending on the magnitude of the source of the vibration or the distance associated. Relatively simple prediction methods are available in textbooks, codes of practice and standards, however, it is preferable to assess site transmission and propagation characteristics between source and receiver locations through measurements.

Guidance for measures available for the mitigation of vibration transmitted can be sought in more detailed standards, such as BS 5228-2 or policy documents, such as the NSW DEC *Assessing Vibration: A technical guideline*. Identifying the strategy best suited to the control of vibration follows a similar approach to that of noise: avoidance, control at the source, control along the propagation path, control at the receiver, or a combination of these. It is noted that vibration sources can include stationary plants (pumps and compressors), portable plants (jackhammers and pavement vibrators), mobile plants, pile-drivers, tunnelling machines and activities, and blasting, amongst others. Unusual ground conditions, such as a high water-table, can also cause a difference to expected or predicted results, especially when considering the noise propagated from piling.

7.3 Complaint Handling Procedures and Community Liaison

It is recommended that the builder directly contact adjacent noise sensitive receivers and provide them with the following information:

- The contact details for a nominated representative in order to make noise / vibration complaints.
- Explain the timeframe for the construction works and the proposed activities, i.e. the proposed start / stop dates of work and a description of the noise producing equipment that will be used.
- Notify the noise sensitive receivers and Liverpool City Council in a timely manner should there be any need for an extension to the proposed arrangements.
- Provide them with a copy of this report as approved by the Liverpool City Council.
- Liverpool City Council should be notified of the nature and details of complaints received (time, complainant etc.) and what remedial action has taken place, if any.
- Where noise is demonstrated as being compliant with criteria, this should not limit the proponent in undertaking further additional reasonable and feasible steps to reduce noise emissions.

To assist in the management of noise and vibration complaints various procedures are to be followed. These include:

- Clearly visible signage identifying any key personnel along with their contact details to be erected along the perimeter of the building site including;

- A 24-hour contact name, phone number and email address provided for the resident to address any complaint. The signage will declare; “For any enquiry, complaint or emergency relating to this site at any time please contact…”

- Give complaints a fair hearing.
- Have a documented complaints process, including an escalation procedure so that if a complaint is not satisfied there is a clear path to follow.
- Call back as soon as possible to keep people informed of action to be taken to address noise problems. Call back at night time only if requested by the complainant to avoid further disturbance.
- Implement all feasible and reasonable measures to address the source of the complaint.
- A register is to be kept by the contractor to keep a record of complaints and detail any information associated with them. The contents of the register will include:
  - The name and the address of the complainant
  - Time and date of the complaint
  - The nature of the complaint (Noise/Vibration)
  - Subsequent details
  - Remedial action undertaken

The contents of the register will be maintained and updated with any new complaint without delay. The complaints will be reported to both Liverpool City Council and the Contractor. The investigation of the complaint and any remedial actions will be performed by the builder and/or client representative.

In the event of noisy works scheduled, the builder will notify residents 5 business days in advance.

7.4 Noise & Vibration Monitoring Strategy

7.4.1 General Methodology

Noise and vibration levels should be monitored from time to time 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 or vibration complaints. Where noise and vibration criteria are being exceeded or in response to valid complaints, noise and / or vibration 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 and vibration monitoring professional or an acoustic consultant. The results of any noise or vibration 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 and vibration monitoring can take two forms:

- Short-term monitoring
- Long-term monitoring

Both of these approaches are elaborated below.

7.4.2 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.

7.4.3 Long-term Monitoring

Similarly, 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, such as the demolition and excavation phases.

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.

7.4.4 Noise & Vibration Monitoring Program

A monitoring programme for the early works construction is proposed in Table 13. The monitoring programme is to be carried out during the likely noisiest periods during each construction phase as agreed with the Acoustic engineer and Contractor.

Refer to Figure 7 for the receiver locations corresponding the monitoring locations.

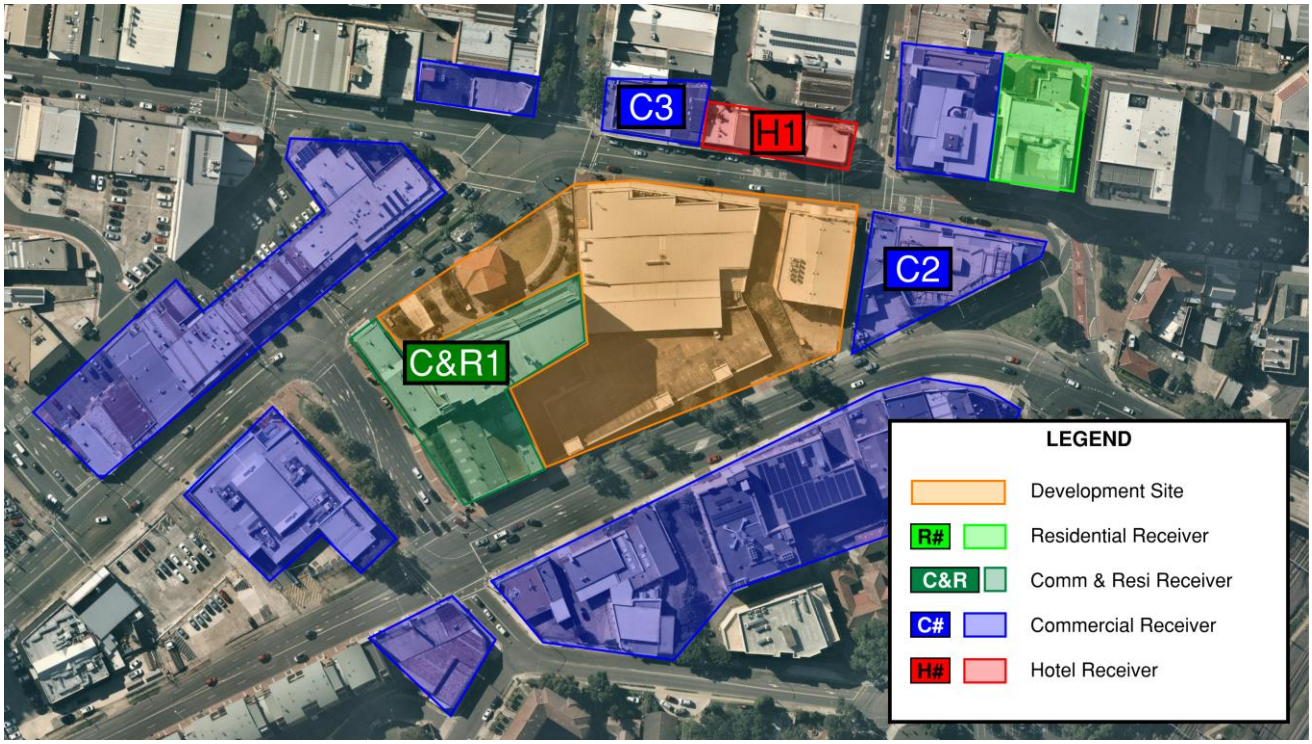


Figure 7: Proposed monitoring locations

Table 13: Noise and vibration monitoring programme

Construction Phase	Location Reference	Monitoring Required
Demolition	C&R1	Noise & Vibration
	C2	Noise & Vibration
	C3	Noise
	H1	Noise
Excavation	C&R1	Noise & Vibration
	C2	Noise & Vibration
	C3	Noise
	H1	Noise

8. Conclusion

A Construction Noise and Vibration Management Plan has been provided for the site preparation and early works at 52 Scott Street, Liverpool. This document was prepared in support of a development application that is to be presented to the Liverpool City Council (Council).

The details of the noise and vibration modelling and assessment undertaken to predict the impacts on sensitive receivers have been presented in Sections 5 and 6.

To reduce the noise and vibration impacts on the sensitive receivers, noise and vibration management strategies have been proposed in Section 7.

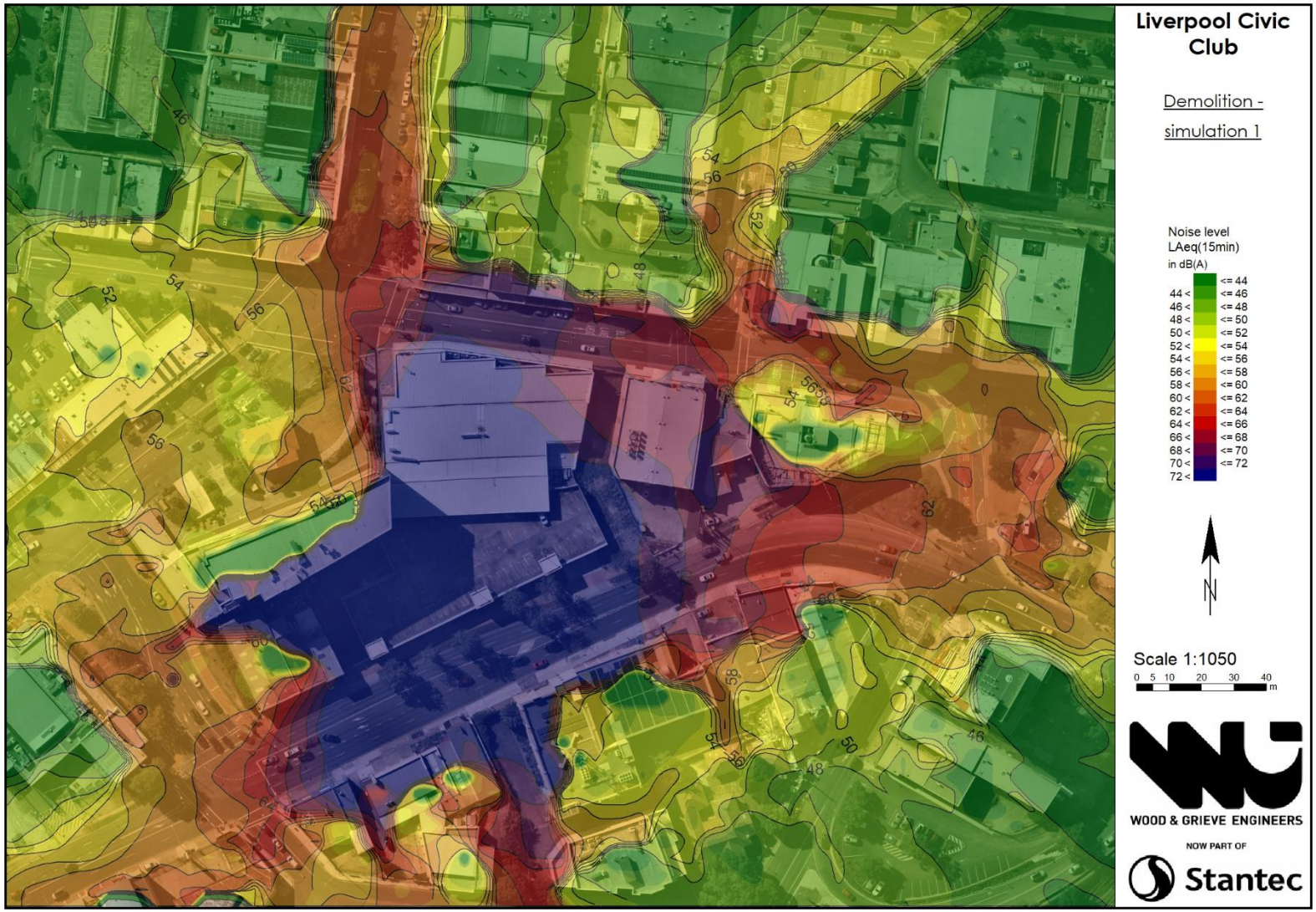
The information presented in this report shall be reviewed if any modifications to the features of the development specified in this report occur, including and not restricted to selection of equipment/machinery and modifications to the early works construction program.

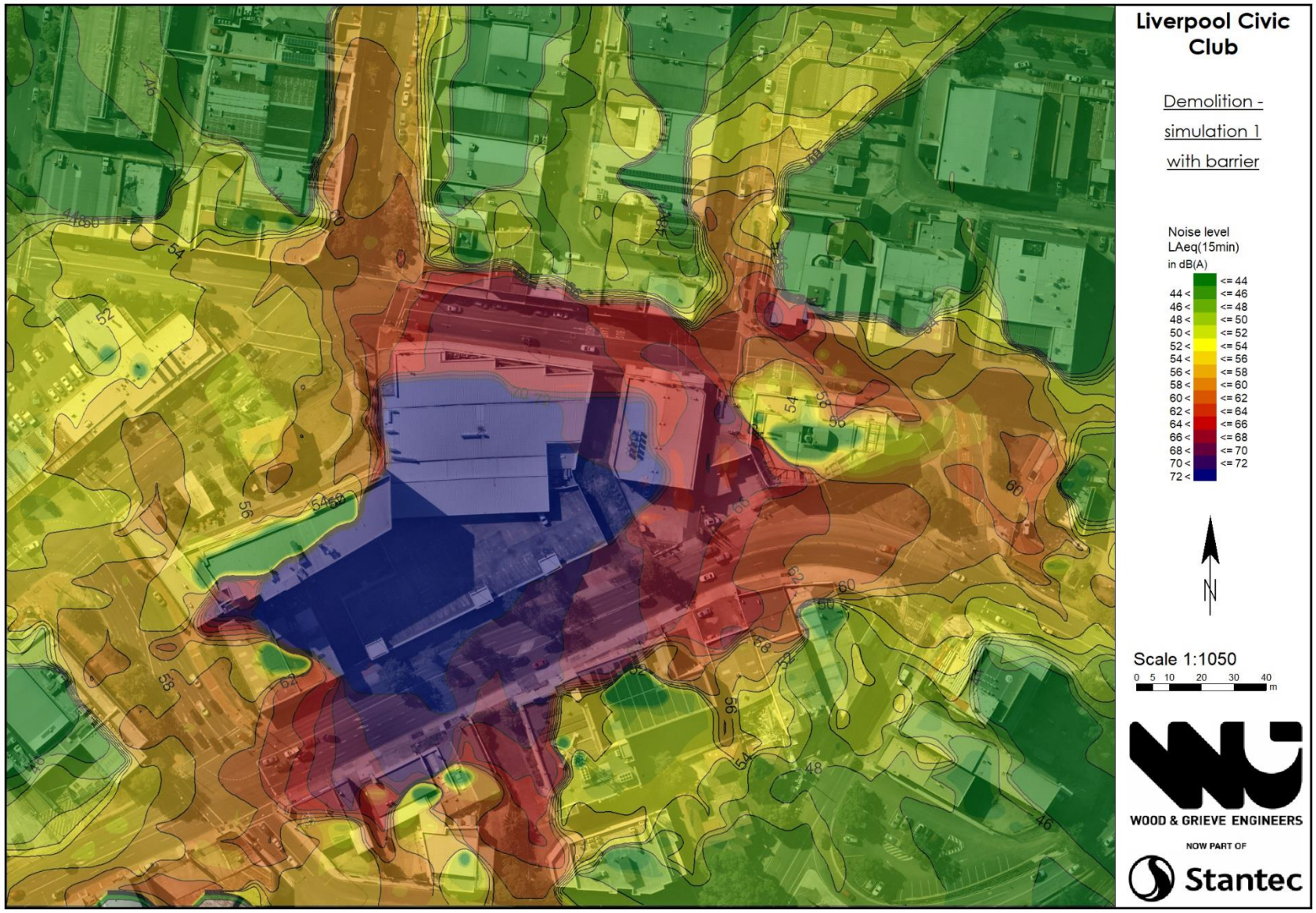
Appendix A Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable L_{Aeq} noise level from industrial sources, recommended by the EPA (Table 2.1, INP). 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.

Appendix B Noise Emissions Contour Maps

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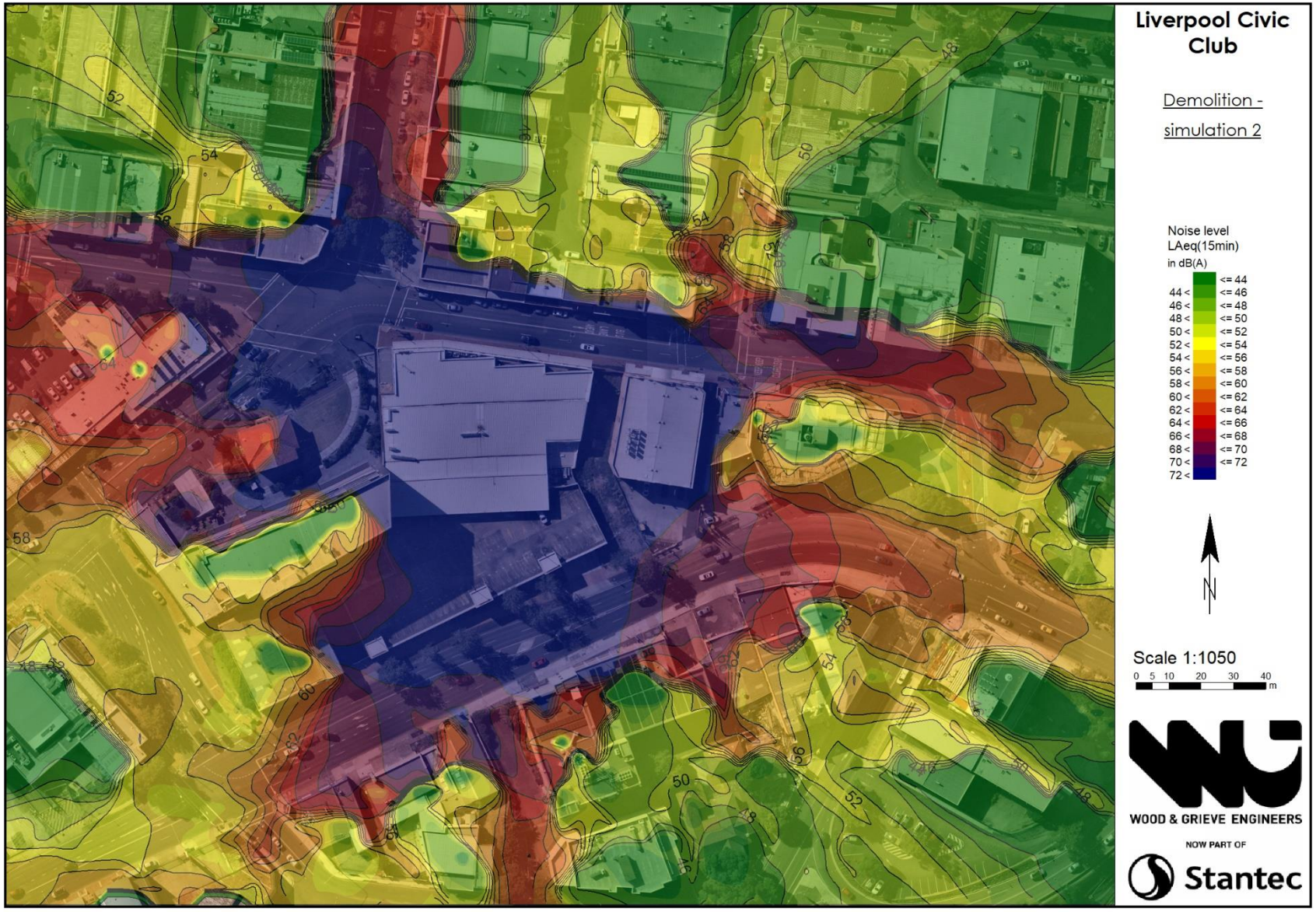
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Liverpool Civic Club
Demolition - simulation 2 with barrier
Noise level LAeq(15min) in dB(A)
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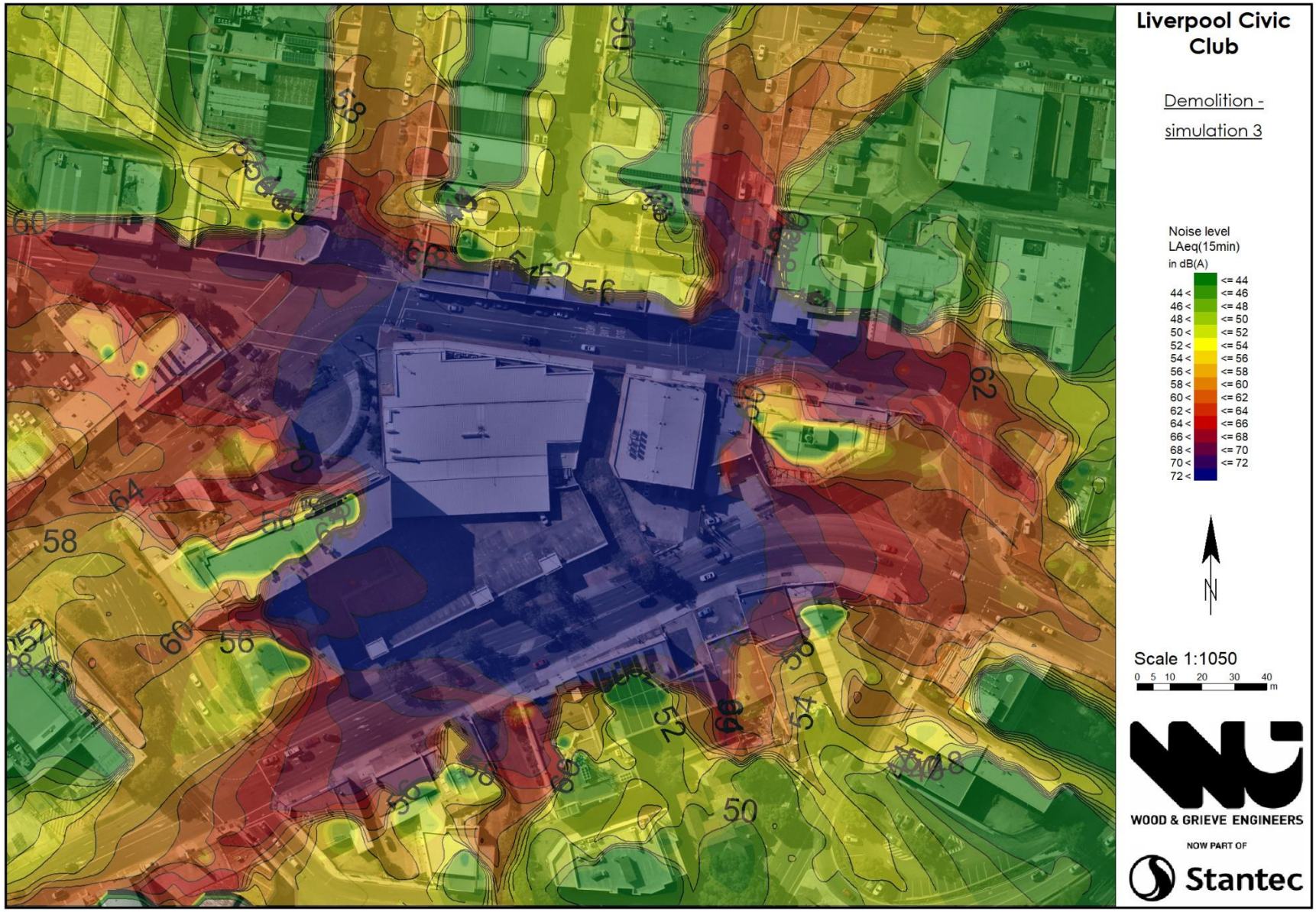
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Demolition - simulation 3
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in dB(A)
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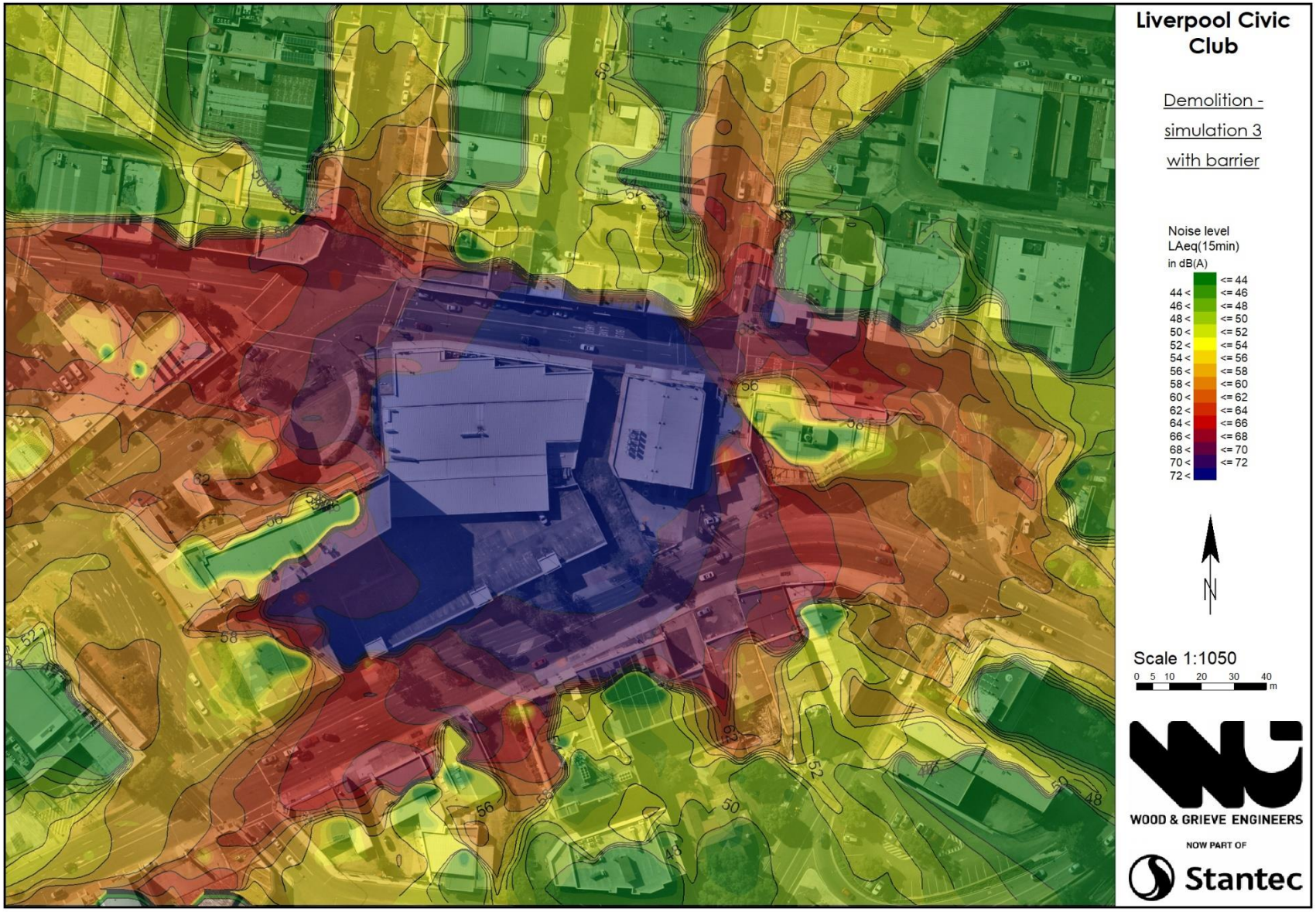
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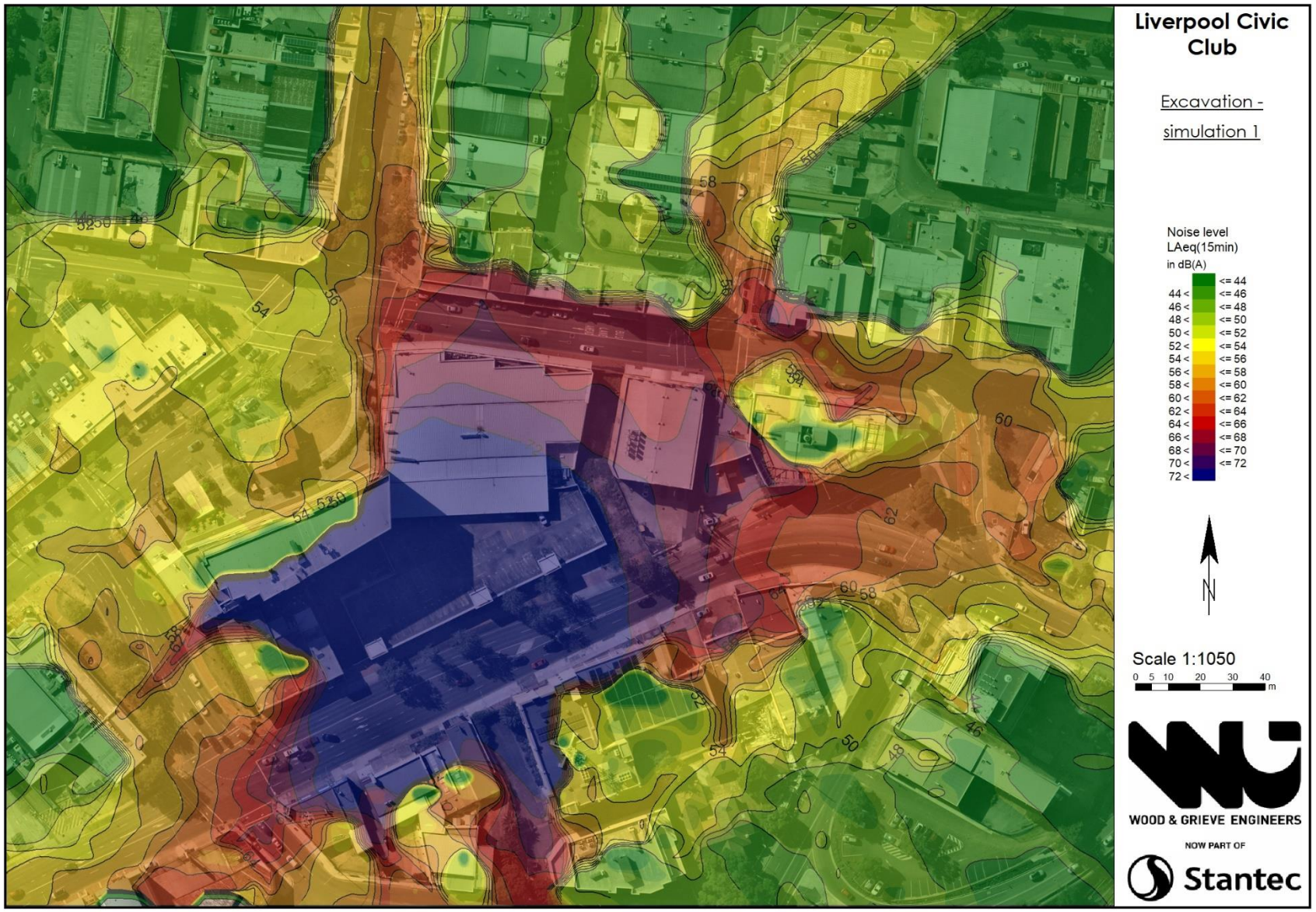
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Excavation - simulation 1
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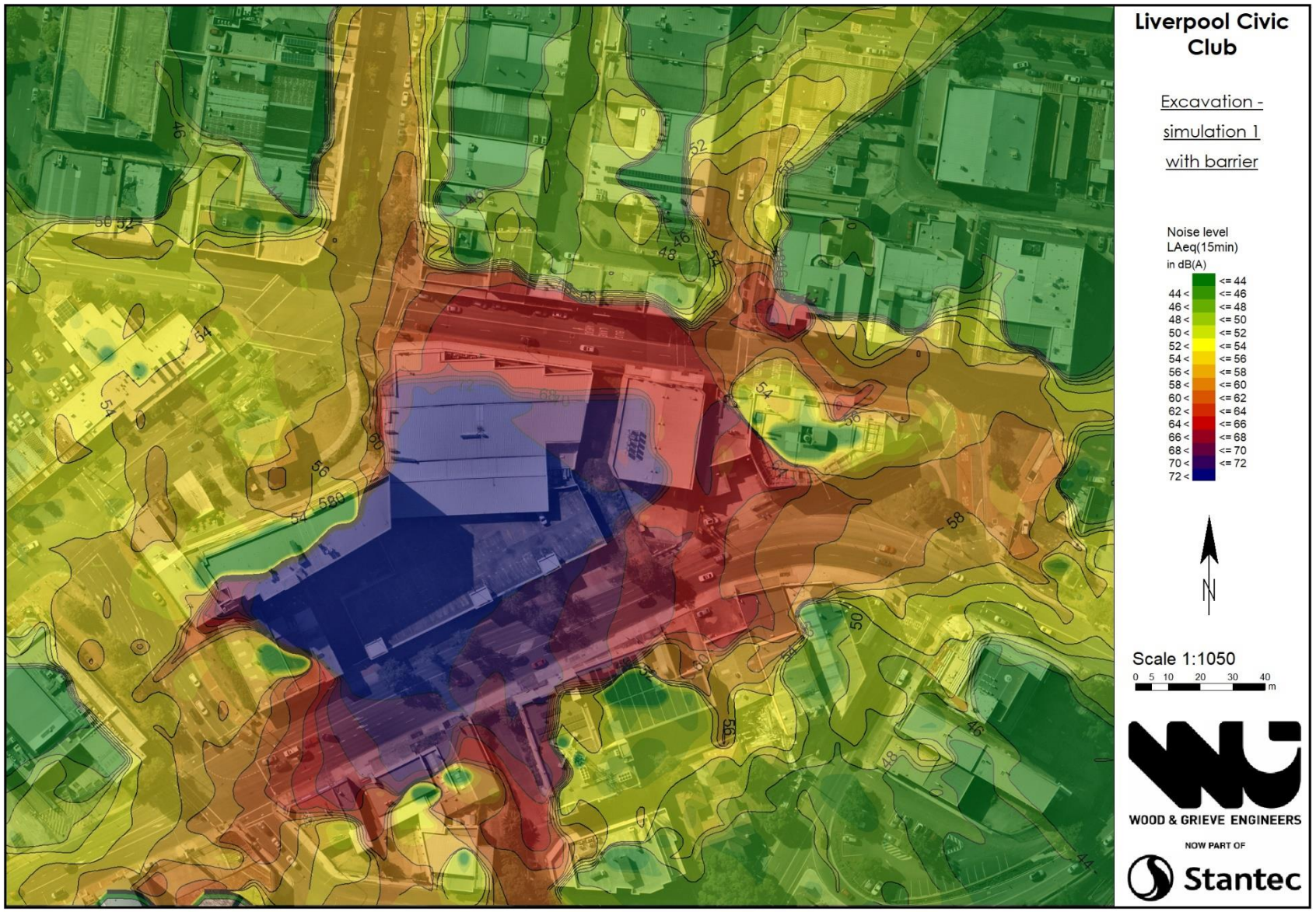
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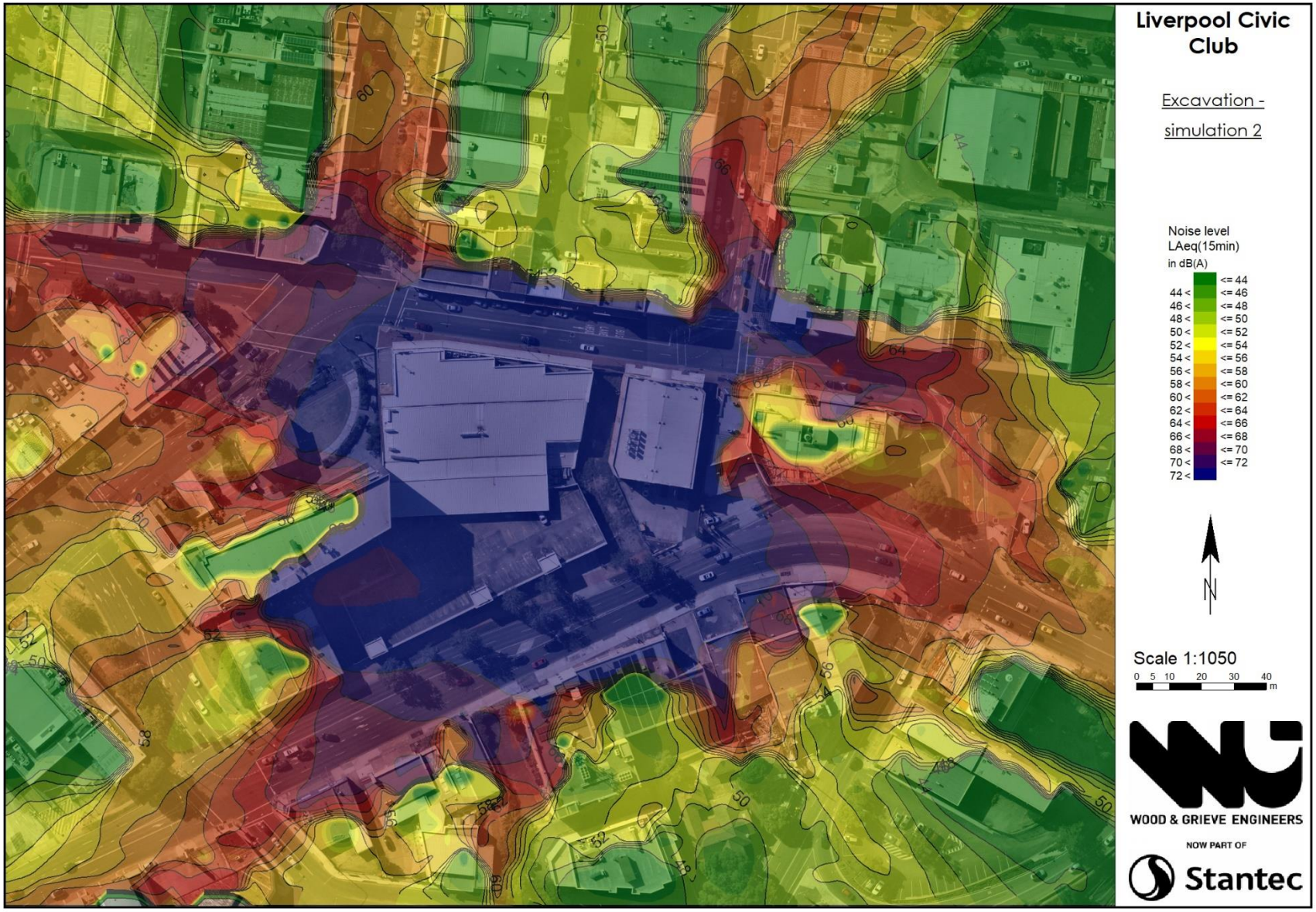
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Excavation - simulation 2
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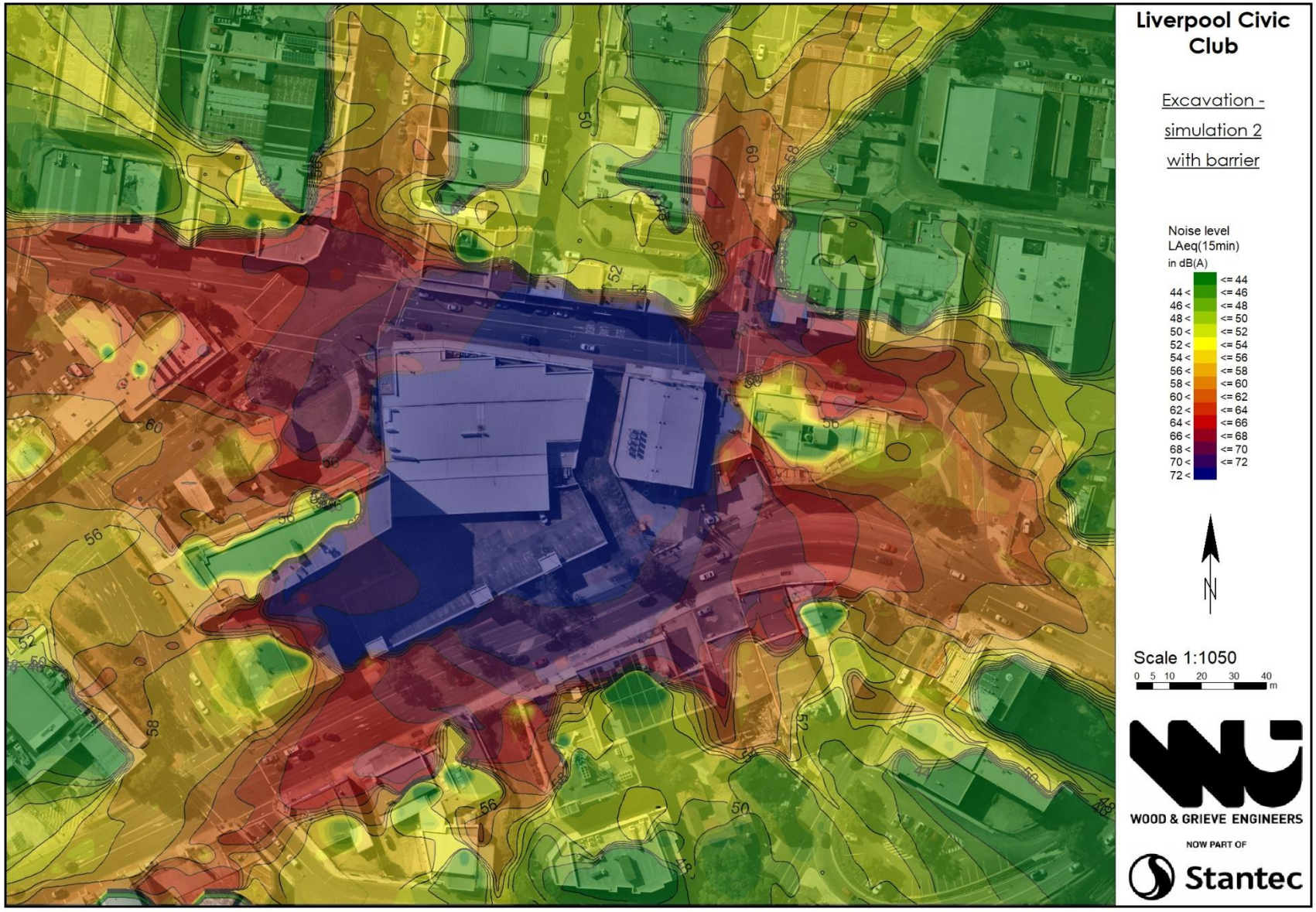
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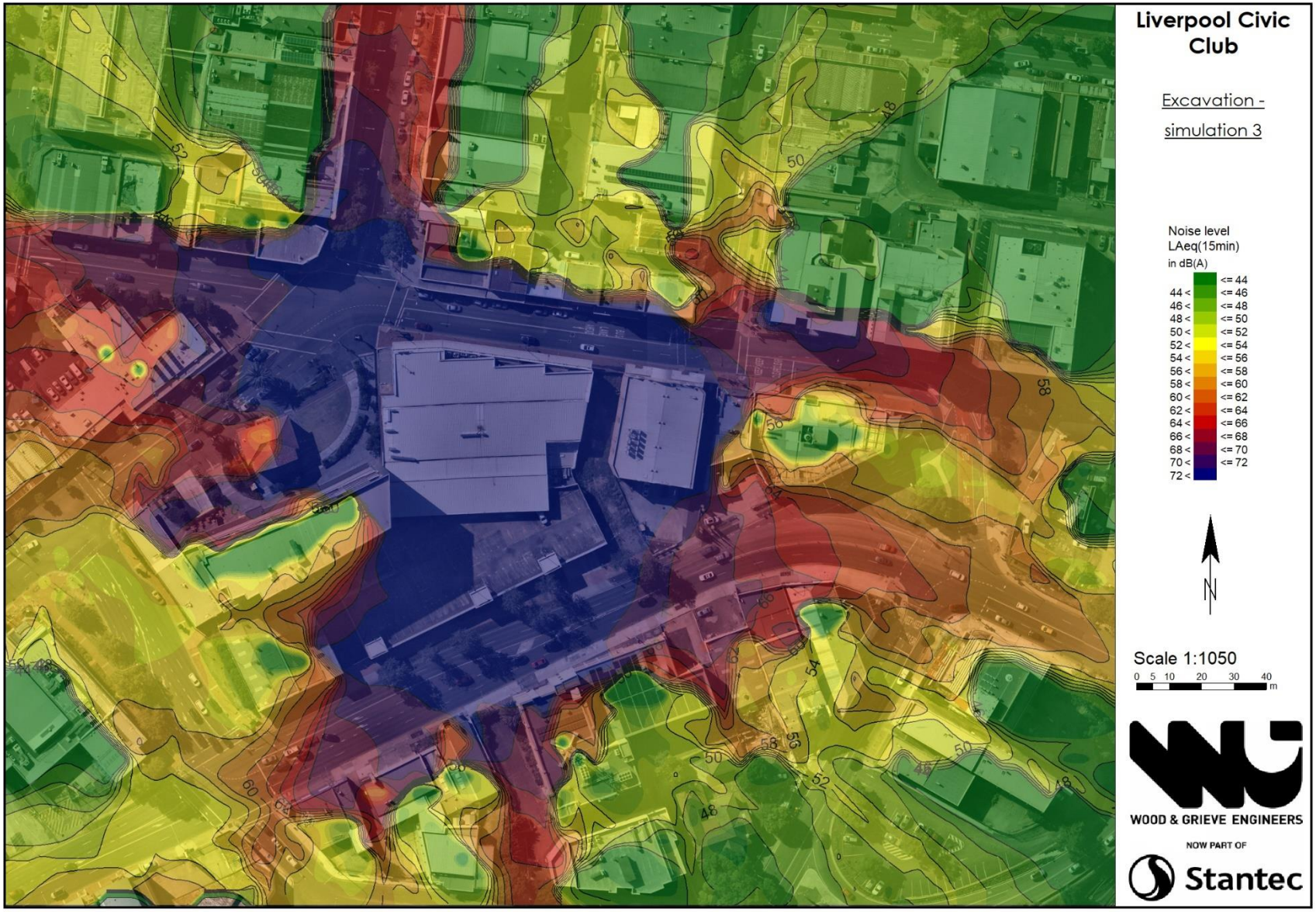
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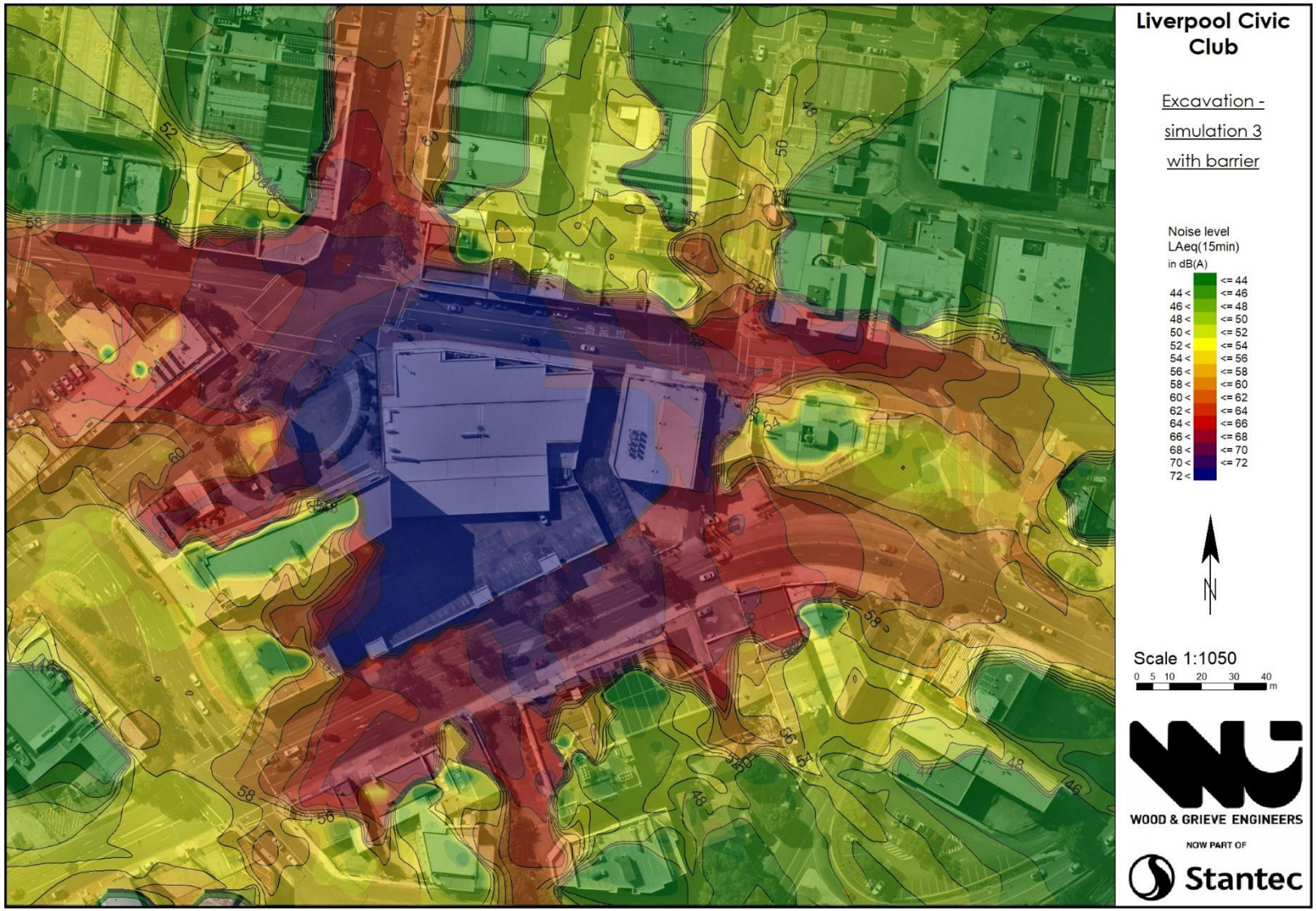
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