Multi-storey Carpark, The Children's Hospital at Westmead

Acoustics Report

State Significant Development Application

Prepared for: Health Infrastructure c/- PwC

Attention: Mary Sakr

Date: 15th June 2021

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Contents

Revision

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002	25/01/2021	Updated with Comments	Mia Strembickyj	Olivier Gaussen
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Contents

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Contents

Contents

List of Figures

List of Tables

1. Executive Summary

Based on the findings and recommendations of this noise and vibration impact assessment, the following measures are suggested to mitigate the identified impacts of the development:

Table 1: Summary of suggested mitigation measures

Mitigation Measures
Construction Noise – Section 12.1.1 A solid 2.4m hoarding is to be erected around the site.
Construction Vibration - Section 12.1.1 No additional mitigation measure required
Carpark Noise Emissions – Section 11.1 Carpark Façade to meet a minimum rating as assumed during assessment (Section 9.2)

2. Introduction

The purpose of this report is to provide an environmental noise impact assessment as part of the State Significant Development Application (SSDA) for the proposed multi storey car park (MSCP) of The Children's Hospital at Westmead. The proposed work will involve the construction of a new multi-storey car park, which is required to replace the P17 staff car park which has been demolished to make way for the new Paediatric Services Building (PSB). The location selected for the multi-storey carpark (MSCP) is the site of the Lodge, north east of the existing Children's Hospital at Westmead (CHW), between it and the new Ronald McDonald House.

The scope of the proposed works includes:

- Demolition of The Lodge
- Construction of a new MSCP approximately 8 car parkings storeys:
  - Facilitating approximately 1000 car parking spaces for staff and visitors
  - Vehicular access from Labyrinth Way and/or Redbank Road
  - A split-level approach to the MSCP to respond to the natural ground level
- Ancillary retail facilities
- Road works:
  - Realignment of Redbank Road with vehicular access connection to MSCP
- Tree removal
- Associated landscape work

The MSCP is being designed to be construction in a single stage yet car parking will be staged operationally to come on-line with parking demand across the Precinct:

- The first stage of car parking operation would provide replacement car parking for the demolished P17 car park. There would be no net increase of parking on site under this stage.
- The second stage of car parking operation to serve the growth in hospital activity associated with the future PSB would only come on-line operationally with the PSB SSDA consent becoming operational, specifically at occupation. This would provide growth of around 280 additional spaces in line with hospital activity projection until 2031.

The Minister for Planning, or their delegate, is the consent authority for the State Significant Development Application (SSDA) and this application is lodged with the NSW Department of Planning, Industry and Environment (DPIE) for assessment.

This noise assessment is based on ambient noise data collected by noise loggers located at representative locations close to the sensitive receivers, shown in Figure 1.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore, this report shall not be relied upon as providing any warranties or guarantees.

3. Secretary's Environmental Assessment Requirements (SEARs)

This report has been prepared in response to the requirements contained within the Secretary's Environmental Assessment Requirements (SEARs) dated 20 November 2020 and issued for the detailed SSD DA. Specifically, this report has been prepared to respond to the SEARs requirements summarised below.

Item	Description of requirement	Section reference
10	**Noise and Vibration** Provide a noise and vibration impact assessment that: • assesses the potential impacts of all stages of the development on all potentially impacted environments, sensitive receivers, stakeholders and future developments.	Section 10
	• includes a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation and construction.	Section 10
	• details the proposed construction hours and provides details of, and justification for, instances where it is expected that works would be carried out outside standard construction hours.	Section 10.1
	• includes a quantitative assessment of the main sources of operational noise, including vehicles using the carpark after hours.	Section 9.2
	• outlines measures to minimise and mitigate the potential noise impacts on nearby sensitive receivers.	Sections 11 and 12
	• demonstrates that the assessment has been prepared in accordance with polices and guidelines relevant to the context of the site and the nature of the proposed development.	Section 4.2
	• considers sources of external noise intrusion in proximity to the site (including, road rail and aviation operations) and identifies building performance requirements for the proposed development to achieve appropriate internal amenity standards.	Section 9.3

4. Background

4.1 Information Sources

- This assessment was based on the development application architectural drawings provided by Billard Leece dated 15/01/2021
- Noise data collected on site through the use of noise loggers and a Type 1 handheld sound level meter
- Traffic Impact Assessment Report by WSP dated 21 December 2020

4.2 Reference Documents

- City of Parramatta Council Development Control Plan 2011
- New South Wales Environment Protection Authority (NSW EPA), Noise Policy for Industry (NPI) 2017
- New South Wales (NSW) Department of Environment Climate Change and Water (DECCW) Interim Construction Noise Guideline July 2009
- Australian Standard, AS 2436-1981, “Guide to Noise Control on Construction, Maintenance and Demolition Sites”
- Secretary's Environmental Assessment Requirement for proposed development of Children's Hospital Westmead - Multi-storey Carpark (SSD-10434896)
- NSW Noise Policy for Industry 2017 (NSW Environment Protection Authority (EPA)
- Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)
- Assessing Vibration: A Technical Guideline 2006 (Department of Environment and Conservation, 2006)

5. Project Overview

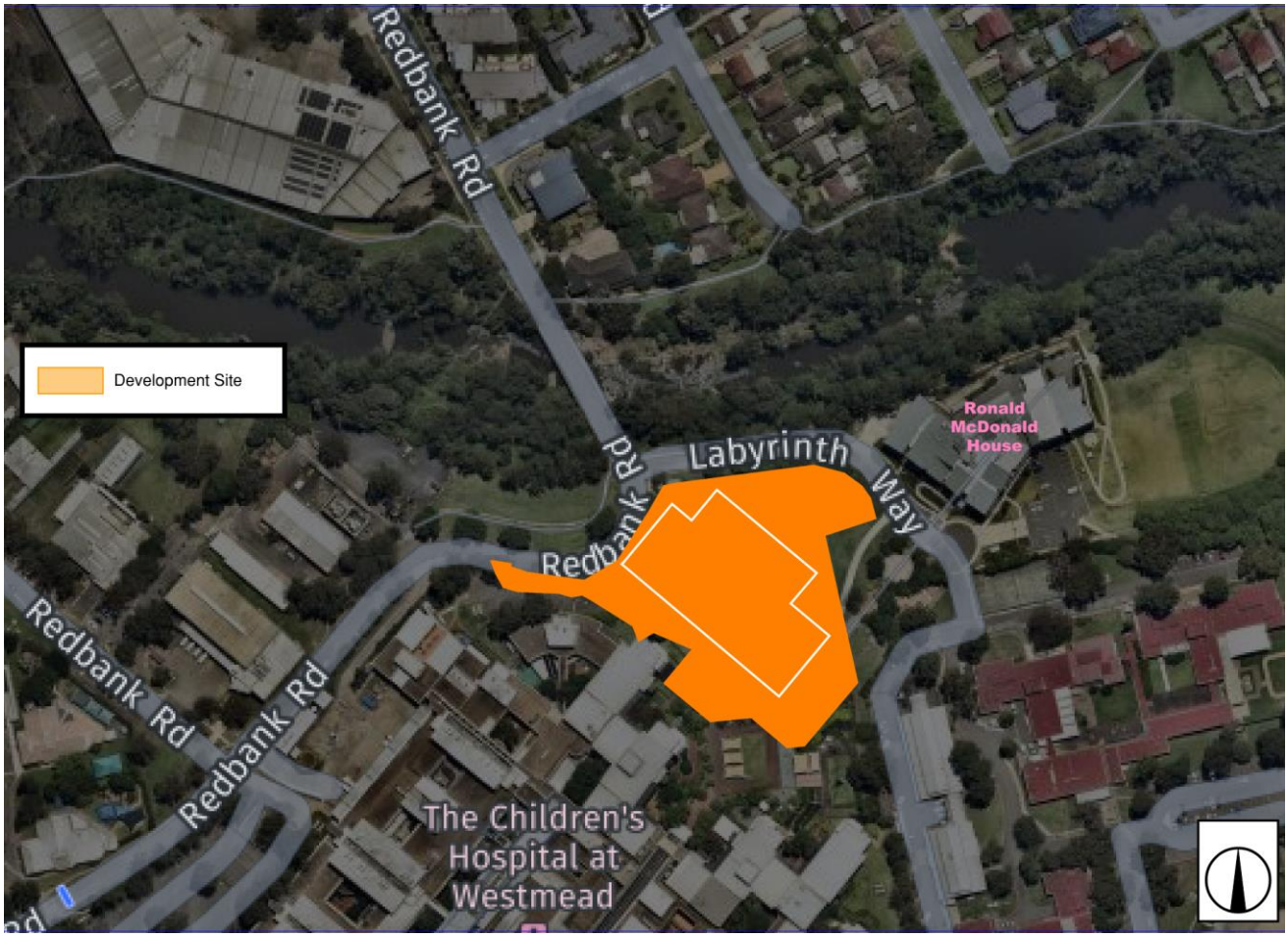
5.1 Site Description

The proposed site for the Multi Storey Car Park at the Children's Hospital at Westmead located along Redbank Rd, which is currently the site of the Lodge, north east of the existing CHW, between it and the new Ronald McDonald House.

The noise sources to be assessed for impact on the development are as follows:

- Noise emissions from vehicle movements on Redback Rd generated from the proposed new car park
- Noise emissions from operation of the carpark to the surrounding receivers

Figure 1: Overview of the Site



Source: nearmap.com

6. Site Noise Investigations

The Environment Protection Authority Noise Policy for Industry (EPA NPI, 2017) requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods.

The NPI defines these periods as follows:

- Day is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- Night is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays

Previous noise monitoring was undertaken at locations illustrated in Figure 2 below, during the early works of the Children's Hospital Westmead Stage 2 development, by Stantec Australia.

The existing background noise at the site is typical for a suburban area that has characteristically intermittent local traffic flows with some limited commerce or industry.

Figure 2: Overview of the Site and Measurement Locations

6.1 COVID-19 Pandemic and Effects on Noise Surveys

Site noise surveys have been previously conducted by Stantec Australia during the early stage works of the project to gain an understanding of the background levels within the surrounding buildings.

These noise surveys were carried out under noise-subdued circumstances as a result of the COVID-19 pandemic. For background and ambient noise, the noise statistics obtained are considered to be lower than that of a typical day to day operation. Therefore, the ambient noise levels can be considered a conservative scenario, due less foot and road traffic during the Public Health Order where minimal movement was allowed.

6.2 Instrumentation

The equipment used for the noise survey was the following:

- ARL Environmental Noise Logger, NL-42EX, S/N 1173759
- Hand-held sound spectrum analyser Brüel & Kjær 2250, S/N 2709742
- Brüel & Kjær Sound Calibrator, S/N 2709826

All Stantec equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

6.3 Short-term (Attended) Survey Results

An attended noise measurement of 15-minute duration was conducted on site to characterise the noise intruding into the development and to validate the results of the unattended noise monitoring. A summary of the attended noise measurement taken in the vicinity of the proposed development site and site measurements locations are shown in Table 2.

Table 2 below displays the summary of the unattended noise measurements.

Table 2 Summary of attended noise measurements

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{Amax} dB(A)	Comments
P1	04/07/20 2:18pm	44.3	59.0	Constant nature sounds with intermittent pedestrian movements

6.4 Long-term (Unattended) Survey Results

6.4.1 Background Noise Monitoring

A long-term noise monitor was placed at position L1 as shown in Figure 2 to measure the background and ambient noise that is representative of the surrounding noise-sensitive receivers. Noise monitor L1 was installed from the 27th July 2020 to the 5th August 2020. A summary of the results of the unattended background and ambient noise survey is shown in Table 3 (for the day, evening and night periods).

Table 3: Long-Term Unattended noise measurements of L1

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	51	52	48	43	44	42

The local ambient noise environment for L1 included nearby construction noise and general day-to-day office activities throughout the majority of the day, evening and night periods. Note that any rain affected data during the period of logging has been excluded from the calculations.

Refer to Figure 3 for the noise data.

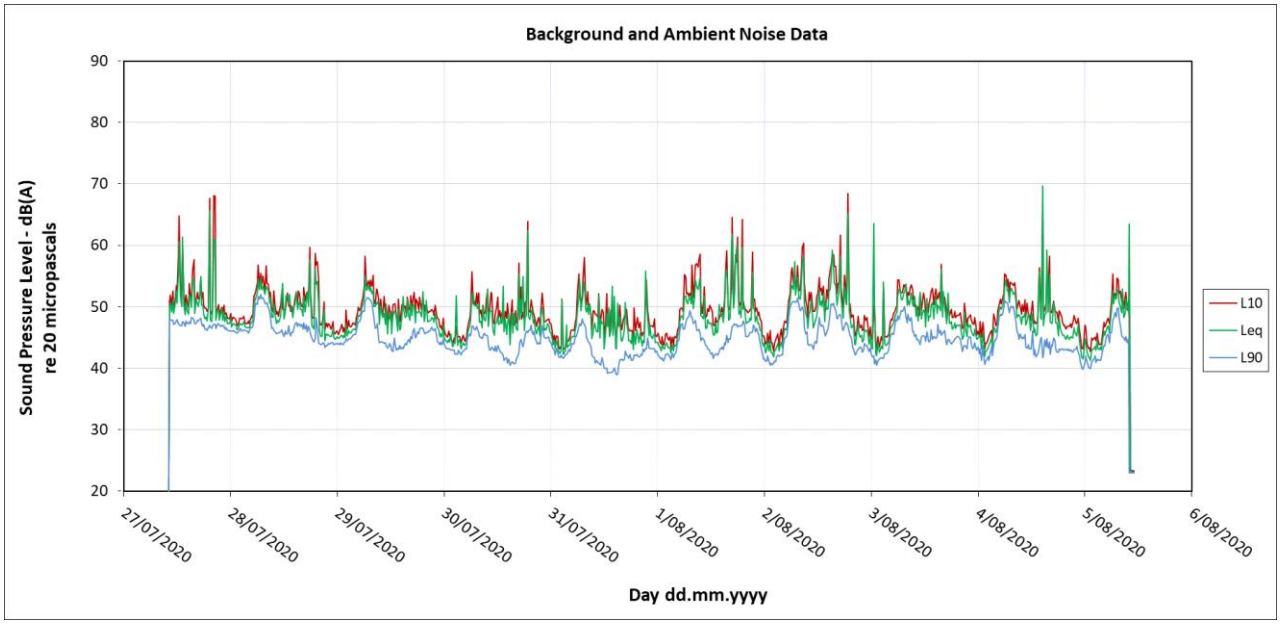


Figure 3: Unattended background and ambient noise monitoring data – L1

6.5 Summary of Noise Investigations

The site noise investigations are a key piece of information when understanding the existing ambient noise environment characteristic of the surrounding receivers to the proposed development.

Figure 4 has identified the nearby receivers. Within each labelled receiver we have outlined the mixed types of receivers. In Sections 9 and 10, assessments have been conducted at the receiver with the most stringent criteria listed below.

- R1
  - Residential
- S1
  - Short-term Accommodation (Ronald McDonald House)
- H1
  - Medical exam rooms
  - Office areas
- H2
  - Medical exam rooms
  - Office areas
  - Mental health wards
- C1
  - Commercial
- C2
  - Commercial

Figure 4: Overview of the Site and Measurement Locations

7. Operational Noise and Vibration Criteria

7.1 Internal Noise Emissions

SEPP (Infrastructure) 2007 & Development Near Rail Corridors and Busy Roads – Interim Guideline

The proposed development is not considered to be near any nearby busy roads, and is greater than 80m to a operational railway track to apply the SEPP criteria to this project.

The Development Near Rail Corridors and Busy Roads – Interim Guideline of defines a busy road as:

> *"Busy road defined as:*
>
> *Roads specified in Clause 102 of the Infrastructure SEPP: a freeway, tollway or a transitway or any other road with an average annual traffic (AADT) volume of more than 40,000 vehicles (based on the traffic volume data provided on the website of the RTA).*
>
> *Any other road – with an average annual daily traffic (AADT) volume of more than 20,000 vehicles (based on the traffic volume data published on the website of the RTA)*
>
> *Any other road – with a high level of truck movements or bus traffic."*

Redbank Road and Labyrinth Way are not considered a busy road under Clause 102 of the Infrastructure SEPP and therefore no assessment is required for these roads.

The internal noise limits for both windows closed and open established in Clause 3.6 "What Noise and Vibration Criteria Should Be Applied" of the DoP Interim Guideline outlines an internal noise criteria for habitable spaces, and due to the nature of use of a carpark no set criteria is outlined.

AS2107:2016

The Australian Standard (AS2107:2016) outlines the recommended internal design sound level for enclosed carparks, which is presented in Table 4.

Table 4: Recommended design sound levels for building interiors (AS2107:2016)

Type of occupancy/activity	Design sound level ($L_{Aeq,t}$) range
Enclosed Carpark	< 65

7.2 External Noise Emissions

7.2.1 New South Wales (NSW) Noise Policy for Industry (NPI)

The NSW Noise Policy for Industry has been applied to address the noise emissions from the development to the surrounding noise-sensitive receivers. The NSW NPI sets out noise criteria to control the noise emission from industrial noise sources generated by the proposed development. Operational noise emissions from the development shall be addressed following the guideline in the NSW NPI.

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established, the most stringent for each considered assessment period (day, evening, night) is adopted as the project noise trigger level (PNTL).

Intrusiveness Criteria

The NSW NPI states the following:

> *"The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (represented by the LAeq descriptor), measured over a 15minute period, does not exceed the background noise level by more than 5 dB when beyond a minimum threshold."*

The intrusiveness criterion can be summarised as L_{Aeq}, 15 minute ≤ RBL background noise level plus 5 dB(A).

Table 5: NSW NPI Rating background noise levels (RBLs)

Period	Noise Descriptor – dB(A)	Noise Criteria – dB(A)
Residential – R1		
Daytime 7am – 6pm	$L_{Aeq,15min}$ ≤ RBL + 5	48
Evening 6pm – 10pm	$L_{Aeq,15min}$ ≤ RBL + 5	49
Night 10pm – 7am	$L_{Aeq,15min}$ ≤ RBL + 5	47

Amenity Criteria
The NSW NPI states the following:

> *"To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance. The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004).*

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows "Project amenity noise level for industrial developments = recommended amenity noise level (Table 2.2) minus 5, +3 dB(A) to convert from a period level to a 15 minute level"

The applicable parts of Table 2.2: Amenity noise levels from Industrial Noise Sources – L_{Aeq}, dB(A) which are relevant to the project are reproduced below:

Table 5: NSW NPI amenity criteria for external noise levels

Type of Receiver	Noise amenity area	Time of Day	L_{Aeq}, dB(A) Recommended amenity noise level	Project amenity noise level $L_{Aeq, period}$
Residential (R1)	Suburban	Day	55	50
		Evening	45	40
		Night	40	35
Commercial premises (C1, C2 and office areas within H1 & H2)	All	When in use	65	60
Hospital and Mental Health Ward (H1 & H2)	All (Internal)	Noisiest 1hr	35	30
	All (External)	Noisiest 1hr	50	45
Accommodation (S1)	Suburban	Day	60	55
		Evening	50	45
		Night	45	40

*Suburban area as defined in EPA NPI Table 2.2.

Note that where the resultant project amenity noise level is 10dB or more lower than the existing industrial noise level the project amenity noise levels can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

'Modifying Factor' Adjustments

The NSW NPI also states:

> *"Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."*

In order to take into account the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table C1 of Fact Sheet C of the NSW NPI (see Table 6 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 6: Table C1 from the NSW NPI – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method *(ISO1996.2-2007 – Annex D)*.	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. **Note**: Narrow-band analysis using the reference method in *ISO1996-2:2007, Annex C* may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10–160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

1. Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.

2. Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

3. Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard.

Sleep Disturbance

The NPI establishes sleep disturbance criteria for residential receivers in close proximity to industrial noise sources during the night-time period, such as vehicle movements and car door slams on private roads. The criteria for protecting the amenity of surrounding residential receivers in regard to sleep disturbance is:

- $L_{Aeq,15min}$ 40 dB(A) or prevailing RBL plus 5dB, whichever is greater, and/or
- L_{AFmax} 52 dB(A) or prevailing RBL plus 15dB, whichever is greater

Table 7 summarises the sleep disturbance criteria for the proposed development.

Table 7: Sleep Disturbance Criteria

Period	Sleep Disturbance Criteria	
	dB L_{AFmax}	dB $L_{Aeq,15min}$
Residential		
Night (10:00pm to 7:00am)	57	47

7.2.2 Aircraft Noise Criteria

Schedule 1 of The Environment Operations Act 1997 reads as follows:

> ***20 Helicopter-related activities***
>
> *This clause applies to a "helicopter-related activity" but not including an activity that is carried out exclusively for the purposes of emergency aeromedical evacuation, retrieval or rescue.*

On this basis there are no mandatory noise emission criteria resulting from helicopter noise operations from the Westmead Children's Hospital. In addition, there are no current NSW EPA criteria for aircraft noise that are available to assess helicopter noise from a development. Previous assessments in the Land and Environmental Court NSW have applied noise criteria obtained from Airservices Australia.

Airservices Australia Principles and Procedures for minimising the impact of aircraft noise 'Fly Neighborly Guide' are as follows:

- No overflight of residential areas, if this can't be achieved then;
- No overflight of residential area below 1,500 ft AGL, if this can't be achieved then;
- Minimisation of incidence of helicopters flying below 1,500 ft AGL, if this can't be achieved then;
- Minimisation of noise impact on residential areas by helicopters below 1,500 ft AGL,
- Minimisation of noise impacts on residential areas by hovering/circling helicopters
- Implement Fly Neighbourly procedures

Helicopter Noise Criteria

No further assessment is considered for the current Environmental Acoustic Assessment on the basis that there is no proposed change to the helicopter pad location or helicopter movements.

7.2.3 Project Target Noise Level

Refer to Table 8 for the NSW NPI criteria applicable to the external noise emissions from the carpark. These project specific noise levels are in accordance with the requirements of the NSW NPI and shall be assessed to the most affected point on or within the residential boundary.

Table 8: Project Target Noise Levels

Receiver ID	Receiver Category	Period	Descriptor	PTNL dB(A)
R1	Residential	Day	$L_{Aeq,15min}$	48
		Evening	$L_{Aeq,15min}$	43
		Night	$L_{Aeq,15min}$	38
			$L_{AF,max}$	57
S1	Residential	Day	$L_{Aeq,15min}$	53
		Evening	$L_{Aeq,15min}$	48
		Night	$L_{Aeq,15min}$	43
H1	Medical exam rooms	All (Internal)	$L_{Aeq,,noisest\ 1hr}$	30
	Office areas	All	$L_{Aeq,period}$	60
H2	Mental health wards and Sleep Clinic	All (Internal)	$L_{Aeq,noisest\ 1hr}$	30
C1	Commercial	All	$L_{Aeq,period}$	60
C2	Commercial	All	$L_{Aeq,period}$	60

7.3 Operational Vibration Criteria

7.3.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day. The vibration emitted from construction works should be such that it does not exceed the maximum limits set out in the criteria presented in Table 9 to Table 12. 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 9.

Table 9: 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
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
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
Workshops	Day or night time	0.040	0.029	0.080	0.058
Impulsive Vibration		z axis	x and y axis	z axis	x and y axis
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	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
Workshops	Day or night time	0.64	0.46	1.28	0.92

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. The criteria applicable when considering periods of intermittent vibration are presented in Table 10.

Table 10: Acceptable Vibration Dose Values for Intermittent Vibration (1.75 m/s)

Location	Daytime		Night time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

7.3.2 Structural Damage

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 10

Table 11: 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 12 indicates the vibration limits presented in DIN 4150-Part 3 to ensure structural damage does not occur.

Table 12: Guideline Value of Vibration Velocity (v_i) for Evaluating the Effects of Short-Term Vibration – DIN 4150-Part 3

Line	Type of Structure	Vibration velocity, v_i, in mm/s			
		Foundation 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.					

8. Construction Noise and Vibration Criteria

8.1 Construction Noise

8.1.1 External Noise Criteria

We understand the proposed hours of construction are outlined below:

- Mon to Fri: 7am to 6pm
- Saturday: 8am to 5pm

In this report, it is assumed that all works are performed during these proposed hours.

Works are not usually permitted outside of the standard hours outlined in the ICNG, however as per the NSW DEC Interim Construction Noise Guideline Section 2.3 (Construction outside the recommended standard hours), there are five categories of works that might be undertaken outside the recommended standard hours, which are:

- The **delivery of oversized plant or structures** that police or other authorities determine require special arrangements to transport along public roads
- **Emergency works** to avoid the loss of life or damage to property, or to prevent environmental harm
- **Maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- **Public infrastructure works** that shorten the length of the project and are supported by the affected community
- Works where a proponent demonstrates and justifies **a need to operate outside the recommended standard hours**

In the case of the project, the MSCP can be assimilated to a public infrastructure works further to this the following can be considered as a justification as to why the works could be permitted outside of the recommended standard hours (Saturday 8am-5pm):

- The quantitative results of the noise and vibration impact assessment presented in Section 10 of this report demonstrates that none of the main construction phases of the proposed MSCP exceeds the established noise criteria during standard hours of construction, in fact the results shows that all activities conservatively comply with the established criteria. If we are assuming that outside of standard hours construction have the potential to greater impact the surrounding community or occupants of adjacent buildings to the construction site, the results presented in Section 10.1.5 shows that lower noise levels will be achieved. Indeed, the ICNG recommends a more stringent criteria for construction works conducted outside standard working hours for residential receivers. The nearest external resident receiver (R1) has been assessed in Section 10.1 against both the standard hours and the OOHW and no exceedances are predicted.
- The surrounding residential receivers respectively R1 are located approximately 80m from the construction site. These distances eliminate the risk for any vibration impact. Hoarding has been proposed in Section 12.1 to mitigate noise disturbance to the nearby receiver.

All these factors considered, clearly indicate that the risks for noise and vibration impact associated with conducting construction works outside of standard hours (nominally on Saturdays between 8am and 5pm) on the surrounding community and adjacent occupant of surrounding buildings are minimal.

Further to the above, previous works within the precinct and within close proximity to the MSCP were successfully conducted under the Environmental Planning and Assessment (COVID Development - Construction work days) 2020 Ministerial Order, works are permitted under the outlined following conditions:

> *"(2) The conditions specified for the development are that the development must-*
>
> *(a) Be the subject of a development consent, and*

(b) Comply with all conditions of the consent other than any condition that restricts the hours of work or operation on a Saturday, Sunday or public holidays, and

(i) Comply with the conditions of the consent that restrict the house of work or operation on any other days as if the conditions applied to work or operation on a Saturday, Sunday or public holiday, and

(ii) Not involve the carrying out of rock breaking, rock hammering, sheet piling, pile driving or similar activities during the hours of work or operation that would not be permitted but for this Order, and

(iii) Take all feasible and reasonable measures to minimise noise."

The assessment undertaken in Section 10, demonstrates compliance with the Ministerial Order, following conditions set, and criteria outlined by the ICNG during the out of hours works (OOHW).

The Parramatta Council DCP (2011) also requires a Construction Noise and Vibration Management Plan to be prepared, which will outline the exact procedures and processes required to properly manage the process. This should be prepared prior to the commencement of construction of the proposed development.

The noise criteria associated with construction and its related activities are shown in Table 13, as presented in Section 4.1.1 Table 2 of the ICNG.

Table 13: 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.

Time of Day	Management Level $L_{Aeq,15min}$	How to Apply
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 14 below (Section 4.1.2 and 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 point within 50 m of the area boundary for recreation areas and at the most affected occupied point for commercial and industrial uses. In general, the internal criteria can be converted to external criteria by adding 10 dB as advised in the ICNG.

Table 14: Construction Noise Criteria for Other Land Uses

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilised
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Offices	External noise level 70 dB(A)
Short-term Accommodation	Internal noise level 35 dB(A)

Based on the criteria in the tables above, the following noise management levels in Table 14 should be applied to all receivers outlined in Section 6.5. Construction during standard hours has been assumed.

Table 15: Project Specific Construction Noise Management Levels

Receiver	Location of Receiver(s)	Management Level, $L_{Aeq,15min}$
Residential	R1	RBL + 10dB = **52 dB(A)**
Short-term accommodation	S1	Internal noise level **35 dB(A)**
Hospital wards and operating theatres (including Labs)	H1	Internal noise level **45 dB(A)**
Mental health wards	H2	Internal noise level **45 dB(A)**
Commercial	C1, C2 Office Spaces of H1 & H2	External noise level **70 dB(A)**

8.2 Construction Vibration

8.2.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day. The vibration emitted from construction works should be such that it does not exceed the maximum limits set out in the criteria presented in Table 9 to Table 12. 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 summarised in Table 16.

Table 16: 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
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences & Short-term Accommodation	Daytime Night time	0.010 0.007	0.0071 0.005	0.020 0.014	0.014 0.010
Offices	Day or night time	0.020	0.014	0.040	0.028
Impulsive Vibration		z axis	x and y axis	z axis	x and y axis
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences & Short-term Accommodation	Daytime Night time	0.30 0.10	0.21 0.071	0.60 0.20	0.42 0.14
Offices	Day or night time	0.64	0.46	1.28	0.92

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 17.

Table 17: Acceptable Vibration Dose Values for Intermittent Vibration (1.75 m/s)

Location	Daytime		Night time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences & Short-term Accommodation	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

8.2.2 Structural Damage

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 18

Table 18: 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 12 indicates the vibration limits presented in DIN 4150-Part 3 to ensure structural damage does not occur.

Table 19: Guideline Value of Vibration Velocity (v_i) for Evaluating the Effects of Short-Term Vibration – DIN 4150-Part 3

Line	Type of Structure	Vibration velocity, v_i, in mm/s			
		Foundation 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.					

9. Operational Noise and Vibration Assessment

9.1 Noise Considerations

The following activities have been identified as being likely to generate noise with the potential to impact the surrounding environment. These noise sources include:

- Intermittent noise from activities such as;
  - Loading cars
  - Slamming doors
  - Patrons talking whilst walking to and from vehicles
  - traffic noise from car movements entering and exiting the carpark

As predicted traffic movements have not been finalised, an indicative assessment has been conducted.

9.2 Carpark Noise Emission Impact Assessment

The predicted noise emissions generated from the car park has been calculated based on the predicted car movements and spaces presented in the Traffic Impact Assessment report by WSP dated 21 December 2020.

It is predicted that a total of:

- 446 cars are entering during the AM period (7:00am to 6:00pm)
- 300 cars exiting during the evening period (6:00pm to 10:00pm)
- 300 cars exiting during the PM period (10:00pm to 7:00am)

These traffic movements and activities have been assessed using a 15-minute period for both the daytime and night-time movements, as required by the Noise Policy for Industry criterion (see Section 7.2.2) . The following assumptions have been made:

- Approximately 1,000 parking bays are available
- Evening period (6pm – 10pm) as defined by the NPI has used the same predicted movements as included in the PM period (10pm – 7am) of the WSP Traffic impact Assessment report
- The Night-time period as defined by the NPI will operate at 70% of the movements predicted for the evening (PM) period
- Worst-case 15-minute period events during peak hour:
    - AM (NPI day-time period)
        i. 112 car doors slamming closed (96dB L_{Amax})
        ii. 56 car engines starting (90dB L_{Amax})
        iii. 112 cars movements (90dB L_{Amax})
    - PM (NPI evening period)
        i. 75 car doors slamming closed (96dB L_{Amax})
        ii. 19 car engines starting (90dB L_{Amax})
        iii. 75 cars movements (90dB L_{Amax})
    - NPI night-time
        i. 53 car doors slamming closed (96dB L_{Amax})
        ii. 13 car engines starting (90dB L_{Amax})
        iii. 53 cars movements (90dB L_{Amax})
- Majority of the carpark activities and movements occur on Level 1 (carpark fills capacity from Level 1 through to Level 9)
- Smooth concrete car park surface
- Façade of carpark achieves a sound reduction of approximately 5dB of mitigation.
- Closed windows (non-operable windows) are installed at receiver H2. Glazing system is assumed to be 6mm Glass (R_w30)
- A sleeping clinic has been identified on Level 2 within receiver H2

The predicted noise level at the nearest sensitive receivers are outlined below:

Table 20: Predict noise level from the proposed multi-storey carpark

Receiver ID	NPI Criteria PTNL dB(A)	Period	Predicted Noise ($L_{Aeq,15mins}$) Level No mitigation	Predicted Noise Level ($L_{Aeq,15mins}$) with mitigation	Complies? (Yes/No)
R1	48	Day	45	40	Yes
	43	Evening	43	38	Yes
	38	Night	42	37	Yes, with mitigation
S1	53	Day	49	44	Yes
	48	Evening	47	42	Yes
	43	Night	47	42	Yes, with mitigation
H1	30 (Internal)	Day	18[1]	13[1]	Yes
		Evening	17[1]	12[1]	Yes
		Night	16[1]	11[1]	Yes
H2	30 (Internal)	Day	26[1]	21[1]	Yes
		Evening	25[1]	20[1]	Yes
		Night	24[1]	19[1]	Yes
		Night (Sleep Clinic)	24[1]	19[1]	Yes
C1	60	Day	45	40	Yes
		Evening	44	39	Yes
		Night	43	38	Yes
C2	60	Day	37	32	Yes
		Evening	35	30	Yes
		Night	34	29	Yes

Note 1: Transmission loss through the façade of receiver has been assumed. Glazing system is assumed to be 6mm Glass (Rw30)

As part of the SEARs requirement a quantitative assessment of the main sources of operational noise, including vehicles using the carpark after hours has been conducted above to each receiver, the night-time criteria outlined above in Table 20 would be considered after hours.

9.3 External Noise Intrusion Impact Assessment

In order to provide acoustic amenity to occupants of the proposed development and comply with the project specific internal noise limits, as presented in Section 7.1.

As outlined in Section 7.1, there are not specific internal noise requirements outlined by the SEPP for the proposed development, a non-habitable space. The assessment criteria would have to be conducted to the Australian Standard (AS2107:2016 refer to Table 21. This table applies to an enclosed carpark, which the proposed development would be considered a semi-open multistory carpark, with 50% of the façade being open.

Table 21: Recommended design sound levels for building interiors (AS2107:2016)

Type of occupancy/activity	Design sound level ($L_{Aeq,t}$) range
Enclosed Carpark	< 65

Due to the internal noise limits being generated by the operation of the carpark exceeding the external noise generated by Redbank Road, it would not be considered to affect the acoustic amenity of the occupants within the proposed development.

No additional treatment to the façade is required to achieve internal acoustic amenity for occupants.

10. Construction Noise and Vibration Assessment

10.1 Construction Noise Assessment

10.1.1 Proposed Construction Activities

In this assessment, the noise impact from the construction works is considered. The construction works are expected to occur during the following hours:

- Mon to Fri: 7am to 6pm
- Saturday – 8am to 5pm
- Safety inspections are permitted from 7:00am

Works are not usually permitted under the standard hours outlined in the ICNG, however with the Environmental Planning and Assessment (COVID Development - Construction work days) 2020 Ministerial Order (Refer to Section 8.1), works are permitted under the outlined following conditions:

> *"(2) The conditions specified for the development are that the development must-*
>
> *(c) Be the subject of a development consent, and*
>
> *(d) Comply with all conditions of the consent other than any condition that restricts the hours of work or operation on a Saturday, Sunday or public holidays, and*
>
> *(iv) Comply with the conditions of the consent that restrict the house of work or operation on any other days as if the conditions applied to work or operation on a Saturday, Sunday or public holiday, and*
>
> *(v) Not involve the carrying out of rock breaking, rock hammering, sheet piling, pile driving or similar activities during the hours of work or operation that would not be permitted but for this Order, and*
>
> *(vi) Take all feasible and reasonable measures to minimise noise."*

The hours for construction are consistent with the Environmental Planning and Assessment (COVID Development - Construction workdays) 2020 Ministerial Order. The assessment undertaken in Section 10.1, demonstrates compliance with the Ministerial Order, following conditions set, and criteria outlined by the ICNG during the out of hours works (OOHW).

10.1.2 Precinct Segments and Construction Description

It is to our understanding that the construction stages are to proceed as outlined below.

- Early Works – Demolition & Dismantle
- Excavation, Retention and Foundation
- Structural Works
- Façade

10.1.3 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 22. The equipment noise levels have been extracted from AS 2436:2010 Guide to *Noise and Vibration Control on Construction, Demolition and Maintenance Sites.*

Table 22: Cumulative impact - Construction equipment noise levels

Phases	Equipment	Quantity	Sound Power Level – dB(A)	Acoustical Usage Factor (%)	Usage in 15-minute period (minutes)	Time Corrected Sound Power Level ($L_{Aeq,15min}$)
Early Works – Demolition & Dismantle	Jackhammer	1	113	20	3	106
	Electric hand tools	4	102	50	7.5	99
	Excavator 30 tonne	1	110	40	6	106
	Excavator breaker	1	115	40	6	111
	Dump truck	2	108	40	6	104
Excavation, Retention and Foundation	Excavator 30 tonne	1	110	40	6	106
	Jackhammer	1	113	20	3	106
	Powered hand tool	4	102	50	7.5	99
	Concrete pump	1	109	50	7.5	106
	Mobile crane	2	110	16	2.4	102
	Bored piling	1	110	16	2.4	102
	Generator	1	104	20	3	97
	Truck	2	108	40	6	104
Structural Works	Powered hand tool	4	102	50	7.5	99
	Concrete pump	1	109	50	7.5	106
	Mobile crane	2	110	16	2.4	102
	Bored piling	1	110	16	2.4	102
	Generator	1	104	20	3	97
	Truck	2	108	40	6	104
Structural Works & Façade	Powered hand tool	11	102	50	7.5	99
	Concrete pump	1	109	50	7.5	106
	Mobile crane	2	110	16	2.4	102

10.1.4 Noise Modelling and Assumptions

To assess the noise impact from the site during the various construction stages, a noise model was prepared using commercial software SoundPLAN v8.2, 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 between the source and receivers, and the construction plant and equipment were positioned as noise sources.

The locations of these noise sources were positioned within the model so that the worst case scenario is all equipment are placed to the nearest boundary in the construction site, and best case being furthest from the nearest boundary. 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 assumptions that were made within the assessment include the following:

- The mitigation measures outlined in Section 12 are implemented.
- Neutral weather conditions.
- The worst and average case were considered by placing all plant and equipment on the closest boundary to the receiver and in the middle of the site respectively.

10.1.5 Predicted Noise Levels

The maximum predicted noise levels have been presented in Table 23, Table 24, Table 25, and Table 26 have been assessed to the construction noise criteria established in Section 8.1.1. The noise contour maps produced by the three-dimensional noise propagation modelling are provided in Appendix B.

Table 23: Predicted noise levels – Scenario 1: Early Works – Demolition & Dismantle

Receiver	Predicted Worst-Case Noise Level - Without Mitigation $L_{Aeq,15min}$	Predicted Worst-Case Noise Level - With Mitigation $L_{Aeq,15min}$	Noise Management Level $L_{Aeq,15min}$	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
H1	58 – 64	24 – 32	45 (Internal)	-	No
H2	54 – 61	34 – 38	45 (Internal)	-	No
S1	63 – 68	33 – 34	35 (Internal)	12	No
R1	55 – 66	53 – 62	52	10	No
C1	57 – 66	55 – 65	70	-	No
C2	55 - 63	53 – 62	70	-	No

Note 1: For the internal predicted noise levels presented in the table, it has been assumed windows are not operable. Glazing assumed to be 6mm thick, achieving R_w30. With the short term accommodation (S1) being airconditioned (therefore windows closed)

Table 24: Predicted noise levels – Scenario 2: Excavation, Retention & Foundations

Receiver	Predicted Noise Level - Without Mitigation $L_{Aeq,15min}$	Predicted Noise Level - With Mitigation $L_{Aeq,15min}$	Noise Management Level $L_{Aeq,15min}$	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
H1	56 – 64	25 – 29	45 (Internal)	-	No
H2	64 – 68	28 – 38	45 (Internal)	-	No
S1	63 – 64	30 – 33	35 (Internal)	-	No
R1	55 – 62	54 – 62	52	10	No
C1	56 – 62	55 – 62	70	-	No
C2	54 – 59	53 - 59	70	-	No

Note 1: For the internal predicted noise levels presented in the table, it has been assumed windows are not operable. Glazing assumed to be 6mm thick, achieving R_w30. With the short term accommodation (S1) being airconditioned (therefore windows closed)

Table 25: Predicted noise levels – Scenario 3: Structural Works

Receiver	Predicted Noise Level - Without Mitigation $L_{Aeq,15min}$	Predicted Noise Level - With Mitigation $L_{Aeq,15min}$	Noise Management Level $L_{Aeq,15min}$	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
H1	55 – 62	23 – 28	45 (Internal)	-	No
H2	64 – 68	29 – 38	45 (Internal)	-	No
S1	60 – 62	25 – 31	35 (Internal)	-	No
R1	53 – 61	52 – 60	52	8	No
C1	54 – 61	53 – 60	70	-	No
C2	52 – 58	52 – 58	70	-	No

Note 1: For the internal predicted noise levels presented in the table, it has been assumed windows are not operable. Glazing assumed to be 6mm thick, achieving R_w30. With the short term accommodation (S1) being airconditioned (therefore windows closed)

Table 26: Predicted noise levels – Scenario 5: Façade and Finishes

Receiver	Predicted Noise Level - Without Mitigation $L_{Aeq,15min}$	Predicted Noise Level - With Mitigation $L_{Aeq,15min}$	Noise Management Level $L_{Aeq,15min}$	Noise Management Level Exceedance (dB)	Exceeds Highly Noise Affected Level? (> 75dBA)
H1	56 – 63	24 – 30	45 (Internal)	-	No
H2	64 – 69	30 – 35	45 (Internal)	-	No
S1	61 – 63	30 – 31	35 (Internal)	-	No
R1	55 – 60	55 – 59	52	7	No
C1	55 – 60	55 – 60	70	-	No
C2	54 – 58	53 – 55	70	-	No

Note 1: For the internal predicted noise levels presented in the table, it has been assumed windows are not operable. Glazing assumed to be 6mm thick, achieving R_w30. With the short term accommodation (S1) being airconditioned (therefore windows closed)

Given there is no exceedance in the highly noise noise-affected level (75 dB(A) at any receivers surrounding the proposed construction works (upon implementation of the mitigation measures outlined in Section 12) it is not expected there will be significant construction noise impacts on the surrounding noise-sensitive receivers.

10.1.6 Cumulative noise impact from construction works

The construction program indicates the following timing for construction:

- The MSCP construction will be occurring for the duration of the PSB construction
- The structure and façade works for the MSCP are proposed to occur from July 2022 to March 2023
- The PSB is proposed to occur from July 2022 to February 2024

Given that the MSCP and PSB are 250m apart and buildings that separate them provide acoustic shielding between the sites, the cumulative noise impact during simultaneous construction is negligible. During a worst-case scenario without mitigation, the PSB construction noise would be less than 30 dB(A) at the site of the MSCP and would not contribute to the noise level at receivers adjacent to the MSCP.

10.2 Construction Vibration Assessment

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type.

Generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the transport for NSW 'Construction Noise Strategy' document. This document presents the safe construction working limits for Cosmetic Damage to adjacent structures (in accordance with BS 7385) and Human Comfort (OH&E).

Table 27: Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Concrete Vibrator	<50 kN (Typically 1-2 tonnes)	5m	15m to 20m
CFA Piling Rig	≤ 800mm	2m (nominal)	N/A
Excavator with hydraulic hammer (15t)	(900kg – 12 to 18t excavator)	7m	23m

Concrete vibrators & excavators are not expected be used in close proximity to the nearby receivers and therefore no further mitigation measures are required. It is still advised that the general recommendations outlined in Section 12.2.5 are followed.

11. Operational Mitigation Measures

11.1 Carpark Noise Mitigation

To ensure that compliance with the EPA's Noise Policy for Industry it is recommended that the envelope of the carpark achieves a minimum rating of R_w 5dB, to be developed further in design stages with the appointed Façade Engineer. The insertion loss used for the assessment conducted in Section 9.2 is outlined in below:

Table 28: Minimum transmission loss requirements for carpark façade envelope

Required Transmission Loss– Octave Band Centre Frequency						
63Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
0	3	4	5	5	5	5

As part of the SEARs requirement a quantitative assessment of the main sources of operational noise, including vehicles using the carpark after hours has been conducted above to each receiver. The night-time criteria outlined in Table 20 would be considered after hours**.**

The predicted noise levels from the operation of the multi-storey carpark are expected to comply with the criteria set by the NPI (Section 7.2.2). No further mitigation measures are required should the façade envelope meet the required sound reduction outlined in Table 28.

12. Construction Mitigation Measures

12.1 Project Specific Recommendations

Project specific recommendations and required mitigation methods have been listed below. For further noise mitigation and management measures refer to Section 12.2 in order to comply with the standards outlined in this report.

12.1.1 Noise

The excavators with the rock breaker attachment are predicted to produce the highest noise levels during the demolition and excavation phases at the surrounding most affected sensitive receivers.

The use of a standard 2.4 metre tall A-class hoarding of the following materials and construction will suffice to mitigate the impact of the highest predicted noise levels, erected around the construction site.

- 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

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 surrounding residents is also encouraged. More details regarding communication with the community can be found in Section 12.2

In addition, noise monitoring is recommended to be conducted at the most-affected noise-sensitive receivers in accordance with the monitoring program proposed in Section 12.4.4.

12.1.2 Vibration

Due to the proximity of demolition works to the S1 residential receivers, 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 8.2.

Upon any exceedances in vibration levels, reasonable and feasible measures should be considered to lessen the impact, such as alternative means of demolishing or reducing the capacity of the excavator to achieve a safe working distance. Using an excavator less than 18t would mean the safe working distance for structural damage can be achieved but the human comfort might still be exceeded. However, this would only occur for a small portion of work within the safe working distance.

CFA piling and other activities are not expected to result in the exceedance of vibration limits to the surrounding residential receivers, provided the safe working distances are complied with.

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.

12.2 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.

12.2.1 Noise

Figure 5 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 minimised. 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.

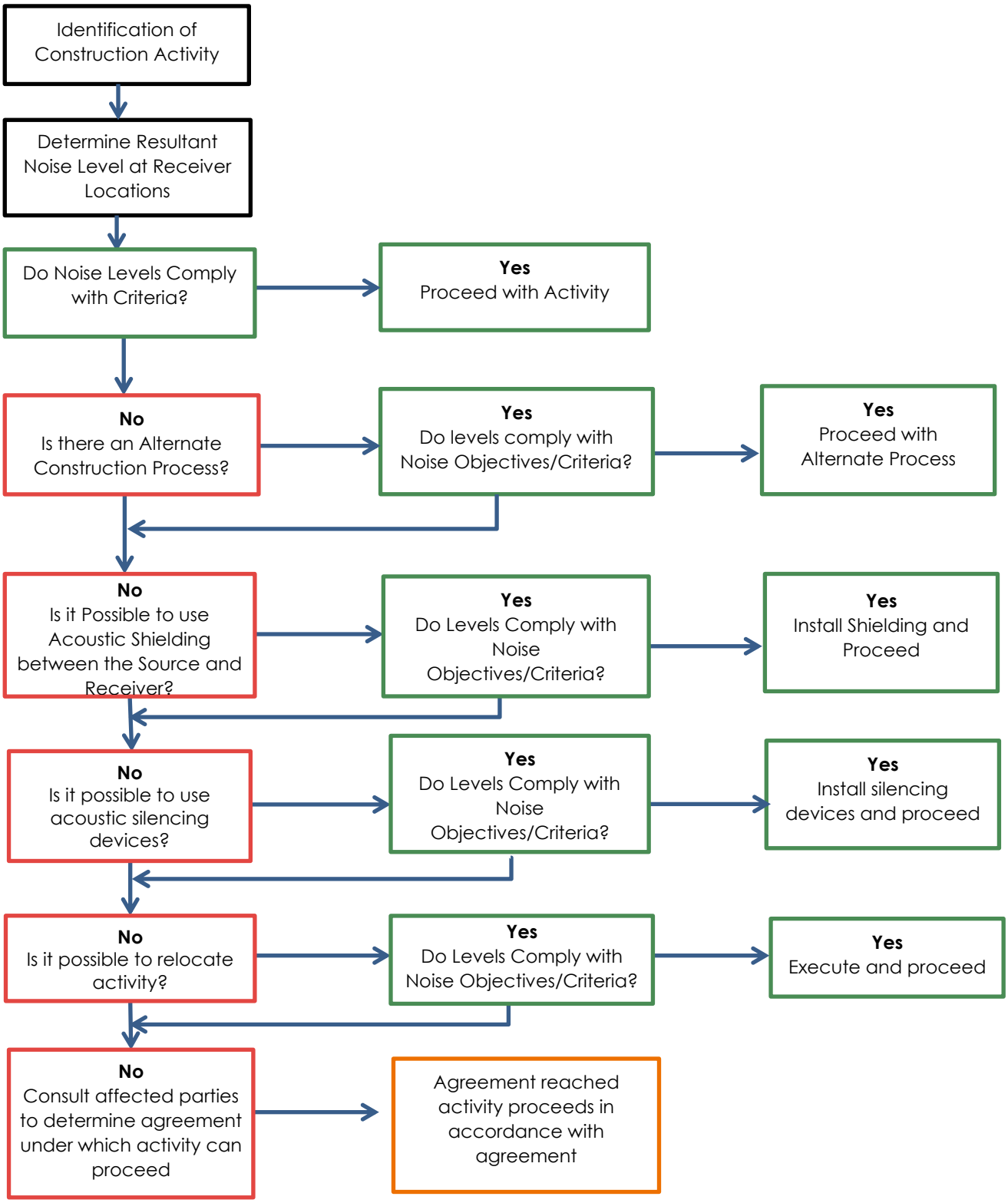


Figure 5: Noise Mitigation Management Flow Chart

12.2.2 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. Some examples of screening options for various situations are described below. Screening methods should be incorporated early in the site planning process where possible.

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 a hoarding that includes a site office on an elevated structure. This option offers superior noise reduction when compared with a standard, simple hoarding, as the hoarding can be higher, or if the site office is the barrier itself, it will have better acoustic isolation performance. . The acoustic performance is further enhanced when the hoarding is a continuous barrier, where the sound cannot refract around the sides of the hoarding.

Partial building structures: On some sites, partially completed or demolished buildings can be used as noise shields for certain equipment. A noisy, stationary item of plant can be placed in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is also necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficiency when operating the equipment.

Earth mounds and embankments: Where constructing noise barriers and using partial building shells is not practical, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen any noise sensitive areas from the plant. These mounds can often be designed into the construction schedule or site arrangement for future landscaping.

Long, temporary earth embankments can provide quite an effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed, if possible, with smaller quieter excavators. A noise barrier like this may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

Where earth noise barriers are not practical due to lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any equivalent material in surface density.

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 an item of 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.

12.2.3 Crane (diesel operated)

An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from the machine.

12.2.4 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.
- Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, provided that safety considerations are not compromised.
- 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.

12.2.5 Vibration

Vibration can be more difficult to control than noise, and there are few generalisations 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 be expected or predicted results, especially when considering the noise propagated from piling.

12.3 Complaint Handling Procedures and Community Liaison

Upon receipt of a complaint, it is recommended that the site foreman 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 Health Infrastructure 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 PwC/Health Infrastructure.
- PwC/Health Infrastructure 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 PwC/Health Infrastructure 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.

12.4 Noise & Vibration Monitoring Strategy

12.4.1 General Methodology

Noise and vibration levels should be monitored from time to time to ensure that noise generated as a result of demolition and construction activities does not disturb local residential, commercial and hospital noise sensitive receivers.

Monitoring may be in the form of regular checks by the contractor or indirectly by an acoustic consultant who is engaged by the Client, 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.

12.4.2 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.

12.4.3 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. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities through the Development Approval conditions.

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

12.4.4 Noise & Vibration Monitoring Program

As there is no predicted exceedances and the proximity and distance to the sensitive receivers however, it would be the responsibility of the main contractor to ensure that noise and vibration criteria outlined in this document are complied with.

13. Conclusion

This report presents the results of a study of operational and construction noise emission from the proposed multi-storey carpark development (MSCP) of the Children's Hospital at Westmead, NSW. This report forms a part of the documentation package to be submitted to the public authority (Health Infrastructure) as part of State Significant Development application process for the proposed development.

The environmental noise and vibration intrusion criteria for the operation and construction of the proposed development have been established based on the following policies and guidelines:

- NSW Noise Policy for Industry 2017 (NSW Environment Protection Authority (EPA)
- Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)
- Assessing Vibration: A Technical Guideline 2006 (Department of Environment and Conservation, 2006)

The establishment of the noise criteria was based on Stantec's noise survey, undertaken form 27th July 2020 to the 5th August 2020, which monitored ambient and background noise levels using both handheld sound level meters and long-term noise loggers at relevant locations close to the boundary of the potentially most-affected receivers.

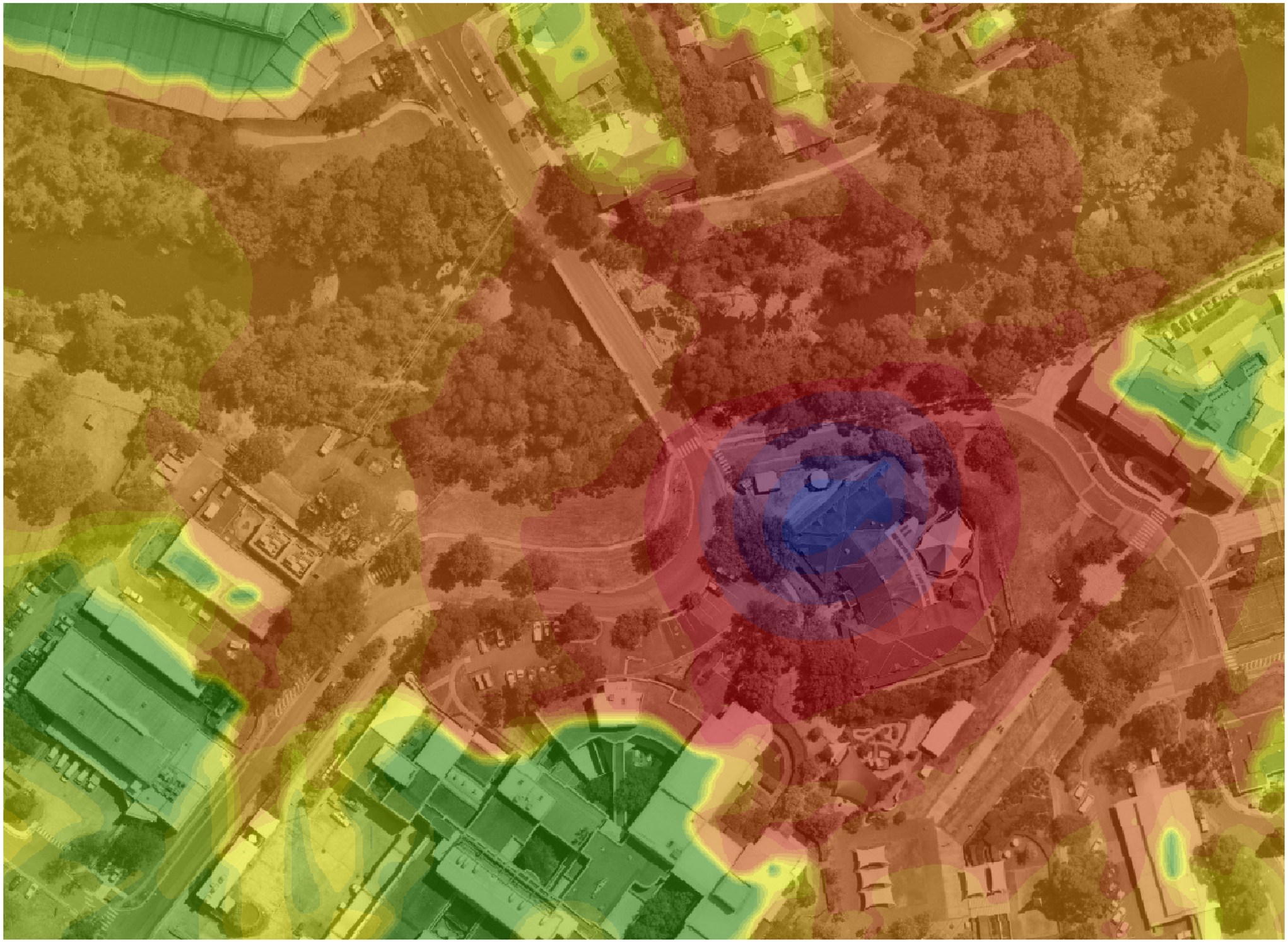
Should the noise and vibration mitigations measures are followed in this document, we expect that the operation and construction of the Multi-storey carpark (MSCP) should comply with established noise and vibration criteria outlined in Sections 7and 8 of this report

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 L90 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.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted “equivalent noise level” is the summation of noise events and integrated over a selected period of time.

LAeqT	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 Leq 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 Construction Noise Modelling Results – Noise Contour Maps



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001	SSDA Package	MIS	ORFG	22/01/21

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 32	40-44	52-56	64-68	80-84
32-36	44-48	56-60	68-72	84-88
36-40	48-52	60-64	76-80	> 88

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ARCHITECT/CLIENT

CHILDREN'S HOSPITAL AT WESTMEAD
MULTISTORY CARPARK (MSCP)

PROJECT

CONSTRUCTION NOISE EMISSIONS - DEMOLITION, NO MITIGATION
WORST CASE SCENARIO

TITLE

Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

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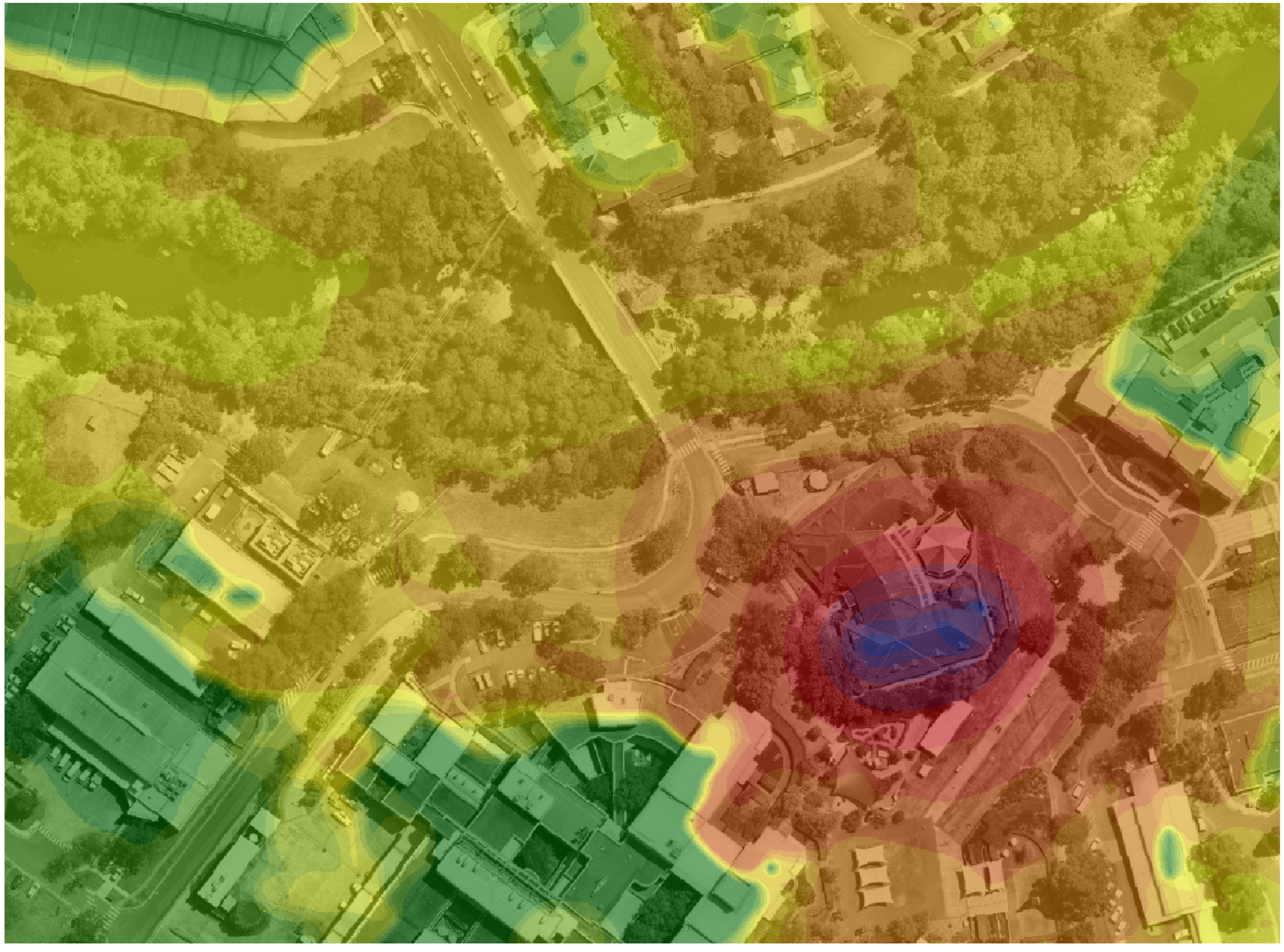

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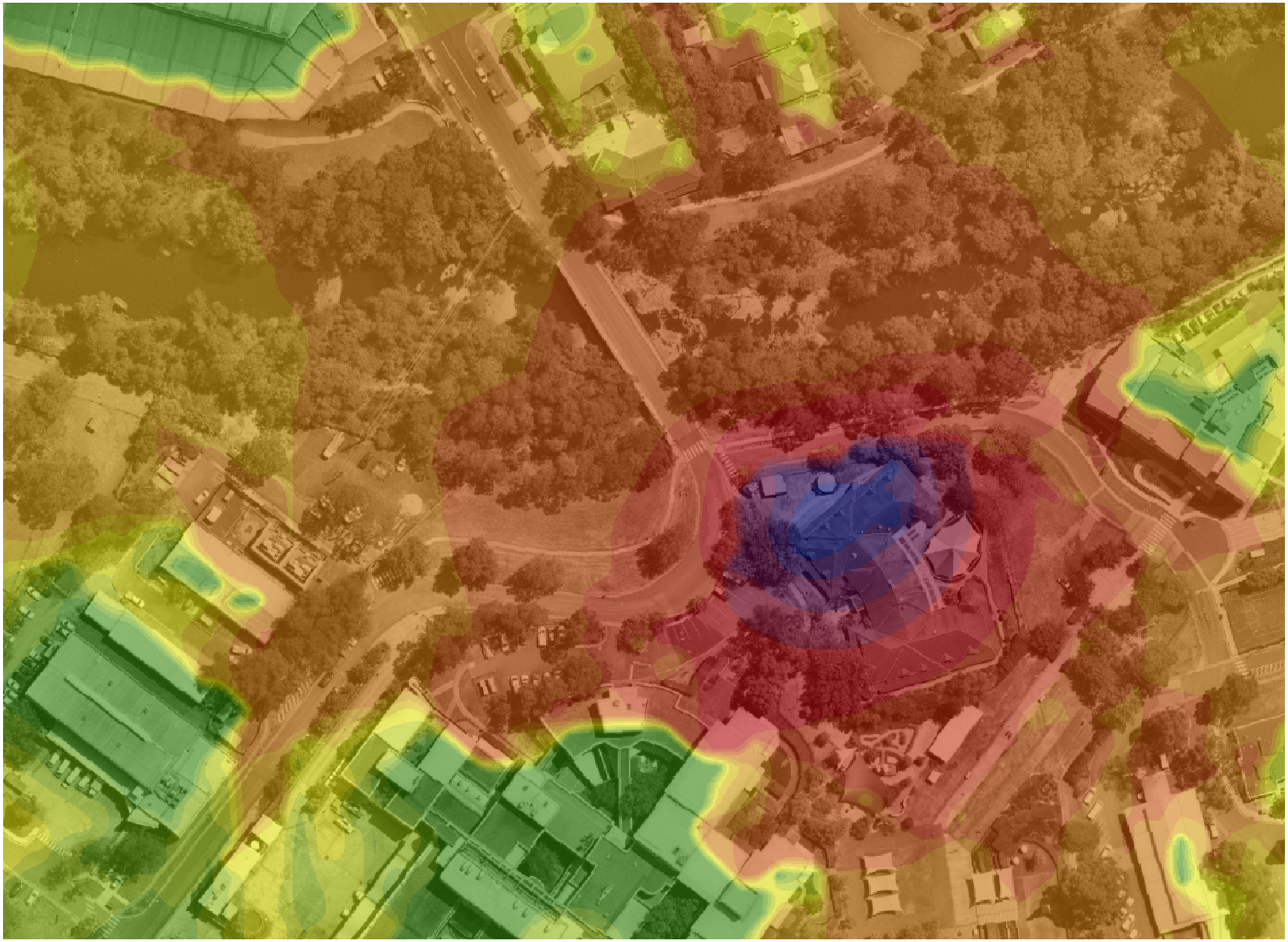

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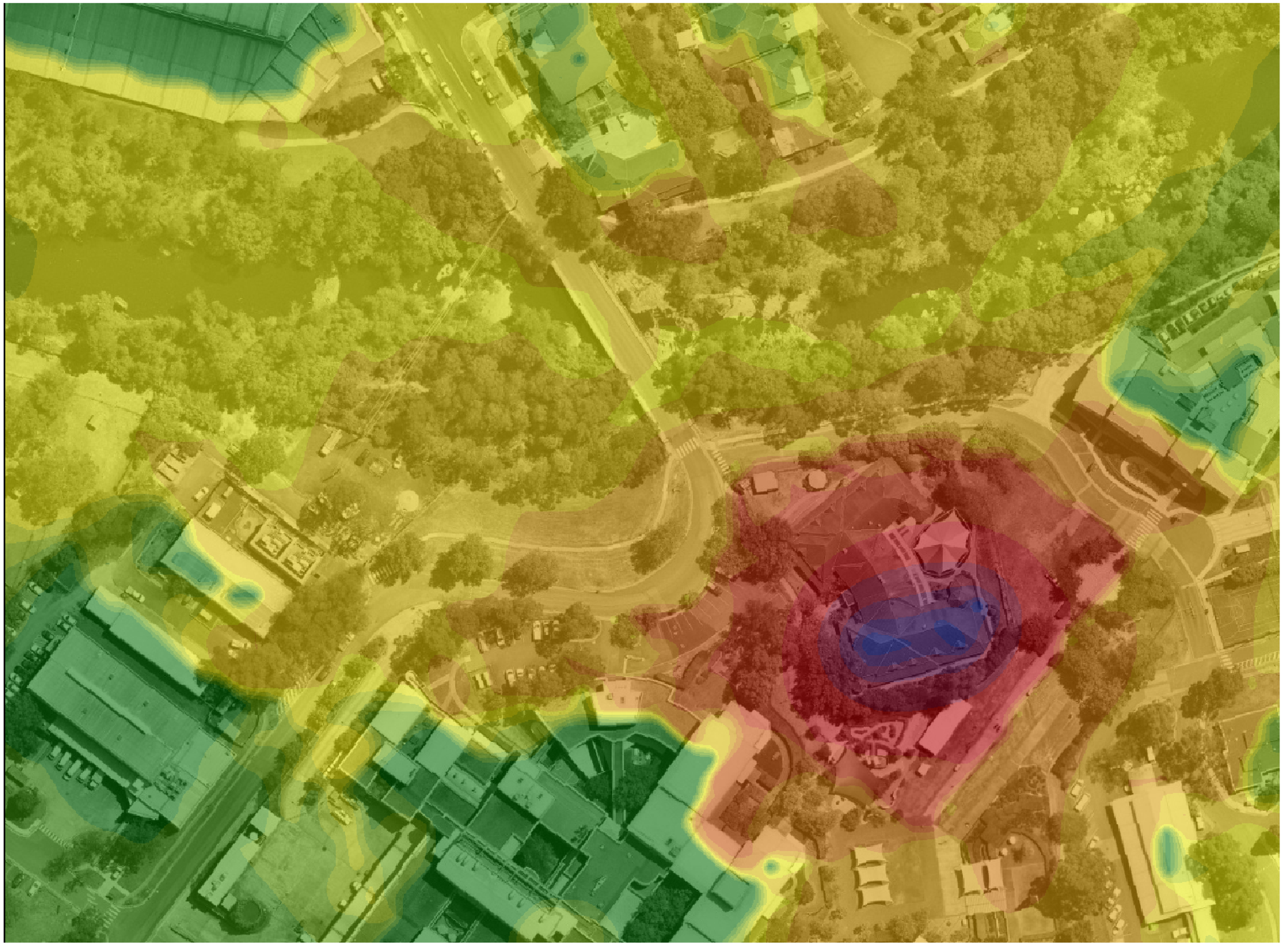

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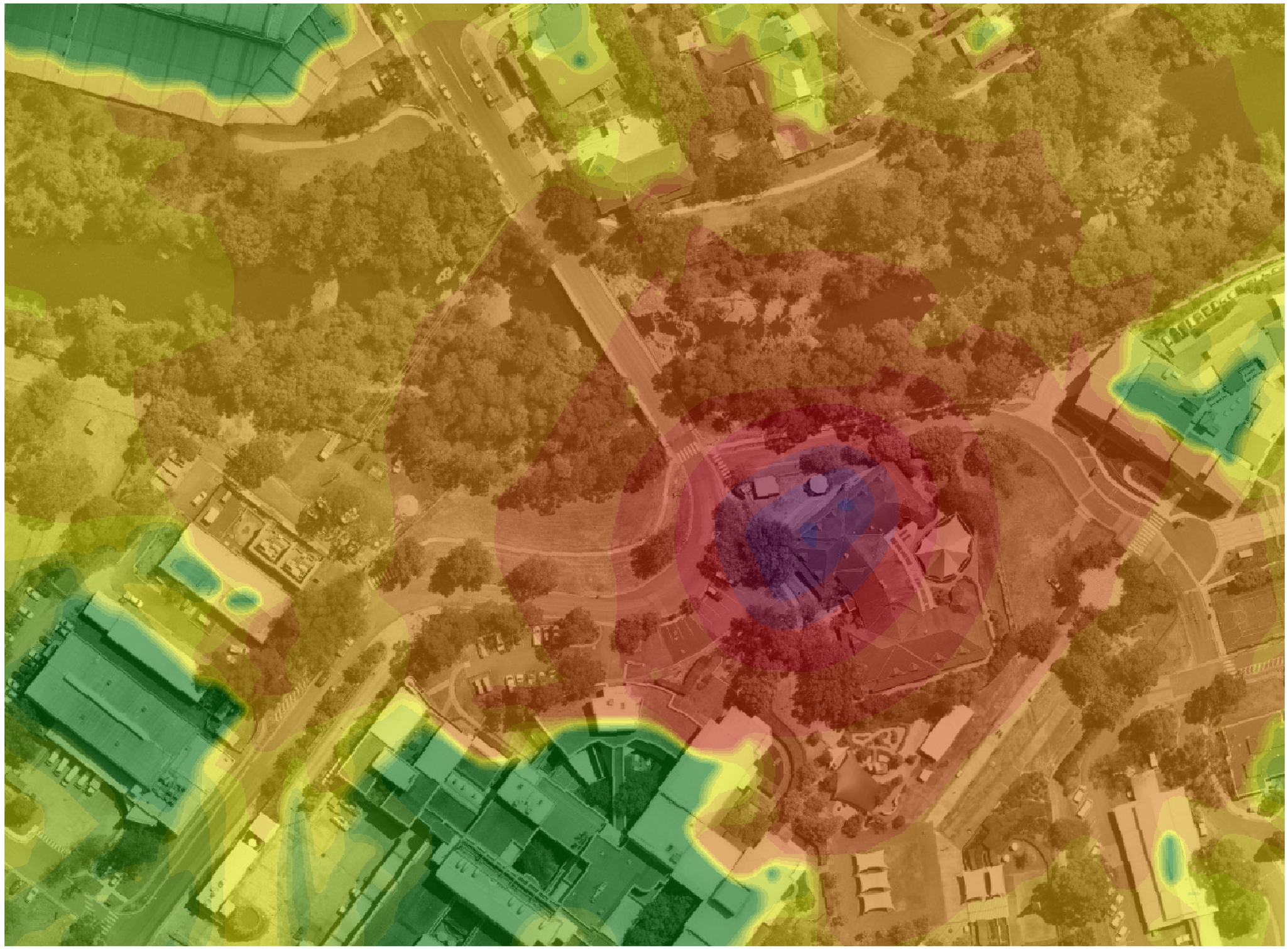

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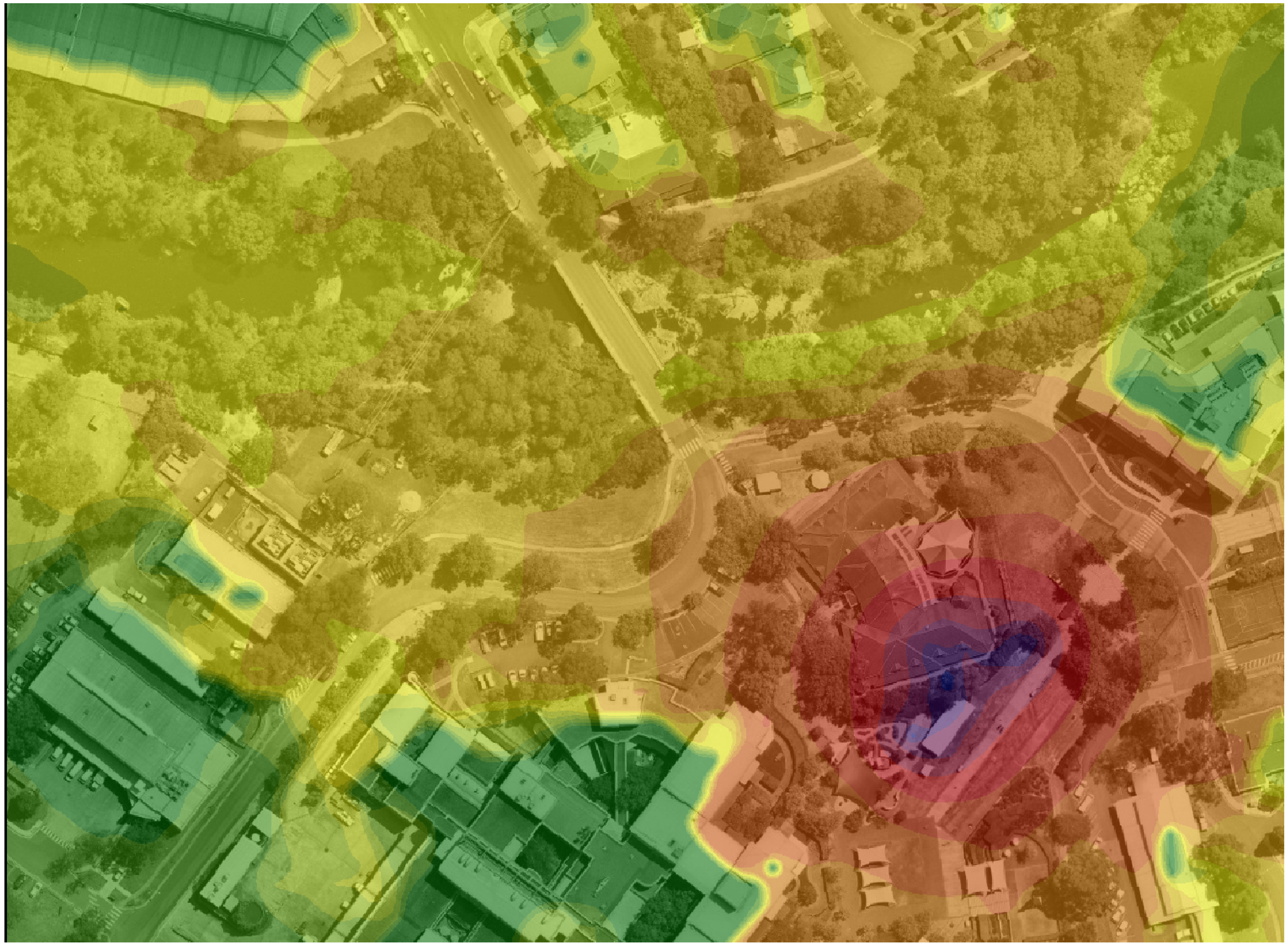

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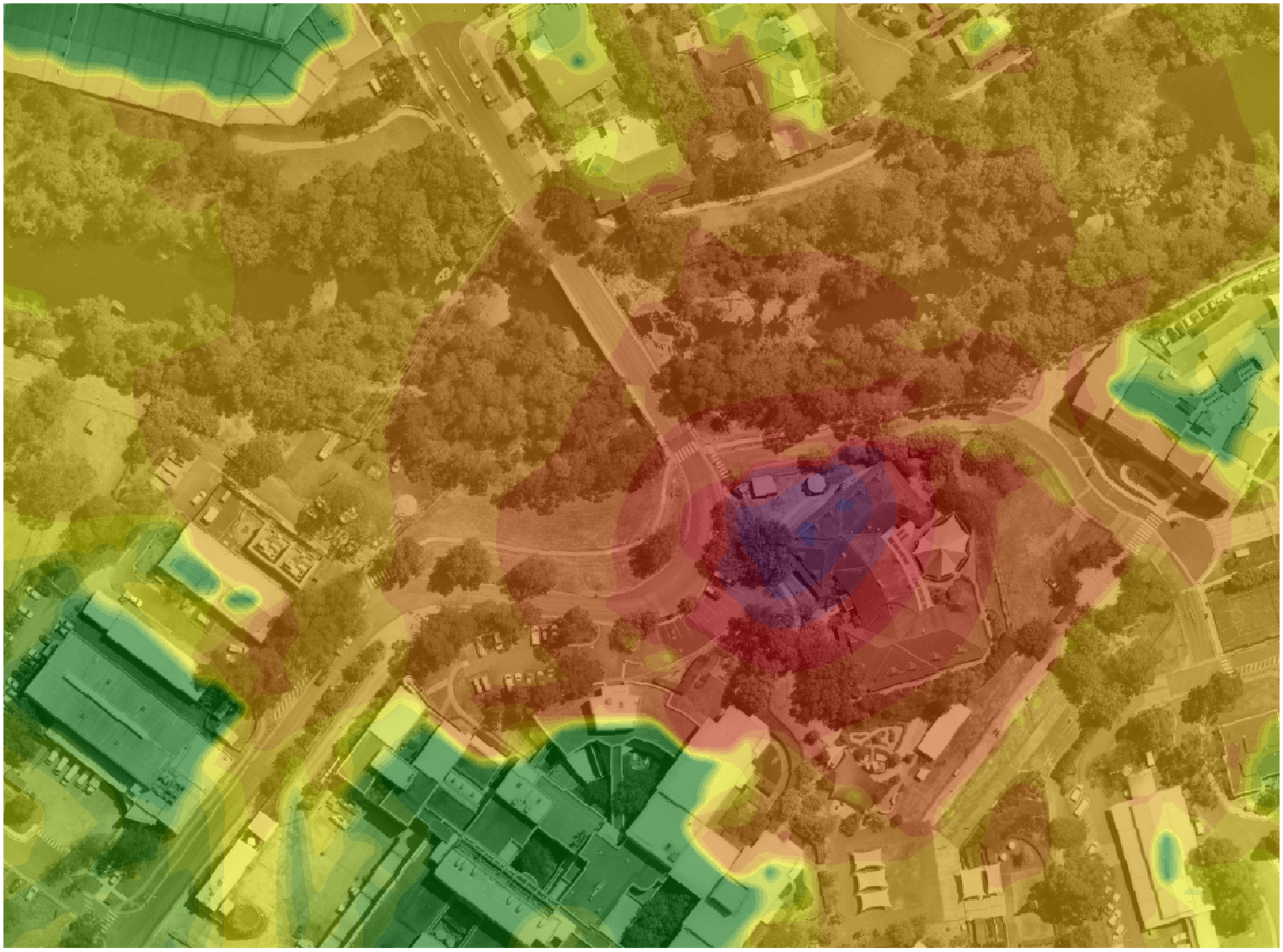

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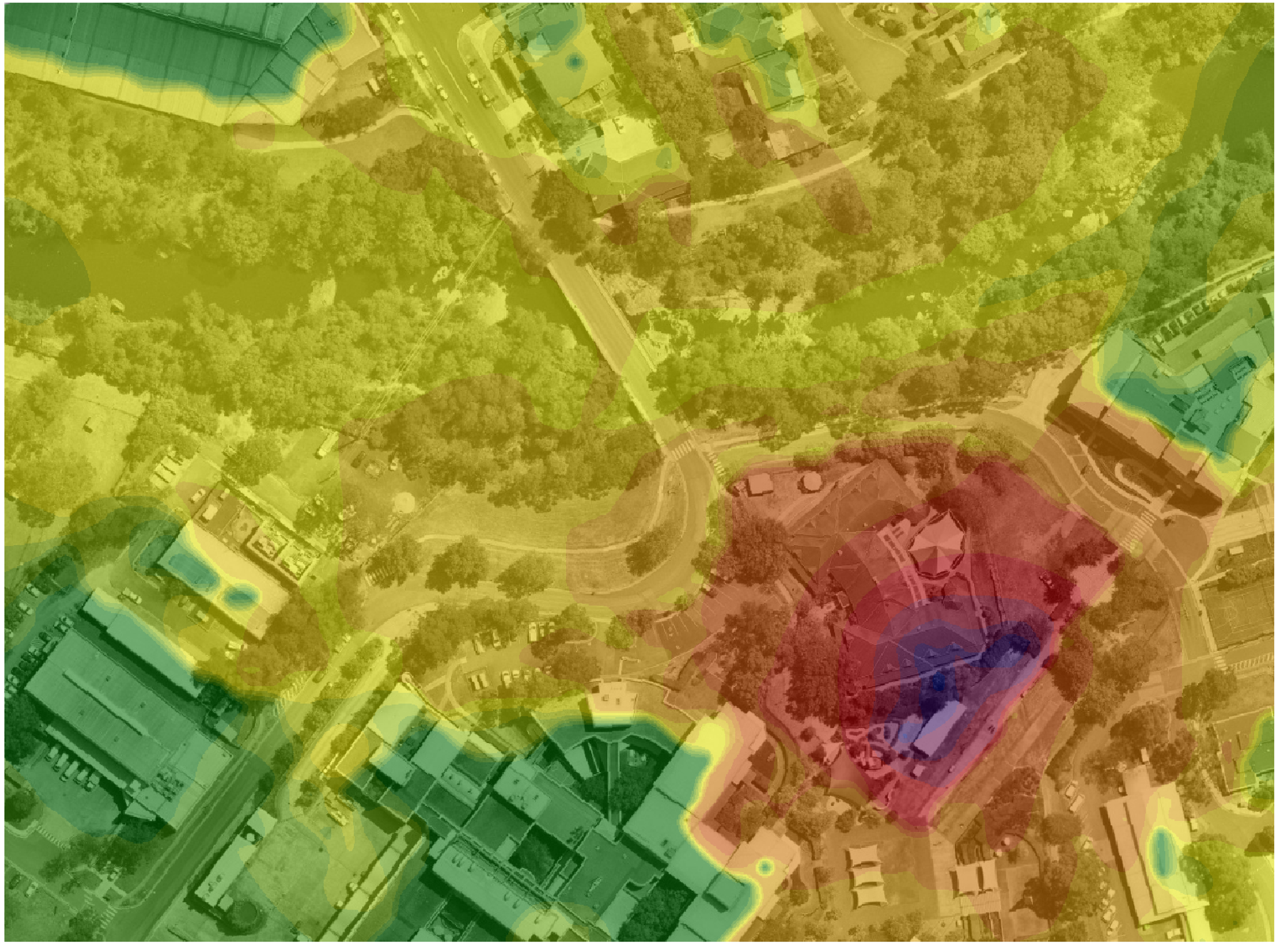

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TITLE: CONSTRUCTION NOISE EMISSIONS - EXCAVATION, MITIGATION BEST CASE SCENARIO

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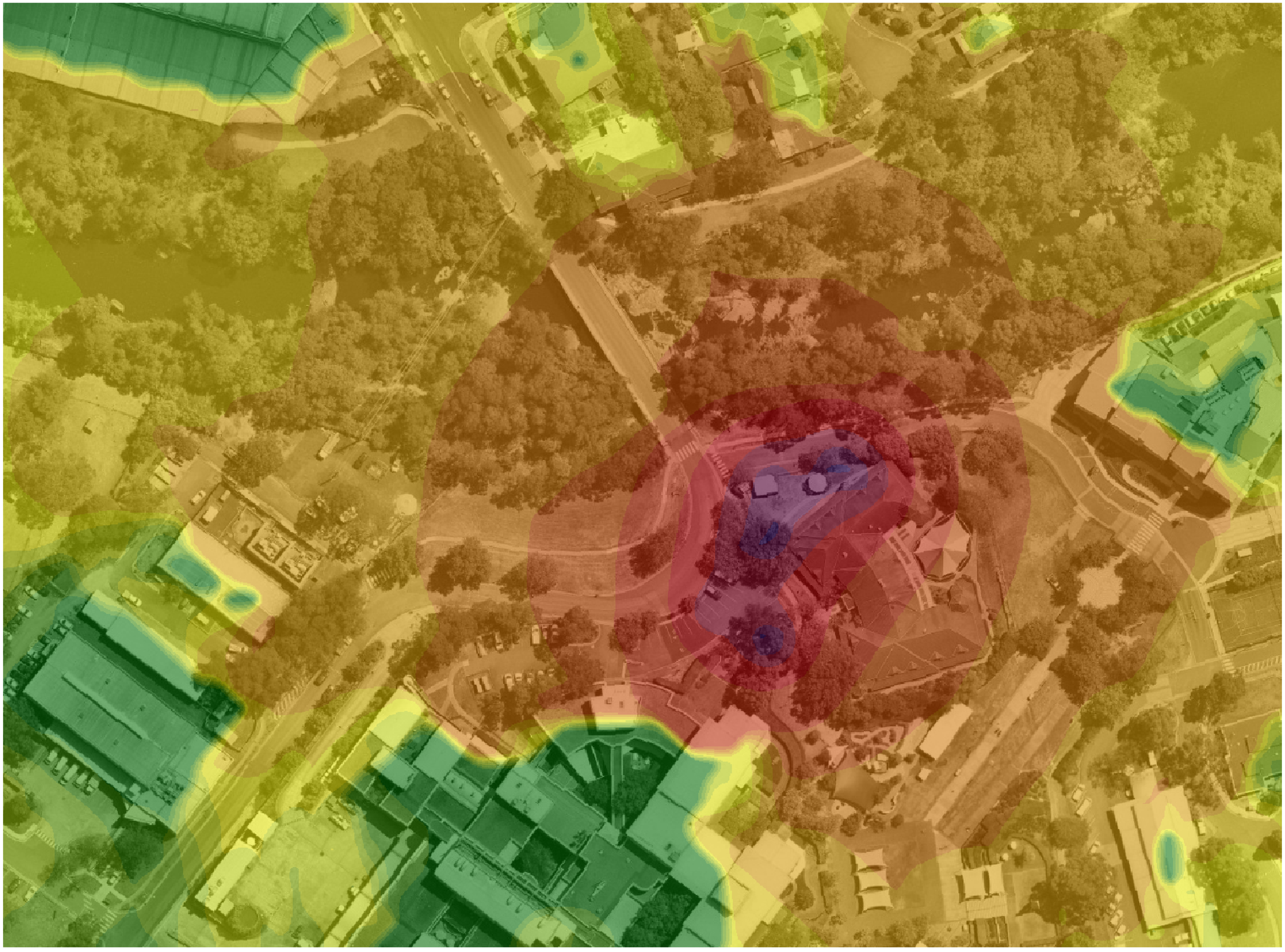
Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A3	PROJECT No	DRAWING No	REV
1:200	44311	MSCP-AC-GRM	001



Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 32	40-44	52-56	64-68	80-84
32-36	44-48	56-60	68-72	84-88
36-40	48-52	60-64	76-80	> 88

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REV	DESCRIPTION	DRAWN	APP'D	DATE
001	SSDA Package	MIS	ORFG	22/01/21

NSW GOVERNMENT Health Infrastructure
pwc
ARCHITECT/CLIENT

PROJECT: CHILDREN'S HOSPITAL AT WESTMEAD MULTISTORY CARPARK (MSCP)

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE, NO MITIGATION WORST CASE SCENARIO

Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

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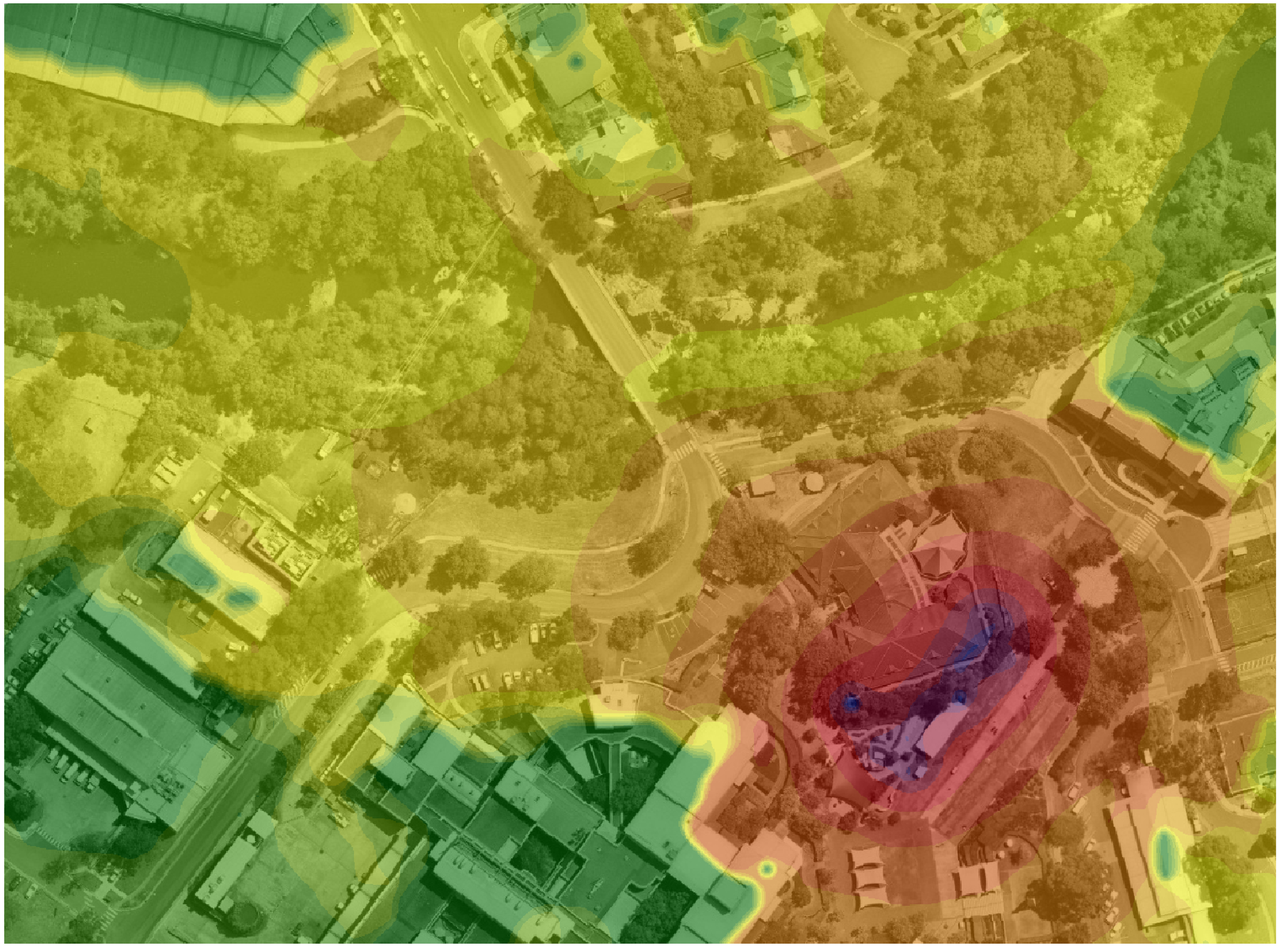

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ARCHITECT/CLIENT

PROJECT: CHILDREN'S HOSPITAL AT WESTMEAD MULTISTORY CARPARK (MSCP)

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE, NO MITIGATION BEST CASE SCENARIO

Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

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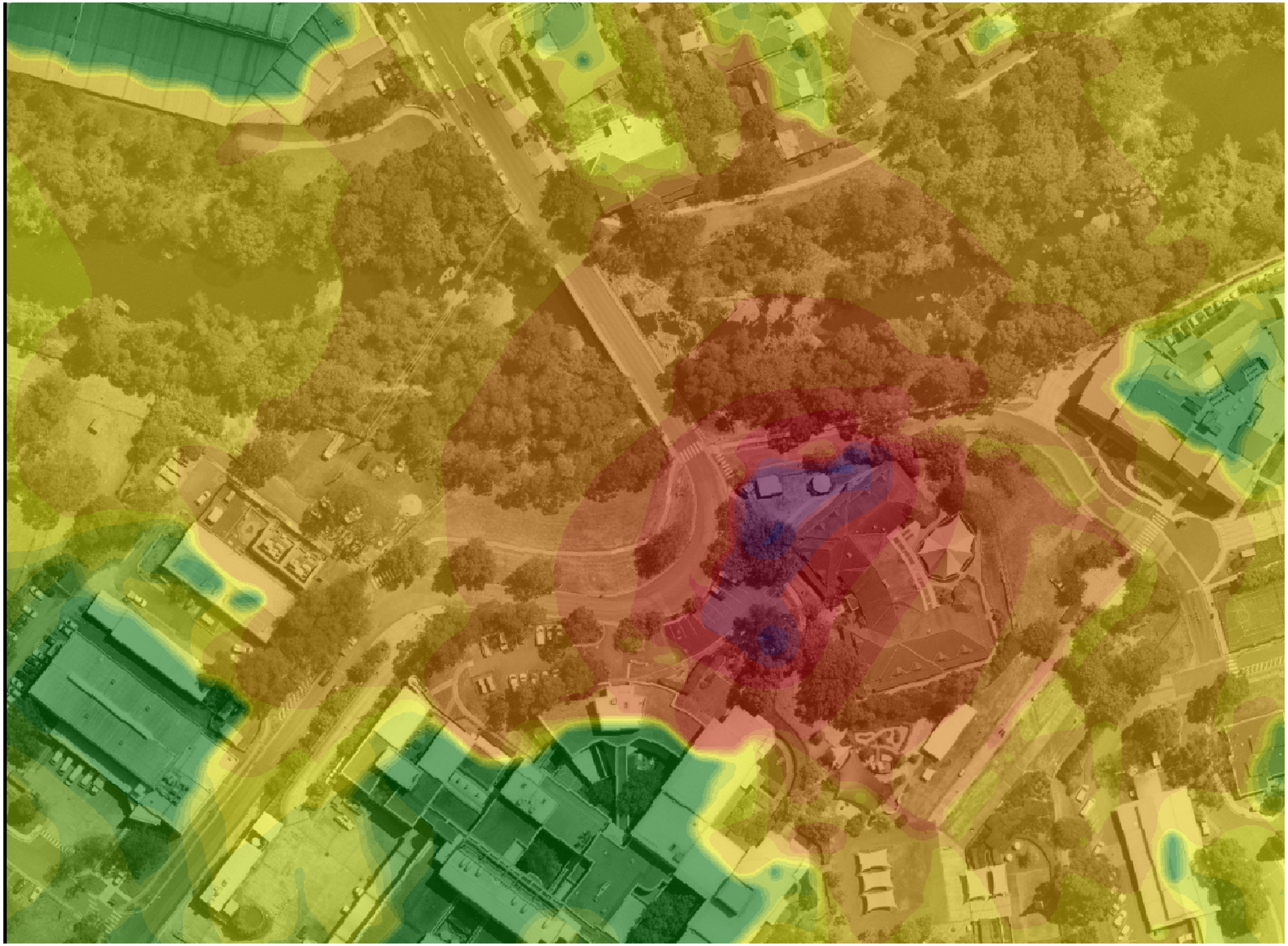

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PROJECT: CHILDREN'S HOSPITAL AT WESTMEAD MULTISTORY CARPARK (MSCP)

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE, MITIGATION WORST CASE SCENARIO

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Construction Noise Modelling Results

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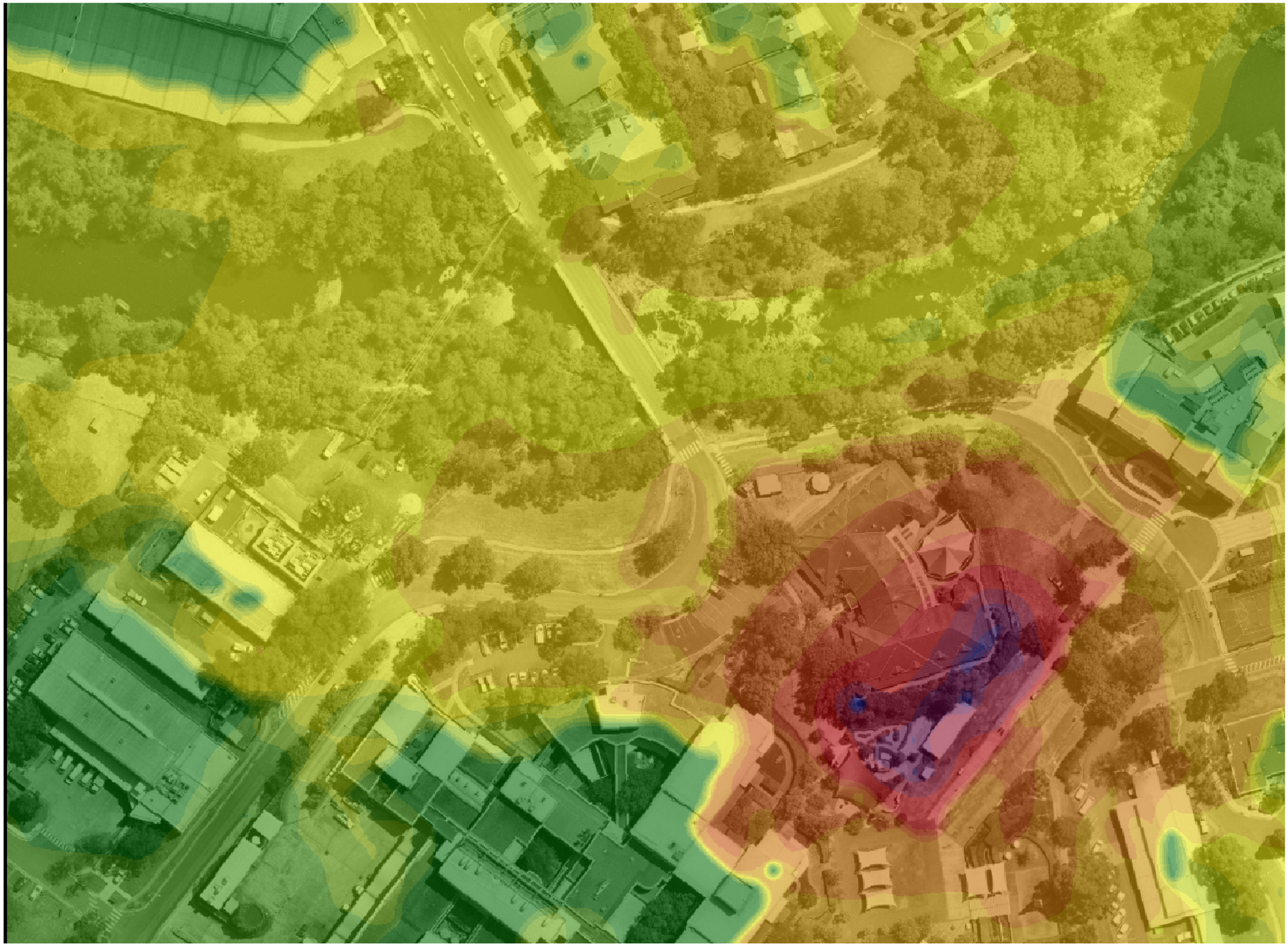

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NSW GOVERNMENT Health Infrastructure
pwc
ARCHITECT/CLIENT

CHILDREN'S HOSPITAL AT WESTMEAD
MULTISTORY CARPARK (MSCP)
PROJECT

CONSTRUCTION NOISE EMISSIONS - STRUCTURE, MITIGATION BEST CASE SCENARIO
TITLE

Stantec

Noise Model

Construction Noise Modelling Results

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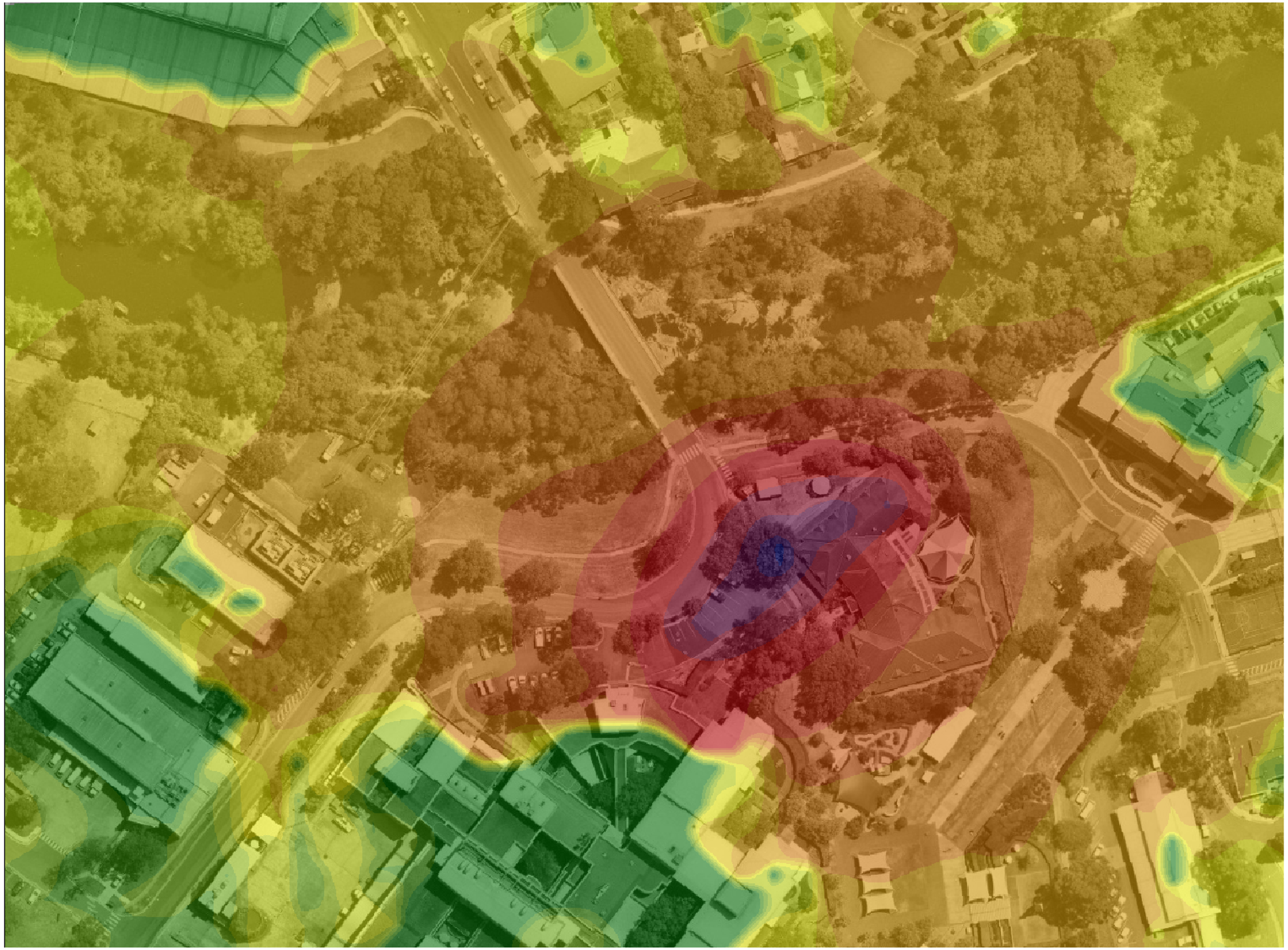

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ARCHITECT/CLIENT

PROJECT: CHILDREN'S HOSPITAL AT WESTMEAD MULTISTORY CARPARK (MSCP)

TITLE: CONSTRUCTION NOISE EMISSIONS - FACADE, NO MITIGATION WORST CASE SCENARIO

Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

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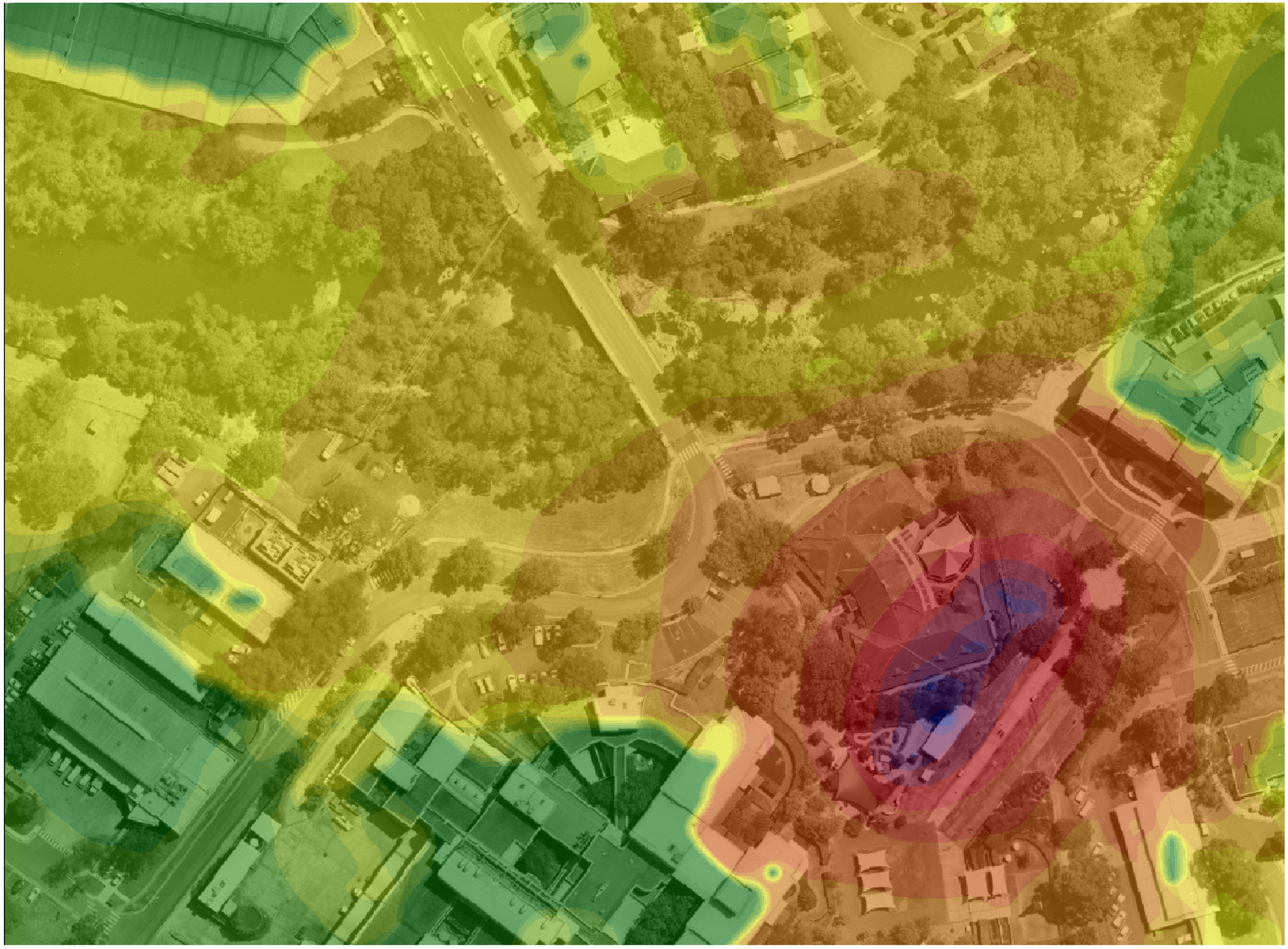

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NSW GOVERNMENT Health Infrastructure
pwc

ARCHITECT/CLIENT

PROJECT	TITLE
CHILDREN'S HOSPITAL AT WESTMEAD MULTISTORY CARPARK (MSCP)	CONSTRUCTION NOISE EMISSIONS - FACADE, NO MITIGATION BEST CASE SCENARIO

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Noise Model

Construction Noise Modelling Results

Noise & Vibration

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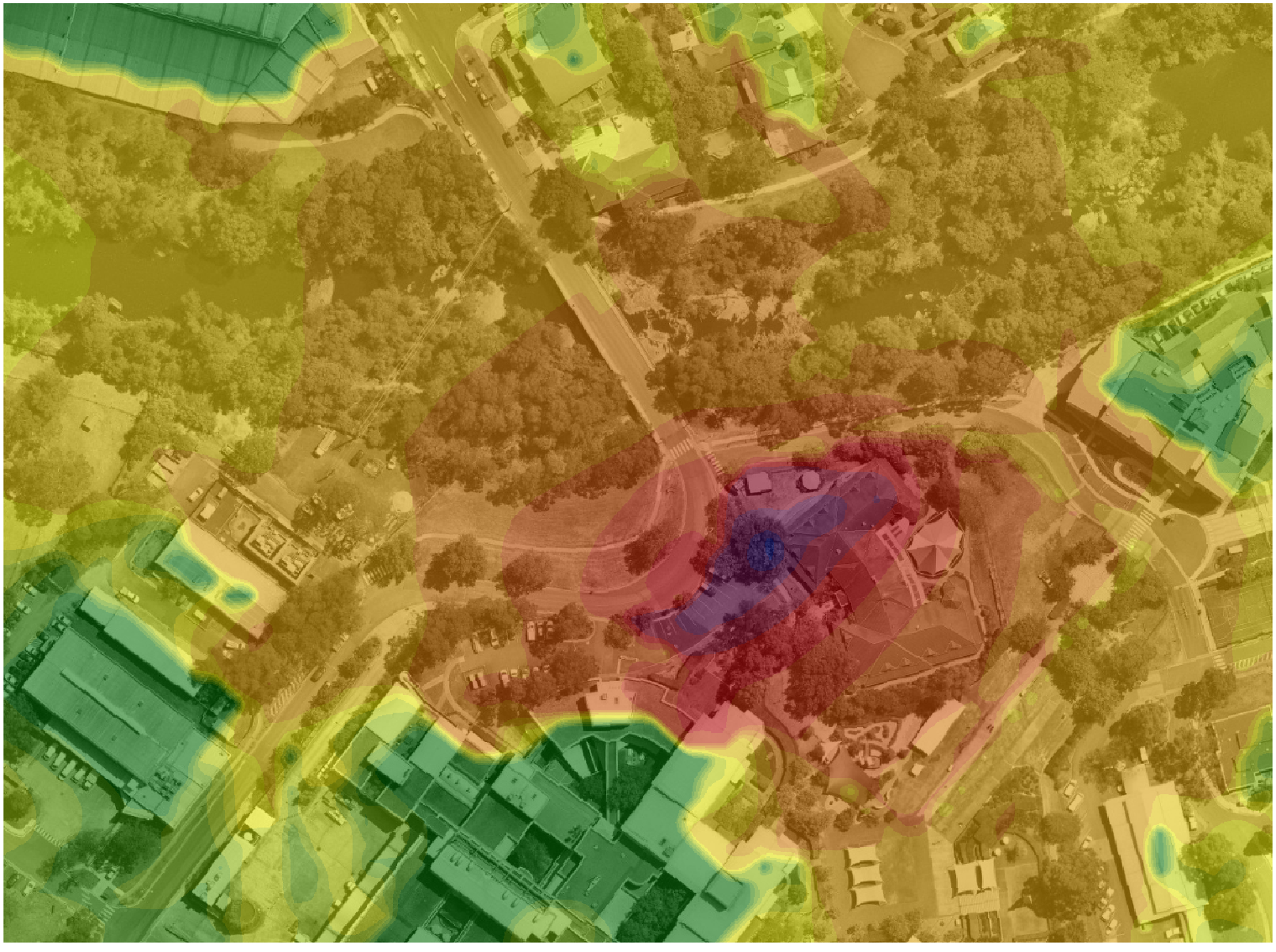

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PROJECT: CHILDREN'S HOSPITAL AT WESTMEAD MULTISTORY CARPARK (MSCP)

TITLE: CONSTRUCTION NOISE EMISSIONS - FACADE, MITIGATION WORST CASE SCENARIO

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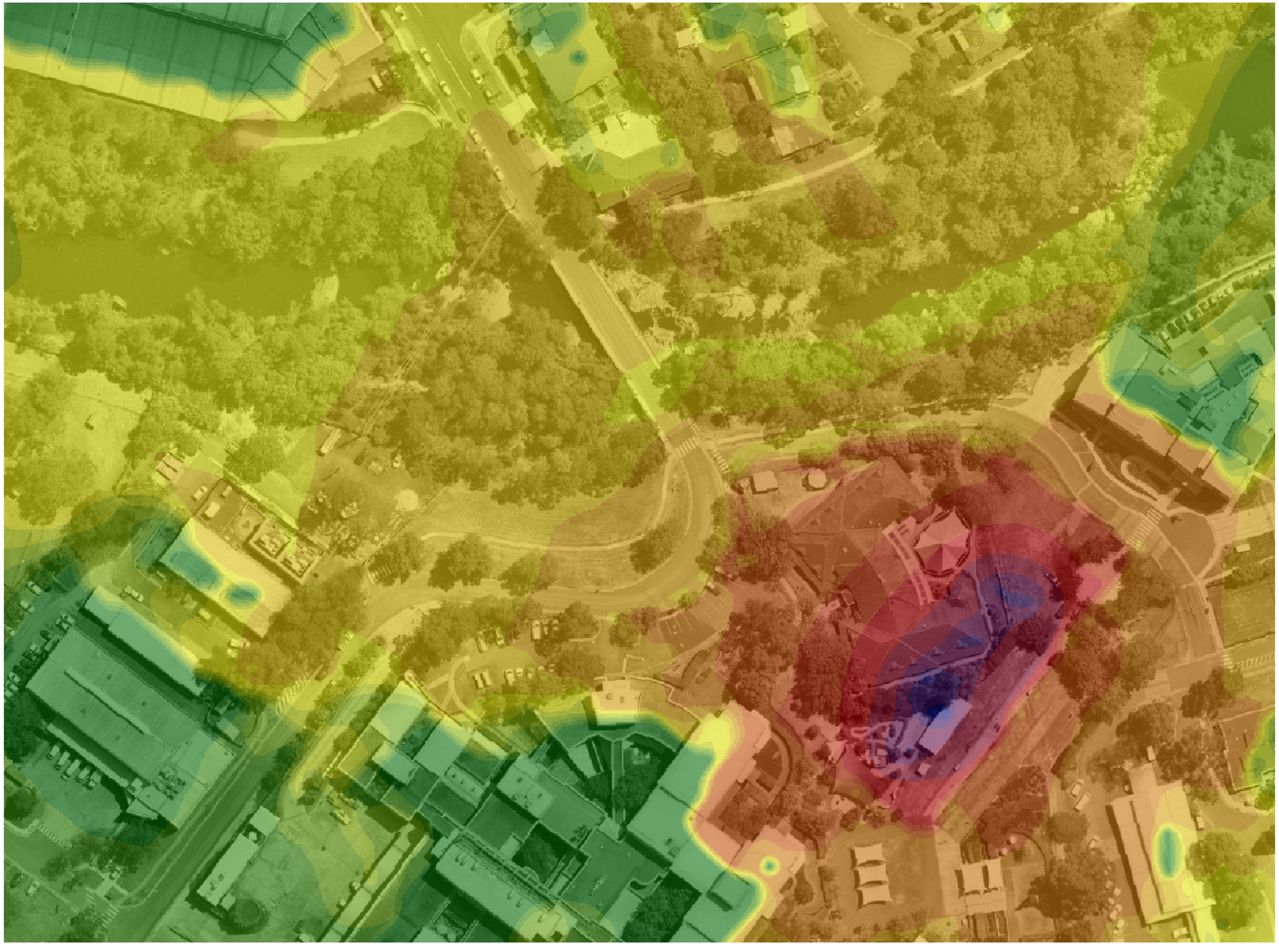

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ARCHITECT/CLIENT

CHILDREN'S HOSPITAL AT WESTMEAD
MULTISTORY CARPARK (MSCP)

PROJECT

CONSTRUCTION NOISE EMISSIONS - FACADE, MITIGATION
BEST CASE SCENARIO

TITLE

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Construction Noise Modelling Results

Noise & Vibration

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1:200	44311	MSCP-AC-GRM	001

Design with
community in mind

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207 Pacific Highway
St Leonards NSW 2065
Tel +61 2 8484 7000

For more information please visit
www.stantec.com

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