REPORT

COMPLYING DEVELOPMENT PATHWAY FOR DATA CENTRES

NSW AUSTRALIA

NOISE STUDY
RWDI # 2101093
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TABLE OF CONTENTS

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors are here defined.

dBA – A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.

Point Source – A single noise source that radiates from one position, e.g., a person speaking.

Line Source – A source that emits noise along a path, e.g., vehicles on a road.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

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 – The logarithmic measure of the power of a sound source.

Weighted Sound Reduction Index (R_w) - This is a single number value in decibels given to an individual element or path through a construction, providing guidance on its sound insulation performance across the spectrum of audible frequencies. Different building elements may have different R_w values, and a single R_w value may be used to represent the overall 'composite' value. Consider for example a brick wall (R_w 45 dB) with a lightweight door inset (R_w 20 dB) and a gap underneath (R_w ~0 dB). The R_w value representing the overall wall, door and gap will depend on the relative size of each component and real examples typically range from 10 dB to 30 dB.

1 INTRODUCTION

This study has been completed to review the potential noise implications associated with the proposed complying development pathway for data centres. The study has included:

- A review of the key noise impacts associated with data centres and identification of the significant noise sources and their operation in relation to the data centre.
- A review of existing and historical acoustic assessment frameworks from local and international regulatory authorities in order to determine acceptable noise criteria.
- A review of Development Applications for data centres in order to understand the current assessment methodology.

The outcomes of this study would be to:

- develop a complying development pathway for data centres specifically looking at noise controls for back-up power supplies and cooling units.
- develop simplified acoustic measures that could be used as a surrogate that would indicate practical compliance with noise objects. For example, distance to nearest residential receiver, commercial, or industrial neighbour.
- develop recommended performance requirements and parameters for back-up power supply and cooling unit operations and specifications for noise control equipment suitable for complying development pathway.

2 PLANNING CONSIDERATIONS

2.1 Existing Development Pathway for Data Centres

The current development pathway for data centres would involve a standard approval process where, depending on the size of the development, the application would be processed by the local council (less than $50 million) or processed via a State Significant Development (SSD) pathway (>$50 million).

For both pathways, noise from data centres would be assessed in accordance with the NSW EPA *Noise Policy for Industry (NPfI)*. This assessment would involve:

1. Long-term noise monitoring (at least 7 days) at surrounding potentially affected receivers to determine existing background noise levels.
2. Review of the existing background noise levels and establish noise criteria in accordance with the *NPfI*. Section 2.2 of this report provides further details on the *NPfI* noise goals.
3. A noise prediction exercise would be completed which would consider:
    a. All noise sources on site, their locations, and sound power levels.
    b. Distance to the nearest receivers.
    c. Screening effects from surrounding buildings and topography.
    d. Attenuation due to geometric spreading.
    e. Attenuation due to absorption (ground and atmospheric).
4. Compare predicted noise levels against the established noise criteria.
5. Consider feasible and reasonable mitigation if predicted noise levels exceed the established noise criteria.

2.2 NSW EPA Noise Policy for Industry

The *Noise Policy for Industry (NPfI)* guideline is considered appropriate to develop noise criteria to assess the potential noise impact from proposed data centres on surrounding receivers. The assessment procedure outlined in the *NPfI* has two components: intrusiveness and amenity.

2.2.1 Intrusiveness Noise Level

The intrusiveness noise level requires that the L_{Aeq} noise level from the source being assessed should not exceed the Rating Background Noise Level (RBL) by more than 5 dBA. The RBL is the overall single-figure background noise level representing each assessment period (day/evening/night) which is determined after a period of long-term (at least one week) noise monitoring at the receiver site in the absence of noise from the proposed development. **Table 2-1** (Table 2.3 from the *NPfI*) presents typical RBLs for different receiver categories and provides descriptions for expected noise environment at each of these receiver types.

Table 2-1 Residential Receiver Categories and Typical existing background noise levels

Receiver Category	Typical Planning Zoning – standard instrument	Typical existing background noise levels	Descriptions
Rural Residential	RU1 – primary production RU2 – rural landscape RU4 – primary production small lots R5 – large lot residential E4 – environmental living	Daytime RBL <40 dBA Evening RBL < 35 dBA Night RBL < 30 dBA	Rural – an area with an acoustical environment that is dominated by natural sounds, having little or no road traffic noise and generally characterised by low background noise levels. Settlement patterns would be typically sparse. Note: Where background noise levels are higher than those presented in column 3 due to existing industry or intensive agricultural activities, the selection of a higher noise amenity area should be considered.
Suburban Residential	RU5 – village RU6 - transition	Daytime RBL <45 dBA Evening RBL < 40 dBA Night RBL < 35 dBA	Suburban – an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.
Urban Residential	R1 – general residential R4 – high density residential	Daytime RBL > 45 dBA Evening RBL > 40 dBA Night RBL > 35 dBA	Urban – an area with an acoustical environment that: Is dominated by 'urban hum' or industrial noise source, where urban hum means the

Receiver Category	Typical Planning Zoning – standard instrument	Typical existing background noise levels	Descriptions
	B1 – neighbourhood centre (boarding houses and shop-top housing) B2 – local centre (boarding house) B4 – mixed use		aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources. Has through-traffic with characteristically heavy and continuous traffic flows during peak periods. Is near commercial districts or industrial districts. Has any combination of the above.

2.2.2 Amenity Noise Level

The recommended amenity noise level sets a limit on the total noise level from all industrial noise sources affecting a receiver. Different criteria apply for different types of receiver (e.g., residence, school classroom); different areas (e.g., rural, suburban); and different time periods, namely daytime (7.00am-6.00pm), evening (6.00pm-10.00pm) and night-time (10.00pm-7.00am) (See **Table 2-2**).

The recommended amenity noise levels represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location.

Where a new noise source is proposed in an area with negligible existing industrial noise, the amenity noise trigger level for that source may be taken as being equal to the recommended amenity noise trigger level. However, if there is significant existing industrial noise, the project amenity noise trigger level for any new source must be 5dB less than the recommended amenity noise trigger level for the receiver. This is to ensure that the addition of the new source does not raise industrial noise levels beyond the recommended amenity noise level.

There are certain exceptions where the above method to derive the project amenity noise level does not apply. This is outlined in detail in the *NPfI*.

Table 2-2 *NPfI* Amenity Noise Levels

Receiver	Noise Amenity Area	Time of Day	Recommended Amenity Noise Level L_{Aeq} dBA
Residential	Rural	Day	50
		Evening	45
		Night	40
	Suburban	Day	55
		Evening	45
		Night	40
	Urban	Day	60
		Evening	50
		Night	45
Hotels, motels, caretakers' quarters, holiday accommodation, permanent resident caravan parks	See column 4	See column 4	5 dBA above the recommended amenity noise level for a residence for the relevant noise amenity area and time of day
School classroom internal	All	Noisiest 1-hour period when in use	35

Receiver	Noise Amenity Area	Time of Day	Recommended Amenity Noise Level L_{Aeq} dBA
Hospital ward internal external	 All All	 Noisiest 1-hour Noisiest 1-hour	 35 50
Place of Worship internal	All	When in use	40
Area specifically reserved for passive recreation (e.g., national park)	All	When in use	50
Active recreation area (e.g., school playground, golf course)	All	When in use	55
Commercial Premises	All	When in use	65
Industrial Premises	All	When in use	70
Industrial interface (applicable only to residential noise amenity areas)	All	All	Add 5 dBA to recommended noise amenity area

2.3 Other Relevant Noise Policies

2.3.1 Protection of the Environment Operations (POEO) Act 1997

Below is an extract from the POEO (Section 17 of Schedule 1) regarding its definitions for electricity generation which need to be considered for Data Centres:

17 Electricity Generation

(1) This clause applies to the following activities-
Metropolitan electricity works (internal combustion engines), meaning the generation of electricity by means of electricity plant-
- *(a) That is based on, our uses, an internal combustion engine, and*
- *(b) That is situated in the metropolitan area or in the local government area of Port Stephens, Maitland, Cessnock, Singleton, Wollondilly or Kiama.*

(1A) However, this clause does not apply to the generation of electricity by means of electricity plant that is emergency stand-by plant operating for less than 200 hours per year.

2.3.2 NSW Environmental Noise Control Manual (ENCM)

Below is an extract from the ENCM which provides guidance for noise from emergency generators.

Chapter 151 – Generators, Emergency

Emergency electricity generators which are used in the event of power shortages, should not exceed the following maximum noise level, in order to minimise disturbance to the community. These criteria are for guidance only and variations may be made where necessary.

Residential Receiving Areas

Daytime and Evening:

From 7am to 10pm any day of the week, the LA10 sound pressure level should not exceed the LA90 background level by more than 10 dBA at the boundary of any nearby affected residence, and in any case, the LA10 level at the residential boundary should not exceed 55 dBA

Night-time:

From 10pm to 7am the LA10 level should not exceed the LA90 background level by more than 5 dBA at the boundary of any nearby affected residence, and in any case the LA10 level at the residential boundary should not exceed 45 dBA

Industrial and Commercial Receiving Areas

At no time should the LA10 level exceed the LA90 background level by more than 15 dBA at the boundary of any nearby affected industrial or commercial premises, and the LA10 level at the receiving boundary should not exceed 65dBA.

Where emergency generators are being used in the total absence of fixed power supplies such as for urgent reconstruction works, alternative criteria may be agreed to in discussions with the EPA.

2.3.3 Victoria SEPP N-1

Below is an extract from the Victorian SEPP N-1 regarding noise from standby equipment.

B4 Standby Generators, Standby Boilers and Fire Pumps

Where the noise source under consideration is a standby generator, standby boiler or fire pump, the noise limit shall be increased by 10 dB for a day period and by 5 dB for all other periods.

For the purposes of this section:

a. *A fire pump means a water pump permanently installed on a premises for extinguishing fires in emergencies*
b. *A standby boiler means a boiler which is used to supply hot water or steam in an emergency as an alternative to the normal boiler; and*
c. *A standby generator means a generator of electrical power used as an alternative to the mains supply in emergencies for a maximum period of 4 hours per month for maintenance purposes.*

2.3.4 Ontario Canada, NPC-300

Below is an extract from the Ontario Canada NPC-300.

B7.3 Sound Level Limits for Emergency Equipment

The sound level limits for noise produced by emergency equipment operating in non-emergency situations, such as testing or maintenance of such equipment, are 5 dB greater than the sound level limits otherwise applicable to stationary sources, described in Sections B7.1 and B7.2

The noise produced by emergency equipment operating in non-emergency situations should be assessed independently of all other stationary sources of noise, Specifically, the emissions are not required to be included with the overall noise assessment of a stationary source facility.

In addition, sound level limits do not apply to emergency equipment operating in emergency situations.

2.3.5 City of Westminster Unitary Development Plan 2007 Chapter 9

Below is an extract from the City of Westminster Unitary Development Plan 2007.

Chapter 9 B Noise from emergency generators

Where emergency generation plant is installed and requires testing, the City Council will permit noise emitted from this plant to increase the minimum assessed background noise levels by no more than 10dB for the purpose of testing. This testing period is for up to one hour per month between 09.00 and 17.00 Monday to Friday only and not on public holidays.

3 NOISE EMISSIONS FROM DATA CENTRES

3.1 Introduction

Historically, data centres have just simply been the server room supporting and organisation or business. As the demand for IT operations increased and businesses and technology move towards cloud computing infrastructure, data centres have shifted from being house internally to large single purpose facilities.

Modern data centres are large facilities which house the necessary computer servers, telecommunication equipment, and data storage systems to support the huge IT demand that businesses now have. The facility is designed to provide uninterrupted operation of the computer systems at optimal performance levels. This is achieved by employing numerous redundancy systems for heating and cooling needs, power supplied, and data communication as well as contingencies for physical security and natural disasters.

The ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centres specifies minimum requirements and guidelines for the design and installation of a data centre or computer room. This standard has four ratings (formerly referred to as "tiers") for data centres based on their specifications and their ability to reliably operate. Descriptions for these ratings are presented in **Table 3-1**.

Table 3-1 ANSI/TIA-942 Data Centres Standard

Tier	Description
Rated-1 'Basic' 99.671% Availability	- Susceptible to disruptions from both planned and unplanned activity - Singe path for power and cooling distribution, no redundant components (N). - Annual downtime of 28.8 hours.
Rated-2 'Redundant Component' 99.741% Availability	- Less susceptible to disruptions from both planned and unplanned activity. - Singe path for power and cooling distribution, includes redundant components (N+1). - Annual downtime of 22.0 hours.
Rated-3 'Concurrently Maintainable' 99.982% Availability	- Enables planned activity without disrupting computer hardware operation, but unplanned events will still cause disruption. - Multiple power and cooling distribution paths but with only one path active, includes redundant components (N+1) - Annual downtime of 1.6 hours.
Rated-4 'Fault Tolerant' 99.995% Availability	- Planned activity does not disrupt critical load and data centre can sustain at least one worst-case unplanned event with no critical load impact. - Multiple active power and cooling distribution paths; includes redundant components (2 (N+1), i.e., 2 UPS each with N+1 redundancy). - Annual downtime of 0.4 hours.

3.2 Data Centre Noise Sources

In order to meet operational requirements, data centres employ a large number of mechanical plant. These plant items service three main purposes:

- Cooling systems
- Electrical distribution and storage
- Power generation

Depending on the design of the data centre, some or all of these items could be internal with noise transmission out of the data centre through the supply air and exhaust ducting.

3.2.1 Cooling Systems

The large amount of computer systems in the facility requires a large amount of cooling and ventilation capacity to ensure that the systems operate at an optimal efficiency. The required cooling capacity is dependent on a few factors including, outside temperature, the size of the facility, the number of IT hardware within the facility.

Typical cooling systems for data centres include chillers or cooling towers, air handling units (AHUs) and computer room air conditioners (CRACs) as well as numerous supporting relief air fans.

Depending on the design of the facility, the majority of these systems could be housed within the data centre in appropriately designed plantrooms. In this case, the cooling towers would be the only major external noise source and would typically be installed on the roof.

3.2.2 Electrical Distribution and Storage

The equipment associated with electrical distribution and storage include transformers, uninterrupted power supplies (UPS), and associated electrical switch components. The majority of this equipment would be housed internally, with the exception of the transformers which may need to be external due to space limitations.

3.2.3 Power Generation

Data centres are typically powered off mains power supply, however, in order to meet redundancy requirements, Tier 3 and Tier 4 data centres employ additional standby generators in case of interruptions in power supply, emergencies, and disaster recovery.

It is seldom that data centres would enter an emergency operation mode where a significant number of the standby generators would need to operate, however, regular maintenance and testing of these units would result in a small number operating for a short period of time.

Depending on the design of the data centre, these generators could be installed internally with supply air and exhaust air being ducted out of the plantrooms and out of the building. Typically, significant noise attenuation measures, such as duct lining, silencers, and acoustic louvres would be employed. Where these generators are installed externally, acoustic enclosures which, could include attenuators or silencers, would be implemented to minimise noise emissions from the operation of these units.

4 PROPOSED NOISE PROVISIONS FOR COMPLYING DEVELOPMENT

4.1 Introduction

Reviewing the noise sources associated with data centres and relevant noise policies, the following complying development pathway is proposed.

The sound power level for all noise generating plant on site is to be summed logarithmically to determine a "Site Sound Power Level". This Site Sound Power Level would then be compared to the distance from the centre of the noise emitting area (this could be the building envelope or the entire site depending on the location of noise sources) to the façade of the affected receiver to determine the noise level from the site at these locations.

The level at the receiver would then be compared against relevant noise criteria for the respective receiver type. The following sections provides further detail on the steps involved.

4.2 Proposed Noise Criteria

For the purposes of a complying development pathway, noise goals are proposed to be established for two operation scenarios: normal operation and testing/maintenance operation. Normal operation would include all cooling plant and other noise sources which are required to operate day to day. Testing operation would include all normal operation plant as well as the noise emissions from all testing operation plant (standby generators).

Available data has indicated that there have been very little instances where a data centre has had to enter emergency operation, and when it did, the duration was brief. Based on this and existing regulations, noise limits for emergency operation are not required and have not been proposed.

4.2.1 Normal Operation

It is proposed that noise from normal operation be assessed against the *NPfI* Amenity Noise Level. The recommended amenity noise levels have been designed to protect 90 percent of the community from being highly annoyed by noise. The intrusiveness noise level aims to protect residents from any significant increases in industrial noise. Review of existing data centres have indicated that the majority of these sites are located within industrial zones with surrounding industry.

It is expected that the data centres applying to the complying development pathway would be located within business/industrial parks alongside. Surrounding receivers would therefore be exposed to an existing level of industrial noise, therefore reducing the intrusiveness impact of the data centre.

Table 4-1 presents the proposed normal operation noise criteria. Noise limits have been provided for the three assessment periods (day, evening, and night) as defined in the *NPfI*. The limits have been determined in accordance with the *NPfI* where 5 dB has been taken off the recommended amenity level to account for contribution from other noise sources and 3 dB has been added to convert the $L_{Aeq,period}$ limit to an $L_{Aeq,15min}$ limit.

Table 4-1 Proposed Normal Operation Noise Limit

Receiver Type	Noise Amenity Area	Time of Day	Recommended Amenity Noise Level Leq,period, dBA	Limit Leq,15min dBA
Residential	Rural	Day	50	48
		Evening	45	43
		Night	40	38
	Suburban	Day	55	53
		Evening	45	43
		Night	40	38
	Urban	Day	60	58
		Evening	50	48
		Night	45	43
Non-Residential	All	When in use	65	63

RWDI has compared the proposed normal operation limits for residential receivers against the intrusiveness limit for these receivers based off typical background noise levels identified in **Table 4-1** of this report and Table 2.3 of the *NPfI*. RWDI notes that although **Table 4-1** presents upper limits for rural and suburban receivers and lower limits for urban receivers. **Table 4-2** presents the two limits, with the higher limit in **BOLD**.

Table 4-2 Comparison of Proposed Normal Operation Limit and Typical Intrusiveness Limit

Noise Amenity Area	Time of Day	Proposed Normal Operation Limit $L_{Aeq,15min}$ dBA	Intrusiveness Limit RBL + 5 dBA $L_{Aeq,15min}$ dBA	Difference
Rural	Day	**48**	45	3
	Evening	**43**	40	3
	Night	**38**	35	3
Suburban	Day	**53**	50	3
	Evening	43	**45**	-2
	Night	38	**40**	-2
Urban	Day	**58**	50	8
	Evening	**48**	45	3
	Night	**43**	40	3

Table 4-2 demonstrates that the proposed noise limits would generally be within 3 dB of the intrusiveness noise limit based off typical background noise levels. The only exception is the day period for urban receivers where an 8 dB difference is presented. This would be due to the *NPfI* only presenting a lower limit for the urban noise amenity area. RWDI has completed extensive noise monitoring in urban areas and the backgrounds at these locations could range up to 60 dBA during the day period where the receiver is impacted from nearby road traffic noise. This would push the intrusiveness noise limit to be closer in range to the amenity noise limit.

A 3 dB difference, though might be barely noticeable to some, would be considered to be a minor impact on the noise amenity of receivers.

4.2.2 Testing Operation

Proposed noise limits for testing operation have been considered with respect to the limits imposed in the ENCM, Victoria SEPP N-1, Ontario Canada, and City of Westminster. These guidelines/policies appreciate that testing/maintenance of standby generators are expected to occur intermittently and for short periods of time. Limits for testing/maintenance have all been shown to be higher than the limits for normal operation provided it meets some requirements with regards to timing and duration.

It is proposed that for testing operation, the noise limits would be 10 dB higher than normal operation. Testing and maintenance is to only occur during the day period (7.00am-6.00pm) and limited to 200 hours a year. If the noise from testing operation complies with daytime normal operation noise limits, then no limit on the number of hours of testing is required. **Table 4-3** presents the proposed testing operation noise criteria.

Table 4-3 Proposed Testing Operation Noise Criteria

Receiver Type	Noise Amenity Area	Time of Day	Limit $L_{Aeq,15min}$ dBA
Residential	Rural	Day	58
		Evening	53
		Night	48
	Suburban	Day	63
		Evening	53
		Night	48
	Urban	Day	68
		Evening	58
		Night	53
Non-Residential	All	When in use	73

4.3 Site Sound Power Level Calculation

4.3.1 Noise Assessment Calculator

A noise assessment calculator has been prepared which aims to assist with the determination of the site sound power level and assessment to the nearest receivers within a complying development framework. This calculator takes the form of a spreadsheet and relies on high level inputs to complete a noise propagation calculation.

Table 4-4 below presents detailed descriptions for the high-level inputs required for the calculation.

Table 4-4 Info Page Inputs

Input	Description
Site Area (m^2)	Area of the site buildings
Nearest Residential Receiver	Identification of nearest residential receiver
Distance (m)	Distance to the nearest residential receiver
Zoning	Land Use Zoning of nearest residential receiver
Nearest Non-Residential Receiver	Identification of nearest non-residential receiver
Distance (m)	Distance to the nearest non-residential receiver

Appendix A presents screenshots of the "Normal Operation" and "Testing Operation" worksheets of the calculator. A sample data centre has been inputted into the calculator to demonstrate the outputs. Applicants are required to enter the noise data for the proposed equipment.

4.3.2 Calculation Methodology

All the individual noise sources would have their own noise propagation path which would include any shielding or reflections encountered on the way to the receiver. This would mean that when receivers are close to the site, the relative position of the plant on the site could greatly vary the noise level at the receiver. These effects are less apparent as the distance to the receiver increases.

The calculator attempts to account for these differences by completing two different calculations based on the distance from the receiver to the site.

For when the receiver is close to the site, a line source propagation calculation is completed. For when the receiver is far from the site, a point source propagation calculation is completed. Both calculations account for the distance between the site and the receiver and effects of air absorption along the transmission path.

Appendix B presents further details regarding the noise propagation calculation.

4.3.3 Plant Noise Levels

The main inputs required from the calculator are the sound power levels for all noise emitting plant. Applicants are to provide a complete list of noise emitting plant for both normal operation and testing operation. For normal operation, Applicants are to provide plant equipment schedules for the three assessment periods (daytime 7.00am-6.00pm, evening 6.00pm-10.00pm, and night 10.00pm-7.00am).

The sound power levels for these items must be referenced from manufacturers data or approved by an acoustic engineer. The reported sound power levels must be obtained by the appropriate measurement standard for the equipment type.

Where a sound pressure level at a distance is provided, the sound pressure level must be converted to a sound power level. This is to be done with the following equation:

$$L_w = L_p + 20\log(R) + 8$$

Where:

$L_w = Sound\ Power\ Level$
$L_p = Sound\ Pressure\ Level$
$R = distance\ from\ source$

Where noise emitting plant is located internally, the sound power level inputted into the calculator is the sound power level exiting the site after any inline attenuation. This is discussed in the following section.

4.3.4 Source Noise Control

Source noise controls includes acoustic enclosures for generators, and any inline attenuation, such as duct lining, silencers, or acoustic louvres for fans/cooling units. These items would effectively lower the source sound power level for the individual noise emitting plant for the purposes of this calculator.

These controls may be manufacturer standard equipment or custom designed. Where they are custom designed, the attenuation from these items must be confirmed via an acoustic engineer or manufacturer testing in accordance with appropriate measurement standards.

Additionally, for some cooling equipment, different operational loads may be required for different periods of the day. As a result, the noise emitted from the equipment may also change according to the operational load. Applicants are to obtain the expected noise generation from the equipment for all of the proposed operational loads. For example, if a certain plant item is proposed to operate at a “high mode” during the day, at a “medium mode” during the evening, and a “low mode” during the night period, then the Applicant must provide the sound power levels for “high”, “medium”, and “low” modes. The provided sound power level must be referenced from manufacturers data or approved by an acoustic engineer.

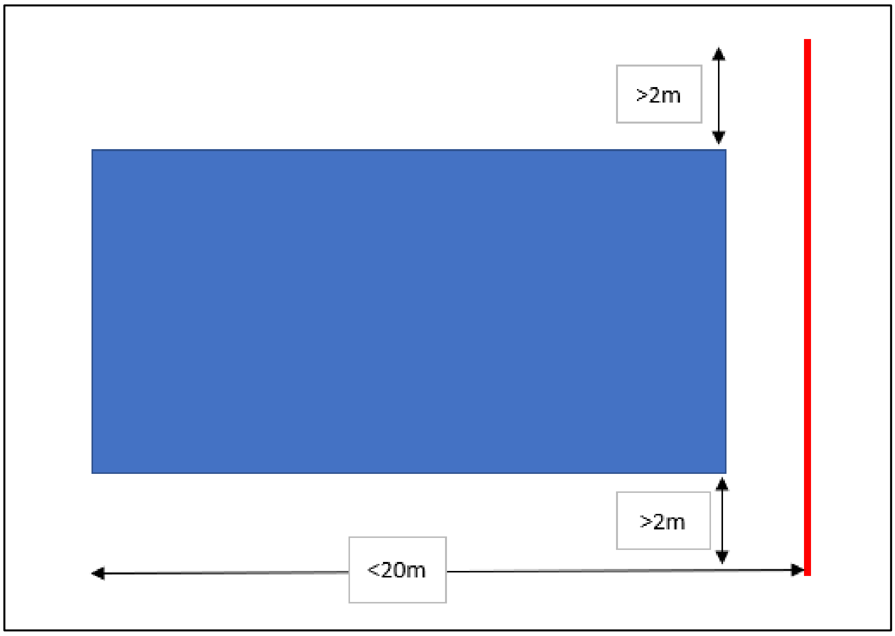
When completing the calculator, the “Sound Power Level” field is to be the value after any source controls.

4.3.5 Additional Noise Control

Additional noise controls would consist of any acoustic barriers in the transmission path to the receiver or if all external plant is enclosed in a plantroom or internal to the building. It is proposed that these would be standardised as follows:

Acoustic Barrier – 8 dB reduction

- A solid barrier within 20 m of the source.
- The height is to be at least 4 m from the FFL of the source and breaks line of sight to the nearest receiver.
- If the acoustic barrier does not surround the noise source, then the width must extend at least 2 m beyond the length of the noise source.
- The figure below presents the distance requirements for the acoustic barrier. The blue area is the noise source, and the red line is the acoustic barrier.



Enclosed Plantroom/Internal to the building – 25 dB reduction

- All bounding walls should be of solid construction or acoustically treated – solid blockworks, Hebel, or insulated stud walls.
- Roof sheeting is to be R_W 47 at a minimum.
- All gaps in constructions to be acoustically sealed.
- Ventilation, if required, are to have the following minimum insertion loss:

Table 4-5 Minimum Insertion Loss for Plantroom Louvres

Hz	63	125	250	500	1000	2000	4000	8000
Insertion loss	6	12	16	22	27	27	24	23

5 CASE STUDIES

RWDI has reviewed publicly available development applications for data centres of various sizes to confirm the feasibility of the proposed methodology. Noise and vibration impact assessments were reviewed to determine the mechanical plant schedule, mechanical plant sound power levels, distance to nearest receivers, and predicted noise levels.

Distances provided in the tables below are the distances determined from the proposed methodology, which is from the centre of data centre building extents, or the noise emitting area, to the façade of the affected receiver.

The comparisons have indicated that the predicted noise levels from the proposed methodology was generally within 3 dB of predicted noise levels from the noise impact assessments. It was also found the that proposed methodology generally was more conservative than the impact assessments in the far field, and marginally under predicting the nearfield.

The comparison has also identified that the proposed testing operation noise limits are considerably higher than what was implemented in the noise impact assessments. However, it was found that the predicted noise levels at the receiver from testing operation was not significantly higher than normal operation and generally less than 5 dB greater than normal operation noise levels.

5.1 Data Centre A

Data Centre A is an approved data centre in an industrial zone. The noise impact assessment completed predictions for normal operation and emergency/backup operation. This data centre was one of the smaller data centres reviewed.

Table 5-1 presents a comparison of the outcomes of the assessment to the outcomes of the proposed methodology. All noise emitting plant for this development was external.

Table 5-1 Data Centre A Results

Receiver	Distance	Operation	Noise Assessment		Proposed Methodology	
			Predicted Level	Criteria	Predicted Level	Criteria
Residential Receiver	472 m	Normal (night)	<20	36	30	38
		Emergency (day)	<30	40	38	63

5.2 Data Centre B

Data Centre B is a proposed data centre that is under assessment. A noise impact assessment was completed, which reviewed the operational and construction noise impacts from the proposed development. The assessment considered noise from both normal operations and testing operations and includes prediction for noise enhancing conditions. All noise emitting plant for this development was internal, with noise breakout via discharges.

Table 5-2 presents a comparison of the outcomes of the assessment to the outcomes of the proposed methodology.

Table 5-2 Data Centre B Results

Receiver	Distance	Operation	Noise Assessment		Proposed Methodology	
			Predicted Level	Criteria	Predicted Level	Criteria
Residential Receiver	376 m	Normal (night)	40	43	43	43
		Testing (day)	40	47	44	68
Non-Residential Receiver	77 m	Normal (day)	65	63	62	63
		Testing (day)	65	68	63	73

5.3 Data Centre C

Data Centre C is a proposed data centre that is under assessment. The noise and vibration impact assessment considers normal operations, testing operation, and emergency operation. All noise emitting plant are enclosed in acoustically rated rooftop plantrooms. This data centre was one of the larger data centres and was located relatively close residential receivers. **Table 5-3** presents a comparison of the outcomes of the assessment to the outcomes of the proposed methodology.

Table 5-3 Data Centre C Results

Receiver	Distance	Operation	Noise Assessment		Proposed Methodology	
			Predicted Level	Criteria	Predicted Level	Criteria
Residential Receiver	151 m	Normal (night)	<30	35	34	38
		Testing (day)	<35	40	34	63

5.4 Data Centre D

Data Centre D is an approved data centre in an industrial zone. This was one of the largest data centres reviewed and was processed via the SSD pathway. The nearest residential receivers were at least 1 km away and were considered as rural receivers. The noise and vibration impact assessment considered noise from normal operation, testing operation, and emergency operation.

Table 5-4 presents a comparison of the outcomes of the assessment to the outcomes of the proposed methodology.

Table 5-4 Data Centre D Results

Receiver	Distance	Operation	Noise Assessment		Proposed Methodology	
			Predicted Level	Criteria	Predicted Level	Criteria
Residential Receiver	990 m	Normal (night)	34	38	38	38
		Testing (day)	36	43	41	58
Non-Residential Receiver	229 m	Normal (day)	53	63	58	63
		Testing (day)	53	63	61	73

6 CONCLUSION

RWDI has reviewed noise impact assessments of proposed and approved data centres of various sizes and application pathways (local government development application, and state significant applications) in order to understand the noise impacts associated with data centres and current approaches to noise mitigation and management.

RWDI has also reviewed relevant existing and historical noise guidelines in order to develop applicable noise limits and noise provisions for a complying development pathway. For normal operations, i.e., general cooling plant and services, noise limits have been developed with reference to the NSW EPA's Noise Policy for Industry. For testing/maintenance operations, noise limits have been developed with reference to the Victoria SEPP N-1. No noise limits have been proposed for emergency operation as it is unlikely that emergency operation would occur for more than 200 hours a year.

From the review, proposed noise provisions were developed, including a noise assessment calculator. These proposed provisions were tested on the reviewed data centres and it was found that the resultant noise levels were comparable and slightly conservative.

APPENDIX A – CALCULATOR

Site Sound Power Level - Normal Operation

Residential Receiver - Normal Operation

Period	Site Sound Power Level	Distance	Sound Pressure Level at Receiver	Noise Limit	Compliance
Day	111	990	40	48	Yes
Evening	111	990	40	43	Yes
Night	110	990	40	38	No

Non Residential Receiver - Normal Operation

Period	Site Sound Power Level	Distance	Sound Pressure Level at Receiver	Noise Limit	Compliance
Day	111	229	60	63	Yes

Site Sound Power Level

Day	111	dBA
Evening	111	dBA
Night	110	dBA

Period	Plant Item	Source Control	Quantity	Sound Power Level	Additonal Controls	Item Cumulative	Reference Document
Day	Evaporative Cooler	n/a	8	83	8	84	
Day	Chillers	n/a	5	100	8	99	Manufacturer data/approved calculation from acoustic engineer
Day	ERV	n/a	2	86	8	81	
Day	Exhaust Fan	n/a	1	91	8	83	
Day	Exhaust Fan	n/a	1	86	8	78	
Day	AHU	n/a	1	83	8	75	
Day	PAC	n/a	2	83	8	78	
Day	Chillers	n/a	2	103	8	98	
Day	PAC	n/a	2	83	8	78	
Day	Chillers	n/a	32	103	8	110	
Day	PAC	n/a	48	89	8	98	
Day	Condenser	n/a	20	89	8	94	
Evening	Evaporative Cooler	n/a	8	83	8	84	
Evening	Chillers	n/a	5	100	8	99	
Evening	ERV	n/a	2	86	8	81	
Evening	Exhaust Fan	n/a	1	91	8	83	
Evening	Exhaust Fan	n/a	1	86	8	78	
Evening	AHU	n/a	1	83	8	75	
Evening	PAC	n/a	2	83	8	78	
Evening	Chillers	n/a	2	103	8	98	
Evening	PAC	n/a	2	83	8	78	
Evening	Chillers	n/a	32	103	8	110	
Evening	PAC	n/a	48	89	8	98	
Evening	Condenser	n/a	20	89	8	94	

Site Sound Power Level - Testing Operation

Residential Receiver - Testing Operation

Period	Site Sound Power Level	Distance	Sound Pressure Level at Receiver	Noise Limit	Compliance
Day	104	376	44	68	Yes

Non Residential Receiver - Testing Operation

Period	Site Sound Power Level	Distance	Sound Pressure Level at Receiver	Noise Limit	Compliance
Day	104	77	63	73	Yes

Site Sound Power Level	dBA	104	dBA

Plant Item	Source Control	Quantity	Sound Power Level	Additonal Controls	Item Cumulative	Reference Document
Fan Coil Unit	acoustic louvre	64	77		95	
Relief Air Fan	acoustic louvre	324	60		85	Manufacturer data/approved calculation from acoustic engineer
CRAC	N/A	16	91		103	
Diesel Generator	acoustic enclosure	1	78		78	

APPENDIX B – NOISE PROPAGATION CALCULATION AND ASSUMPTIONS

Reference Formulae

The calculator assumes that the site acts as a single area/plane source and applies a noise propagation method appropriate for this source type. Strutt Acoustics is a calculation software developed by ARUP and provides guidance on area source propagation.

The radiation of noise from an area source encompasses three main regions: the near field close to the source, an intermediate zone where the source acts as a line source, and the distant zone where the source behaves as a point source. Due to the (assumed) location of the plane source on a reflective surface in the far-field the plane source approaches hemispherical radiation.

Strutt applies equation 5.105 of Engineering Noise Control, Theory and Practice by Bies and Hansen, and provides equations for the three regions.

In the near field, the sound level can be approximated as:

$$L_p = L_w - 10\log_{10} S + DI$$

In the line-source intermediate region, the sound level can be approximated as:

$$L_p = L_w - 10\log_{10} S - 10\log_{10}\left(\frac{\pi r}{a}\right) + DI$$

In the point-source far region, the sound level can be approximated as:

$$L_p = L_w - 10\log_{10} S - 10\log_{10}\left(\frac{b}{a}\right) - 20\log_{10}\left(\frac{\pi r}{b}\right) + DI$$

Where:

$L_w = Sound\ Power\ Level$

$L_p = Sound\ Pressure\ Level$

$r = distance\ from\ source$

$a = the\ smaller\ dimension\ of\ the\ source$

$b = the\ large\ dimension\ of\ the\ source$

$S = Area\ of\ the\ source\ (a\ \times b)\ m^2$

$DI = the\ directivty\ index\ of\ the\ source$

Noise Emitting Area

In order to simply and generalise the use of the calculator, it has been assumed that noise emitting area is square, i.e., the values of a and b are equal. This would most likely affect the point-source far region calculation as this formula considers the ratio between the two dimensions in the term $10\log_{10}\left(\frac{b}{a}\right)$.

RWDI completed testing to determine the implications of this assumption. **Table B-1** below compares the amount of attenuation gained acquired from the STRUTT calculation and the assumed method. Calculations have been completed for an arbitrary r value of 100 m. Levels from a point source calculation have also been provided for comparison.

Table B-1 Comparison of Far Region Propagation Methodologies

Plane Source Dimensions	Attenuation		
	STRUTT	Assumed Method	Point Source
20 m x 50 m	48.4 dB	46.9 dB	48.0
10 m x 90 m	48.4 dB	46.9 dB	48.0
45 m x 45 m	48.2 dB	46.9 dB	48.0
30 m x 70 m	48.3 dB	46.9 dB	48.0

Results from **Table B-1** confirms that the assumed method results in marginally less attenuation than the STRUTT calculation. Additionally, **Table B-1** identifies that the STUTT method results in a slightly more attenuation compared to the point source method. On this basis, it is reasonable to assume that the noise emitting area is square and prediction would be marginally conservative.

Source Type Transition Distances

Strutt provides arbitrary values to determine the distance where the noise propagation transitions between the three regions. These values are:

- $r < \frac{2a}{\pi}$ for the near field region,
- $\frac{2a}{\pi} < r < \frac{2b}{\pi}$ for the line-source intermediate region, and
- $r > \frac{2b}{\pi}$ for the point-source far region.

As the proposed methodology assumes the site area is square, the values a and b would be equal, effectively removing the line source intermediate region. It was found that the resulting plane source to point source transition distance of $\frac{2b}{\pi}$ was under predicting noise levels at nearby receivers as this when tested on the reviewed data centres.

Further testing determined that the value b as the line-source to point-source transition distance resulted in levels that were more comparable to what was reported in the reviewed data centres.

Atmospheric Absorption

Attenuation due to atmospheric absorption has been included in the noise propagation calculation. The calculator applies the ISO 9613-2-1996: *Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2 General Method* algorithm for air absorption. ISO 9613-2 determines attenuation due to atmospheric absorption using the following formula:

$$A_{atm} = \frac{\alpha d}{1000}$$

Where:

$\alpha = atmospheric\ attenuation\ coefficient$

$d = distance$

Table B-2 below provides the atmospheric attenuation coefficients for octave bands for various levels of ambient temperature and relative humidity of air.

Table B-2 ISO 9613-2 Atmospheric Attenuation Coefficient for Octave Bands of Noise

Temperature °C	Relative Humidity %	Atmospheric Attenuation Coefficient α, dB/km							
		Octave band							
		63	125	250	500	1000	2000	4000	8000
10	**70**	0.1	0.4	1.0	1.9	3.7	9.7	32.8	117
20	**70**	0.1	0.3	1.1	2.8	5.0	9.0	22.9	76.6
30	**70**	0.1	0.3	1.0	3.1	7.4	12.7	23.1	59.3

The calculator assumes 30°C 70% conditions for the day and evening periods and 10°C 70% conditions for the night period,