WAPOU C/o- Whitehaus Architects

WAPOU Offices, No. 38 Summers St, E PERTH, WA

Acoustics - Schematic Design Report for DA

07 DEC 2020

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PROJECT PARTNERS

Discipline	Entity	
Principal Client	WAPOU, C/o- WHITEHAUS Architects Pty Ltd	WAPOU WA Prison Officers' Union
Architectural Design	Whitehaus Architects	WHITEHAUS architecture I interior design I drafting
Planning Consultant	Hemsley Planning	hemsley planning
Building Services Consultant(s)	TBC	

REPORT ABSTRACT

Sealhurst were appointed by WAPOU, C/o- WHITEHAUS Architects Pty Ltd, to provide acoustic engineering and design consultancy relating to the WA Prison Officers Union (WAPOU) Office Building development project at Lot 18, No. 38 Summers St in East Perth.

The site is located within 100m of East Perth passenger rail station which carries Midland line rail passengers as well as periodic locomotive services. The site is also within 50m of East Parade which runs adjacent to the rail line, carrying >46,000 vehicles of Annual Average Weekday Traffic (AAWT) volume identifying this as a major State transport corridor.

Where "noise sensitive land use" development is proposed adjacent to recognised transport corridors, *State Planning Policy 5.4 Road and Rail Noise*, Sep 2019 Edition (*"SPP 5.4"*) is mandated as a planning instrument at Development Approval stage to ensure adequate building envelope design provision is incorporated to account for transportation noise. *"Noise sensitive"* use is defined under *SPP 5.4* as "residential", "educational", "child care/hospital/aged care" and the like, attracting specific internal design noise criteria during day and night time periods.

In the case of the WAPOU office (e.g. commercial use) building, *the Policy* defers to the national standard *AS2107:2016 Acoustics: Recommended design sound levels and reverberation times for building interiors* to account for the presence of road and rail noise – both current, and in future forecast scenario over a 20-Yr planning horizon.

In terms of acoustic design, assessment of the site has been undertaken to devise a suitable façade construction of sufficient resistance to the passage of road and rail transportation sound to achieve the target internal design sound levels within the proposed office spaces.

In wider building design and approvals context, the building will also require demonstration of compliance with the *WA Environmental Protection (Noise) Regulations 1997 (Incl. Amendments), ("the Regulations")* as statutory legislation covering any sources of noise emission which are proposed as part of the development. In this project, the building's AC and ventilation plant are anticipated as the primary sources.

Building services concept and design details are not yet determined as is appropriate for pre-DA stage design, hence the applicable limits are calculated under *the Regulations* for 2 x Noise Sensitive Receiver (NSR) locations, in order to quantify the limits for the practical specification of appropriate mechanical services equipment further on in the design of the building.

This report therefore establishes an acoustic Schematic Design scheme for the building envelope and noise emissions elements identified above, referencing current drawn documentation as at 7/12/2020. Advice is provided regarding internal acoustic conditions typical of offices, and areas for construction detailing to maximise the acoustic performance of the building at this Schematic Design stage.

The report is intended to form a reference baseline for the design, with expectation that this report will be developed to inform the Detailed Design phase of the building, as more and better particulars become known.

EXECUTIVE SUMMARY

Sealhurst were appointed by WAPOU, C/o- WHITEHAUS Architects Pty Ltd, to provide acoustic engineering and design consultancy relating to the WA Prison Officers Union (WAPOU) Office Building development project at Lot 18, No. 38 Summers St in East Perth.

The project is to provide a 3-storey office building with on-grade car parking for 10 vehicles located at Ground Level accessed via Summers Street – facilities include reception, meeting rooms, multi-purpose function rooms, archive/storage and staff amenities across 1st and 2nd Floor Levels.

This report therefore establishes an acoustic Schematic Design scheme for the building envelope and noise emissions elements identified above, referencing current drawn documentation as at 7/12/2020. The report is intended to form a reference baseline for the design, with expectation that this report will be developed to inform the Detailed Design phase of the building, as more and better particulars become known.

A summary of our report findings is presented below:

BUILDING ENVELOPE DESIGN FOR EXTERNAL NOISE

The development site is situated 50m east of East Parade south-bound carriageway edge, which carries an annual average weekday traffic (AAWT) volume of 46,015 vehicles flowing north/south to/from the CBD. On the opposite side of East Parade lies East Perth metropolitan passenger rail station, some 120m west of the site.

Road transportation noise is a persistent noise source, punctuated by incidental pass-by events from public transport (buses), private and commercial individual light vehicles, truck/HGV and motorcycles. However, despite the proximity the site is partially screened to East Parade by an existing commercial building, which limited traffic noise levels to a typical average of 55 – 60dB(A) at the noise survey location during day time hours at approx. 3.5m above ground level.

In accordance with *State Planning Policy 5.4* (See Section 4.1.2) for future predicted road traffic noise, an additional 2dB(A) has been added to the recorded noise levels, commensurate with realistic and practicable increases to road traffic volumes, allowing for the existing road traffic infrastructure as 4-lanes of traffic.

Resulting building façade scheme glazing is to be rated at Rw 33dB, equivalent to a minimum 6.38mm laminate single glazing provision or 6/12/6.38mm laminate DGU. Assuming a surrounding building envelope construction of cavity masonry (90/70/90) rated at Rw+Ctr 53 or above, this glazed provision achieves internal design sound levels in accordance with *State Planning Policy 5.4*-referenced criteria under AS2107:2016 for commercial buildings – in both "General Office Areas" and in "Board Room" area facing Summers St at 2nd Floor level.

Considering the likelihood for public safety specification of a toughened glazing unit, the Principal client may opt for an increased glazing specification thickness of 10mm toughened (float) glazing where Board Room balcony doorsets are concerned, rated at Rw 34dB. Note, balcony doorsets must be supplemented with acoustic seals – preferably using a mechanically operated closing mechanism to engage the seals. TBC during Detailed Design.

ENVIRONMENTAL NOISE EMISSIONS COMPLIANCE

Environmental noise emissions must comply with the *Environmental Protection (Noise) Regulations 1997 (incl amendments).* The Assigned Noise Level (ANL) limits have been determined based upon an Influencing Factor of **+11**, and applied at the nearest noise-sensitive receiver (NSR 2), identified as the adjacent residential use property at 36 Summers Street.

This equates to ANL limits of 56dB L_{A10} during daytime (7AM – 7PM) hours; 51dB L_{A10} during the evenings (7PM – 10PM) and 46dB L_{A10} during night time hours (10PM – 7AM).

Guidance for anticipated mechanical noise systems and ancillary noise sources as part of building operation are understood to be for potential air conditioning condenser units (CUs) and ventilation equipment only.

Mechanical concepts are not yet determined as is appropriate for this stage of pre-DA Schematic Design. However, to provide a practical preliminary indication of likely noise emission compliance, we have developed a calculated assessment using "Heating Mode" (highest noise emission) in all cases, emanating from an estimated 4 xCU units located centrally at roof level;

Indicative compliance assessment is calculated at 15m (nearest) distance to NSR 2, at a Sound Pressure level of 41.5dB(A) inclusive of a conservative attenuation allowance for roof screening.

This result demonstrates the predicted outcome which complies during all times of the day, evening and night-time hours. No further noise mitigation would be required on this scenario on proviso that:

- CU's be placed as indicated to take advantage of the roof pitch line to eliminate direct line-of-sight from street (t comply with DA Condition 5; And,

It is anticipated that any changes to CU unit specification, location, and/or enclosure design will be determined during the Detailed Design phase – where the CU selections and locations carry through to procurement, no further mitigation will be required for off-site noise emissions.

Commercial-grade CU units are typically broadband and steady-state in nature, hence tonality, modulation and impulsive penalties are not anticipated. Sealhurst recommend the final selections for procurement be reviewed prior to installation, in terms of octave band sound levels, to determine and any additional noise emissions sources not yet identified, be assessed to ensure the building is able to comply with the limits at all times.

ADDITIONAL SCHEMATIC DESIGN ADVICE FOR OFFICE SPACES

SEPARATING PARTITIONS

The design provision of office accommodation is "standardised" in terms of internal sound levels from external noise and from building services noise, though acoustic (Rw) ratings for partitions is largely at Principal client discretion, pending levels of quality, privacy and separation between adjacent spaces.

We have put forward a palette of typical partition types with recommended minimum ratings and uses for each. Further, the provision of office acoustics is a combination of partition type (rating) and building services noise in each adjacent space – resulting in a Privacy Factor rating (dB) – which describes how intelligible normal (unamplified) speech is when transferring from one room to another.

Mechanical services concepts are to be determined, as is appropriate for this stage of (pre-DA) design – anticipation is for actual ratings and services noise levels to be specified in accordance with Principal client consultation to provide desired office conditions in the finished space.

REVERBERATION TIME

Acceptable standards for reverberation times is prescribed under *AS2107:2016 Acoustics: Recommended design sound levels and reverberation times in building interiors*. We have assumed "General Office" type for the purposes of establishing reverberation time control targets, except where otherwise noted.

In order to meet reverberation time targets in general office environments, typical treatments are mineral fibre ceiling tiles in a tegular grid over commercial floor area, with office grade carpet tiles as a floor covering. The two parallel absorptive surfaces are sufficient to deliver control of reverberation time in rooms of standard height (e.g. 2.7m) based upon the ratio of volume to area.

A perforated plasterboard treatment with insulated fibre glass (absorbing) quilt laid in the void space over will also provide reverberation time control, in conjunction with office grade carpet tiles. This ceiling option will offer a slightly greater acoustic barrier performance (over a lightweight ceiling tile) for any ceiling void located FCU units, where installed.

NB – Outside of toilet areas, the application of **no ceiling treatment** (e.g. standard plasterboard ceilings) in will result in general office environments that fail to meet reverberation time criteria.

SERVICES NOISE LEVELS

Mechanical concepts are not yet determined as is appropriate for this stage of design, however individual office areas are likely to be heated/cooled using internal wall mounted, ceiling cassette or ducted FCU systems connected to an external condenser unit or bank of units (CU(s)).

Typical office grade FCUs are readily available which generate Sound Pressure Levels of ~35-40dB(A) at 1m. In the context of the office environment, FCU noise will be able to be designed in combination with partitions (Rw) ratings to meet Privacy Factors sought in the finished Detailed Design.

Concealed services reticulation is anticipated to from part of the building services design. Though not a compliance requirement in commercial office settings, rated constructions are taken from rated services concealment constructions which meet the minimum standards under the BCA/NCC for residential grade buildings. Services concealment (ducts) build-ups are provided for information to give a useful indication of requirements expected to achieve a satisfactory level of services noise insulation in the project, where not otherwise specified.

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1 INTRODUCTION

1.1 Project Appreciation

1.1.1 General Overview

Sealhurst were appointed by WAPOU, C/o- WHITEHAUS Architects Pty Ltd, to provide acoustic engineering and design consultancy relating to the WA Prison Officers Union (WAPOU) Office Building development project at Lot 18, No. 38 Summers St in East Perth.

The project site is proposed to be developed by the WA Prison Officers Union (WAPOU) into a central administrative office and headquarters – provision of a 3-storey office building with on-grade car parking for 10 vehicles located at Ground Level accessed via Summers Street – facilities include reception, meeting rooms, multi-purpose function rooms, archive/storage and staff amenities across 1^{st} and 2^{nd} Floor Levels.

The existing site is a vacant Lot amidst a number of commercial and industrial use buildings which sit opposite the site of the old East Perth Power Station. To the west is located approx. 120m south-east of the East Perth metropolitan passenger rail terminal, on the east side of East Parade.

1.1.2 Project Status

The project is understood to be commencing Schematic Design phase toward the submission of Development Application. Request for scope has been received to assess the building and provide design and documentation toward the DA submission.

1.2 Applicable Acoustic Design Criteria

1.2.1 AS2107:2016 Acoustics: Recommended design sound levels for building interiors

Where “noise sensitive land use” development is proposed adjacent to recognised transport corridors, *State Planning Policy 5.4 Road and Rail Noise*, Sep 2019 Edition (*“SPP 5.4”*) is mandated as a planning instrument at Development Approval stage to ensure adequate building envelope design provision is incorporated to account for transportation noise. *“Noise sensitive”* use is defined under *SPP 5.4* as “residential”, “educational”, “child care/hospital/aged care” and the like, attracting specific internal design noise criteria during day and night time periods.

In the case of the WAPOU office (e.g. commercial use) building, *the Policy* defers to the national standard *AS2107:2016 Acoustics: Recommended design sound levels and reverberation times for building interiors* to account for the presence of road and rail noise – both current, and in future forecast scenario over a 20-Yr planning horizon.

1.2.2 WA Environmental Protection (Noise) Regulations 1997 (Incl. Amendments)

In wider building design and approvals context, the building will also require demonstration of compliance with the *WA Environmental Protection (Noise) Regulations 1997 (Incl. Amendments), (“the Regulations”)* as statutory legislation covering any sources of noise emission which are proposed as part of the development. In this project, the building’s AC and ventilation plant are anticipated as the primary sources.

1.2.3 Schematic Design Report Aims

The primary aim of our report is to demonstrate means for the design to achieve compliance with the relevant acoustic standards and criteria applicable to these premises under the Development Approval submission, as applicable to noise.

Our report will achieve this by presenting a technical assessment of each applicable element of the project via detailed site appraisal and available concept design information. Each design element is identified against the applicable design requirement, and compliance (or guidance advice) is presented.

1.3 Project Inputs

1.3.1 Schedule of Architectural Drawings

The assessment has been carried out based upon the latest available architectural drawings supplied by Whitehaus Architects.

Design advice contained in this report is based upon this set of documentation - a full list of these drawings are presented in Appendix A.1. Details are current at the date of this report (07 DEC 2020).

2 PROJECT CONTEXT

2.1 Development Definition

2.1.1 Project Site No. 38 Summers Street, EAST PERTH, WA

38 Summers Street is located approx. 110m south-east of the East Perth metropolitan passenger rail terminal, on the east side of East Parade. The site is proposed to be developed by the WA Prison Officers Union (WAPOU) into a central administrative office and headquarters – an architectural render is shown in the images, upper right.

The project is to provide a 3-storey office building with on-grade car parking for 10 vehicles located at Ground Level accessed via Summers Street – facilities include reception, meeting rooms, multi-purpose function rooms, archive/storage and staff amenities across 1st and 2nd Floor Levels.

The existing site is a vacant Lot amidst a number of commercial and industrial use buildings which sit opposite the site of the old East Perth Power Station.

Existing condition of the site is shown right, below the architectural rendering with aerial mapping images showing site location and extents taken from the architectural DA package.

2.1.2 Site Surrounds & Environs

The surrounding area of East Perth is an established multiple mixed use with passenger rail transport, existing commercial office buildings and industrial land uses relating to existing electrical power grid infrastructure. Residential streets are located some 80m to the north of the site.

East Parade passes the site some 50m to the east and access to the nearby Graham Farmer Freeway is within 250m offering the site excellent transportation links.

To the south and east of the Summer Street frontage is situated the East Perth Power station. The site has been subject to a number of development initiatives, with the site and surrounding area of land currently in the process of site preparation for development. Referencing the East Perth Power Station Masterplan (2007), (indicated in the schematic image, lower right, the development area indicates a combination of mixed-use developments are proposed.

3 EVALUATION OF LOCAL ENVIRONMENT

3.1 Existing Local Noise Climate

3.1.1 Summary of Relevant Noise Sources

Images column shown right present site photographs taken during a number of attended periods during the 7-day noise monitoring survey during October 2020. The development site is situated 50m east of East Parade south-bound carriageway edge, which carries an annual average weekday traffic (AAWT) volume of 46,015 vehicles flowing north/south to/from the CBD. On the opposite side of East Parade lies East Perth metropolitan passenger rail station.

As could be expected, road traffic noise is a persistent, dominant noise source, punctuated by public transport (buses), private and commercial individual light vehicles, truck/HGV and motorcycle pass-by noise.

Weekdays produced a consistent pattern of onset and receding of daily noise level, attributable to daily traffic flow patterns, of which onset of morning traffic movements are clearly visible in the monitoring results in Appendix B.1. Intermittent periods were identified with peak noise events from individual vehicle pass by activity, occasional police sirens, unrestricted (loud) motorcycles and the like, and general ambient sounds consistent with the road-side setting as described above.

Despite the proximity of the site to established transport infrastructure, the site is partially screened to East Parade by an existing commercial building, which limited traffic noise levels to a typical average of 55 – 60dB(A) at the noise survey location during day time hours at approx. 3.5m above ground level.

Into evening periods, road traffic volume and consequential noise levels recede after approx. 7PM to around 50dB(A) on average. During evening and night time periods before 12AM, passing rail services are more audible due to the reductio in road traffic, however rail services noise does not present a dominant noise source.

The resulting external acoustic climate is anticipated to be adequately controlled to internal office space(s) by incorporating acoustic design principles detailed herein, using appropriate minimum-rated glazing units within the building envelope construction. Accompanied by careful selection of mechanical building services plant equipment for heating and cooling, the project design can be successfully integrated to engage with the local environmental noise sources whilst providing the required amenity from (and contribution to) local external noise.

3.2 Existing Environmental Noise Assessment

3.2.1 Designing for Noise Ingress

Our approach to satisfying this aspect of the building design aspect cites *AS2107:2016 Acoustics: Recommended design sound levels and reverberation times for building interiors*, as the prevalent Australian national "standard" for internal design sound level criteria - the referenced internal sound levels criteria for finished, unoccupied commercial spaces being used to determine compliance of predicted calculations from external noise.

To deliver a building design able to respond to an existing or future-defined acoustic environment, reliable sound level data is crucial information, particularly in relation to noise-sensitive building uses, whereby noise ingress is a design parameter. Reliable sound data allows informed decisions to be made regarding building facade materials which will influence both project cost, and ultimately the internal acoustics of the finished space as a result of external noise climate in which the finished development will inhabit.

In order to make acoustically-compliant and cost-effective design decisions to satisfy internal noise level criteria, the building façade, (specifically building envelope materials selections), must consider and ensure appropriate acoustic ratings for walls, glazing units and ventilation openings within the primary building envelope construction. These decisions allow the building to successfully engage with an identified local environmental, whilst retaining the required internal noise amenity in commercial office areas.

3.2.2 Noise Survey Analysis Methodology

Our approach to satisfying *AS2107:2016* "standard" internal design sound level criteria, is to undertake a determination of current, reliable site noise data, obtained during a detailed noise survey of the area prior to Schematic Design. The process is undertaken to specifically address the building façade design, and to accurately assess the development site in terms of external noise. Noise survey analysis offers best-available practical relevance to any building facade design, and provides an objective baseline which can be very useful as a strategy to demonstrate responsible project design.

3.2.3 Noise Survey Details

Sealhurst presented engineering staff to the project site to establish a noise monitoring station over the period 15th – 21st OCT 2020 to undertake a baseline noise survey analysis via 24-hour continuous data logging. Sound pressure levels and detailed spectral and time resolution data were obtained for consecutive 5-minute periods, complete with audio recordings of significant noise events set to trigger at a Sound Pressure Level of ≥60 dB(A).

Collected data was then processed and analysed to determine an objective design case data set for assessment of the building facade and hence proof the currently proposed building materials and glazing in terms of design compliance with the prevailing standard for internal noise (See Section 4).

3.2.4 Measurement Equipment Details

Attended and logged measurements were recorded using a Norsonic Nor140 Type 1 Sound Level Meter. The meter complies with all relevant specification standards for Type 1 integrating sound measurement equipment and was within a valid laboratory-calibration period at the time of survey. The meter also satisfies all relevant and applicable Australian Standards for acoustic measurement devices, including Schedule 4 clauses contained within the *Environmental Protection (Noise) Regulations 1997 (inc. amendments).*

The meter was field-calibrated before and after the measurement series, which consisted of continuous data logging with synchronised measurements stored in 5-minute intervals. All measurements were taken in accordance with the relevant guidance in *AS1055.1-1997: Acoustics – Description and Measurement of Environmental Noise, Part 1: General Procedures*.

3.2.5 Detailed Noise Analysis - Measurement Locations

1 x Norsonic 140 Type 1 noise monitoring station was established on Lot 18 (No. 38) Summers Street, at a location approx. 50m from the south-bound carriageway edge of East Parade indicated on the schematic image below. As the site is partially screened from East Parade by existing commercial buildings, an elevated microphone position was installed at 3.5m above ground level.

Measured data is accordingly representative of the proposed new First Floor building façade. We anticipate the data from road traffic noise levels) to be representative of noise incident upon all floor levels.

3.3 Design Sound Level Data

3.3.1 External Noise – Summary Average Design Sound Level Data

The table below presents averaged measurements taken over all survey period(s) as an energetic or statistically-averaged single figure value(s) to serve as summary levels for evaluation of the existing noise climate. Equivalent (L_{Aeq}), Maximum (L_{Amax}) and L_{A90} is presented, along with statistical noise indices L_{A1}, and L_{A10} sound level data to offer an overview of the local acoustic environment:

Measurement Location	Period	$L_{Aeq,T}$ (dB)	L_{A1} (dB)	L_{A10} (dB)	L_{A90} (dB)	L_{AFmax} (dB)
Summers Street, 3.5m above Ground level, set back 50m from East Parade south-bound carriageway edge;	Day time (0700-1900 hrs)	**58.2**	65.4	59.8	52.2	89.4
	Evening Time (1900-2200 hrs)	**56.1**	63.4	57.6	49.7	88.7
	Night time (2200-0700 hrs)	**54.6**	59.4	53.1	45.3	81.1

3.3.2 24-Hour Noise Monitoring - Logged Measurements

Average values are taken over representative periods of the survey, arranged into day (6AM – 7PM), Evening (7PM – 10PM) and Night-time (10 PM – 6AM). Sound Pressure Level ($Lp_{,5min}$, dB(A)) data periods over the course of the week are plotted using statistical indices which allow a more detailed understanding of the noise environment, providing a clear and objective baseline for evaluation of existing noise impacts, most notably from road traffic noise as the recognised dominant noise source.

All noise data traces recorded over the survey period are presented in Appendix B.1. The following subjective descriptors apply:

L_{Aeq} (dB) noise levels (shown solid green trace) are used for assessment of internal design sound level criteria, representing the equivalent sound energy recorded in each successive period – the L_{Aeq} is a measure of general activity noise level recorded at the proposed building façade location throughout the day. A general trend line during weekday daytime hours)0600 – 2200) can be drawn in the range 55 – 60dB(A)), attributable to existing traffic conditions.

L_{AMAX} (dB) noise levels (shown solid red trace) report the loudest incidental sound pressure level recorded during each consecutive 5-minute period. The L_{AMAX} values are generally attributable to incidental local events and/or transient sound pressure from the passing of louder vehicles, motorcycles, emergency vehicle sirens, street cleaning vehicles and the like, and are not descriptive of the general acoustic climate.

L_{A90} (dB) noise levels (shown dashed green trace) report the statistical lowest (90th percentile) sound pressure levels recorded during each measurement period, which can sometimes be referred to as "background noise" or "residual noise level", pending source reference.

Between the Equivalent (L_{Aeq}), Maximum (L_{AMAX}) and L_{A90} Sound Pressure Level indices, a reasonable overview and understanding of the typical acoustic environment at the development site can be drawn, supported by post processing audio analysis of recorded sound events. Where the L_{A90} trace closely resembles the L_{Aeq} trace, this is indicative of a consistent noise environment; Conversely, where the L_{Aeq} varies from the L_{A10} considerably, this is indicative of a site with fairly constant changeable conditions, such as where passing road traffic vehicles are prevalent.

3.3.3 Comment on Detailed Survey Data & Future Forecast for 20-Yr Planning Horizon

Measurements show trending at 57-58dB(A) during weekday daytime(s), and 54-55dB(A) during weekend day daytime periods, with all sound pressure levels and corresponding recorded audio sample files typically dominated by road traffic noise with incidental "peak" occurrences from noise sources identified as passing buses, cars, motorcycles and HGV/truck movements.

The site presents lower acoustic conditions than those which might be expected, relative to the traffic flow volumes published by Main Roads WA (https://trafficmap.mainroads.wa.gov.au/map). When corrected for Floor Levels 1 – 3 by the addition of+2dB(A), the corrected incident Sound Pressure Level at the proposed building façade of ~59dB(A) is reasonable and presents no significant impediment to the building design in the existing condition, in terms of specialist materials and any incumbent costs.

In accordance with State Planning Policy 5.4 (See Section 4.1.2) for future predicted road traffic noise, an additional 2dB(A) has been added to the recorded noise levels, commensurate with realistic and practicable increases to road traffic volumes, allowing for the existing road traffic infrastructure as 4-lanes of traffic.

4 ACOUSTIC DESIGN FOR EXTERNAL NOISE

4.1 Internal Sound Level Design for Commercial Buildings

4.1.1 *AS 2107:2016 Acoustics: Recommended Design Sound Levels ..[…].. for Building Interiors*

AS 2107:2016 presents the applicable Australian Standard for internal sound levels in building interiors, defining criteria which are deemed *"acceptable"* and suitable for a range of spaces within completed buildings. Compliance is derived by the prediction of internal building sound levels using the methodology set out in Appendix B.3, and a comparison of results against *AS 2107:2016* criteria for the relevant internal space.

A selection of commercial spaces which may be applicable to this project are presented in the table below:

Type of Occupancy	Recommended design sound level range, L_{AEQ}, (dB(A))
OFFICE BUILDINGS	
Board and conference rooms	30 - 40
Computer rooms	45 - 50
Corridors and lobbies	45 - 50
Design offices	40 - 45
Drafting offices	40 - 50
General office areas	40 - 45
Private offices	35 - 40
Public Spaces	40 - 45
Reception areas	40 - 45
Rest room and tea rooms	40 - 45
Toilets	50 - 55
Undercover car parks	55 - 65

4.1.2 *Note re: State Planning Policy 5.4* – Trigger Distances

The site is located within 100m of East Perth passenger rail station which carries Midland line rail passengers as well as periodic locomotive services. The site is also within 50m of East Parade which runs adjacent to the rail line, carrying >46,000 vehicles of Annual Average Weekday Traffic (AAWT) volume identifying this a s a major state transport corridor.

Where *"noise sensitive land use"* development is proposed adjacent to recognised transport corridors, *State Planning Policy 5.4 Road and Rail Noise*, Sep 2019 Edition (*"SPP 5.4"*) is mandated as a planning instrument at Development Approval stage to ensure adequate building envelope design provision is incorporated to account for transportation noise.

In summary language, for *"Noise Sensitive"* land use/development, *SPP5.4 Policy* requires an examination of development in proximity to road traffic corridors within the set "trigger distances", applying a 20-yr planning horizon assessment window be examined in terms of consequential noise impacts related to the prospective increase(s) in road traffic volume, and consequential noise levels, in view of the building design;

State Planning Policy 5.4 "trigger distances" are set out below, taken as a direct *extract* from *the Policy* below:

Transport Corridor Classification	Trigger Distance	Distance measured from
Roads		
Strategic freight and major traffic routes Roads as defined by Perth and Peel Planning Frameworks and/or roads with either 500 or more Class 7 to 12 Austroads vehicles per day, and/or 50,000 per day traffic volume	300 metres	Road Carriageway Edge
Other significant freight/traffic routes These are generally any State administered road and/or local government road identified as being a future State administered road and other roads that meets the criteria of either >= 100 Class 7 to 12 Austroads vehicles daily or >= 23,000 daily traffic count (averaged equivalent to 25,000 vehicles passenger car units under region schemes).	200 metres	Road Carriageway Edge

4.1.3 "Noise Sensitive" and Commercial Land Use

"Noise sensitive" use is defined under *SPP 5.4* as "residential", "educational", "child care/hospital/aged care" and the like, attracting specific internal design noise criteria during day and night time periods.

In the case of the WAPOU office (e.g. commercial use) building, *the Policy* defers to the national standard *AS2107:2016 Acoustics: Recommended design sound levels and reverberation times for building interiors* to account for the presence of road and rail noise – both current, and in future forecast scenario over a 20-Yr planning horizon.

4.2 Calculation Methodology

Quantification of the existing noise climate allows the acoustic performance of the building façade materials to be engineered and designed to respond to the particular noise sources which impinge upon the building. The exercise is undertaken to enable noise amenity in the finished building to meet acceptable criteria with respect to the governing Australian Standards.

This is achieved by matching appropriate sound resisting components to measured noise level data (including spectral content), and then optimised where capacity is identified, to achieve the best cost outcome whilst preserving internal noise amenity.

Calculations are then optimised using known façade material properties to determine a result able to meet the *AS2107:2016* standard for internal areas. Any improvement in façade material performance(s) thereupon would equate to quieter internal noise levels within the various internal areas, and hence an improved (quieter) acoustic amenity for eventual occupants.

4.2.1 Elemental Sound Reduction Index (R) Data

Sound reduction index data is available from a number of sources, most commonly from laboratory-measured data or technical product information direct from manufacturers and from reputable technical literature. Field-measured data can also be used.

Data is given in the form of a sound reduction index value "R_i" (dB) for each octave band centre frequency over the range 125Hz-4kHz, along with a weighted single-figure rating value R_w (dB). Sealhurst maintain a large volume of sound reduction index data for common and specialist building elements, construction types and finishes to allow the calculation and facade optimisation process.

It should be noted that all sound reduction index data quoted as R_w is referenced to standard test panel sizes, which are typically of a minimum of 10m^2 for wall constructions, and 2.4m^2 for glazing panels. Building façade elements with increasingly larger surface areas may suffer from a decrease in sound transmission loss performance, specifically at low frequency due to wave-based phenomena, and therefore a higher specification may apply to achieve internal design sound levels.

4.2.2 Composite Sound Reduction Index

Assessment is by means of a composite sound reduction index (SRI) calculation, which examines the building envelope at various noise-sensitive points, for example a noise-receiving bedroom, and calculates sound transmission through the building envelope, bounded at the limits of the subject internal space.

The Sound Reduction Index (R_w) performance characteristics of each individual façade element (and any known penetrations) are summed together in octave bands (125Hz-4kHz), and mathematically weighted according to their relative 'elemental' façade area. The resultant figure is the composite sound reduction index (R_w) performance of the building façade and is typically dictated by the 'weakest' element of the construction, which in many cases can be glazing, ventilation louvers or other building penetrations.

Once calculated, representative noise spectra obtained during our site noise survey is applied to the composite building facade performance to optimise the building facade materials, identifying the minimum and/or best cost-versus-performance parameters to apply to the building in terms of the specification of the building facade's glazed elements.

A description of the calculation principles and reference standards is included in Appendix B.3 of this report.

4.2.3 Proposed Building Façade Elements

It is understood that the building envelope is to be constructed from precast tilt-up concrete panel (150mm thickness or greater), and a range of glazed elements, including both sliding and fixed awning windows.

4.2.4 Façade Element Detailing

Where properly designed, installed and detailed, tilt up concrete is rated at Rw54dB/Rw+Ctr 50dB, which offers significantly greater resistance to sound ingress than glazed elements, therefore the (acoustic) performance of the facade design is primarily dependent upon glazing specification, and frame and installation detailing. There are obvious cost implications for the choice of glazing option, plus additional considerations regards coordinating an appropriate (acoustic) selection with energy/ESD and architectural preferences.

4.2.5 Example Sound Reduction Index Data

The table below presents sound reduction index (Rw) data for cavity masonry walls, and potential façade glazing construction elements, which have been used in noise ingress calculations.

Construction Element	Sound Reduction Index (R_i)						
	R_w (dB)	Octave Band Centre Frequency (Hz)					
		125	250	500	1000	2000	4000
External Wall System(s)							
150mm tilt-up concrete panel	**54**	34	40	46	52	60	70
Glazing							
6mm float	**30**	20	24	30	35	29	36
6.38mm laminate glazing	**33**	21	24	31	35	33	38
8.38mm laminate glazing	**34**	23	27	32	34	35	43
10.38mm laminate glazing	**36**	26	27	33	36	38	46
8.5mm specialist acoustic laminate glazing	**38**	24	30	34	39	40	42
10.5mm specialist acoustic laminate glazing	**39**	27	31	36	40	40	47
Double Glazed Units (DGU), incl. Magnetite Retrofit Secondary Glazing							
6/12/6 standard float DGU	**33**	26	18	29	39	34	47
10/12/6.38 standard laminate DGU	**36**	27	29	34	41	37	47

4.2.6 Comparison of Double Glazed versus Single Glazed Laminate

As can be seen from the table above, the relative acoustic (Rw) performance(s) of single laminate glazing Rw is comparable to double glazed units (DGUs) Rw, in a single figure rating, which implies the Rw rating is the key determinant for any upgrade to building envelope/glazed openings. This is highlighted in the table above which compares 6/12/6mm DGU with single pane 6mm and 6.38mm laminate glazing.

4.2.7 Comparison of Float versus Laminate re: "Coincidence"

Use of laminates and specialist acoustic laminates also significantly improves acoustic performance – in single and DGU units, specifically where transportation noise character is concerned. Comparing single glazed 6mm float with 6.38mm laminate shows a significant increase in Rw performance of +3dB. This increase is largely due to the improvements laminate glazing provides with particular attention is drawn to the acoustic phenomena of "coincidence".

"Coincidence" describes the physical interaction which occurs between external sound and glazing when the incident external sound upon the windowpane corresponds to the airborne sound-induced transverse vibration wave occurring across the glazing pane – e.g. coincidence. Where the pane is monolithic "float" glass at 6mm thickness, this corresponds to a transverse wave around 2kHz – this frequency is characteristically present in road transportation noise as aerodynamic noise from passing cars and tyre interaction with the road surface.

Human hearing is most sensitive between 1kHz and 3.15kHz which exacerbates the effect – subjectively perceived as a characteristic high-pitched component in received sound which can lead to audio fatigue where present for extended periods.

The introduction of a standard (.38mm thick) laminate interlayer construction bonding 2 x 3mm glazing panes effectively shifts the coincidence wave to a less sensitive region of the human auditory range, which removes the 2kHz component. This is also highlighted in the table – a difference of 4dB at 2kHz which is significant.

Further improvements are available using specialist acoustic laminates, at .5mm (and greater) thicknesses, which improves transmission at 2kHz by up to 6dB, however this type of glazing typically attracts cost-premiums associated with the manufacturing and acoustic performance.

4.3 Predicted Internal Noise levels

4.3.1 Internal Noise Levels from Existing External Noise Survey Levels

The following table summarises internal noise levels that are predicted to exist in a worst-case external noise environment (i.e. 10pm – 2am Friday or Saturday night). These calculations have assumed all existing windows have a performance rating of Rw 24dB, considered equivalent to sash windows glazed with 5mm float.

Internal Area	Current Assumed Glazing Format		
Internal Area	Min. R_w (dB) (Equivalent System)	Design Criteria (*AS2107:2016*) LAeq (dB)	Predicted Internal Level LAeq (dB)
1st Flr General Office (Typical)	R_w33 (6.38mm laminate)	40 – 45dB	30.2 dB
2nd Flr Board Room	R_w33 (6.38mm laminate)	30 - 40	34.1 dB

4.3.2 Assessment of Recommended Glazing Specification - Commercial

Assessment procedure is carried out for the commercial spaces identified above, with compliance criteria taken from the "General Office Areas" target of 40-45dB(A), and Board Room criteria at 30 – 40 dB(A).

Internal noise levels have been predicted during daytime external noise conditions with balcony doors closed, calculated using office grade carpeted finish, with mineral fibre tiles to ceilings.

On this basis, internal criteria may be met in all commercial tenancies using a glazing specification with minimum rating of Rw 33dB, considered equivalent to a 6.38mm standard single laminate.

In practice, Commercial glazing suite acoustic minimum requirements may be overridden by the increased thickness(s) and toughening required for public safety under non-acoustic glazing standards; In this respect, 10mm or greater toughened (single glaze panels) or equivalent toughened DGUs are rated at Rw 34 and above, hence will comply with *AS 2107:2016* "General Office" internal noise conditions' specification.

4.4 Building Envelope Design Considerations

4.4.1 Notes on Glazing Installation

The determination of laboratory data (R_w) for standard glazing elements includes the performance of the frame. For a large group of glazing elements, particularly domestic glazing and non-specialist applications with R_w ratings below 37dB, the sound transmission of the window frame can be considered as equal to that of the glazing panel, (assuming adequate seals) except in the case of sliding window arrangements, which exhibit significantly lower R_w performance ratings due to poor sealing around the sliding mechanism at the frame perimeter.

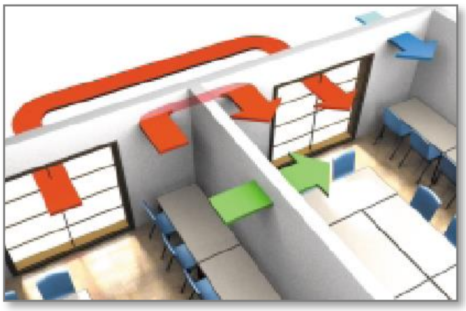
In order to maintain the predicted acoustic amenity, all operable windows must be fitted with good quality seals to minimize transmission of noise through the facade. Very small air gaps can be severely detrimental to the aggregate window/façade performance, resulting in non-compliant internal noise levels.

Special attention must be taken during installation of any sliding door set to ensure they are well fitted with a robust closing mechanism to avoid introducing acoustically weak transmission paths for noise to enter through the façade. Balcony door sets and frames must be supplemented with compressible neoprene seals at both jambs, and a continuous double brush seal at the threshold and head to minimise transmission of noise into living areas.

At the junction between the window sub-frame (cavity masonry aperture) and glazing frame proper, **ALL** voids must be fully sealed, or the full extent of the sound transmission performance will not be realised. Any voids between concrete and frame must be packed with fibreglass insulation and fully sealed with dense mastic.

4.4.2 Flanking Transmission

Certain types of construction such as architectural cladding systems, cavity block work and particular lightweight constructions are susceptible to the excess ingress of noise through poor junction detailing and voids between sound attenuating elements, known as flanking transmission paths.



The preferred building methodology for this project is understood to be composed of concrete and glazed wall elements in a composite system, and is considered to be able to provide robust resistance to the passage of sound when fully sealed and properly detailed during construction.

In order to ensure that this performance is not compromised at junctions with building penetrations, and at junctions with external cladding elements, the following measures must be taken:

- Junction detailing at window frames are stuffed with glass wool insulation off cuts and sealed with a dense mastic bead of minimum depth 10mm;
- ALL voids between building penetrations and cavity masonry wall systems must be packed/stuffed glass wool insulation off cuts and sealed with a dense mastic bead of minimum depth 10mm;
- Where external wall elements meet perpendicular internal and party walls, all voids/gaps must be packed/stuffed glass wool insulation off cuts and sealed with a dense mastic bead of minimum depth 10mm;
- Any structural movement joints are to be fully sealed with a flexible sealant.

It is anticipated that there will be no degradation of acoustic performance of the facade at wall/floor slab junctions.

4.4.3 Notes for Glazing Schedule and Drawings

Sealhurst recommend the project architect annotate building plans with the following notes regarding glazed elements installation notes to allow the builder to follow the necessary detailing.

Installing Contractor to Ensure:

1. Chosen glazing/frame combination can achieve minimum acoustic R_w rating(s);
2. All operable windows to be fitted with good quality seals, with no air gaps;
3. All glazed door sets be fitted with compressible neoprene seals at both jambs, and a continuous double brush seal at the threshold and head; and
4. All voids between cavity masonry and glazing sub-frame must be packed with dense fibreglass insulation and fully sealed with dense mastic.

Failure to correctly install and seal glazed elements, in particular glazed sliding door sets is likely to weaken the building façade design sound resistance such that it cannot achieve the specified performance, and as a result *AS2107:2000* internal design sound levels may not be met in the completed building.

4.4.4 Ventilation Openings

In some instances, ventilation grilles exhausting air to atmosphere create paths for external noise to enter the building which can negate the engineered glazing/façade wall performance if not appropriately considered during design. Ventilation openings should be located away from sensitive spaces where practicable. Where ventilation openings enter bedrooms or living spaces, internal ductwork linings, acoustically absorptive baffles or attenuating louver grilles may be used to ensure the building faced retains its design resistance to noise ingress.

4.4.5 Glazing Specification Coordination

Glazing specifications are for acoustic performance (Rw) only and must be correlated with ESD/energy requirements and integrated into the façade design at an early stage. Architectural window (and door) schedules should nominate the Rw rating AND the pane/laminate thickness during documentation to ensure a fully coordinated building design solution. R-values and energy-specific coatings may influence glazing type;

4.5 Roof Construction

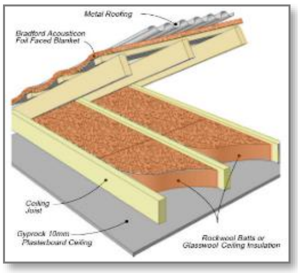
4.5.1 Rain Noise

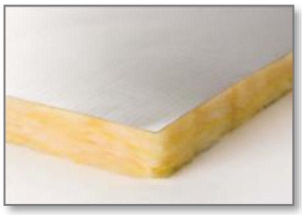
A common issue with lightweight profile steel roof sheeting systems over framing is the acoustic response to excitation from falling rain.

Droplets of water impacting upon the sheet cause it to vibrate in a manner analogous to a drum membrane. Unconstrained membranic excitation of the roof sheeting can cause high levels of intrusive noise in top floor commercial spaces during downpours, causing nuisance/annoyance and a reduction in acoustic amenity and perceived quality.

Generally speaking, rain noise is excluded from any standard classifications for environmental noise and its transitory nature and difficulty in field testing implies no fixed criteria to be achieved. However, levels as high as 70 to 80 dB L_{Aeq} can be generated during downpours.

4.5.2 Mitigation of Rain Noise





Where lightweight roof sheeting is installed, the issue of rain noise can be mitigated at nominal additional cost by the appropriate consideration during design of the installation of acoustic and thermal insulation layers usually already present, between critically connected roof elements.

An acoustically absorptive quilt must be installed to be laid in the ceiling void as part of the Mechanical and Hydraulic services treatments detailed in Section 7.3.1 to absorb reverberant noise within roof cavities, therefore this insulation quilt is anticipated to be coordinated into the roof construction already, providing a quietening function assisting in rain noise mitigation.

The roof sheeting and steel I-beams must be installed such to incorporate any thermal and acoustic insulation to underside of roof sheet. It is assumed that a combination of insulation in the roof space will be installed to provide the required energy efficiency/thermal rating, typically around R2.5 - 3.0 - It should be noted that **thermal** R values do not consider sound insulation performance, however a denser insulating blanket should have a positive effect on the roof construction's ability to resist the passage of sound.

As an additional measure, resilient hangers can be used to suspend the plasterboard ceiling layer for maximum rain noise attenuation in the detail shown. These are NOT REQUIRED to attain compiance, but may be added to provide an improved level of internal amenity during rain fall/downpours.

Pending final roof construction specification, appropriate detailing notes should be incorporated into the architectural Tender drawing set to ensure inclusion in both the documentation set and the pricing for Tender. During construction phase, this detailing should be subject to QA and inspection procedures to ensure the installed detail is able to perform in-situ.

4.6 Additional Notes on Predicted Internal Noise Amenity

4.6.1 Installation Detailing

It is important to note that at the time of completion, internal noise levels measured within the completed building spaces will be a combination of external noise sources, building services operation noise and noise from adjacent units. Internal ambient conditions will ultimately depend on the quality of workmanship during construction phase and adherence to the advice and specific detailing requirements at window frame, between window frame and facade concrete walls, and at junctions between external wall elements as set out in this report.

4.6.2 Preliminary Recommended Practical Detailing

The following measures are recommended to be incorporated as part of "Quiet House" design principles:

- Fully enclosed eaves at roof level;
- Where balconies have operable glazed doors, a mechanically operated closing mechanism fully sealed with compression gaskets should be installed to all closing edges for optimum acoustic performance – where sliding doors are preferred, acoustic compression seals must be fitted;
- Where practicable, passive ventilation and/or exhaust grilles facing east preferred;

4.6.3 Design Review, Inspection and QA

Effective site inspections and QA/checking procedures on site during construction phase are critical in ensuring the design acoustic performances are not compromised by omissions, incomplete detailing, poorly sealed junctions and interstitial spaces in construction elements or other voids gaps introduced due to site tolerances and the like.

Sealhurst recommend early site inspections be carried out during construction phase to coincide with acoustically critical installations of separating walls, floor/ceiling construction installations, glazing and window frame installations and roof construction sealing to establish and advise site staff of the standard of detailing to seek in regular day-to-day QA checks.

5 PARTITIONS - SOUND TRANSMISSION & INSULATION

5.1 General Overview of Standard Office Partitions

5.1.1 Application of Practical Acoustic Separation (Rw) Ratings

Separating partition types and acoustic performance(s) thereof in commercial building, administrative office and entertainment space(s) are not subject to specific minimum acoustic (Rw/Rw+Ctr) performance and/or construction criteria per se. Rather, partitions and respective acoustic performance(s), are determined practically as part of overall design, based upon commercial layout, anticipated activity noise levels in each space, the adjacencies of noise-sensitive (or non-noise-sensitive) spaces, and any overarching Principal client requirement(s) for privacy, confidentiality and the like.

5.1.2 Subjective Descriptors for Typical Acoustic (Rw) Ratings

In order to provide a tangible rating scheme to the Principal client, the following subjective descriptions applicable to Rw performances are presented. The ratings are informative only, and is intended to familiarise the Principal and project partners as to the numerical context of Rw specification, and allow more subjectively informed decisions where an acoustic recommendation is made, for example to performance upgrades, and the impact this may on costings to achieving a desired or practical level of acoustic separation performance.

The table assumes full height wall construction in all cases;

Rw rating	Fixed & Glazed Full Height Partition - Separation Afforded
	n/a
	n/a
25dB	Normal speech easily understood
30dB	Normal speech audible, partially intelligible
35dB	Normal speech barely audible, Loud speech understood
40dB	Normal speech barely audible, Loud speech audible, partially intelligible
45dB	Loud speech audible
50dB	Raised voices audible
55dB	Raised voices barely audible

5.1.3 Laboratory R_w, and Field-Equivalent D_{nTw} Partition Ratings and Privacy Factor

Notwithstanding Principal client specifics for the finished building, the acoustic (Rw) rating specification for a given separating partition is only one component of the overall desired acoustic in the finished office building – the end acoustic result must necessarily take into account the use(s) and anticipated activity noise levels of adjacent spaces either side of the partition, requirements for confidentiality or speech privacy in each space, and expected background noise in the unoccupied space from building services.

As a means to quantify this balance, the term "Privacy Factor", or "Acoustic Privacy" can be applied:

Privacy Factor (dB) = Weighted Level Difference (D_w) + Background Noise Level (L_{Aeq})

The Privacy Factor rating describes how intelligible unamplified spoken conversation is expected to be when a partition rating is combined with background noise conditions in a receiving space. Consider the example where a managerial office requiring confidential speech exchanges has a partition rating of Rw 50dB; The adjacent store room has very low background noise levels at 25dB. The Privacy Factor is therefore 75dB, which may not be sufficient:

- Generally, where an acoustic privacy level of 70 dB or below is provided, then speech will be considered "intelligible", i.e. able to be understood in the adjacent room. In other words, a privacy rating of 70dB will be considered "not private".
- Conversely, Privacy Factor (dB) ratings above 90dB are likely to provide unintelligible speech, i.e. high levels of privacy.

In the illustrative example of managerial office to storeroom adjacency, as the storeroom might have no building services noise component, hence a solution would be to increase the partition rating to Rw60dB or greater to achieve the desired Privacy Factor.

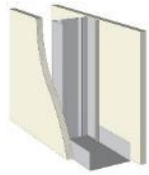
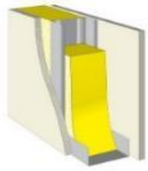
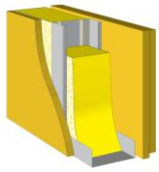
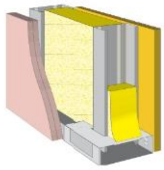
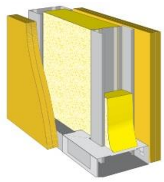
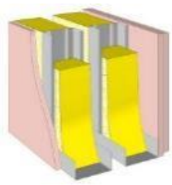
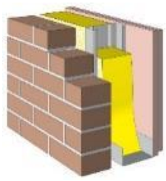
One final note refers to the practical difference between laboratory (Rw) acoustic ratings, measured using 10m^2 of partition test sample under controlled conditions with no flanking transmission at partition edges or over ceiling voids; And, the practical sound insulation performance achieved in the field, referred to as Level Difference (Dw) between two adjacent rooms with site tolerances, potential for detailing workmanship variance, and potential non-full height installation.

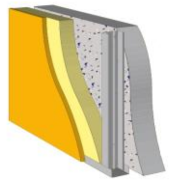
To achieve a desired Privacy Factor (dB) rating in the as built, a tolerance of minimum 5dB must be added to the Rw rating to allow for site tolerances and installation anomalies sufficient to meet the Dw equivalent Privacy Factor.

NB – where non-full height walls are proposed, then acoustic Rw ratings become severely limited – typically to around Rw30 - 35dB where an office-grade ceiling tile and open ceiling void is positioned over. In non-full height wall cases where acoustic performance is required, specific detailing using construction above the line of the partition to close out the ceiling void is required.

5.1.4 Typical Acoustic Performances of Lightweight Partitions & Corresponding Rw Ratings

The table below is intended to provide a palette of typical partition specifications, of the range typically found in office environments. The table below supplements the subjective descriptions in Section 5.1.2, presenting typical lightweight and lightweight/masonry combination partitions and their corresponding Rw ratings, when installed full height:

Description	Notes on Use	Est. Rating	Schematic
"Standard 64mm Stud Partition, 13mm Gyproc" 64mm steel stud lined both sides with 1 x 13mm Gyproc (standard) plasterboard, taped and sealed, NO INSULATION **Nominal wall width 90mm**	No practical acoustic separation;	Rw 35dB	
"Standard 64mm Stud Partition, 13mm Gyproc" 64mm steel stud lined both sides with 1 x 13mm Gyproc (standard) plasterboard, taped and sealed, with 75mm thick, min. $12kgm^{-3}$ insulation quilt to entire wall cavity; **Nominal wall width 90mm**	Nominal acoustic separation, Cleaners cupboards, BoH areas with low speech privacy/confidentiality requirements; Suitable for toilets/WC	Rw 42dB	
"Standard 76mm Stud Partition, 13mm SoundCheck" 76mm steel stud lined one side with 13mm Soundcheck plasterboard, other side with 2 x 13mm standard plasterboard; Cavity lined with min 75mm thick, min. density $12kgm^{-3}$ insulation quilt to entire wall cavity; **Nominal wall width 90mm**	Reasonable acoustic separation, suitable for private offices in low noise areas, Can be used to achieve medium speech privacy/confidentiality;	Rw 49dB	
"Staggered 92mm Steel Track & Stud Partition, 13mm SoundCheck/13mm FR " 92mm staggered stud lined one side with 13mm Soundcheck plasterboard, other side with 2 x 13mm FR plasterboard; Cavity lined with min 75mm thick, min. density $12kgm^{-3}$ insulation quilt to entire wall cavity; **Nominal wall width 131mm**	Good acoustic separation in commercial areas, with adjacent low noise requirements; Can be used to achieve medium-to-high speech privacy/confidentiality;	Rw 54dB	
"Staggered 92mm Steel Track & Stud Partition, 13mm SoundCheck" 92mm staggered stud lined both sides with 2x13mm Soundcheck plasterboard; Cavity lined with min 75mm thick, min. density $12kgm^{-3}$ insulation quilt to entire wall cavity; **Nominal wall width 144mm**	Excellent acoustic separation in commercial areas, with adjacent low noise areas; Suitable for walls, where internal noise levels could be up to <80 dB(A); Can be used to achieve high speech privacy/confidentiality;	Rw 58dB	
"Twin 64mm Steel Stud Partition, 13mm FR" 2 x 64mm separate stud studs, min. 40mm clear air gap between stud frames; Lined one side with 1x13mm FR plasterboard, opposite stud lined aith 2x13mm FR Plasterboard; Cavity lined with 2 x 75mm thick, min. density $12kgm^{-3}$ insulation quilt to entire wall cavity; **Nominal wall width 200mm**	Excellent acoustic separation in commercial areas; Suitable for Function Room walls, where internal noise level from events is <85 dB(A); Discontinuous construction provides reliable acoustic separation between adjacent areas;	Rw 62dB	
"90mm Masonry w/ 92mm Steel Stud Combination, 13mm FR" 90mm masonry with 40m clear air gap to 92mm stud, lined with 2x13mm FR plasterboard; Cavity lined with min 75mm thick, min. density $12kgm^{-3}$ insulation quilt to entire wall cavity; **Nominal wall width 268mm**	Excellent acoustic separation in commercial areas; Suitable for Function Room walls, where internal noise level from events is <85 dB(A); Discontinuous construction provides reliable acoustic separation between adjacent areas;	Rw 62dB	

Description	Notes on Use	Est. Rating	Schematic
“>100mm Concrete Panel w/64mm Steel Stud Combination, 13mm SoundCheck” 64mm steel stud (or timber batten) with min 20mm clear air gap between panel and stud frame; stud clad with 13mm Soundcheck plasterboard as lining to one side of >100mm thick concrete panel; Cavity lined with min 75mm thick, min. density 12kgm^{-3} insulation quilt to entire wall cavity; **Nominal (min.) wall width 197mm**	Excellent acoustic separation in commercial areas; Suitable for walls, where internal noise level from events is 85-90dB(A); Discontinuous construction provides reliable acoustic separation between adjacent areas;	Rw 64 dB	

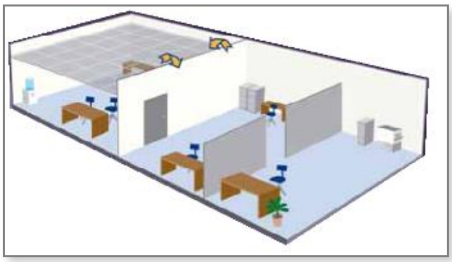
5.1.5 Plasterboard Sheeting – Reference Material Properties

Two types of CSR plasterboard product names are listed on the proposed wall types, which can infer different performances in situ. The most notable difference is density, which plays a key role in sound insulation performance of one board over another, particularly where single boards are concerned. The following table is intended to serve as a reference for materials purchasers, to ensure the listed (estimated or measured) acoustic materials and associated ratings are able to be achieved in the finished building.

Soundcheck and standard (Gyproc) are colour coded to partition type table schematics:

Cladding Material	Thickness (mm)	Type	Surface Mass	Acoustic Rating	Est. Rating w/Insulation
Plasterboard	13mm	Gyprock	8.5 kgm^{-2}	Rw+Ctr 22 dB	Rw+Ctr 22 dB
Plasterboard	13mm	Aquachek	10.4 kgm^{-2}	Rw+Ctr 24 dB	Rw+Ctr 27 dB
Plasterboard	13mm	Soundcheck	13.0 kgm^{-2}	Rw+Ctr 26 dB	Rw+Ctr 29 dB
Plasterboard	13mm	Fyrchek	10.5 kgm^{-2}	Rw+Ctr 24 dB	Rw+Ctr 27 dB
Plasterboard	16mm	Fyrchek	12.5 kgm^{-2}	Rw+Ctr 24 dB	Rw+Ctr 27 dB
Plasterboard	25mm	Shaftliner	19.8 kgm^{-2}	Rw+Ctr 28 dB	Rw+Ctr 31 dB

5.1.6 Full Height Walls on Ground Floor to Underside of First Floor Slab



Acoustic ratings (Rw) for separating partitions refer to a full height wall, constructed from fixed heavyweight floor to underside of concrete slab over, without gaps or penetrations. The schematic diagram (right) shows a typical layout, where full height walls are installed above line of the architectural suspended ceiling grid;

The principal element to consider in terms of maintaining separating wall Rw performance(s) and hence achieving practical levels of privacy and/or confidentiality in finished office spaces is therefore noise transmission passing over installed partitions via ceiling void space.

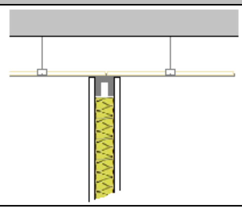
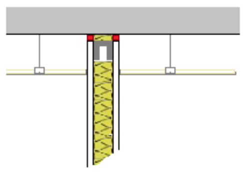
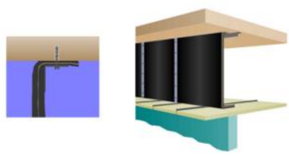
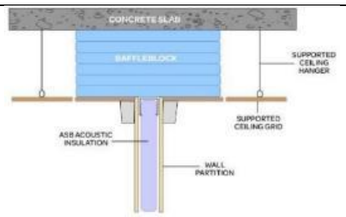
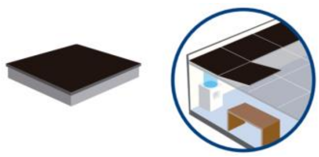
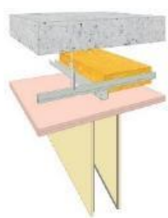
Where partition walls are taken up to underside of suspended ceiling only, the separation performance is less dependent upon the partition and more dependent upon the transmission via ceiling space. Using lightweight mineral fibre ceiling tile on tegular grid, with insulation in the void over, partitions in this arrangement typically achieve Rw 35dB only, which renders loud speech audible/intelligible in adjacent space.

Where separation performances of Rw 42dB and greater are sought, (typically all cases), in order to maintain R_w ratings above Rw 35dB, full height walls or an acoustically equivalent ceiling void barrier must be installed over the line of the rated partition to avoid flanking transmission over the wall apex in the completed space.

NB - This is a requirement in any area where privacy/confidentiality is a functional requirement.

5.1.7 Non-Full Height Wall – treatment Options/Types

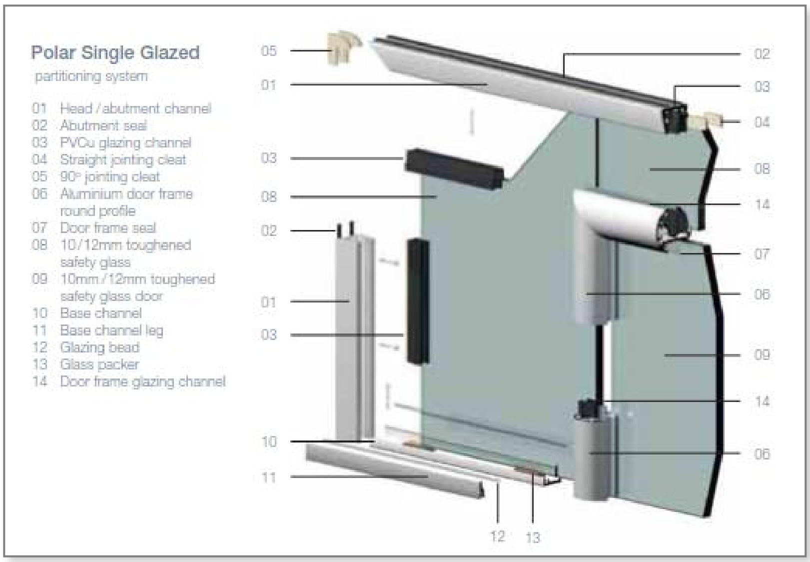
In each circumstance, a full height wall, ceiling void cavity barrier detail or increased mass ceiling layer must be installed to retain the acoustic separation performance between the adjacent areas, as indicated on mark-ups. The table presented below shows three types of minimum ceiling void detail options, each of which are able to retain the design rating (R_w):

Option	Detail	Schematic	Opinion
Non-Full Height Wall	Partition up to mineral fibre suspended ceiling tile, open over ceiling void above		WALL RATING (Rw) LIMITED TO Rw30 -35 dB
Full Height Wall	Partition sealed to slab over, packing any voids with a mineral wool or glass fibre insulation batt off-cut, and sealing with a dense mastic.		RETAINS WALL RATING (Rw)
Ceiling Void Cavity Barrier	Install loaded vinyl ceiling void cavity barrier of min. density 8kgm^{-2} over framing detail system mechanically pinned to u/side slab; and folded 2 – 3 times for 300mm extents to either side of full extents of partition line to form compression seal;		RETAINS WALL RATING (Rw)
Baffle Block Cavity Barrier	Install Autex Baffle Block^{TM} 100mm thick pre-cut 600mm wide insulation batts at 15kgm^{-3} density over line of partition to 300mm either side, and under compression of 35% (e.g. installed thickness of each batt to <65mm;		RETAINS WALL RATING (Rw) up to Rw 50dB in conjunction with ceilings to both sides;
Increased Mass Ceiling Tile	Install additional mass layer over ceiling tiles to full extent of room on both sides of separating wall to achieve equivalent separation in situ; Typical mass increase to 1 x 16mm FR P/Board equivalent, ~12.5kgm^{-2}		RETAINS WALL RATING (Rw) to extent of increase in mass, typically up to to Rw 55dB where ceiling mass up to 12kgm^{-2}
2 x 13mm FR Plasterboard as suspended mass ceiling	Install 2 x 16mm FR P/Board (mass ~25kgm^{-2}) as suspended ceiling to both rooms either side of non-full height partition, to full extents of room, with insulation quilt over; *Requires uprated ceiling framing Note – will increase room reverberation times in both spaces where replacing mineral fibre (absorptive) ceiling tile		RETAINS WALL RATING >Rw 55dB in conjunction with 25kgm^{-2} mass ceilings to both sides;

5.2 Fixed Glazed Partitions (Informative)

The following information is intended for advanced stages of the project to assist in communicating practical acoustic performance expectations, costs and limitations involved when specifying glazed partitions in contemporary office environments:

5.2.1 Glazed Wall Specification



Principal to acoustic separation performance(s) through glazed partitions are the type and thickness of the glazed pane – single or double glazed units; the type of glazing framing – e.g. framed or frameless glazing, and entry doorsets.

Key differences between lightweight plasterboard partitions (range Rw35dB – Rw 60dB) and glazed partitions are in available Rw performances, and relative cost/complexity to achieve:

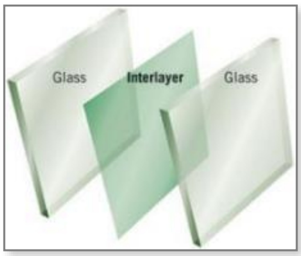
Glazed partition performances can be generally grouped as follows:

- Rw34-38dB using typically available single pane glazing (e.g. 10mm toughened – 12.8mm specialist laminates) in standard framing;
- Rw 40-42dB using specialist heavyweight (e.g. >16mm laminated) single panes;
- Practical maximum of Rw 45dB using specialist argon-filled double glazed units (DGU) less than 40mm thickness;

Higher performances (up to Rw55dB) can be physically achieved, though this performance is highly specialised, using secondary glazing construction with airgap between double glazed panes of >150mm, insulated frames, and would come with significant cost implication when compared to a standard single glazed partition.

Aside from the identified performance limitations, glazed partitions are subject to equivalent installation and detailing requirements above suspended ceilings, and below access floors, where present. Advice in Section 5.1.4 and 5.1.5 re: ceiling barrier alternatives is applicable where speech privacy/confidentiality is a requirement.

5.2.2 Glazing Thickness Versus Acoustic (Rw) Performance

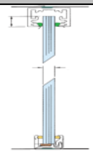
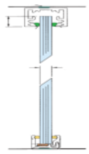
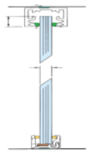
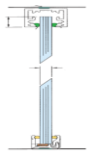
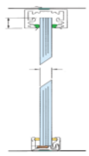


Monolithic (i.e. single pane) glazing has a unique response pattern to sound transmission at specific frequencies, known as "coincidence effect". The effect relates to a glazing pane's thickness, and effectively causes increased sound transmission (i.e. reduced performance) at a particular band of frequencies, when the incident sound level wavelength (λ) matches that of the surface bending wave present in the glazing.

Typically this occurs at around 2kHz in 6mm glass, and moves down in frequency as pane thickness increases. To combat this effect, glazing is often manufactured/supplied in laminate build ups, using a pvb or vinyl interlayer to "de-couple" the panel bending waves from the incident sound waves. Using a "standard laminate", e.g. .38mm interlayer, the result is a significant boost in sound transmission performance to those frequencies otherwise affected by coincidence.

As a rule of thumb, the thicker the interlayer between panes, the better decoupling effect – "acoustic" laminate glazing is recognised by a .4A, .5 or .8mm laminate thickness. Additionally, the thicker the overall glazing pane (inclusive of all layers) the greater the overall mass and greater Rw performance is achieved.

5.2.3 Typical Glazed Partitions and Relative Acoustic (Rw) Performance(s)

Description	Est. Rating	Schematic
"Standard Glazed Partition" 100mm x 50mm powder coated glazing frame with single glazing panel; Head track taped and sealed at sus. ceiling over, no cavity barrier above or below access floor	Rw 30 dB	
"Standard Glazed Partition – Flexible Cavity Barrier" 100mm x 50mm powder coated glazing frame with single glazing panel; Head track taped and sealed at sus. ceiling over, Cavity barrier (Autex compressed baffle block) installed above sus ceiling to soffit AND below access floor (where installed)	Rw 34 dB	
"Standard Glazed Partition – Fixed Cavity Barrier" 100mm x 50mm powder coated glazing frame with 13mm thick SWITCHABLE single glazing panel; Head track taped and sealed at sus. ceiling over with foam/rubber sealing detail; Fixed Cavity barrier 2 x 13mm Plasterboard to both sides of stud frame, insulation lined with 70mm, 12kgm-3 quilt) installed above sus ceiling to soffit AND below access floor (where installed)	Rw 38 dB	
"Standard Glazed Partition – Fixed Cavity Barrier" 100mm x 50mm powder coated glazing frame with min 10.38mm (Rw 36dB) single glazing panel; Head track taped and sealed at sus. ceiling over with foam/rubber sealing detail; Fixed Cavity barrier,	Rw 36 dB	
"Standard Glazed Partition with transom rails – Fixed Cavity Barrier" 100mm x 50mm powder coated glazing frame with specialist 10.5mm (Rw 38dB) single glazing panel; Head track taped and sealed at sus. ceiling over with foam/rubber sealing detail; Fixed Cavity barrier,	Rw 38 dB	
"Operable Glazed Partition – Fixed Cavity Barrier" Double Glazed Acoustic Operable Wall Panels TBC	TBC	

5.2.4 Subjective Performance Scale – Glazed Partitions

The following table demonstrates a range of subjective scale to assist Principal client understanding regards typical glazing panes and Rw performances, ranging from basic float panes up to high performance sound studio-grade systems.

Note performances > Rw45dB are of significant construction and at likely cost premiums:

Glazed Partition Type	Rw rating		Rw Rating Scale	Practical Separation Afforded
n/a			25dB	Normal speech easily understood
6mm Toughened	32dB		30dB	Normal speech audible, but unintelligible
6.38mm Standard Laminate	33dB			
10mm Toughened	34dB		35dB	Loud speech understood
12mm Toughened	34dB			
15mm Toughened	35dB			
10.38mm Standard Laminate	36dB			
12.4mm Fire Safety Glass	37dB		40dB	Loud speech audible, but unintelligible
10.8mm Specialist Acoustic Laminate	38dB			
12.8mm Specialist Acoustic Laminate	39dB			
16.4mm STADIP SILENCE	42dB		45dB	Loud speech barely audible
20.4mm STADIP SILENCE	44dB			
DGU 12/16/10.4A (38.4mm thick)	45dB			
DGU 8.4A/24 (Argon filled)/14.8A (43mm thick)	50dB		50dB	Shouting is audible
Secondary DGU Format Glazing est. 12/200/12.8mm, Min 200mm Airgap, heavyweight, insulation-lined frames absorptive reveals;	55dB		55dB	Shouting becoming barely audible

5.2.5 Glazed Partition Specification versus Client Performance Expectation

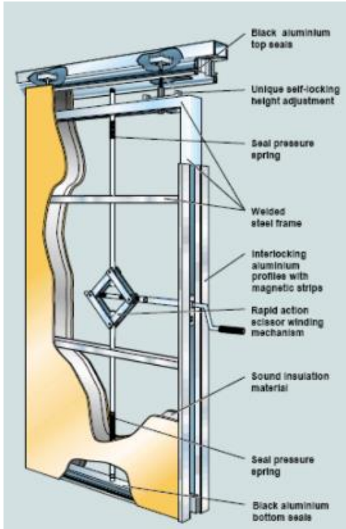
Using 12.8mm laminate glazing in a proprietary framing system, single glazed partition walls can achieve Rw 39 dB, which in practical terms, affords loud speech to be "audible but unintelligible". Increasing performance above this level of separation is available to the Principal, but would be expected to attract increased cost per m^2 for glazing and frame, most likely in a proprietary system;

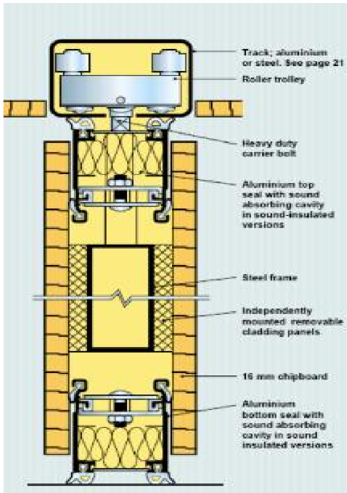
Where a subjective performance is desired by the Principal Client or end-tenant client over-and-above this grade, we recommend a specialist installer – Lotus Doors (www.lotusdoors.com.au) Opera system can be specified from Rw 41 – Rw 60, using a standard 70mm thick glazed framing panel.

5.3 Operable Walls

The following information is intended for advanced stages of the project to assist in communicating practical acoustic performance expectations, costs and limitations involved when specifying operable partitions in contemporary office environments:

5.3.1 Basic Anatomy of an Operable Wall





Alco Beldan NW 100 Movable Wall (Vertical Section Through Standard Panel)

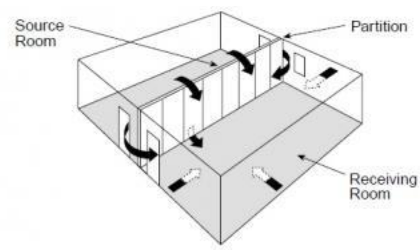
Operable walls offer flexibility of space/use which are attractive for modern office fitouts. Key to specification of an operable wall is understanding it's effective sound reduction between the adjacent spaces, which is a sum of multiple parts. Key to understanding the decision, and procuring a cost-effective and useful operable partition is the basic anatomy of the operable wall. The following basics apply:

- **Top Track**, the running system – must be insulated where sound transmission control is required; Ceiling void barrier of equivalent separation (Rw) performance must be specified;
- **Height adjustment/Seal Pressure Spring**s – set at installation, continuous force seals are a minimum for any degree of privacy/separation of speech intelligibility between adjacent spaces;
- **Panel-to-Panel Seal** – determines effectiveness of compressional seal and resulting sound transmission through main body of operable wall; Where practical sound separation is the principal driver, mechanical lever closure panels should be employed, rather than passive hinged closure panels;
- **Panel Surface Mass** – mass of any fixed or operable partition system is a critical determinant of sound transmission performance. The greater surface mass per m^{-2}, the greater Rw rating can be achieved, (flanking transmission dependent), though with increased panel mass comes increase in partition cost, installation complexity and potential structural considerations at v high performance specifications;
- **Bottom Seal** – Anatomy shown (right) Alco Beldan NW100 standard panel shows absorptive cavity with mechanically operated continuous pressure seals to both sides, to maintain seal at threshold;

5.3.2 Flanking Noise Transmission

Operable wall system performances are typically offered as airborne sound insulation ratings, e.g. Rw 54dB, which describe the acoustic separation performance between two adjacent spaces in a laboratory setting. However, laboratory tests are carried out in virtually ideal conditions that effectively remove "flanking noise transmission", that is, noise passing around, over and via gaps in the partition, as opposed to directly through it.

In all "real" buildings with fixed partitions, flanking noise will always occur in some form due to construction methodology (e.g. concrete walls, lightweight walls etc), workmanship, building materials, construction tolerances, perimeter junctions, etc. Where operable partitions are concerned, flanking noise is subject to further sensitivities "in the field" which mean the specification of acoustic rating (Rw) value, and resultant implied performances on site, can and do vary greatly from the lab-measured result.



Based upon numerous studies and lab versus field results of operable walls, operable wall field ratings can range between -5 and -12 dB less performance in field settings when compared to their lab equivalent. For this project, we recommend a rule of thumb of -10 dB be applied when specifying operable walls. This allowance will have a direct implication on operable wall costing.

5.3.3 Laboratory Performance versus Practical Specification

The above basic understanding of operable walls was discussed during our site visit and liaison with the Principal client, as a means to set practical goals and offer alternatives where operable walls form a key component of the finished building use and flexibility requirement(s).

5.3.4 Subjective Performance Scale – Operable Partitions

To set out the basis of this advice, the table below demonstrates lab performance (Rw) values versus what this means to office-type activity noise separation; The 10dB "rule-of-thumb" allowance is then applied, with resulting spec. shown below:

Rw rating	Lab Separation Afforded	Typical Operable Panel Weight	Practical Separation Afforded (dB Rating, adjusted by 10dB "Rule-of-Thumb")
25dB	Normal speech easily understood	>30kgm^{-2}	n/a
30dB	Normal speech audible, but unintelligible	>35kgm^{-2}	n/a
35dB	Loud speech understood	>37kgm^{-2}	25dB – Normal speech easily understood
40dB	Loud speech audible, but unintelligible	Min. 37kgm^{-2}	30dB - Normal speech audible, but unintelligible
45dB	Loud speech barely audible	Min. 42kgm^{-2}	35dB - Loud speech understood
50dB	Shouting is still audible	Min. 60kgm^{-2}	40dB - Loud speech audible, but unintelligible
55dB	Shouting not audible	Min. 75kgm^{-2}	45dB - Loud speech barely audible

5.3.5 Operable Wall Seals

Continuous force seals for Panel to Panel, top track, and bottom seals are rubber items and can be expected to perish over time. Replacement of operable wall seals should be considered under building lifecycle costing as a maintenance item, and costs be sought from the appointed operable wall manufacturer/installer at the time of Tender. Frequency of use, handling and cleaning general maintenance will determine life of seals.

6 REVERBERATION TIME TARGETS

6.1 Applicable Criteria

6.1.1 AS2107:2016 - Design Reverberation Times

Reverberation Time is a measure of the echoic nature of a room. It is normally measured in 1/3 octave or octave bands by exciting the space with a high level interrupted source or impulse, and measuring the time taken for the signal to decay to silence. The longer the reverberation time, the more 'echoic' a room sounds.

Acceptable standards for reverberation times is prescribed under *AS2107:2016 Acoustics: Recommended design sound levels and reverberation times in building interiors*. We have assumed "General Office" type for the purposes of establishing reverberation time control targets:

Type of Occupancy	Recommended reverberation time (T), s
OFFICE BUILDINGS	
Board and conference rooms	0.6 - 0.8
Computer rooms	*See Note 3*
Corridors and lobbies	0.4 - 0.6
Design offices	0.4 - 0.6
Drafting offices	0.4 - 0.6
General office areas	0.4 - 0.6
Private offices	0.6 - 0.8
Public Spaces	0.5 - 1.0
Reception areas	*See Note 3*
Rest room and tea rooms	0.4 - 0.6
Toilets	-
Undercover car parks	-

6.1.2 Reverberation Time Notes

Reverberation time target criteria in the *AS2107:2016* extract above:

"*Note 3*" states: *Reverberation Time should be minimised as far as practicable for noise control*"; *And,*

"*Curve 1*" defines reverberation times determined by the volume of the space.

* Curve 1 refers curves 1, 2 and 3 presented in Figure A1, Appendix A of *AS2107:2000* which "*represent mean reverberation times of spaces which are considered to possess good acoustic qualities*".

Section 6.1.3 presents informative notes on acoustic absorption, with the intention of allowing an informed decision on how to apply the most cost-effective treatment for office type spaces.

6.1.3 Application of Acoustic Absorption

The concept of sound absorption can be described as the ability of a material to transform acoustical energy into some other form or energy, usually heat though at lower frequencies the transfer can be to kinetic energy. All materials absorb *some* acoustical energy; some materials such as plasterboard reflect a large portion of the energy that strikes it, whereas other materials such as fibrous insulation will absorb more of the energy.

Alpha (α) is the term used to represent a material's Absorption Coefficient, which mathematically describes the proportion of incident sound energy arriving from all directions that is **not** reflected back into the room i.e. which is absorbed. Alpha (α) ranges between 0 and 1, where 0 is totally reflective and 1 is totally absorptive.

Sound is more readily absorbed at mid-to-high frequencies through fricative (heat) losses, than at low frequencies. This frequency dependent reaction is acknowledged by the measurement of sound absorption coefficients at one third octave band centre frequencies from 125Hz to 4000Hz, giving materials a sound absorption "profile" to allow particular material selection.

Example materials and their respective absorption coefficients typically found in office spaces are shown in the table below:

Material Sound Absorption Coefficient (α) Data								
Internal Room Finish Material	Octave Band Centre Frequency (Hz)						α_w	Abs. Class
	125	250	500	1000	2000	4000		
Windows (glass facade)	0.10	0.08	0.05	0.04	0.03	0.02	**0.05**	-
Office grade carpet tile, medium pile	0.05	0.15	0.55	0.5	0.5	0.5	**0.45**	D
Plasterboard as suspended ceiling	0.2	0.15	0.15	0.05	0.05	0.05	**0.10**	-
12mm square hole Perforated Plasterboard as suspended ceiling (16% open area)	0.42	0.62	0.7	0.68	0.64	0.64	**0.70**	C
Standard Mineral fibre ceiling tile with nominal 200mm void	0.4	0.6	0.65	0.75	0.8	0.75	**0.75**	C
Acoustic ceiling tile (e.g. Ecophon Master A) with nominal 200mm void	0.45	0.8	0.85	0.9	0.95	0.95	**0.90**	A
Plasterboard wall area	0.2	0.15	0.15	0.1	0.08	0.05	**0.10**	-

Two columns are of note - α_w and Abs Class;

α_w describes an overall weighted value across all frequencies, defining the total absorption rating of the material. **Abs Class** rates the material in terms of A - E with A being the highest absorbing across all frequencies. From the example absorption data presented above, particularly in these two columns, one can derive that the vast majority of acoustic absorption in an office space is provided by the ceiling tile, which therefore makes the selection of ceiling material integral to delivering good standard of room acoustics.

6.1.4 Reverberation Time – Base Building Treatments

The acknowledgement of internal fittings and finishes are essential to the finished room acoustic of any commercial office space.

In order to meet reverberation time targets in general office environments, typical treatments are mineral fibre ceiling tiles in a tegular grid over commercial floor area, with office grade carpet tiles as a floor covering. The two parallel absorptive surfaces are sufficient to deliver control of reverberation time in rooms of standard height (e.g. 2.7m) based upon the ratio of volume to area.

6.1.5 Alternative Treatments included in Fitout

A perforated plasterboard treatment with insulated fibre glass (absorbing) quilt laid in the void space over will also provide reverberation time control, in conjunction with office grade carpet tiles. This ceiling option will offer a slightly greater acoustic barrier performance (over a lightweight ceiling tile) for any ceiling void located FCU units, where installed.

A wide range of alternative architectural and aesthetic ceiling types are available into which acoustically-absorptive material can be integrated – slatted timber, "floating" island ceilings, coffered ceilings or spray-on acoustic finishes to blacked out slab finish over; Each can be incorporated into the architectural fitout and effectively control reverberation time. These design options may be assessed in more detail as the project design and tenants' fit out particulars become better known.

NB – Outside of toilet areas, the application of **no ceiling treatment** (e.g. standard plasterboard ceilings) in will result in general office environments that fail to meet reverberation time criteria.

7 INTERNAL BUILDING SERVICES NOISE

7.1 Mechanical Building Services - Internal Noise Levels

7.1.1 Internal Noise Levels - *AS2107:2016*

All operational building services plant and equipment must not exceed the maximum permissible sound levels prescribed under *AS2107:2016 Acoustic - Recommended design sound levels and reverberation times for building interiors*, presented below in tabular summary.

Type of Occupancy	Recommended design sound level range, L_{AEQ}, (dB(A))
OFFICE BUILDINGS	
Board and conference rooms	30 - 40
Computer rooms	45 - 50
Corridors and lobbies	45 - 50
Design offices	40 - 45
Drafting offices	40 - 50
General office areas	40 - 45
Private offices	35 - 40
Public Spaces	40 - 45
Reception areas	40 - 45
Rest room and tea rooms	40 - 45
Toilets	50 - 55
Undercover car parks	55 - 65

Internal noise level limits are considered in terms of building services provision, to include items such as fan coil units (FCU), condenser units (CU) and toilet (TEF) exhaust fans, including noise breakout from duct work/services risers routed adjacent to receiving spaces.

7.2 Anticipated Mechanical Noise Sources

7.2.1 Internal FCU – Ceiling Cassettes, Ducted or Split

Mechanical concepts are not yet determined as is appropriate for this stage of design, however individual office areas are likely to be heated/cooled using internal wall mounted, ceiling cassette or ducted FCU systems connected to an external condenser unit or bank of units (CU(s)).

Typical office grade FCUs are readily available which generate Sound Pressure Levels of ~35-40dB(A) at 1m. In the context of the office environment, FCU noise will be able to be designed in combination with partitions (Rw) ratings to meet Privacy Factors sought in the finished Detailed Design.

7.2.2 Condenser Units A/C

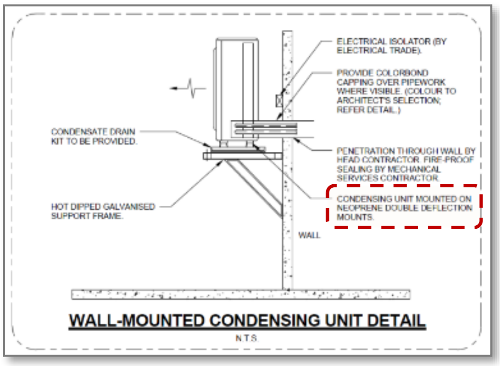
Individual office units are likely to be heated/cooled using internal wall mounted, ceiling cassette or ducted FCU systems connected to an external condenser unit or bank of units (CU(s)). Where CUs are located at roof level, installation considerations can affect internal noise received from the operation of CUs.

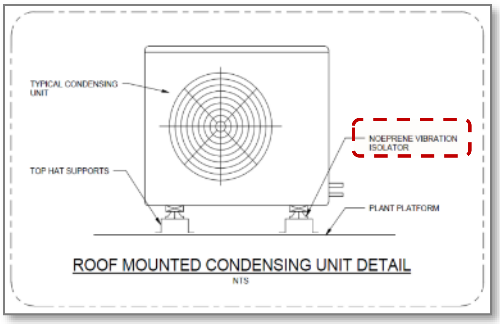
Mechanical concepts are not yet determined as is appropriate for this stage of design, however typical office grade FCUs are readily available which generate Sound Pressure Levels of ~51dB(A) at 1m. Cumulative effects of multiple units will need to be taken into consideration when locating and specifying CUs – TBC during Detailed Design, noting advice on vibration isolation mountings in Section 7.2.3 below.

Note - Externally located CUs must also comply with *Environmental Protection (Noise) Regulations 1997* limits at the nearest noise sensitive receiver - *see Section 8.*

7.2.3 Anti-Vibration Mountings

Any proposed condenser units (CU) should be mounted on vibration isolation hangers and/or neoprene double deflection mountings are (depending upon high or low level instalation location), to avoid introducing structural vibration into connected walls, roof frame/sheeting and/or any connected structural elements, which could be re-radiated as internal noise.





Where external CUs are fixed directly to the floor slab or underside of concrete slab over (or mounted in roof trusses), CUs must be similarly installed to include a neoprene or rubber anti vibration mounts on hanging mechanism to avoid direct transmission of fan operating motion into the structure.

Example details are presented (right) showing intent. Anti-vibration mounting system(s) such as those nominated by the manufacurer of the AC units, are to be installed and checked on site during the construction phase.

7.2.4 Toilet Exhaust Fans (TEF)

TEF fan selections should be selected for the development with sound power and resultant sound pressure levels no greater than those presented in the table below:

TEF System Element	SWL - Octave Band Centre Frequency (Hz)								SPL_{3m} dB(A)
	63	125	250	500	1k	2k	4k	8k	
TEF G.01 [outlet]	48	35	53	45	46	47	35	26	31
TEF G.01 [inlet]	54	44	53	55	53	51	43	36	37

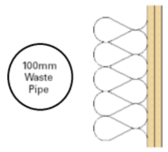
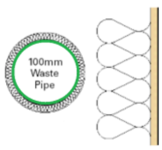
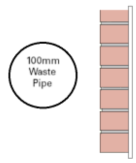
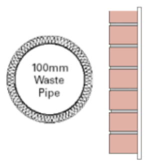
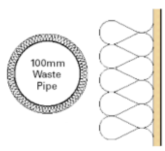
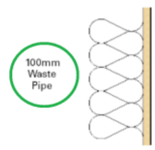
In conjunction with the proposed built form and ceiling finishes, selections above are anticipated to comply with *AS2107:2016* operational internal design sound levels. Any TEF selection to be installed which differs from the data above must be reviewed by the acoustic consultant prior to procurement to ensure internal noise levels are acceptable.

TEF systems must also comply with *Environmental Protection (Noise) Regulations 1997* limits at the nearest noise sensitive receiver - *see Section 8.*

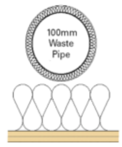
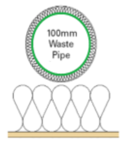
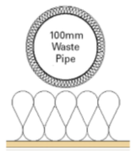
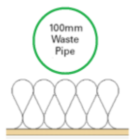
7.3 Building Services Duct Walls - Rated Minimum Constructions

Concealed services reticulation is anticipated to from part of the building services design. The following table(s) present rated services concealment constructions to meet the minimum standards, as set out in the BCA/NCC. Though not a compliance requirement in commercial office settings, these rated constructions are expected to achieve a satisfactory level of services noise insulation in the project, where not otherwise specified, and give a useful indication of noise treatments for services ducts as the project services reticulation design(s) are progressed:

7.3.1 Services Concealed in Vertical Ducts

Application	Specification	Schematic	Est. Rating (R_w+C_{tr})	NCC Compliant
Concealment of shared services riser/duct wall, or services to/from an adjacent apartment which are routed next to an adjoining apartment's **HABITABLE AREAS** (living rooms, bedrooms, etc)	Unlagged Standard PVC Pipe, mounted on rubber isolation pipe clips behind 2 x 13mm plasterboard sheet, with 50mm cavity insulation (min density 11kgm^{-3})		40dB	COMPLIES
Concealment of shared services riser/duct wall, or services to/from an adjacent apartment which are routed next to an adjoining apartment's **HABITABLE AREAS** (living rooms, bedrooms, etc)	Laminated wall (rated) pipe, wrapped with Pyrotek Soundlag 4525C or equivalent performing pipe lagging material, mounted on anti-vibration pipe clips behind 1 x 13mm plasterboard sheet, with 50mm cavity insulation (min density 11kgm^{-3})		43dB	COMPLIES
Concealment of shared services, or services to/from an adjacent apartment which are routed next to an adjoining apartment's **HABITABLE AREAS** (living rooms, bedrooms, etc)	Alternative masonry solution - Unlagged Standard PVC Pipe, mounted on rubber isolation pipe clips behind 1 x 90mm brickwork leaf with render/plaster set over		40dB	COMPLIES
Concealment of shared services, or services to/from an adjacent apartment which are routed next to an adjoining apartment's **HABITABLE AREAS** (living rooms, bedrooms, etc)	Upgraded masonry solution - Standard PVC Pipe, wrapped with Pyrotek Soundlag 4525C or equivalent performing pipe lagging material, mounted on rubber isolation pipe clips behind 1 x 90mm brickwork leaf with render/plaster set over		>45dB	COMPLIES
Concealment of shared services riser/duct wall, or services to/from an adjacent apartment which are routed next to an adjoining apartment's **NON-HABITABLE AREAS** (wet areas etc)	Standard PVC pipe lagged with Soundlag 4525C or equivalent performing pipe lagging material, mounted on anti-vibration pipe clips behind 1 x 13mm plasterboard sheet, with 50mm cavity insulation (min density 11kgm^{-3})		25dB	COMPLIES
Concealment of shared services riser/duct wall, or services to/from an adjacent apartment which are routed next to an adjoining apartment's **NON-HABITABLE AREAS** (wet areas etc)	Laminated wall (rated) pipe, mounted on anti-vibration pipe clips behind 1 x 13mm plasterboard sheet, with 50mm cavity insulation (min density 11kgm^{-3})		25dB	COMPLIES

7.3.2 Services Concealed in Horizontal (Ceiling Space) Ducts

Application	Specification	Schematic	Est. Rating (Rw+Ctr)	NCC Compliant
Concealment of shared services, or services to/from an adjacent apartment which are routed over an adjoining apartment's **HABITABLE AREAS** (living rooms, bedrooms etc) *Typically over habitable area ceiling spaces*	Standard PVC pipe lagged with Soundlag 4525C or equivalent performing pipe lagging material, mounted on rubber isolation pipe clips behind 2 x 13mm plasterboard sheet, with 50mm cavity insulation (min density $11kgm^{-3}$)		43dB	COMPLIES
Concealment of shared services, or services to/from an adjacent apartment which are routed over an adjoining apartment's **HABITABLE AREAS** (living rooms, bedrooms etc) *Typically over habitable area ceiling spaces*	Laminated wall (rated) pipe, wrapped with Pyrotek Soundlag 4525C or equivalent performing pipe lagging material, mounted on anti-vibration pipe clips behind 1 x 13mm plasterboard sheet, with 50mm cavity insulation (min density $11kgm^{-3}$)		43dB	COMPLIES
Concealment of shared services, or services to/from an adjacent apartment which are routed over an adjoining apartment's **NON-HABITABLE AREAS** (bathrooms, laundry, WC etc) *Typically over wet area ceiling spaces*	Standard PVC pipe lagged with Soundlag 4525C or equivalent performing pipe lagging material, mounted on rubber isolation pipe clips behind 13mm plasterboard sheet, with 50mm cavity insulation (min density $11kgm^{-3}$)		25dB	COMPLIES
Concealment of shared services, or services to/from an adjacent apartment which are routed over an adjoining apartment's **NON-HABITABLE AREAS** (bathrooms, laundry, WC etc) *Typically over wet area ceiling spaces*	Laminated wall (rated) pipe, mounted on rubber isolation pipe clips behind 13mm plasterboard sheet, with 50mm cavity insulation (min density $11kgm^{-3}$)		25dB	COMPLIES

7.4 Ancillary Construction Recommendations for Concealed Services Duct Walls

The *NCC* makes provision of additional criteria specific to the placement and function of mechanical building services. Though not a compliance requirement in commercial office settings, these rated constructions are expected to achieve a satisfactory level of services noise insulation in the project, where not otherwise specified, and give a useful indication of noise treatments for services ducts as the project services reticulation design(s) are progressed:

> *"2. Construction deemed to satisfy*
>
> *(e) Services*
>
> *(i) Services must not be chased into concrete or masonry elements*
>
> *(ii) A door or access panel required to have a certain Rw+Ctr that provides access to a duct, pipe or other service must –*
>
> *(A) not open into any **habitable** room (other than a kitchen); and*
> *(B) be firmly fixed such that the rebate or frame is overlapped by the access panel by not less than 10mm, be fitted with a sealing gasket along all edges and be constructed of-*
>
> (aa) *wood, particleboard or block board >33mm thick*
> (bb) *compressed fibre reinforced cement sheeting >9mm thick*
> (cc) *Other suitable material with mass per unit area >24.4 kgm-2*

(iii) A water supply pipe must –

(A) Only be installed in the cavity of a discontinuous construction; and
(B) *In the case of a pipe that serves only one sole-occupancy unit, not be fixed to the wall leaf on the side adjoining any other sole-occupancy unit, and have a clearance of at least 10mm to the other leaf*

(iv) Electrical outlets must be offset from each other –

(A) In masonry walling, not less than 100mm; and
(B) In timber or steel framed walling, not less than 300mm."

7.5 Hydraulic Building Services Noise Control

7.5.1 Hydraulic Services Treatments

For the purposes of this report, "hydraulic services" refers to all piping installations relating to sewerage, storm water, hot and cold water supply and gas; "hydraulic services noise treatments" refers to "hydraulic services" which are reticulated in services ducts adjacent to noise sensitive office spaces.

7.5.2 Use of Pipe Wrapping

For the avoidance of doubt, ALL hydraulic pipe work (inclusive of down pipes, storm water pipes, hot and cold water supply pipes, drainage and foul waste pipes) reticulated within services ducts/risers/concealed ceiling voids adjacent to noise sensitive office spaces are recommended to be wrapped in a suitable loaded vinyl or mineral wool pipe wrapping.

7.5.3 Anti-Vibration Pipe Clips

All pipes should be secured in cavities, voids or service risers using resilient pipe clip connections which incorporate an isolating rubber or neoprene collar, to avoid introducing pipe-borne noise into the surrounding structural elements.

7.5.4 Penetrations into Services Ducts/Riser Walls

All penetrations into services duct risers, plant room walls or any other acoustically rated wall to allow pipe reticulation must be acoustically sealed so as not to introduce degradation to the rated wall acoustic performance. Minimum sealing detail requirements are to pack any gap/void around pipe/duct with fibreglass insulation batt off cuts and then seal with a 10mm dense mastic bead.

Where larger gaps are present, gaps can be filled with 2 x 13mm plasterboard sections cut to fit, and then packed with fibreglass insulation off-cuts and sealed a with a 10mm dense mastic bead.

NB - Expanding foam MUST NOT be used to seal gaps/voids in acoustically rated riser/duct walls, as this can be severely detrimental to the separation performance (R_w) of the wall.

7.5.5 Sound Isolation of Pumps

Section F5.7 of the *NCC* states:

"A flexible coupling must be used at the point of connection between the service pipes in a building and any other circulating or other pump".

All pipe runs connected to hydraulic circulation pumps or similar plant equipment are recommended to be connected via flexible couplings to avoid the introduction of structure borne noise through rigid connections.

7.6 Electrical Building Services Noise Control

The following notes are of significance to the acoustic design, to be coordinated with the Electrical design consultant and installation Contractor:

7.6.1 Location of Back-to-Back Sockets in Acoustically Rated Walls

Where walls between offices have back-to-back GPOs, the following advice applies:

> *"Electrical outlets must be offset either horizontally or vertically from each other -*
> *(A) in masonry walling, not less than 100mm; and*
> *(B) in timber or steel framed walling, not less than 300mm."*

7.6.2 Electrical Services Penetrations

All electrical services penetrations into services duct risers, plant room walls or any other acoustically rated wall to allow electrical cable reticulation (including cable trays) must be acoustically sealed. Minimum sealing detail requirements are to pack any gap/void around cable/cable tray penetration with fibreglass insulation batt off cuts and then seal with a 10mm dense mastic bead.

Where larger spaces are present, the open penetration area can be filled with 2 x 13mm plasterboard sections cut to fit, and then packed with fibreglass insulation off-cuts and sealed a with a 10mm dense mastic bead.

NB - Expanding foam MUST NOT be used to seal gaps/voids in acoustically rated walls, as this can be severely detrimental to the separation performance (R_w) of the wall.

8 NOISE EMISSIONS TO ENVIRONMENT

8.1 Applicable Criteria

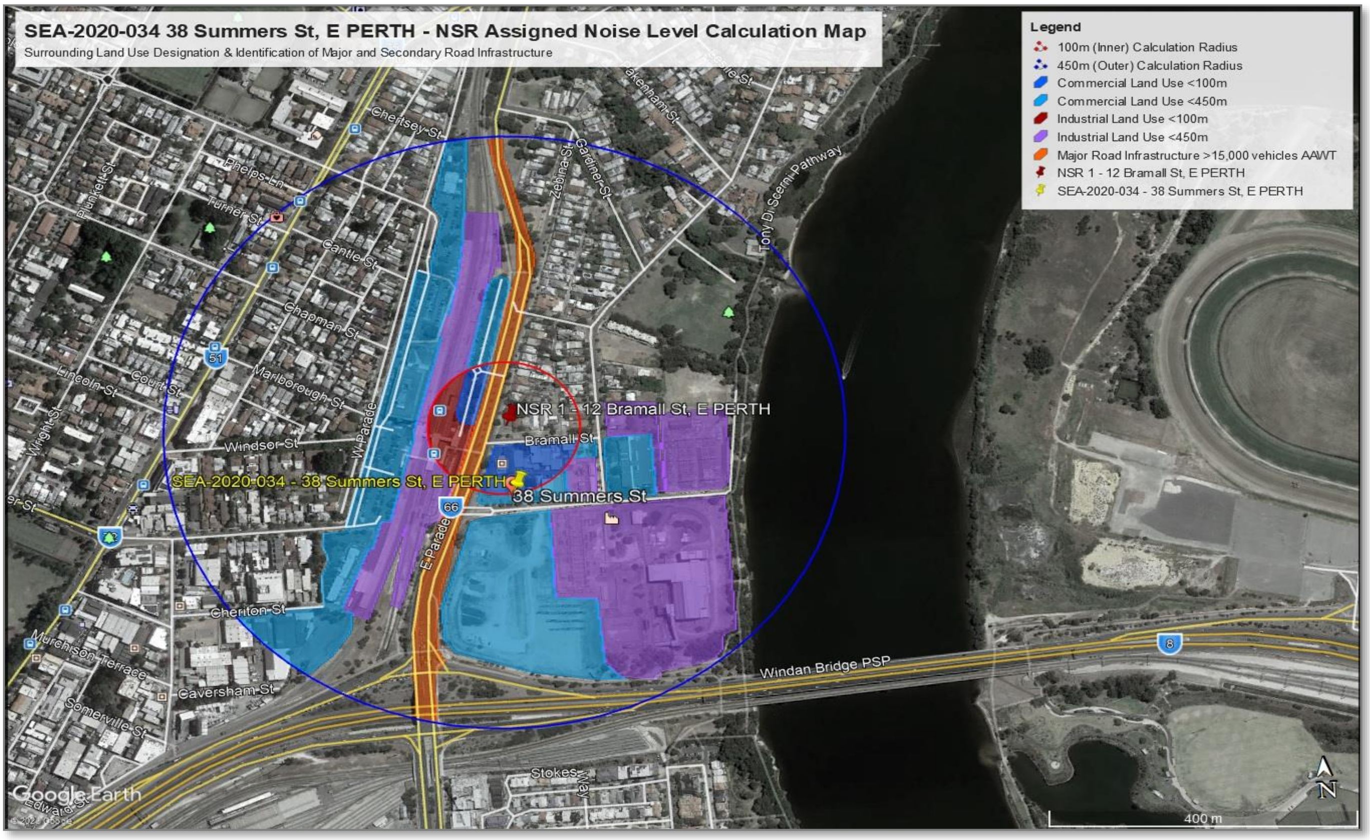
8.1.1 WA Environmental Protection (Noise) Regulations 1997 (Incl. Amendments)

The *Environmental Protection (Noise) Regulations 1997 (inc amendments)* is the applicable legislation governing all sources of noise which are introduced when the new building is constructed, and **applicable at the nearest Noise-Sensitive Receiver (NSR)**. The *Regulations1997* prescribe a specific methodology from which to calculate the Assigned Noise Level (ANL), which is the formal, objective and allowable noise emission limit due to the development. The ANL is different for each NSR, and is based upon an appraisal of the percentage Commercial and Industrial land surrounding the nearest noise sensitive receiver (NSR), and the volume and composition of road traffic in the vicinity of 450m (outer) and 100m (inner) boundary areas surrounding the designated NSR.

8.1.2 Determination of Land Use

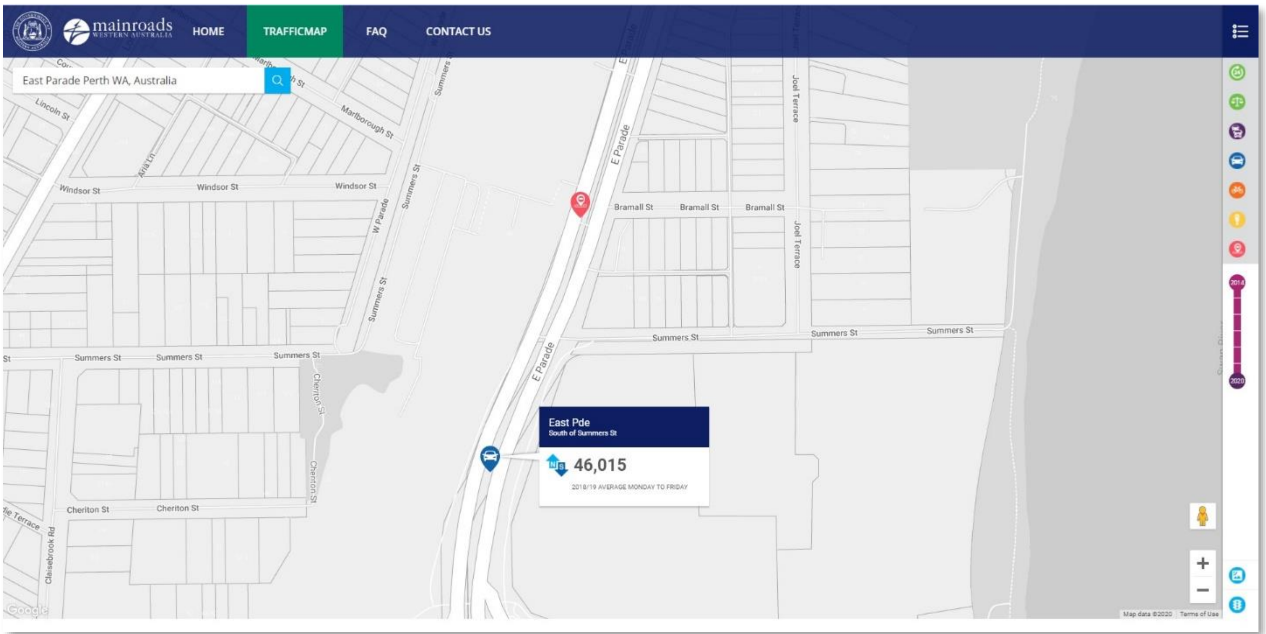
The schematic image below presents review and classification of surrounding Commercial (C) and Industrial (I) land use in the Inner and Outer calculation radii in the vicinity of the site and nearest NSR. ANL limits were calculated on the basis of 30% Commercial (C) Land Use in the Inner circle, and 15% Commercial Land Use within the surrounding Outer Circle calculation radius; 17% Industrial (I) Land Use in the Inner circle and 15% within the surrounding Outer Circle calculation radius.

Road transport infrastructure is identified as East Parade (South of Summers St), carrying a Traffic volume of 46,015 vehicles per Annual Average Weekday (AAWT), identified as a *"Major Road"* in accordance with the *Prescribed Methodology*.



8.1.3 Road Traffic Data

Confirmation of road traffic data taken from Main Roads WA - https://trafficmap.mainroads.wa.gov.au/map:



8.1.4 Identification of Nearest Noise-Sensitive Receiver (NSR)

When calculating an Assigned Noise Level (ANL) limit, one must consider the nearest existing noise-sensitive receiver(s), NSR(s), as prescribed under *Schedule 1 Part C, Environmental Protection (Noise) Regulations 1997*, as the defining receiving location for noise emissions from a new development. The nearest NSRs have been determined as:

- NSR 1, identified as 12 Bramall St, ~71m north; And,
- NSR 2 identified as 36 Summers St, ~15m immediate east;

The NSRs are indicated orange in the figure below, with the development site outlined in red.

8.1.5 Calculated Assigned Noise Level Limits

Under the prescribed calculation methodology, the Influencing Factor (IF) has been calculated at **+11**. The Table below presents the Assigned Noise Level limits, applicable at the nearest NSR.

Part of Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	56	66	76
	0900 to 1900 hours Sundays and public holidays	51	61	76
	1900 to 2200 hours all days	51	61	66
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	46	56	66
Noise sensitive premises at locations further than 15m of a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and Utility premises	All hours	65	80	90

Appendix D presents the calculation methodology and assumptions used in our assessment.

8.1.6 Noise Source Character

In addition to the ANL limits, particular noise sources can attract additional punitive dB levies based upon the noise source characteristics. *Regulation 7* prescribes that the noise character must be "free" of annoying characteristics - specifically:

(i) tonality (e.g. whining, droning)
(ii) modulation (e.g. cyclical change in character, such as a siren)
(iii) impulsiveness (e.g. banging, thumping)

Penalties apply up to a maximum of +15dB, for tonality (+5dB), modulation (+5dB) and impulsiveness (+10dB), where the noise source is NOT music.

8.2 External Mechanical Services Noise Emission Sources

8.2.1 Anticipated A/C Condenser Units

Individual office units are likely to be heated/cooled using internal wall mounted, ceiling cassette or ducted FCU systems connected to an external condenser unit or bank of units (CU(s)). Where CUs are located at roof level, installation considerations can affect internal noise received from the operation of CUs.

Mechanical concepts are not yet determined as is appropriate for this stage of design, however typical office grade FCUs are readily available rated to Sound Power Level (SWL) of 67dB(A).

Externally located CUs must comply with *Environmental Protection (Noise) Regulations 1997* limits at the nearest Noise Sensitive Receivers.

Given the narrow Lot footprint, the design lends itself to an arrangement of externally mounted condensers at roof level, with potential requirement for provision of a visual screen, typical to the satisfy of Council development guidelines.

8.2.2 Individual Dwelling A/C Condenser Units – Noise Source Definition

Example Condenser Units (CUs) selections are presented below for typical units for this scale development

Noise data from various manufacturers is often presented in a range of formats, with quoted numbers referring to of Sound Power Level (SWL) or measured Sound Pressure Levels (SPL) at alternate distances/conditions; Hence a firm grasp of noise data format is essential to ensure accurate and reliable predictions.

To avoid any ambiguity in the referenced noise data terms, and homogenise the assessment (and any dependent calculations), we have presented the source data and adjustments for clarity – acoustic data used in our preliminary assessment(s) is highlighted orange as follows:

Preliminary CU - Make | Model	dB(A)	Octave Band Centre Frequency (Hz)							
Details		63	125	250	500	1k	2k	4k	8k
Daikin | RZQS140AV1 (CU)[1]									
Cooling Mode[2]									
Manufacturer single figure Sound Pressure Level dB(A)	54dB(A)								
Quoted Octave Band Sound Pressure Level, measured at1m in anechoic conditions[3];		56	53	53	53	49	45	39	31
Adjusted to reference Sound Power Level, SWL (dB(A)) using First Principles	65dB(A)	66.8	63.8	63.8	63.8	59.8	55.8	49.8	41.8
Heating Mode[4]									
Manufacturer single figure Sound Pressure Level dB(A)	56dB(A)								
Not Provided – *Assumed*[5] Octave Band Sound Pressure Level, spectrally adjusted based upon single figure value;		58	55	55	55	51	47	41	33
Adjusted to reference Sound Power Level, SWL (dB(A)) using First Principles	67dB(A)	68.8	65.8	65.8	65.8	61.8	57.8	51.8	43.8

[1] NOTE – Manufacturer data quotes "EPA SWL" at 69dB for a 53/55 unit, indicating a drop of 14-16dB(A) between measured SPL and reference SWL in anechoic chamber tests;
[2] Cooling mode generally emits lower sound pressure levels at low frequency due to the physics relating to condenser operation to generate cold coil conditions;
[3] "Anechoic" conditions describes acoustic test chambers which are heavily insulated, and devoid of any reflected sound; The resulting measurement is not influenced by reflections, as occurs in the installed environment;
[4] Heating mode generally emits slightly higher sound pressure levels at low frequency relating to condenser operation whining generate heated coil conditions;
[5] *Assumed* spectrum applies spectral characteristics of the condenser unit to the slightly increased sound pressure level quoted for Heating mode, to generate a spectrum for analysis;

8.2.3 Condenser Unit – Indicative Compliance Summary

Our assessment uses "Heating Mode" (highest noise emission) in all case, emanating from an estimated 4 xCU units in a localised bank in the centre of the roof; Assessments are calculated at 15m (nearest) distance to NSR 2 and include a conservative allowance for screening from the roof location(s), to assess the "worst" (i.e. highest noise) case:

At 15m plus a conservative attenuation allowance for roof screening, the predicted Sound Pressure Levels received at NSR 2 from indicative Condenser Unit bank operation are as follows:

- NSR 1 41.5dB(A)

This demonstrates the predicted outcome for 4 x CUs which complies during all times of the day, evening and night-time hours;

No further noise mitigation would be required on this scenario on proviso that:

- CU's be placed centrally on roof plan so as to take advantage of natural screening to the adjacent property which eliminates direct line-of-sight; And,

Note, compliance is indicative only, using example CU units. Cumulative effects of additional CU units will need to be taken into consideration when locating and specifying CUs – TBC during Detailed Design, noting advice on vibration isolation mountings in Section 8.2.5 below.

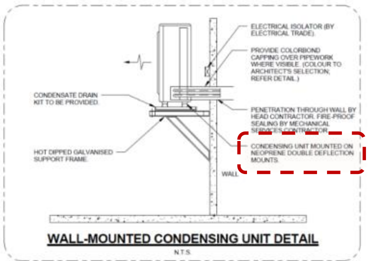
It is anticipated that any changes to CU unit specification, location, and/or enclosure design will be determined during the Detailed Design phase – where the CU selections and locations carry through to procurement, no further mitigation will be required for off-site noise emissions.

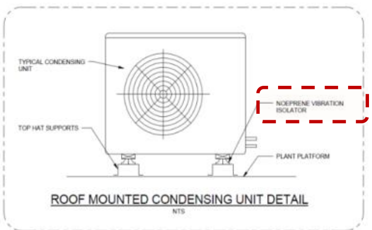
8.2.4 Note on Tonality

Small scale commercial-grade CU units are typically broadband and steady-state in nature, hence tonality, modulation and impulsive penalties are not anticipated. Sealhurst recommend the final selections for procurement be reviewed prior to installation, in terms of octave band sound levels, to determine and any additional noise emissions sources not yet identified, be assessed to ensure the building is able to comply with the limits at all times.

8.2.5 Anti Vibration Mountings

For the avoidance of doubt, where any Condenser Units (CU) or building mechanical plant is mounted on ground or on framed stand(s), all units are to be mounted on anti-vibration mounts, or isolation hangers, or using neoprene double deflection footing mountings, as per schematic detail (right).





Where CU units are anticipated to be fixed directly to the floor slab or underside of the concrete slab above or mounted in steel frame trusses, FCUs must be installed to include a neoprene or rubber anti vibration mounts on hanging mechanism to avoid direct transmission of fan operating motion into the structure.

It is essential these or equivalent anti vibration mounting system(s) such as those nominated by the manufacurer of the ACC units, are installed and checked on site during the construction phase. Failure to install anti vibration or isolation mountings will introduce structural vibration into the roof frame and sheeting and any connected structural elements. Loose laid waffle pad is not sufficient.

A. SCHEDULES OF INFORMATION

A.1 Architectural Drawings

The following Schematic Design drawings have been provided by Whitehaus Architects and used for our design review – acoustic design assessment and advice is based upon the information contained within these drawings:

DWG. REF	TITLE	DATE	REV	ISSUE STATUS
DA00	COVER SHEET	02/12/20	G	ISSUED FOR INFORMATION
DA01	LOCALITY PLAN & SITE SURVEY	02/12/20	G	ISSUED FOR INFORMATION
DA02-A	EXISTING BUILT FORM CONTEXT	02/12/20	G	ISSUED FOR INFORMATION
DA02-B	POWER STATION MASTERPLAN 2007	02/12/20	G	ISSUED FOR INFORMATION
DA02-C	HISTORICAL SETBACKS	02/12/20	G	ISSUED FOR INFORMATION
DA03	PROPOSED SITE PLAN/GROUND FLOOR & FIRST FLOOR	02/12/20	G	ISSUED FOR INFORMATION
DA04	SECOND FLOOR & ROOF PLAN	02/12/20	G	ISSUED FOR INFORMATION
DA05	ELEVATIONS & STREETSCAPE	02/12/20	G	ISSUED FOR INFORMATION
DA06	SHADOW STUDY	02/12/20	G	ISSUED FOR INFORMATION
DA07	LANDSCAPING PLAN	02/12/20	G	ISSUED FOR INFORMATION
DA08	TRAFFIC MANAGEMENT – SWEPT PATHS IN/OUT	02/12/20	G	ISSUED FOR INFORMATION

A.2 Site Inspection Photographs, 15 OCT 2020

The following table lists reference site images taken during noise survey set up and inspection 15th October 2020:

20201015_094425	20201015_094545
	
20201015_094606	**20201015_094609**
	
20201015_094611	**20201015_094641**
	

20201015_094700	20201015_094703
	
20201015_094708	20201015_094717
	
20201015_094730	20201015_094733
	
20201015_094752	20201015_094807
	

20201015_094819	20201015_094835
	
20201015_094919	20201015_094921
	
20201015_094928	20201015_094954
	
20201015_095001	20201015_095010
	

20201015_095029	20201015_095100
	
20201015_095103	20201015_095118
	
20201015_095202	20201015_095225
	
20201015_095256	20201015_095311
	

20201015_095103	20201015_095118
	
20201015_095202	20201015_095225
	
20201015_095256	20201015_095311
	
20201015_095323	20201015_095354
	

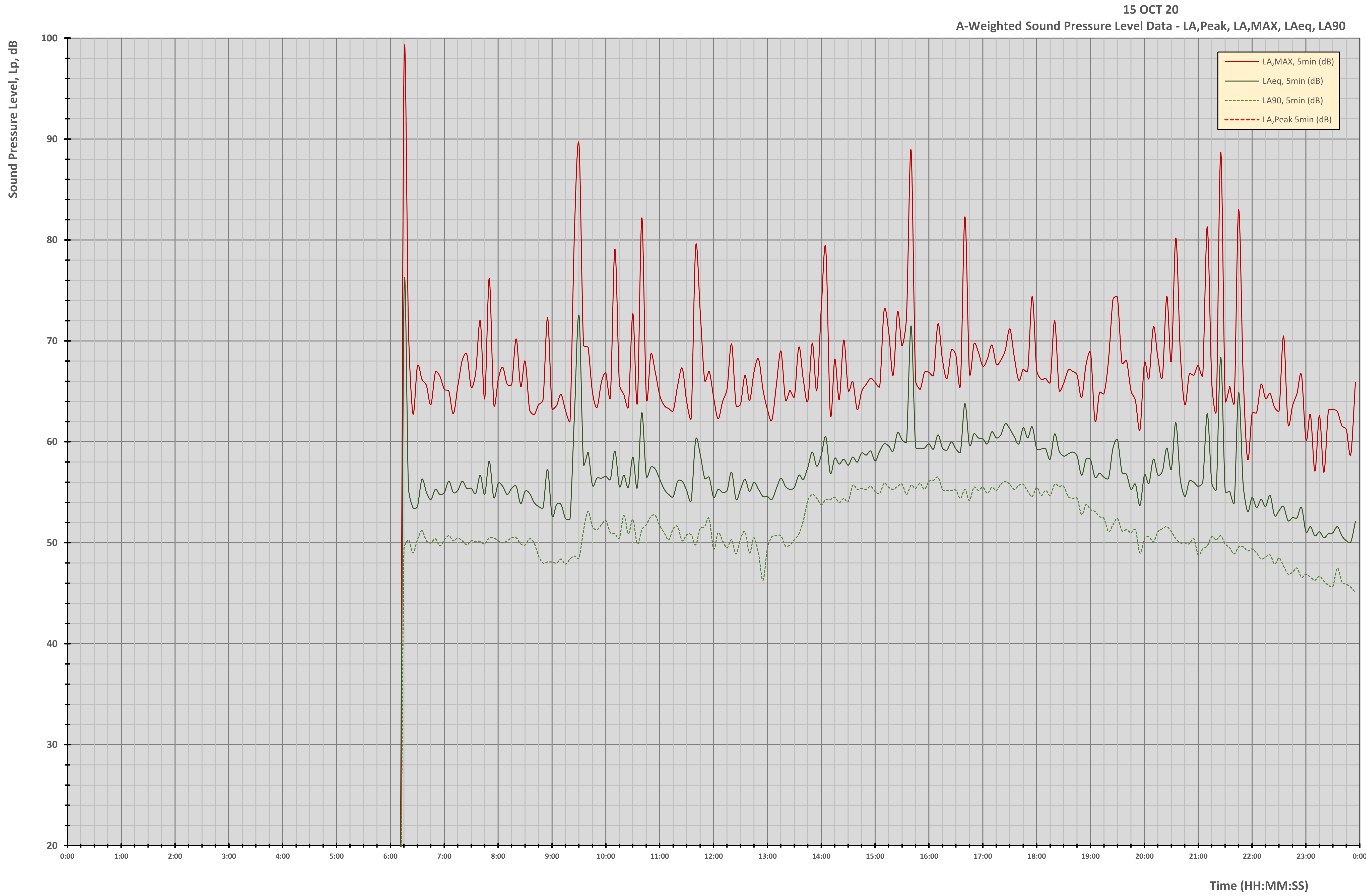
20201015_095357	20201015_095410
	
20201015_095510	20201015_095517
	
20201015_095535	20201015_095537
	

20201015_095539	20201015_095541
	
20201015_095544	20201015_095548
	
20201015_095558	20201015_095610
	
20201015_095641	20201015_095705
	

20201015_095723	20201015_095740
	
20201015_095749	20201015_095803
	

B. BUILDING FACADE CALCULATION METHODOLOGY

B.1 Detailed Noise Survey Analysis – 24 Hour Logged Data



15 OCT 20
A-Weighted Sound Pressure Level Data - LA,Peak, LA,MAX, LAeq, LA90
LA,MAX, 5min (dB)
LAeq, 5min (dB)
LA90, 5min (dB)
LA,Peak 5min (dB)
Sound Pressure Level, Lp, dB
100
90
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
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18:00
19:00
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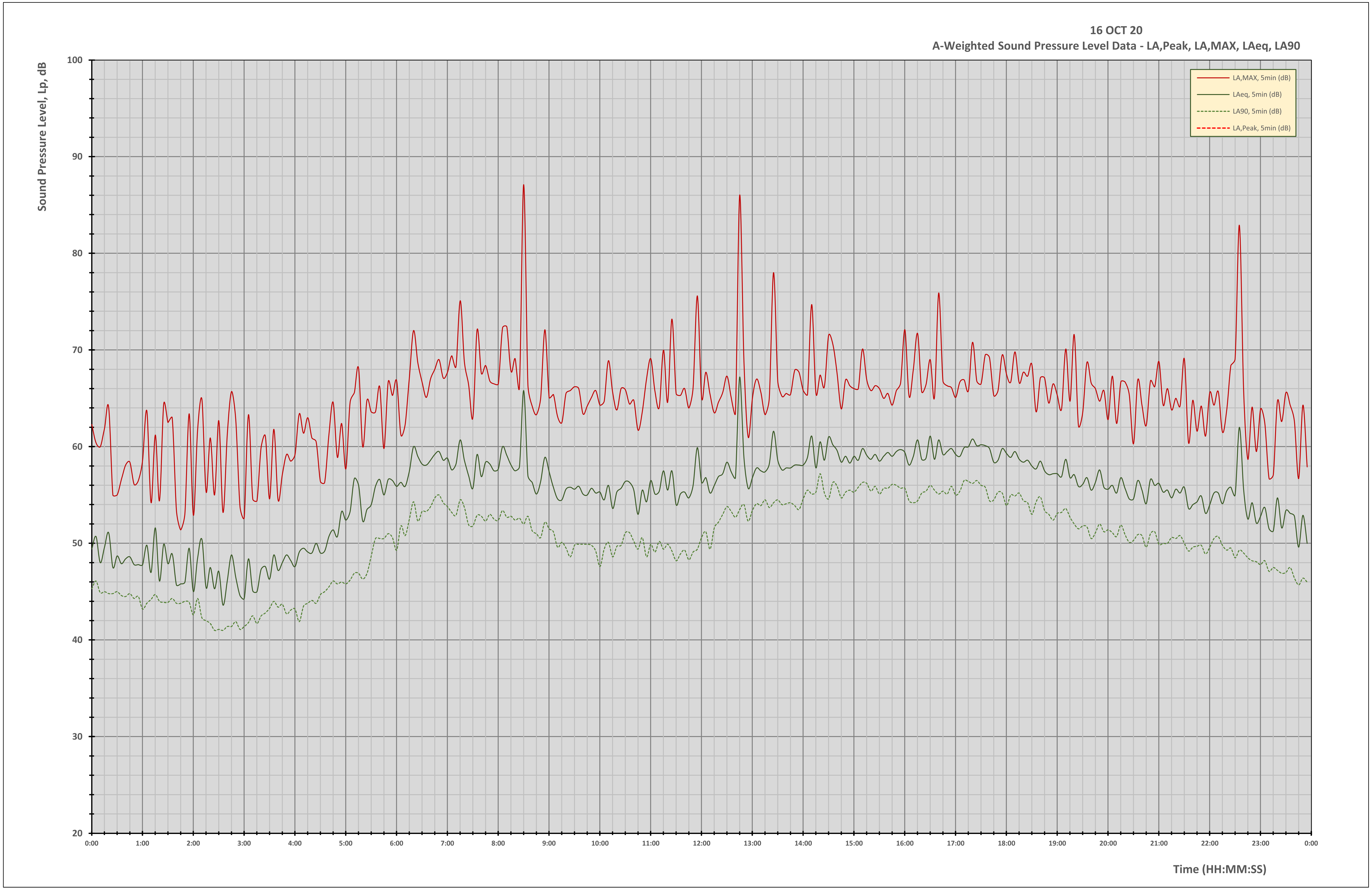
23:00
0:00
Time (HH:MM:SS)


16 OCT 20
A-Weighted Sound Pressure Level Data - LA,Peak, LA,MAX, LAeq, LA90
LA,MAX, 5min (dB)
LAeq, 5min (dB)
LA90, 5min (dB)
LA,Peak, 5min (dB)
Sound Pressure Level, Lp, dB
100
90
80
70
60
50
40
30
20
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
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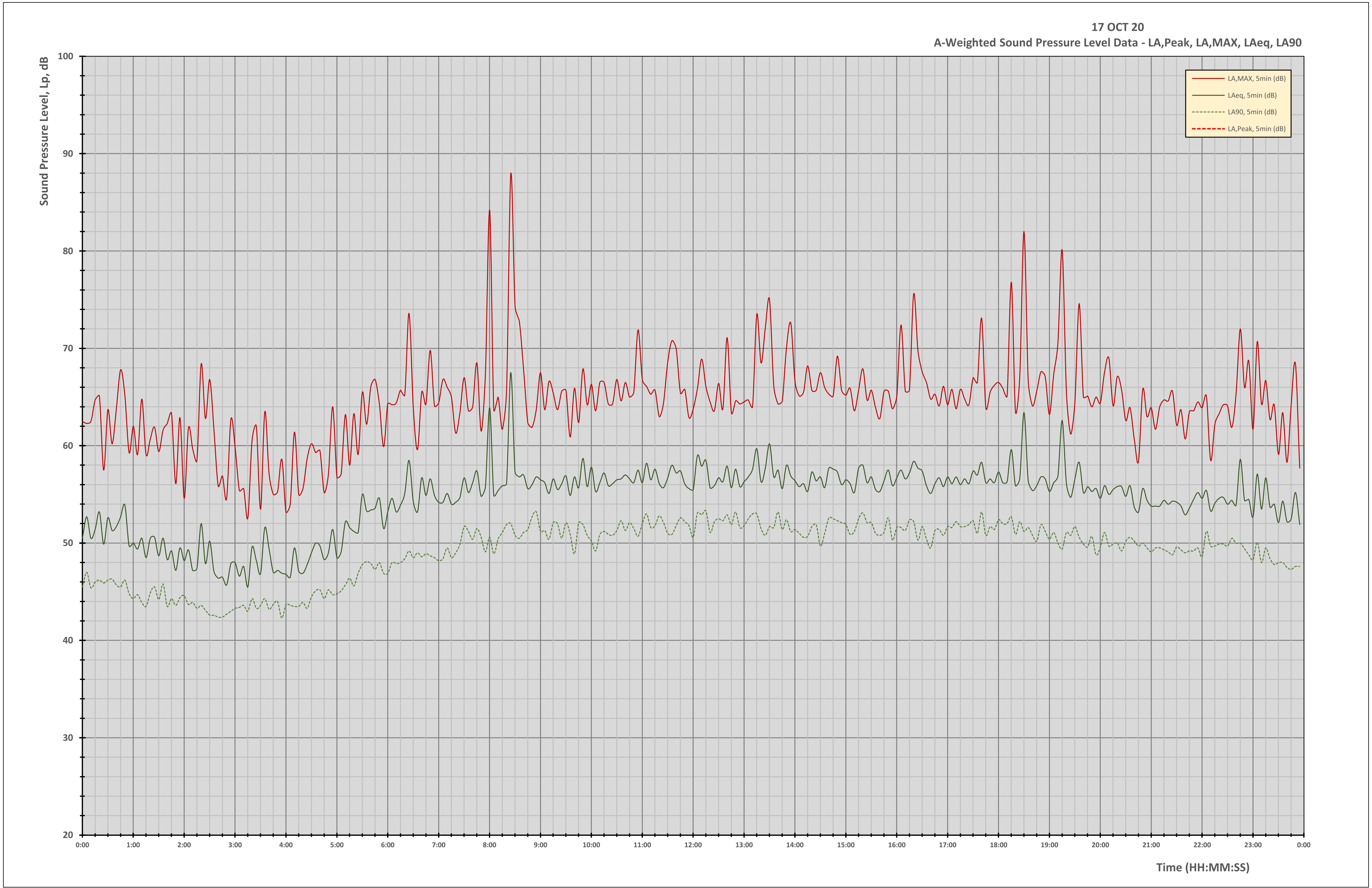
Time (HH:MM:SS)



17 OCT 20
A-Weighted Sound Pressure Level Data - LA,Peak, LA,MAX, LAeq, LA90
LA,MAX, 5min (dB)
LAeq, 5min (dB)
LA90, 5min (dB)
LA,Peak, 5min (dB)
Sound Pressure Level, Lp, dB
100
90
80
70
60
50
40
30
20
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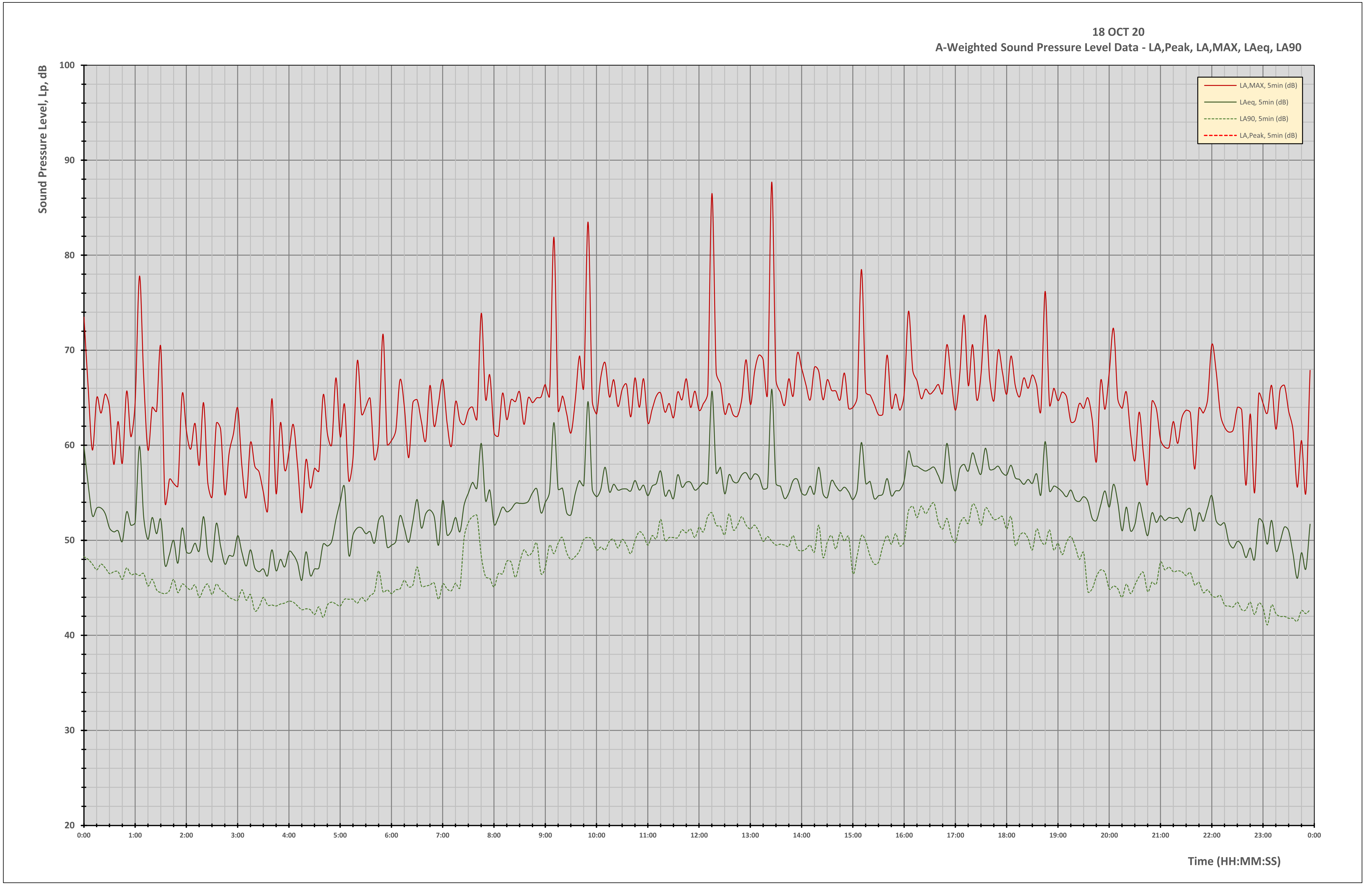

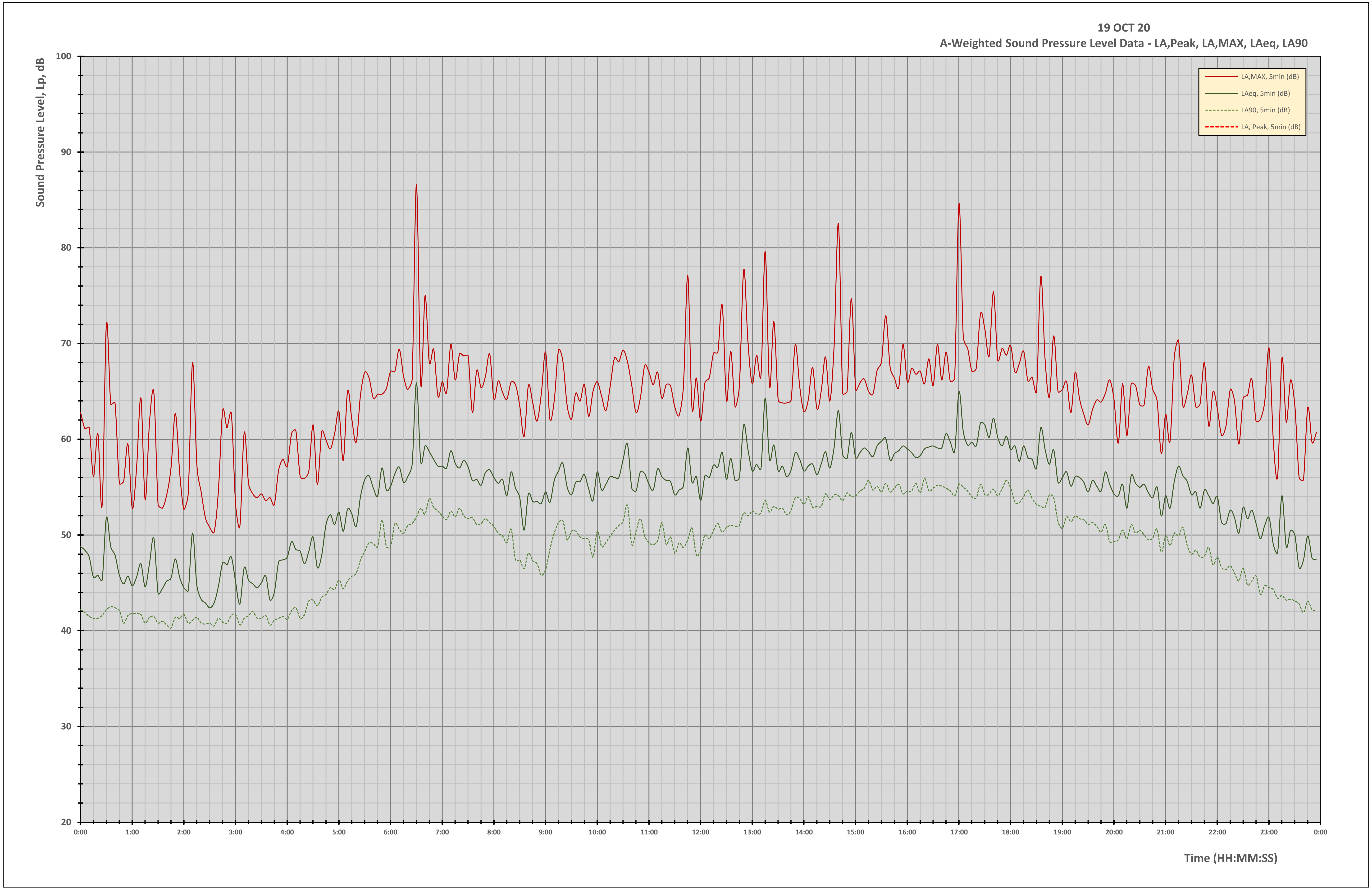
19 OCT 20
A-Weighted Sound Pressure Level Data - LA,Peak, LA,MAX, LAeq, LA90
Sound Pressure Level, Lp, dB
100
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80
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30
20
LA,MAX, 5min (dB)
LAeq, 5min (dB)
LA90, 5min (dB)
LA, Peak, 5min (dB)
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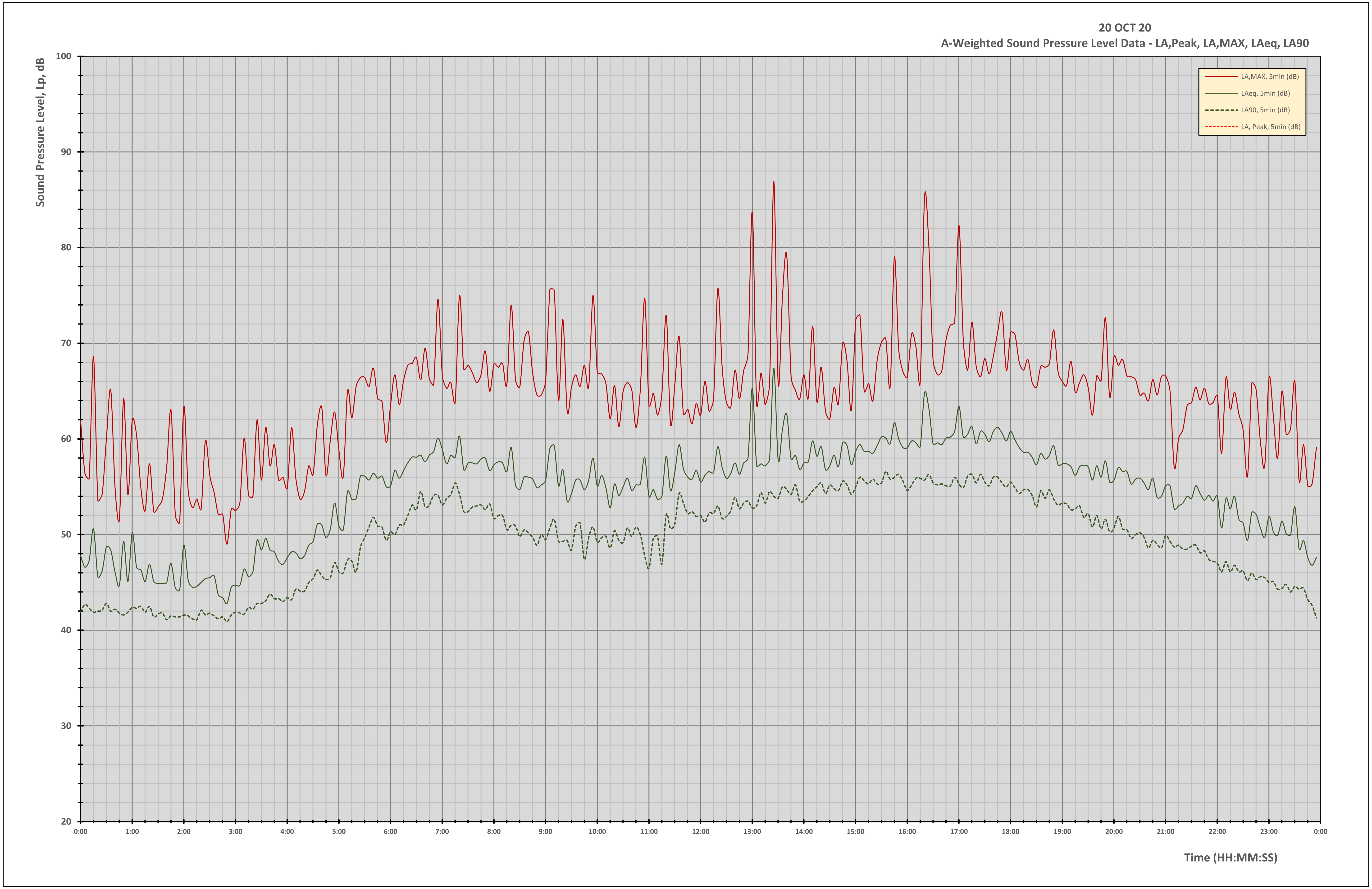
Time (HH:MM:SS)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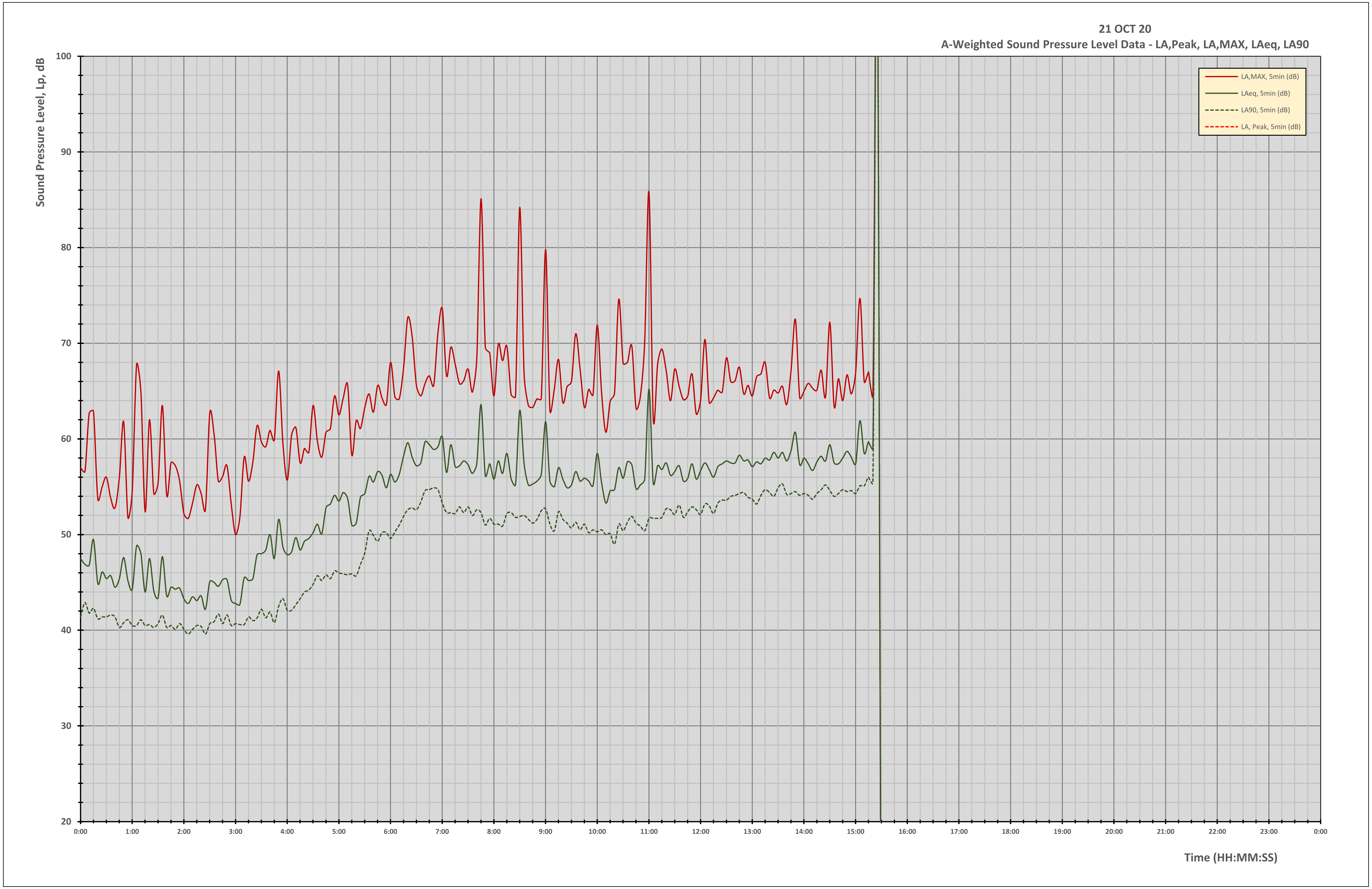
LA,MAX, 5min (dB)
LAeq, 5min (dB)
LA90, 5min (dB)
LA, Peak, 5min (dB)
Sound Pressure Level, Lp, dB
Time (HH:MM:SS)


21 OCT 20
A-Weighted Sound Pressure Level Data - LA,Peak, LA,MAX, LAeq, LA90
Sound Pressure Level, Lp, dB
100
90
80
70
60
50
40
30
20
LA,MAX, 5min (dB)
LAeq, 5min (dB)
LA90, 5min (dB)
LA, Peak, 5min (dB)
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B.2 Internal Nose Level calculations for Building Façade Specification

B.3 Building Façade Noise Ingress - Calculation Principles

Noise data obtained during the documented survey period and presented herein will provide the basis against which predicted internal noise levels can be calculated and compared against the referenced Australian Standard *AS2107:2016* criteria to assess internal noise amenity and compliance. The process of this evaluation assesses the composite acoustic performance of each façade element (e.g. glazing/frame, building envelope, ventilation opening etc) is calculated and the measured external sound field is said to impinge upon it as direct sound. As all measured noise levels were recorded under 'free-field' conditions, a correction of 2.5dB is applied to linear spectral noise levels when calculating façade performance to account for the façade incidence effect.

From the layouts and elevation drawings the building envelope there are typically three material element(s) capable of transmitting sound into the internal space; Concrete, lightweight infill panels (or other main building structure construction), and a range of framed and sliding glazing elements. Airborne sound transmission through the building structural element is less critical than sound transmission through glazed panels, therefore various acoustic performances of glazing types and thicknesses will be assessed and adjusted in design calculation to affect the most cost-effective design solution, whilst ensuring design compliance is demonstrated.

Corresponding internal noise levels are then predicted using these detailed sound transmission loss calculations through the calculated composite façade performance, with resultant internal levels corrected for radiating (exposed) façade area and internal energy 'losses' associated with transmitted sound undergoing absorption from (proposed) internal room finishes. This assessment is generally conservative to allow for unforeseen variation in eventual performance.

Each façade is also assessed for flanking transmission paths. This includes, but is not limited to, transmission through junctions between structural elements, aperture seals, and transmission through inter-connected elements such as mechanical systems.

In order that an acoustically-robust façade design is achieved, building façade assessment calculations are undertaken using 'worst case' (i.e. highest measured) external noise levels, unless otherwise noted. Calculations are carried out on the most sensitive internal spaces – generally those with the largest glazed area and a low internal absorptive area. This methodology provides an efficient review ensuring all spaces meet or exceed the required standard.

All façade ingress calculations are carried out in accordance with the relevant parts of British and European Standard *BS EN 12354:2000 Building Acoustics – Estimation of acoustic performance of buildings from the performance of elements Part 3: Airborne sound insulation against outdoor sound*, which is the most prevalent calculation methodology in the absence of an equivalent Australian Standard.

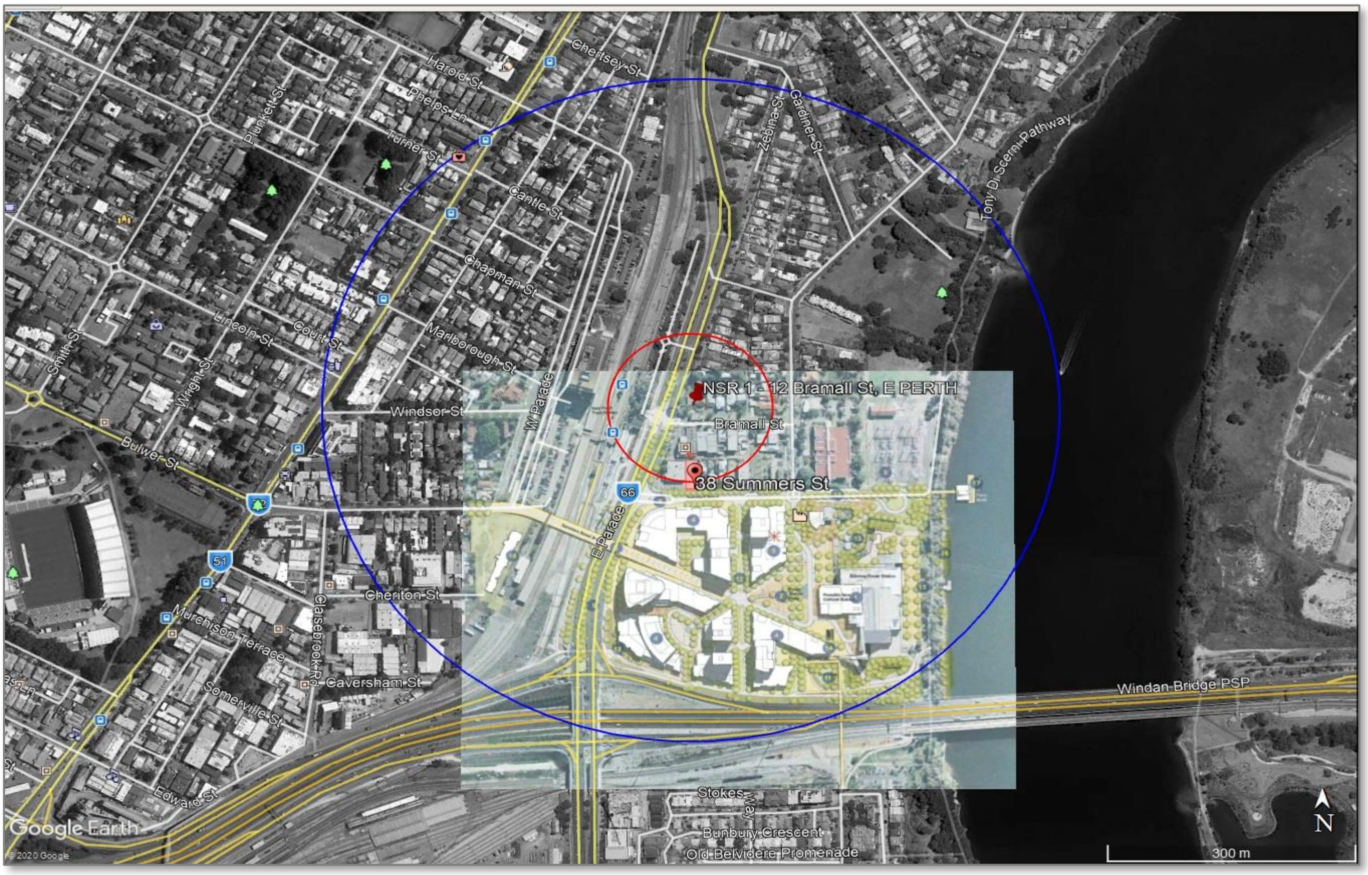
C. ARCHITECTURAL MARK UPS

C.1 Recommended Wall Requirements & Notes

D. CALCULATION OF NOISE EMISSIONS LIMITS

An Assigned Noise Level (ANL) is calculated for each identified noise-sensitive receiver (NSR) using a combination of environmental factors local to the receiver. A base set of ANL's exist to provide a minimum level of acoustic amenity, as shown in the Table below. These levels are modified by the calculation of an Influencing Factor (IF) to reflect noise sensitivity in the specific environment relative to the subject development and noise receiving environment.

To calculate the additional Influencing Factor (IF), concentric circles are drawn around the nearest noise-sensitive reception point; one at 450m radius and one at 100m radius.



Percentage land use areas are calculated for the amount of land use area within the concentric circles which are classified as either Industrial (I) or Commercial (C) uses. Percentage land use areas (not accounting for public roads) are then compared to the total area encompassed by the concentric circles.

Note – East Perth Powerstation Masterplan 2007 defines future mixed use zones shown on the overlay image above, which have been used in our calculation for Assigned Noise Level.

Road traffic volume is taken into account in order to reach an acceptable ANL, or noise reception level, appropriate for the area in which the receiver is to be situated:

- A Major Road is defined as having Annual Average Weekday Traffic (AAWT) flow in excess of 15,000 vehicle movements per day.
- A Secondary Road is defined as having Annual Average Weekday Traffic (AAWT) flows in excess of 6,000 vehicle movements per day.

Base Assigned Noise Levels

Part of Premises Receiving Noise	Time of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises at locations within 15m of a building directly associated with a noise sensitive use	0700 to 1900 hours Monday to Saturday	45 + Influencing Factor	55 + Influencing Factor	65 + Influencing Factor
	0900 to 1900 hours Sundays and public holidays	40 + Influencing Factor	50 + Influencing Factor	65 + Influencing Factor
	1900 to 2200 hours all days	40 + Influencing Factor	50 + Influencing Factor	55 + Influencing Factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays	35 + Influencing Factor	45 + Influencing Factor	55 + Influencing Factor
Noise sensitive premises at locations further than 15m of a building directly associated with a noise sensitive use	All hours	60	75	80
Commercial premises	All hours	60	75	80
Industrial and Utility premises	All hours	65	80	90

Calculation of Influencing Factor (IF)

The Influencing Factor (IF) is calculated using the following equation:

Influencing Factor (IF) = I + C + TF

Where;

I = (% of industrial land usage within 100m + %industrial land usage within 450m) x 1 / 10
C = (% of commercial land usage within 100m + %commercial land usage within 450m) x 1 / 20

TF = +6 if there is a major road within 100m of the development
+2 if there is a major road within 450 m of the development
+ 2 if there is a secondary road within 100m of the development

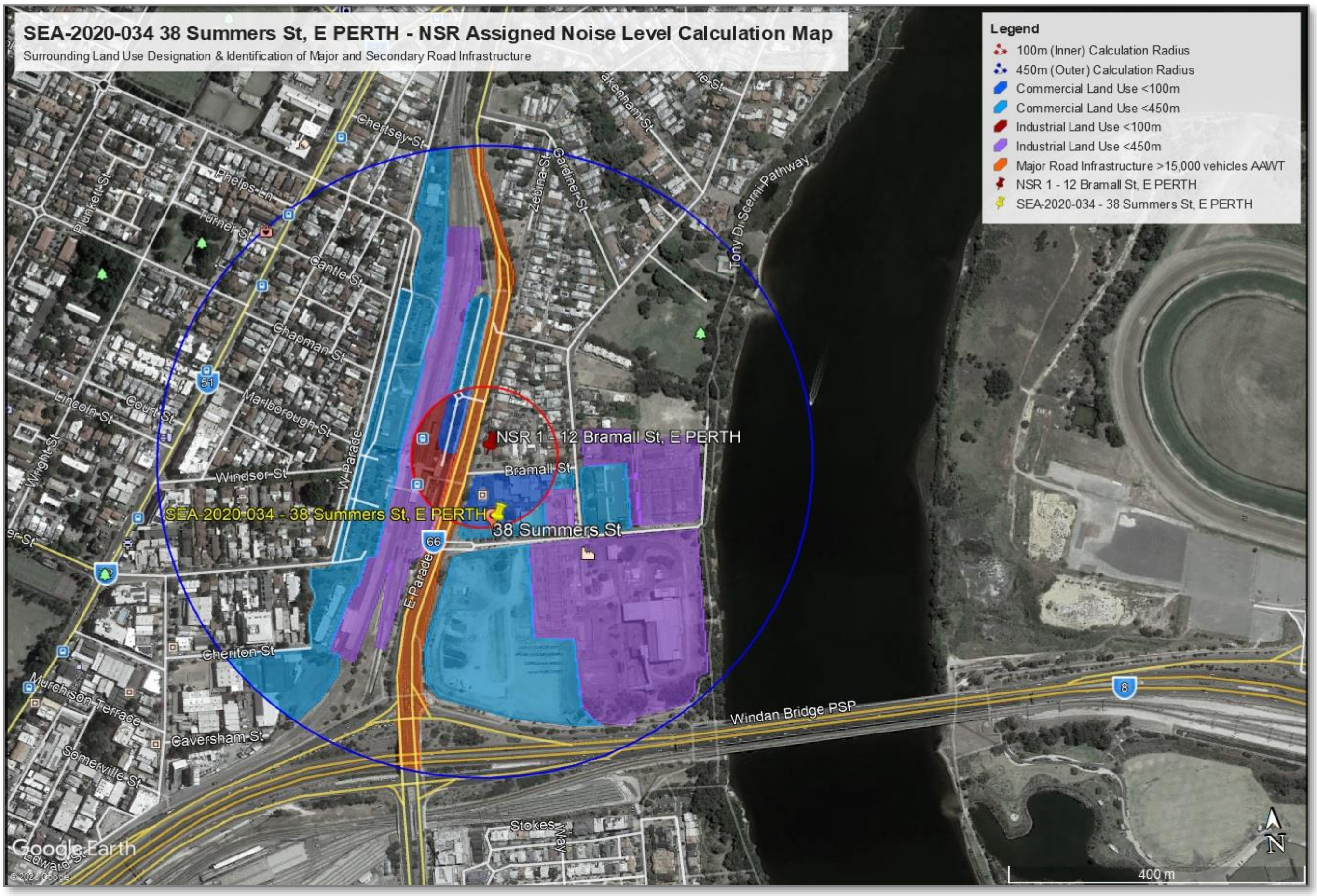
The maximum value the transport factor (TF) can reach is 6;

Identification of Land Use

The schematic image below presents review and classification of surrounding Commercial (C) and Industrial (I) land use in the Inner and Outer calculation radii in the vicinity of the site and nearest NSR. ANL limits were calculated on the basis of 30% Commercial (C) Land Use in the Inner circle, and 15% Commercial Land Use within the surrounding Outer Circle calculation radius; 17% Industrial (I) Land Use in the Inner circle and 15% within the surrounding Outer Circle calculation radius.

Road transport infrastructure is identified as East Parade (South of Summers St), carrying a Traffic volume of 46,015 vehicles per Annual Average Weekday (AAWT), identified as a *"Major Road"* in accordance with the *Prescribed Methodology*.

The calculated ANL limits are applicable to all noise emissions:



ASSIGNED NOISE LEVEL LIMITS – SUMMARY CALCULATION TABLE

Land Use Type & IF Calculation					
Industrial					"I"
% Area in Inner Circle	17%				3.19
% Area in Outer Circle	15%				
Commercial					"C"
% Area in Inner Circle	30%				2.22
% Area in Outer Circle	15%				
Roads	Location	Estimated vehicle Movements per day	Classification	Result	"TF"
E Parade (S of Summers St)	Inner	46, 015	Major	+6	6
INFLUENCING FACTOR					+11.41

The resultant IF therefore equals **11.41**, determining the applicable Assigned Noise Level limits at the NSR.

E. ACOUSTIC GLOSSARY

Acoustic Measurement Parameter Definitions

dB

Decibel: a logarithmic scale applied to acoustic units such as sound pressure and sound power. Decibels are always the ratio between two numbers. Sound Pressure in Pascals becomes "Sound Pressure Level re 2x10-5Pa" in decibels. Sound Power in watts becomes "Sound Power Level re 10-12W" in decibels. It is also used for sound reduction or sound insulation and is the ratio of the amount of sound energy incident upon a partition and the proportion of that energy which passes through the partition. The result is stated as a "decibel reduction".

dB(A)

A-weighting: This is an electronic filter which attenuates sound levels at some frequencies relative to the sound levels at other frequencies. The weighting is designed to produce the relative response of a human ear to sound at different frequencies. The A-weighted sound level is therefore a measure of the subjective loudness of sound rather than physical amplitude. A-weighting is used extensively and is denoted by the subscript A as in LA10, LAeq etc. (Levels given without the subscript 'A', are linear sound levels without the A-weighting applied, e. g. L10, Leq etc.).

Sound Power Level, (SWL)

Sound power level refers to the reference value of acoustic power (of a noise source, e.g. building services plant unit). Given a well-defined operation condition, (i.e. steady state), the sound power level of a machine is a fixed value and describes the rate at which sound energy is emitted, reflected, transmitted or received, per unit time. The SI unit of sound power is the watt (W), and is expressed as a logarithmic ratio of sound power versus reference sound power, re 10-12W" in decibels (dB), or A-Weighted decibels, dB(A);

Sound power level (SWL) is the acoustic energy emitted by a source which produces a resulting Sound Pressure Level (SPL) at some distance. While the Sound Power Level (SWL) of a given source is fixed, the resultant Sound Pressure Level (SPL) at a given receiver location depends upon the distance and angle from the noise source, and the acoustic characteristics of the area in which the receiver is located;

Sound Pressure Level, (SPL)

Sound Pressure Level (SPL) is a measure for the resulting effect of the energy (Sound Power Level, SWL) of an acoustic source (or a collection of sources) and is dependent upon the distance and angle between the source(s) and receiver location, the acoustic properties of the surrounding geometry and influencing surface finishes between the source-receiver path;

Sound Pressure Level (SPL) is always depends on position and environment.

LAeq,T

The "A" weighted equivalent continuous sound pressure level. This may be thought of as the "average" sound level over a given time "T". It is used for assessing noise from various sources: industrial and commercial premises, construction sites, railways and other intermittent noises.

LA90,T

The "A" weighted sound pressure level that is exceeded for 90% of the time T. It reflects the quiet periods during that time and is often referred to as the "background noise level". It is used for setting noise emission limits for industrial and commercial premises.

LAmax

The maximum "A" weighted sound pressure level during a given time on fast or slow response.

LpA

The "A" weighted sound pressure Level. The sound pressure level is filtered through a standard frequency weighting known as A-weighting. This filter copies the frequency response of the human ear, so that the resulting sound level closely represents what people actually hear.

R

Is the sound reduction index of a construction element in octave or 1/3 octave bands and can only be measured in a laboratory. There must be no flanking transmission.

R'

Is the sound reduction index of a construction element in octave or 1/3 octave bands measured on site, and normally includes flanking transmission (i.e. where sound travels via paths other than straight through the element being tested, such as columns, ducts, along external walls, etc.).

Rw

To get the weighted sound reduction index (Rw) of a construction, the R values are measured in octave or 1/3 octave bands covering the range of 100Hz to 3150Hz. The curve is adjusted so that the unfavourable deviation (or shortfall of the actual measurements below this standard curve) averaged over all the octave or 1/3 octave bands is not greater than 2dB. The value of the curve at 500Hz is the Rw.

R'w

The apparent sound reduction index, which is determined in exactly the same way as the Rw but on site where there is likely to be some flanking transmission.

D

This is the "level difference". It is determined by placing a noise source in one room and measuring the noise levels in that room (the "source room") and an adjacent room (the "receiver room"). The level difference is calculated by simply deducting the "receiver" noise level (dB) from the "source" noise level (dB).

Dw

This is the weighted level difference. D is measured on site in octave or 1/3 octave bands covering the range of 100Hz to 3150Hz. The D values are compared to a standard weighting curve. The curve is adjusted so that the "unfavourable deviation" (or shortfall of the actual measurements below this standard curve) averaged over all the octave or 1/3 octave bands is not greater than 2dB. The Dw is then the value of the curve at 500Hz.

Dnw

This is the weighted normalised level difference. D is measured on site in octave or 1/3 octave bands covering the range of 100Hz to 3150Hz. As the level difference is affected by the area of the common wall/ floor and the volume of the receiving room, as well as the amount of absorption in the receiving room, in the case of the DnT,w, the results are "normalised" by a mathematical correction to 10m2 of absorption (Dn). The same weighting curve as for Dw is used to obtain the single figure: Dnw.

Acoustic Performance Guide

DnT,w

This is the weighted standardised level difference. D is measured on site in octave or 1/3 octave bands covering the range of 100Hz to 3150Hz. As the level difference is affected by the area of the common wall/ floor and the volume of the receiving room, as well as the amount of absorption in the receiving room, in the case of the DnT,w, the results are "standardised" by a mathematical correction a reverberation time, usually 0.5 seconds (DnT). The same weighting curve as for Dw is used to obtain a single figure "DnT,w"

DnT(Tmf, max),w

This is the weighted BB93 standardised level difference corresponding to a Building Bulletin 93 reference value reverberation time in a receiving room. It is measured on site in accordance with BS EN ISO 140- 4:1998.

Dn,c

Suspended ceiling normalised level difference. This is the sound level difference between two rooms, separated by a suspended ceiling, normalised to a reference value of absorption in the receiving room (10m2 for the Laboratory as specified in ISO 140-9:1985). It is measured in 1/3 octave or octave frequency bands.

Dn,c,w

Weighted suspended ceiling normalised level difference. This is a single number quantity representing the sound reduction between two rooms separated a suspended ceiling. It is obtained by applying specified weightings to the 1/3 octave band suspended ceiling normalised level differences in the frequency range 100Hz to 3150Hz.

Ctr

Spectrum adaptation term: Value, in decibels, to be added to a single-number rating (e. g. Rw) to take account of the characteristics of particular sound spectra. Ctr is calculated using an A-weighted urban traffic noise spectrum as defined in BS EN ISO 717-1:1997.

NR

Stands for Noise Rating. (It is NOT noise reduction). It is (e. g. NR30, NR35 etc.) a single number, which represents the sound level in a room and takes account of the frequency content of the noise. The lower the NR value, the quieter the room will be. It is mainly used for assessing noise from mechanical services systems. In leisure developments it is used as a standard for noise break-in to rooms from external noise sources such as traffic.

NC

Stands for Noise Criteria. It is very similar to NR but (e.g. NC30, NC35 etc.) uses slightly different frequency weightings.

NRC

Stands for Noise Reduction Coefficient. The noise reduction coefficient of a material is the average, to the nearest multiple of 0.05, of the absorption coefficients at 250Hz, 500Hz, 1kHz and 2kHz.

α

Stands for Absorption Coefficient, which represents the proportion of incident sound energy arriving from all directions that is not reflected back into the room. It ranges between 0 and 1, where 0 is reflective and 1 is totally absorptive.

α w

Stands for Weighted Absorption Coefficient. Single- number frequency dependent value which equals the value of the reference curve at 500Hz after shifting it as specified in EN ISO 11654:1997.

α p

Stands for practical absorption factor. It is a frequency dependent value of sound absorption coefficient which is based on measurements in one- third- octave bands in accordance with ISO 354 and which is calculated in octave bands in accordance with EN ISO 11654:1997. It is the arithmetic mean of the three 1/3 octave sound absorption coefficients within the octave being considered. The mean value is calculated to the second decimal place and rounded in steps of 0.05 up to a value of 1.0.

Class X

Stands for the Absorption Class between 250Hz and 4kHz, as defined by EN ISO 11654. Class A is the best classification representing the highest level of absorption, and Class E offers to lowest classification.

RT or T60

Reverberation Time is a measure of the echoic nature of a room. It is normally measured in 1/3 octave or octave bands by exciting the space with a high level interrupted source or impulse, and measuring the time taken for the signal to decay to silence. The longer the reverberation time, the more 'echoic' a room sounds. For dwellings, a reverberation time of 0.5 seconds or less is normal. Cinema auditoria will have reverberation times of 1.0 second or below when fitted out, but up to 9 seconds at shell completion.

When designing acoustically sensitive areas such as concert halls or lecture theatres, it is necessary to design the room finishes to achieve optimum reverberation times. These will vary depending on the type of activity in the room and the room volume.

Tmf

Stands for the arithmetic average of the reverberation times in the 500Hz, 1kHz and 2kHz octave bands, for the type of receiving room, as defined in UK Schools design manual, Building Bulletin 93.

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