76,80 Great South Road
Proposed Residential Buildings
Remuera, Auckland

ACOUSTICS
OPERATIONAL NOISE AND VIBRATION

Draft for Coordination

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Prepared for: Dilworth Trust Board
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Proposed Residential Buildings

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Alex Jacob s 9(2)(a) s 9(2)(a)	For Internal Review	21/06/2022	Draft 3.0
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1 Introduction

This report has been prepared to assess the internal and external noise requirements for the proposed development at 76,80 Great South Road in Remeura, Auckland. The site for the proposed development is on two lots on the northern side of Great South Road.

The proposal is for two, nine-storey apartment buildings, one along the northern boundary with Mauranui Avenue, (northern building), and another along the boundary with Great South Road (southern building.) The northern building includes a basement level car park.

The subject site has a slight to moderate slope to the north and north-east. The site is in a mixed use zone, with adjacent properties including both commercial premises and residential dwellings, and medical facility to the South-East.

This report is intended as an acoustic assessment of the proposed development against the applicable standards for the subject site, including the Auckland Unitary Plan – Operative Version (**AUP**), Waka Kotahi NZTA, and KiwiRail Reverse Sensitivity Requirements. This report:

- For noise received:
  - Identifies noise and vibrations levels incident on the proposed development from the surrounding environment including allowed zone noise levels, traffic noise and vibrations, and rail noise and vibrations,
  - Assesses these against the proposed building plans.
  - Proposes mitigation measure and construction options for compliance with internal noise and vibration requirements.
- For noise generated:
  - Identifies noise generating activities associated with the operation the site
  - Assesses these against noise compliance criteria for the subject zones, and
  - Proposes mitigation measures and strategies for compliance with noise standards.

This report is based on information in:

- Architectural Plans by JASMAX dated 20/05/2022

2 Site

2.1 Identification

The proposed development site is located in a mixed use neighbourhood at the North-Eastern side of Great South Road in Remuera, Auckland. The area of development is proposed across the two lots comprising the subject site. For ease of reference in this report, as collated with architectural plans, directional boundary references are noted in the figure below. For context, the site is approximately 74m on its North-South Axis between Great South Road and Mauranui Avenue at the eastern boundary.

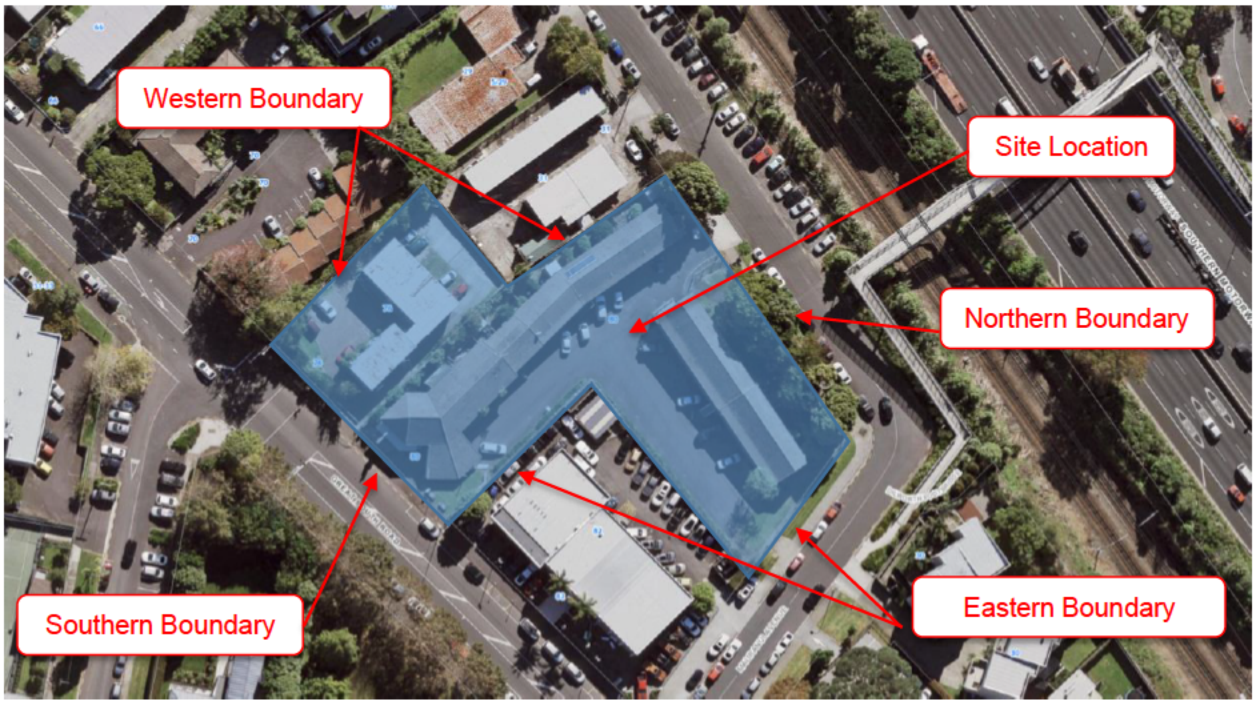

Figure 1 - Site Location

The proposed development covers the following land parcels, as shown in the figure below:

Figure 2 - Site Boundaries

Lot 1 DP 119624
Lot 1 DP 59345

2.2 Zoning

In accordance with the Auckland Unitary Plan – Operative Version, the subject site and adjacent sites are zoned _Business – Mixed Use._ Sites to the north are the transport corridor of State Highway 1 and the Rail corridor. Sites to the South across Great South Road are zoned _Special Purpose – School Zone._

Figure 3 - Site Zoning

2.3 Vicinity

The neighbouring areas to the subject site can be generally characterised as a mix of commercial and residential buildings, and a medical clinics buildings to the South East:

- **West – 31 Mauranui Ave:** Two storey residential buildings (northern end of the closer building noted to be single storey) with the closest building founded at circa 1m from the boundary, other than an ancillary structure founded at the boundary.
- **West – 29 Mauranui Ave:** 2-3 Storey residential apartment building at circa 5m from the boundary, with the top floor (level 3) offset circa 13m from the boundary,
- **West – 70 Great South Road (Motel):** Single Storey temporary accommodation buildings with the closest founded at circa 3m from the boundary of the subject site.
- **South-West 31-33 Great South Road**: Three storey commercial office building at circa 40m from the boundary of the subject site across Great South Road
- **South – 82 Great South Road:** Two storey commercial premises (Nissan Car Dealership) with the western façade at circa 6m from the boundary and the northern façade at c irca 12m from the boundary
- **East – 30-40 Mauranui Ave:** Three storey residential buildings founded at circa 28m from the boundary of the subject site.
- **South-East – 86 Great South Road (Mauranui Clinics):** Two storey building comprising medical clinics with the closest western façade founded circa 35m from the subject site.

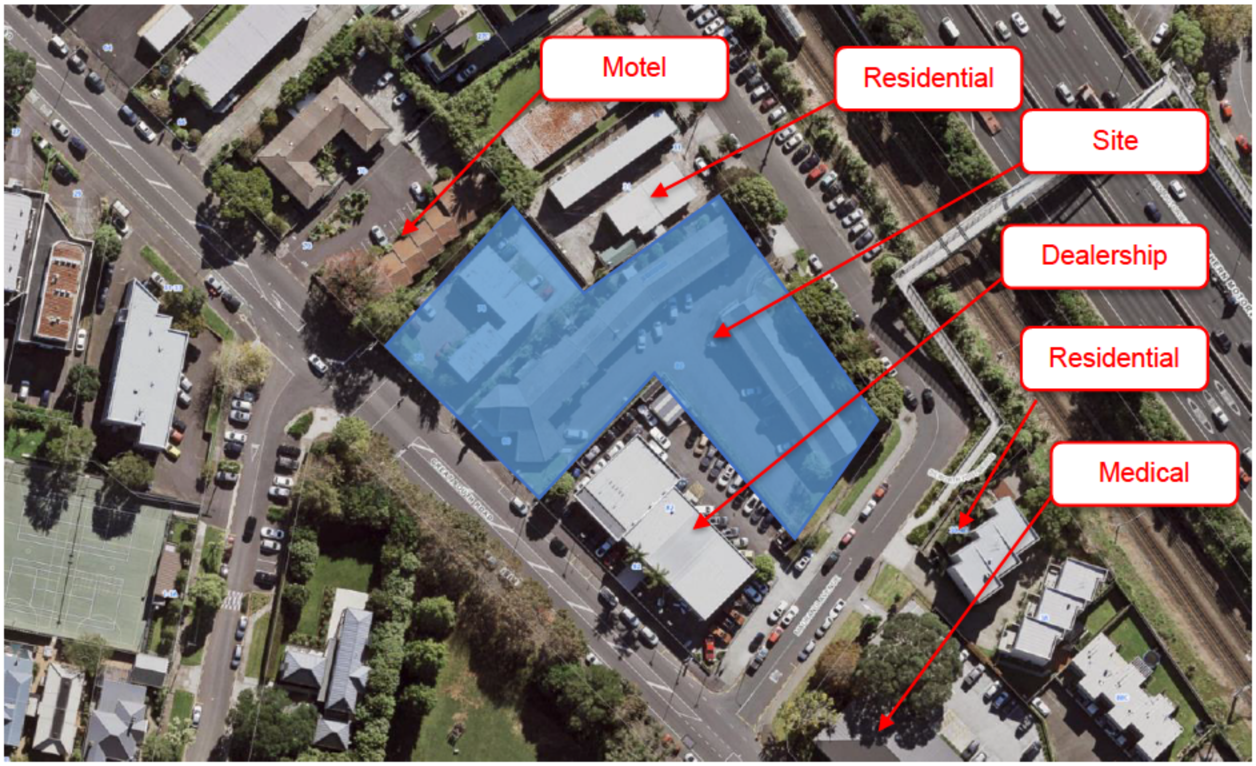

Figure 4 - Site Vicinity - AUP GIS

Figure 5 – North Western Boundary Facing General Compass West – [Google Earth]

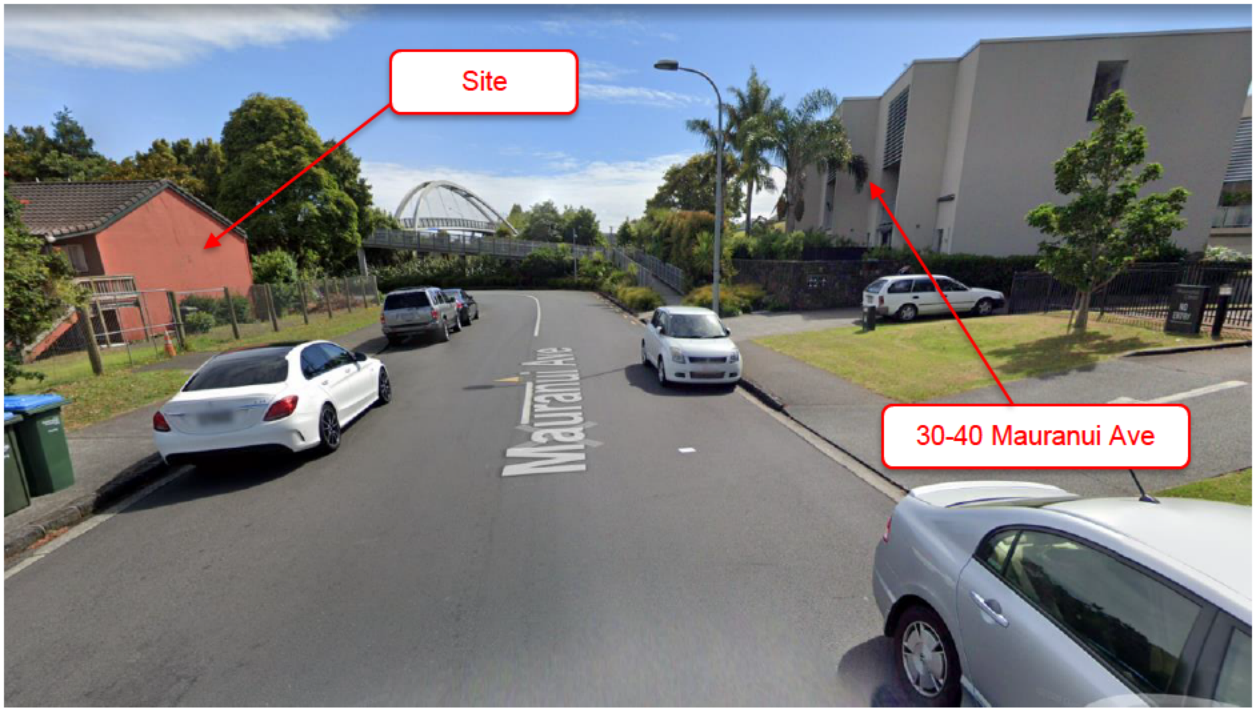

Figure 6 - East Boundary facing general Compass North – [Google Earth]

Figure 7 - East Boundary facing General Compass NW - [Google Earth]

3 Proposed Development

The proposed development includes 2 nine-storey apartment buildings in addition to a basement level and ancillary structures. The following is a site plan of the proposed buildings

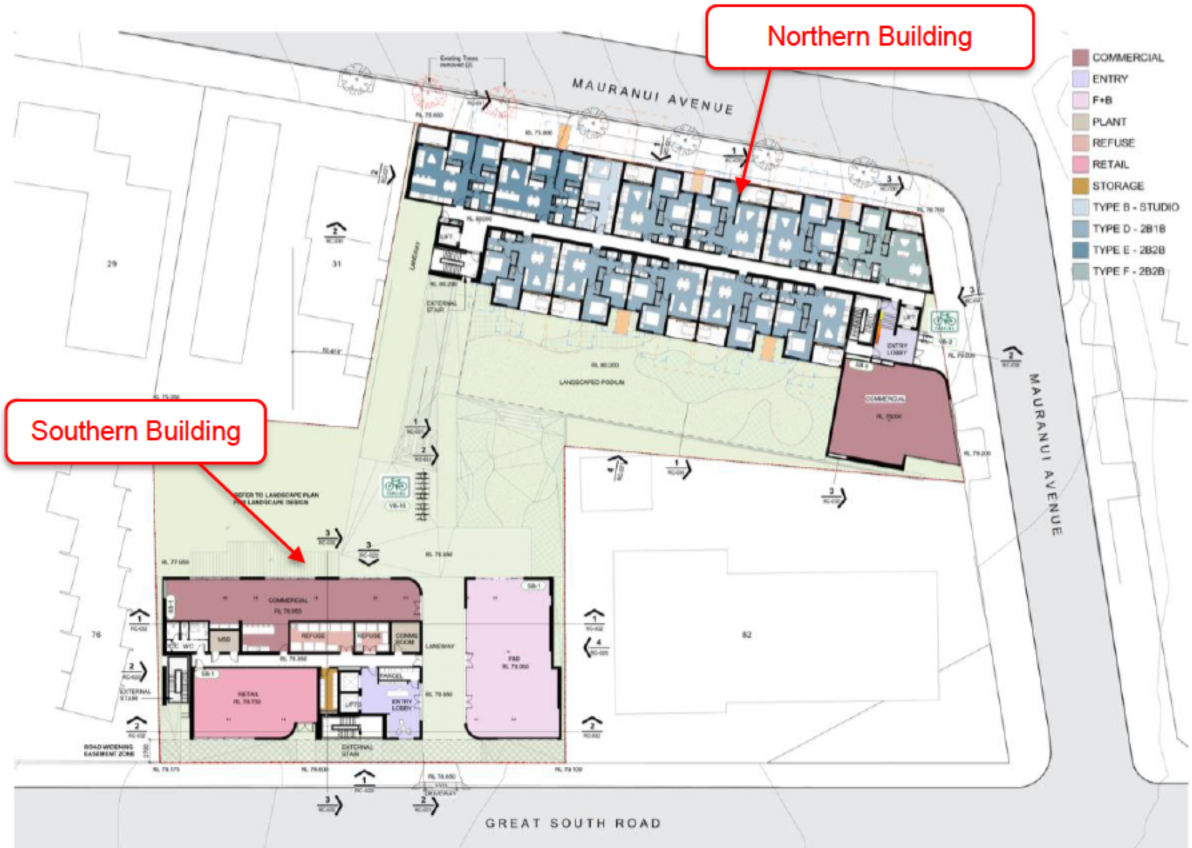

Figure 8 - Site Plan / Ground Level - [JASMAX – DWG:RC-011]

4 Assessment Standards - Noise

4.1 AUP - External - Noise Levels in the Zone *(Regulatory)*

In accordance with the Auckland Unitary Plan (AUP) – E25.6.8, Noise levels from activities within Business – Mixed Use Zones as applies to the subject site and the neighbouring sites are as follows. These levels are in context of both noise emitted from the development to adjacent Business – Mixed Use sites, and received from noise at adjacent sites. These apply when measured within the boundary of any Business – Mixed Use site.

Time	Noise Level
7:00am to 11:00pm	65dB LA_{eq}
11pm to 7:00am	55dB LA_{eq} 65dB at 63Hz 60dB at 125Hz 75dB LAF_{max}

Table 1 - Noise Levels in Business Mixed Use Zones

4.2 AUP - Internal - Noise Levels Between Units *(Regulatory)*

In accordance with the Auckland Unitary Plan (AUP) – E25.6.9, Noise levels between units in the Business Zone are as follows. For the subject development, these are in context of sound emitted from occupancies and the associated sound insulation of building elements.

Unit Affected	Time	Noise Level
Non–Noise sensitive	All Times	50dB LA_{eq}
Bedrooms	11:00pm to 7:00am	35dB LA_{eq} 45dB at 63Hz 40dB at 125Hz
	7:00am to 10:00pm	40dB LA_{eq}
Other Habitable	All other times	40dB LA_{eq}

Figure 9 - Noise Levels between Units

4.3 AUP - Internal - Noise Levels Inside Sensitive Spaces *(Regulatory)*

In accordance with the Auckland Unitary Plan (AUP) – E25.6.10, Noise levels within units in the Business Zone are as follows. These pertain to internal noise levels within proposed dwellings.

Unit Affected	Time	Noise Level
Bedrooms	11:00pm to 7:00am	35dB LA_{eq} 45dB at 63Hz 40dB at 125Hz
All	All other times	40dB LA_{eq}

Figure 10 - Internal Noise Levels

In addition, and as per E25.6.10.(3) pertaining to areas where windows or doors need to be closed for internal noise level compliance, the following applies:

(b) for residential dwellings be mechanically ventilated and/or cooled to achieve either:

(i) an internal temperature no greater than 25 degrees celsius based on external design conditions of dry bulb 25.1 degrees celsius and wet bulb 20.1 degrees celsius; or

Note 1

Mechanical cooling must be provided for all habitable rooms (excluding bedrooms) provided that at least one mechanical cooling system must service every level of a dwelling that contains a habitable room (including bedrooms).

(ii) a high volume of outdoor air supply to all habitable rooms with an outdoor air supply rate of no less than:

- six air changes per hour (ACH) for rooms with less than 30 per cent of the façade area glazed; or
- 15 air changes per hour (ACH) for rooms with greater than 30 per cent of the façade area glazed; or
- three air changes per hour for rooms with facades only facing south (between 120 degrees and 240 degrees) or where the glazing in the façade is not subject to any direct sunlight.

(c) for all other noise sensitive spaces provide mechanical cooling to achieve an internal temperature no greater than 25 degrees celsius based on external design conditions of dry bulb 25.1 degrees celsius and wet bulb 20.1 degrees celsius; and

(d) provide relief for equivalent volumes of spill air; and

(e) be individually controllable across the range of airflows and temperatures by the building occupants in the case of each system; and

(f) have a mechanical ventilation and/or a cooling system that generates a noise level no greater than L_{Aeq} 35 dB when measured 1m from the diffuser at the minimum air flows required to achieve the design temperatures and air flows in Standard E25.6.10(3)(b)(i) and (ii) above.

4.4 Noise – KiwiRail Requirements – *(Reverse Sensitivity)*

In accordance with the KiwiRail reverse sensitivity requirements, the following applies pertaining to Noise:

Indoor railway noise

1. Any new building or alteration to an existing building that contains an activity sensitive to noise where the building or alteration:

(a) is designed, constructed and maintained to achieve indoor design noise levels resulting from the railway not exceeding the maximum values in the following table

Building Type	*Occupancy/ Activity*	*Maximum railway noise level $LA_{eq(1hr)}$*
Residential	*Sleeping spaces*	*35 dB*
	All other habitable rooms	*40 dB*

Mechanical ventilation

2. If a building is constructed in accordance with 1(c), or if windows must be closed to achieve the design noise levels in clause 1(a), the building is designed, constructed and maintained with a mechanical ventilation system that

(a) For habitable rooms for a residential activity, achieves the following requirements:

i. provides mechanical ventilation to satisfy clause G4 of the New Zealand Building Code; and

ii. is adjustable by the occupant to control the ventilation rate in increments up to a high air flow setting that provides at least 6 air changes per hour; and

iii. provides relief for equivalent volumes of spill air;

iv. provides cooling and heating that is controllable by the occupant and can maintain the inside temperature between 18°C and 25°C; and

v. does not generate more than 35 dB LAeq(30s) when measured 1 metre away from any grille or diffuser.

(b) For other spaces, is as determined by a suitably qualified and experienced person.

4.5 Waka Kotahi NZTA – Internal – Noise *(Reverse Sensitivity)*

1. *Any dwelling on the site must be designed, constructed and maintained to achieve a* ***design noise level of 40 dB LAeq(24h)*** *inside all habitable spaces.*
2. *If windows are required to be closed to achieve the design noise level in condition 1, a ventilation system must be designed, constructed and maintained. For habitable spaces the system must achieve the following:*
   a. *Ventilation must be provided to meet Clause G4 of the New Zealand Building Code. At the same time, the sound of the system shall not exceed 30 dB LAeq(30s) when measured 1 m away from any grille or diffuser*
   b. *The occupant must be able to control the ventilation rate in increments up to a high air flow setting that provides at least 6 air changes per hour.* ***At the same time the sound of the system must not exceed 35 dB LAeq(30s)*** *when measured 1m away from any grille or diffuser.*
   c. *The system must provide cooling that is controllable by the occupant and can maintain the temperature at no greater than 250C. At the same time, the* ***sound of the system must not exceed 35 dB LAeq(30s)*** *when measured 1m away from any grille or diffuser.*
3. *A design report prepared by an acoustics specialist must be submitted to Auckland Council demonstrating compliance with conditions 1 and 2, prior to construction or alteration of any dwelling.* ***The design shall take into account future permitted use of the state highway****; for* ***existing roads by the addition of 3 dB*** *to existing measured or predicted levels.*

4.6 NZ Building Code – Internal Airborne and Impact Sound Insulation

STC (Sound Transmission Class) 55 and IIC (Impact Insulation Class) 55 ratings are required between the inter-tenancy floors and walls to prevent undue noise transmission from other occupancies or common spaces to the habitable spaces of the household units. The STC and IIC ratings are required for common walls and floors of different tenancies. The code allows 5dB for field situation; i.e., FSTC 50 and FIIC 50 in situ.

- FSTC is the field measurement based single number derived from measured values of transmission loss in accordance with classification ASTM E 413. The STC rating is given by the value of the contour at 500 Hz.
- FIIC is the field measurement based single number derived from measured values of transmission loss in accordance with classification ASTM E989-89. The STC rating is given by the value of the contour at 500 Hz.

Based on the above and to allow for in-situ field performance, the **minimum design levels required for insulation are STC 55 and IIC 55**.

5 Assessment Standards – Vibrations

5.1 Waka Kotahi NZTA – Vibrations – Traffic (*Reverse Sensitivity)*

New buildings or alterations to existing buildings containing noise sensitive activities, within 40m of the State Highway must be designed, constructed and maintained to achieve internal vibration levels complying with class C of NS 8176E:2005.

5.1.1 NS8176.E:2005

The limits in this standard are selected as guidelines based on statistical studies of population reactions to vibrations, and depend on the classification of the buildings in question. The guidance classes, and the statistical designation for each class are:

- **Class A:** Very good vibration conditions where people will not notice vibrations
- **Class B:** Relatively good vibration conditions where people can notice vibrations.
- **Class C:** New residential buildings where 15% can be disturbed by vibrations
- **Class D:** Existing residential buildings where 25% can be disturbed by vibrations

Type of vibration value	Class A	Class B	Class C	Class D
Statistical maximum value for weighted velocity $v_{w,95}$ (mm/s)	0.1	0.15	0.3	0.6
Statistical maximum value for weighted acceleration $a_{w,95}$ (mm/s^2)	3.6	5.4	11	21

Table 2 - Reference Table B.1 of NS8176 - Upper limits for statistical maximum vibration levels

Where:

- **$v_{w,95}$ (mm/s)** is the 95% statistical maximum vibration velocity measured as the root mean square (r.m.s.) and weighted by NS8176 frequency weighting filter
- **$a_{w,95}$ (mm/s^2)** is the 95% statistical maximum vibration acceleration measured as the root mean square (r.m.s.) and weighted by NS8176 frequency weighting filter

The Norwegian Standard NS 8176.E:2005 (pertaining to the vw,95 criteria) requires waveform recording in established structures for human response analysis, shorter term measured PPV levels corresponding to the NS8176 Vw,95 levels were used for comparison

As such, Vw,95 0.3 mm/s is generally equivalent to 0.42mm/s PPV where shorter duration measurements are undertaken.

5.2 KiwiRail – Vibrations – Rail (*Reverse Sensitivity)*

In accordance with the requirements of KiwiRail reverse sensitivity provisions:

Indoor railway vibration

3. Any new buildings or alterations to existing buildings containing an activity sensitive to noise, closer than 60 metres from the boundary of a railway network:

a) is designed, constructed and maintained to achieve ***rail vibration levels not exceeding 0.3 mm/s vw,95*** *or*

b) is a single-storey framed residential building with:

i. a constant level floor slab on a full surface vibration isolation bearing with natural frequency not exceeding 10 Hz, installed in accordance with the supplier's instructions and recommendations; and

ii. vibration isolation separating the sides of the floor slab from the ground; and

iii. no rigid connections between the building and the ground.

5.3 AUP – Vibrations – Machinery *(Regulatory)*

In accordance with E25.6.30.2 of the AUP:

(2) Permanently installed stationary vibrating, reciprocating and rotating machinery and all piping, ducting and other equipment attached to such machinery must be installed and maintained so that any resulting vibration does not exceed the limits of Table E25.6.30.2 Vibration levels for stationary machinery when measured in any occupied room of any building on another site or in any occupied unit under different ownership from the source of the vibration. Vibration must be measured in accordance with ISO 2631-2:2003 Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 2: Vibration in buildings (1Hz to 80Hz):

Table E25.6.30.2 Vibration levels for stationary machinery

Affected occupied building or area	Time of day	Maximum vibration level in root mean square velocity (mm/s) between 8 and 80Hz
Noise sensitive spaces	7am-10pm	0.20
Bedrooms and sleeping areas only within activities sensitive to noise	10pm-7am	0.14

5.4 Criteria Summary

5.4.1 Metrics

In accordance with the Auckland Unitary Plan and NZ standards NZS6801, NZS6802, and NZS6803, the following metrics are used to quantify Noise

- **LA_{eq} [dB] or L_{eq} [dBA]:** A-Frequency Weighted time average sound level. This metric represents the full audio range weighted against the response of the human ear.
- **LA_{max} [dB] or L_{max} [dBA]:** Maximum sound pressure level.

5.4.2 External Zone Noise Levels / Limits

Noise from the zone, and emitted to the zone:

Time	Noise Level
7:00am to 11:00pm	65dB LA_{eq}
11pm to 7:00am	55dB LA_{eq} 65dB at 63Hz 60dB at 125Hz 75dB LAF_{max}

5.4.3 Internal Noise Limits

For compliance with the AUP regulations and other reverse sensitivity guidelines, the following limits apply. We note that these represent a combination that would satisfy both the regulatory AUP limits and the reverse sensitivity guidelines.

Unit Affected	Time	Noise Level
Bedrooms	All times	35dB LA_{eq} 45dB at 63Hz 40dB at 125Hz
All	All times	40dB LA_{eq}

5.4.4 Vibration Limits

Criteria	Occupancy	Time	Limits
Stationary Machinery	Noise Sensitive Spaces	7am – 10pm	0.2mm/s RMS mm/s 8Hz-80Hz
	Bedrooms	10pm to 7am	0.14mm/s RMS mm/s 8Hz-80Hz
Railway	Habitable Spaces	All	0.3mm/s $v_{w,95}$
Traffic	Habitable Spaces	All	0.3mm/s $v_{w,95}$

6 Noise modelling

6.1 Noise Propagation Modelling Software

To predict noise propagation at the subject site from the movements of traffic, an environmental model was constructed for the extension using the CadnaA computer modelling program. The following applies to the modelling software CadnaA:

- CadnaA is an internationally recognised software package designed for the prediction of noise propagation. CadnaA implements numerous national and international standards and guidelines, including the CoRTN standard of the United Kingdom Department of Transport and Welsh Office for the Calculation of Road Traffic Noise.
- The modelling method for noise propagation over distance is based on the international standard ISO 9613: "Acoustics – Attenuation of sound during propagation outdoors" methodology.
- The model allows importing digital ground elevation contours and data to define the topography and data for each of the noise sources, and the locations, geometry and elevations of the noise receivers. The program then calculates the dB levels as the metric for noise at receivers for the purposes of assessment.
- In-situ measurements were undertaken at the subject site and collated with the predicted models for current traffic volumes. Where the predictive model is within 1-2dBA of the measured values, the predictive model is deemed valid in context of outdoor noise propagation.

6.2 Building Construction Modelling

The following parameters are used for the purposes of assessment of noise levels and attenuation performance:

- Sound Insulation Prediction is done in accordance with EN12354/3 using Insul software Version 8.0.7.
- Assessment is based on attenuation of noise across the 1-Octave frequency range. While a single Standardised Sound Level Difference is provided for each combination, assessment of attenuation performance is based on the frequency based Sound Transmission Loss.
- Frequency distribution is based on entertainment noise in 1 Octaves

Worth noting here that a reduction of 10-12dBA is the maximum that can be achieved with windows open. To achieve higher attenuation levels windows need to be closed and mechanical ventilation installed.

7 External Noise Sources

7.1 Great South Road

Assessment is based on published traffic count data for Great South Road in proximity to the subject site. Latest published data indicates the road has an AADT of 14,560 vpd (vehicles per day) with 6% heavy traffic. We note that a design year of 2036 is assumed, with a 5% annual growth of traffic volumes. This generally corresponds to a doubling of traffic volumes in 15 years, which is also in-line with the Waka Kotahi requirement of adding 3dBA to current noise levels (the equivalent of doubling noise sources.) This yields the following conservative 2036 design year traffic volumes:

- **AADT 30,000 Vehicles per day in both directions combined.**
- **6% Heavy Vehicles.**

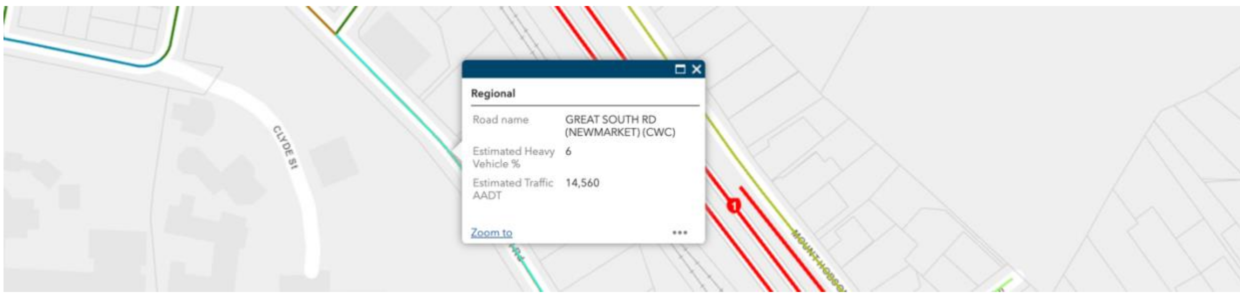

Figure 11 - Published AADT for Great South Road in proximity to site - [Waka Kotahi]

The following parameters were incorporated into the noise propagation model:

Parameter	Value
Standards	International ISO9613 – RLS-90
Ground Attenuation	Open Space: G=1 Roads, Pavements, G=0, Other: G=0.5
Atmospherics	Temperature: 20˚C, Rel. Humidity: 70%
Topography	Imported from AUP GIS
Receiver Heights	Relative AGL – Representative of 1.5 above floor level
Traffic Speed – Light	50 km/hr
Traffic Speed – Heavy	50 km/hr
Road Gradient	As per topography
Frequency Distribution	ISO 717
Traffic Flow	Steady
Road Type	Ordinary Road

7.2 State Highway 1

Assessment is based on published traffic count data for SH1 in proximity to the subject site. Latest published data indicates the road has a Northbound AADT (closest to site) of 78,078 vpd (vehicles per day) with 5% heavy traffic, and southbound AADT 92,929 vpd with 4% heavy traffic. We note that a design year of 2036 is assumed, and the higher volume of the southbound lane assumed for both directions with a 5% annual growth of traffic volumes. This generally corresponds to a doubling of traffic volumes in 15 years, which is also in-line with the Waka Kotahi requirement of adding 3dBA to current noise levels (the equivalent of doubling noise sources.) This yields the following conservative 2036 design year traffic volumes:

- **AADT 185,000 Vehicles per day in each direction, with traffic equally distributed across the closest two lanes in each direction.**
- **5% Heavy Vehicles.**

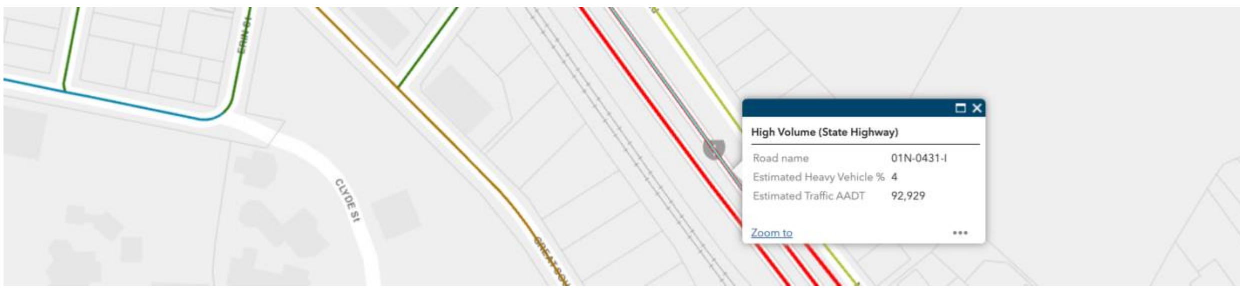

Figure 12 - Published AADT for Great South Road in proximity to site - [Waka Kotahi]

We note the future traffic volumes are intended for noise modelling purposes only to assess against the requirement for future noise levels being doubled as per Waka Kotahi requirements. The following parameters were incorporated into the noise propagation model:

Parameter	Value
Standards	International ISO9613 – RLS-90
Ground Attenuation	Open Space: G=1 Roads, Pavements, G=0, Other: G=0.5
Atmospherics	Temperature: 20˚C, Rel. Humidity: 70%
Topography	Imported from AUP GIS
Receiver Heights	Relative AGL – Representative of 1.5 above floor level of occupied floors.
Traffic Speed – Light	80 km/hr
Traffic Speed – Heavy	80 km/hr
Road Gradient	As per topography
Frequency Distribution	ISO 717
Traffic Flow	Steady
Road Type	Motorway

7.3 Internal Traffic

Internal traffic is assessed for parking area comprising circa 23 carparks. We assessed traffic noise under three separate categories, pertaining to traffic noise within the development, with each category presenting particular sensitivities, these being:

Peak Hour (highest time averaged noise level): In accordance with the transportation assessment the development would generate 20 trips per hour during peak hour. Assessment is made at internal speeds assumed 10kph. The compliance limit during daytime at the receiver sites is 65dB LA_{eq}.

Night-time (highest sensitivity period / lowest compliance limit): In the absence of traffic assessment during night hours, this assessment is based on 10% of the peak hour traffic occurring during night hours, this being 2 trips per hour.

Waste Management (highest instant noise levels): Noise from waste management and heavy vehicle movements would occur at the centre site. This includes rolling of bins and loading of trucks. The process is assumed to require reversing into the loading bay.

7.4 Railway Noise

The site is adjoining the railway corridor, based on railway measurements conducted at the eastern boundary of the site, approximately 30m from the dual railway tracks, noise levels reach **67dB LA_{eq}**. We note this applies in the assessment timeframe of 1 hour independent of time of day (i.e., conservatively assumed present at all times)

7.5 Zone Noise Levels (Received from adjacent sites)

The maximum allowable noise levels are assumed from activities within adjacent sites. We note that regardless of the limits in other site zones, the noise limits of the subject zone apply. These are assumed incident on all facades.

Time	Noise Level
7:00am to 11:00pm	65dB LA_{eq}
11pm to 7:00am	55dB LA_{eq} 65dB at 63Hz 60dB at 125Hz 75dB LAF_{max}

Figure 13 - External Noise Levels from Zone Noise

8 Received Noise Levels

As per the noise propagation model below, assumed conservatively for the highest levels across the floor elevations, noise levels from combined traffic, rail and zone noise sources would reach:

- Northern Building
  - Up to 73-75dBA daytime and 67-69dBA night-time at the northern facades of the northern building closest to the motorway and with line of sight to it.
  - Up to 70-73dBA daytime and 64-67dBA night-time at the Eastern and Western facades of the Northern building
  - Up to 57-61 dBA at the Southern façade facing the interior of the development.
- Southern Building
  - Up to 70-71dBA at the Southern facades of the buildings closest to Great South Road and with line of sight to it.
  - Up to 65-67 dBA at the remaining façades.

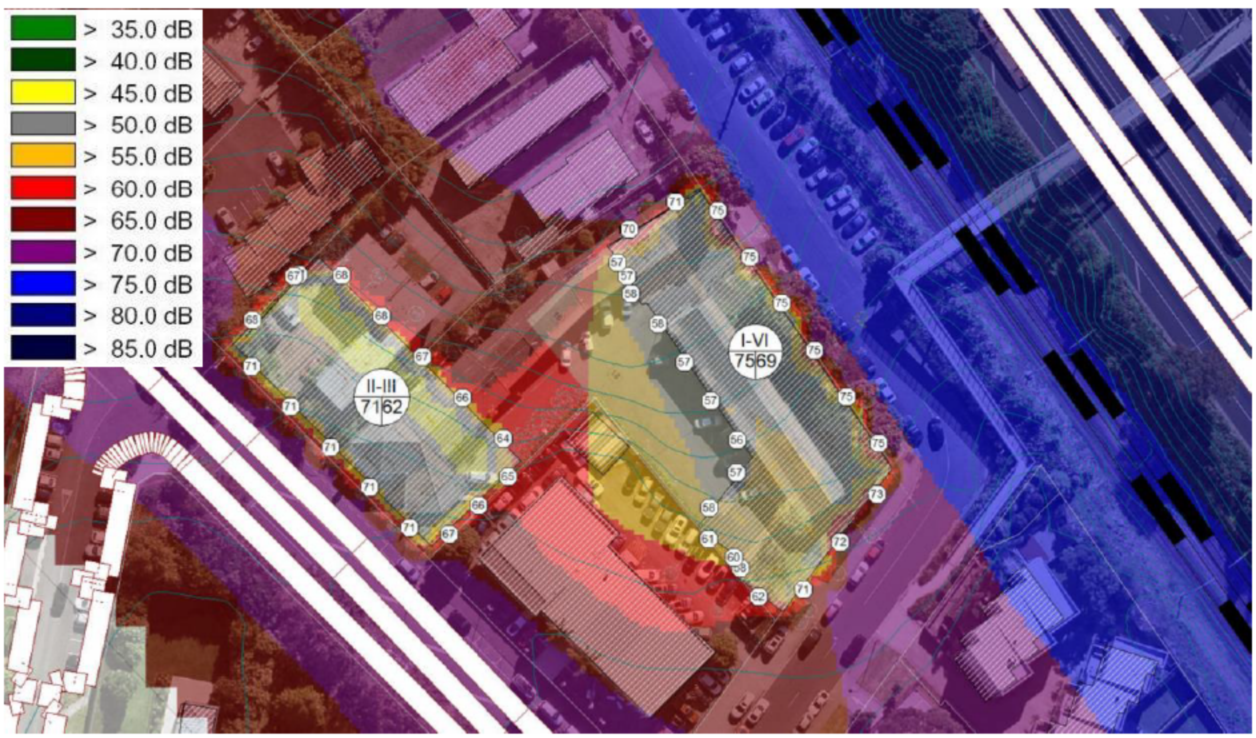

Figure 14 - Predicted Cumulative Noise Levels - Highest Daytime - Design Year 2036

9 Generated Noise Levels

9.1 Waste Management

We note the refuse location for the Northern building is adjacent Mauranui Ave. For the Southern building, the refuse station is location within the development. Notwithstanding that, in order to comply with the AUP external noise levels at the adjacent sites, waste collection is required to only occur during daytime hours of 7am to 11pm, unless proposed to occur within the basement area.

9.2 Car Stackers

Noise propagation from the potential use of car stackers would depend on the location of the stacker machinery and the levels generated by the models proposed including lifting times, and accessories used. The following is a general consideration of the affected receivers in context of noise.

- **Internal receivers:** Noise attenuation of the facades adjacent the carpark would need to be considered depending on the noise levels from the car stackers. This would generally apply to the first and second floors (within 6-9m of the parking area.) Occupancies abutting the carpark would need to have solid heavy weight facades (e.g. concrete)

- **31 Mauranui Ave** is at a sufficient distance for noise from the stackers to comply with the daytime limits. Compliance with night-time limits will depend on whether the noise generated is tonal (requires a +5dB correction or not)

- **82 Great South Rd** may require some level of shielding where there is line of sight to the car park. Depending on the planned structures at the boundary, this may be achieved with simple fencing with a surface density of at least 10kg/m^2 (e.g. blockwork, plywood)

9.3 Mechanical Plant (HVAC)

All mechanical plant shall be designed, selected, positioned and shielded to control noise at any receiver to within the required compliance standards. Furthermore, mechanical plant shall be mounted on suitable vibration isolation mounts to maintain vibration levels within the compliance levels. We note that the above can be achieved with commercially available solutions.

10 Vibration Levels

The main source of vibrations received by the site, is associated with rail operations at the eastern boundary.

The majority of ground vibrations from surface excitation propagate through surface (Rayleigh) waves. Measurements of surface waves for a surface excitation would generally be indicative of the highest vibration levels. The subject site has some ground irregularities between the source and receiver including a steep bank circa 2m in height. Ground irregularities between the source and receiver significantly attenuate the propagation of vibrations[1]

Earcon Acoustics regularly conduct vibration monitoring in proximity to railway tracks for design purposes and for compliance purposes. A representative monitored site was selected based on similar geology, similar contours with irregular ground and inclines from the receiver to the tracks, and similar rail structure, where tracks are straight with no discernible curves. The representative monitored site is circa 1km to the south of the subject site adjacent the same railway line. In addition, vibration levels at the subject site were measured over a 12 hour period at a location representative of the proposed building footprints.

[1] Reference *[Nakagawa, Hiroto and Nakai, Shoichi, "Propagation of Surface Waves in an Irregular Ground Based on the Thin Layered Element and Finite Element Method" (2010).*]

10.1 Train Vibration Analysis – Representative Sites

The proposed building footprints are circa 30m from the closest railway tracks. The ground conditions between the tracks and the receiver locations includes irregular ground with an incline circa 2m in height.

As noted previously, Ground irregularities between the source and receiver significantly attenuate the propagation of vibrations[1]. This has been supported by measurements on a number of sites where vibration levels across flat soft ground can be multiples of the vibration levels encountered over irregular terrain, depending also on ground conditions and track design.

For the subject the site, based on measurement on a similar site in the vicinity, the ground conditions and irregularity of topography to the tracks are expected to result in surface vibration levels being within the requirements for NS8176 Class C buildings.

We note for reference here a distinction in context of vibrations between compliance and complaints. NS8176 is based on statistical response to vibrations, whereby Class C corresponds to vibration level where about 15% of people can be expected to be disturbed by vibrations.

Earcon Acoustics regularly conduct vibration monitoring in proximity to railway tracks for design purposes and for compliance purposes. From our library of measurements, a representative monitored site was selected based on similar Geology in accordance with GNS Geology Maps, similar Contours, sites with irregular ground and inclines from the receiver to the tracks, and similar Rail structure, where tracks are straight with no discernible curves. The highest PPV vibration levels measured at different distances during train traversals at the representative site were as follows. The dominant frequencies of vibrations were between 15Hz and 40Hz:

- At 3m from track: 2.81 mm/s PPV
- At 6m from track: 1.32 mm/s PPV
- At 12m from track: 0.65 mm/s PPV
- At 20m from track: 0.24 mm/s PPV

In addition to the attenuation from irregular ground, vibration levels transferred to building structures are complex and vary depending on foundation types, underlying ground conditions and building construction. For example, in accordance with the US Department of Transportation[2] an empirical factor of 0.79 would be representative of vibration levels transferred from foundations to a ground level concrete floor.

We also note that prediction of vibration propagation within buildings from subsurface strata and through foundations may not be practicable without measurements at similar buildings with similar foundations and structures.

[1] Reference *[Nakagawa, Hiroto and Nakai, Shoichi, "Propagation of Surface Waves in an Irregular Ground Based on the Thin Layered Element and Finite Element Method" (2010).*]

[2] Reference [US DOT/Transportation Systems Center (1982) Handbook of Urban Rail Noise and Vibration Control]

10.2 Train Vibration Measurements – Subject Site

We conducted vibration monitoring during a 12 hour period on the 15th June 2022 at the subject site, at a location representative of the proposed building footprint. Measurements were conducted using:

- **B&K 4450** Vibrations Analyser - B&K 3680 Calibrated Vibrations Monitoring Terminal using a B&K Type 8380 Tri-Axial Geophone with the following characteristics:
    - Dynamic Range: 0.2 up to 312 mm/s with Resolution: 0.008 mm/s
    - Accuracy: ±5% between 1 and 125 Hz
    - Sampling Rate: 24 bit up to 8 kHz
    - Weighting setup for ISO 2631-2 (“w” weighting) as per NS8176
    - Logging includes 1/3 Octave frequencies, raw triaxial data, RMS data and PPV data for each orthogonal direction, and for all displacement, velocity, and acceleration data.

The following images are indicative of the location of monitoring, representative of the closest location of the proposed building footprint to the railway tracks.

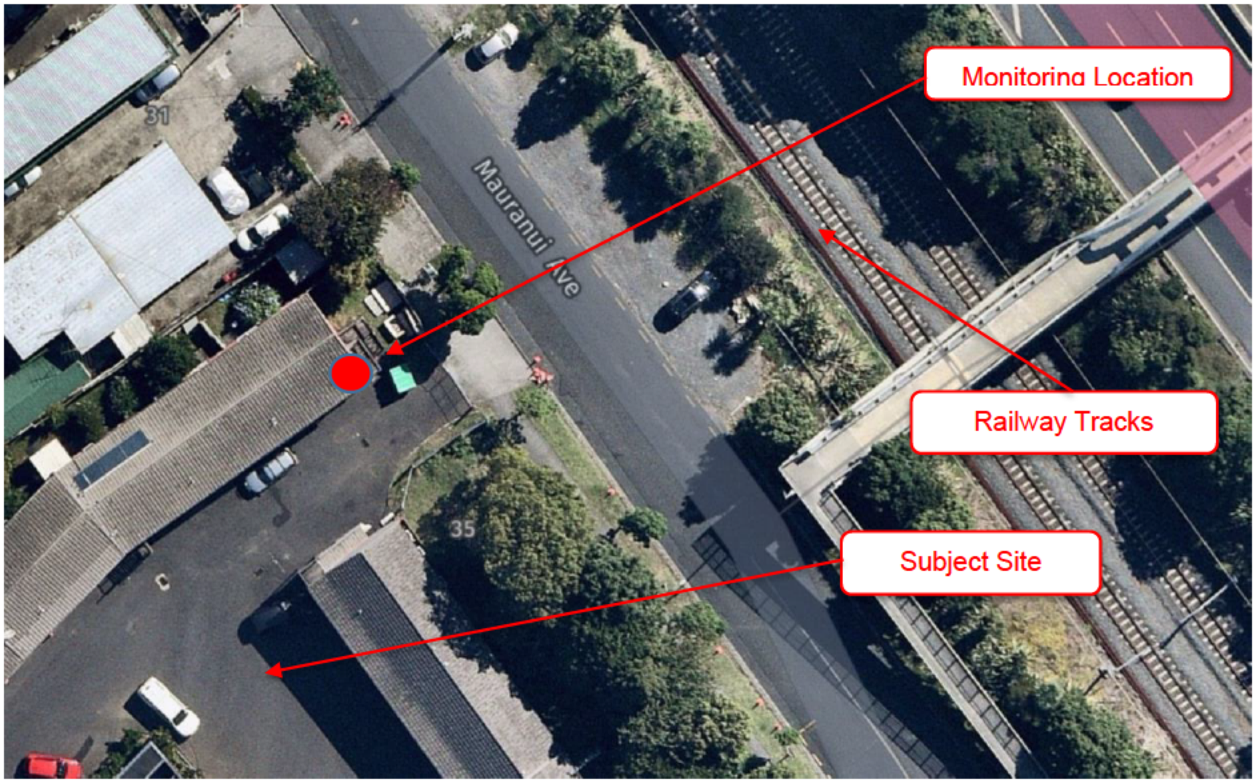

Figure 15 - Vibration Monitoring Location – [nearmap – 26/03/2022]

Figure 16 - Accelerometer on concrete foundations at Eastern end of existing building

10.2.1 Highest Measured Vibration Levels

The highest PPV (Peak Particle velocity) vibration levels measured at the location:

- Longitudinal: 0.06 mm/s PPV
- Lateral: 0.04 mm/s PPV
- Vertical: 0.08 mm/s PPV

We note that due to the varying geological layers across a site, and significant effects of topography on vibration propagation, surface vibration levels are likely to change with ground contouring or introduction of retaining walls.

Notwithstanding that, at the closest distance of a proposed building, the highest vibration levels are well below the equivalent compliance limit of 0.42mm/s PPV (≈ Vw,95 0.3 mm/s)

10.2.2 Logged Vibration levels

The following graph is representative of the logged vibration levels at the subject site during a 12 hour period on the 15th June 2022.

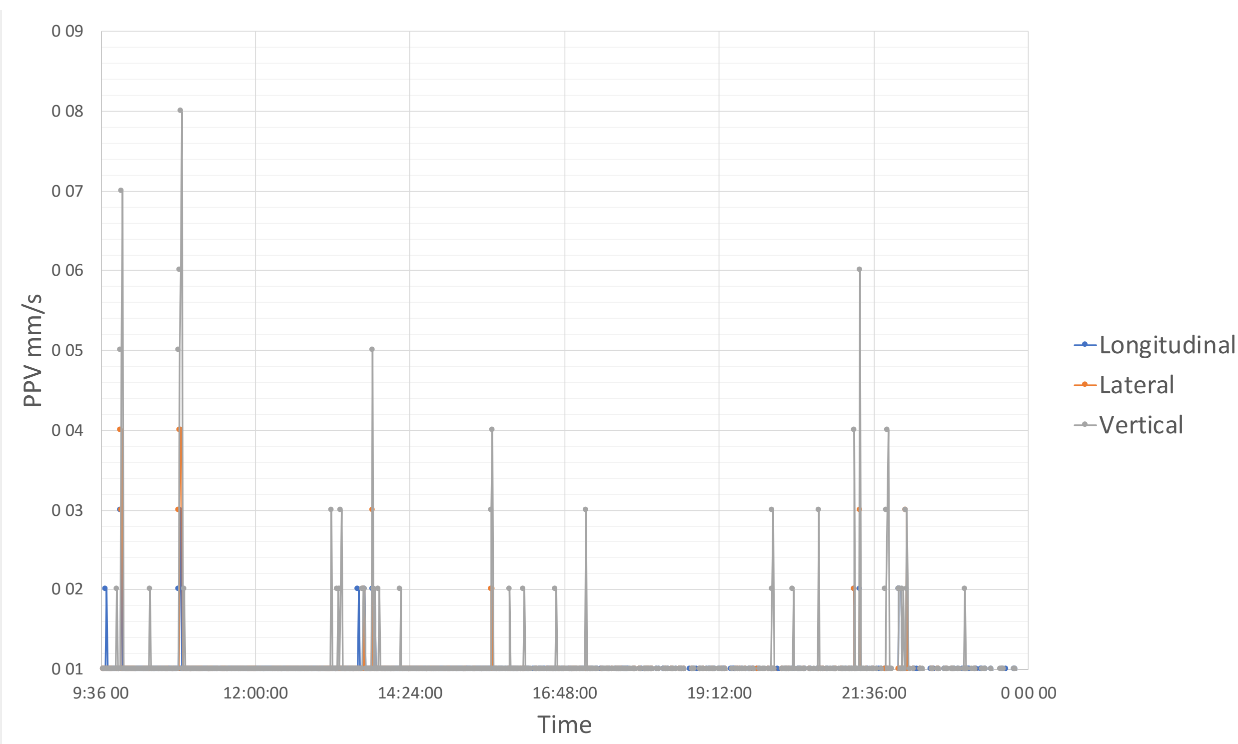

Figure 17 – Logged Ground Vibration Levels – Concrete Foundations - 76-80 Great South Road

10.3 Car Stackers

Concrete buildings are generally prone to propagation of vibrations associated with mechanical machinery. As such, consideration must be given to the mounting and isolation of mechanical stacker equipment from floor structures and wall connections. We note that manufacturers provide optional accessories for vibration reduction. These should be considered where required in conjunction with planned locations of stackers.

In addition, and if required, vibration propagation can be attenuated by specific construction measures such as saw cuts isolating floor areas of stackers from the building structure. These should be considered in conjunction with manufacturer measures.

11 Recommendations

In order to achieve compliance with the criteria, the assessment is based on the cumulative noise from zone, rail and road traffic. This includes low frequency noise associated with traffic, which is taken into account in the recommendations below. Furthermore, for internal noise levels, the assessment is conservatively based on the highest external incident noise levels achieving the lowest required internal noise levels independent of times.

Due to the variable noise levels across the buildings, the facades for residential occupancies are divided into three categories depending on the noise levels at these facades.

- Façade Category I (Red): Cumulative Nosie levels above LA_{eq} 72dB
- Façade Category II (Orange): Cumulative Nosie levels between LA_{eq} 67dB – 72dBA
- Façade Category III (Yellow): Cumulative Noise levels between LA_{eq} 60dB - 67dB
- Façade Category IV (Green): Cumulative Noise levels less than LA_{eq} 60dB

The following figure shows the facades associated with these categories:

Figure 18 - Facade Categories - Noise

We note that at this stage of the application, exact construction materials would not usually be confirmed. As such, the recommendations in this report are indicative of how compliance can be achieved. Other configurations and materials may also achieve compliance but would require assessment for acoustic performance when construction details are developed.

The following general recommendations would be predicted to achieve the required internal noise levels and are presented as possible configurations representative of achievable compliance.

11.1 Façade

11.1.1 Category I &II Facades

- Heavy cladding (e.g. precast concrete, block work, bricks, etc.)
- Internal Lining of 1x13mm Plasterboard (or 2x depending on cladding) on Timber Stud and minimum R1.8 Insulation

The following example figure shows the contribution of the wall and glazing in a generic bedroom exposed to the highest 75dB $LA_{eq\ 24\ hrs}$ noise level at the façade, with 152mm concrete and recommended glazing comprising 30% of the façade:

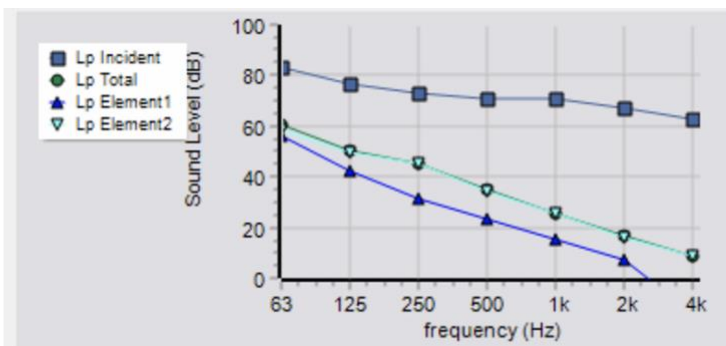

Figure 19 - Category I facade attenuation by element (1: Wall, 2: Window)

As such, and based on preliminary models, it is recommended that the following is considered:

- Category I and II facades to have heavy weight cladding such as Concrete, Bricks or Block, with internal lining of 1x13mm plasterboard and R1.8 insulation, to comply with internal noise limits

11.1.2 Category III & IV Facades:

- Can have lighter cladding (e.g. weatherboard, fibre cement can be used) or heavy cladding
- Internal Lining of 1x10mm Plasterboard on Timber Stud and minimum R1.8 Insulation:

<u>Actual configurations and material options, once decided, should be assessed for acoustic performance.</u>

11.2 Glazing

11.2.1 Category I – [LA_{eq} 72dB and above]

For habitable rooms on Category I facades, the following example configuration would achieve compliance with internal noise levels. **Actual configurations and material options, once decided, should be assessed for acoustic performance.**

- Glazing with manufacturer attenuation of: STC/R_w: 38 and PSR (Perceived Sound Reduction): 55% (e.g. 24.4mm Laminated IGU 6.38mm / 12mm AS / 6mm or equivalent.)
- Glazing up to 30% of external wall area.
- Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals.
- Hinged doors with rubber seals strongly recommended instead of sliding doors.
- Mechanical Ventilation required in all habitable spaces.

In order to meet the internal noise levels, windows of all the habitable spaces need to be closed and hence mechanical ventilation is required for all areas in Category I. We would like to clarify that the windows may be openable, i.e. those are not necessarily fixed windows, but would need to achieve the above performance.

Mechanical Ventilation

Mechanical ventilation will be required in all habitable spaces of the subject apartments to meet ventilation requirements. There is no minimum requirement for glazing in non-habitable spaces such as garages and bathrooms.

Glazed Doors

A number of commercially available hinged doors can achieve the required attenuation for this category. Conversely, we note that most sliding doors would not achieve the performance levels required for this Category.

As such, for glazed doors on Category I facades, we strongly recommend against the use of sliding glass doors. Sliding doors do not usually achieve the performance levels noted above. While some bespoke configurations may approach the required performance, these can be either too heavy to operate in a residential environment, or cost prohibitive or both.

Alternatively, we note that effective attenuation can be achieved if façade doors to balconies are supplemented by glazing systems that acoustically shield the balconies (e.g. making them effectively winter gardens)

11.2.2 Category II – [LA_{eq} 67-72dB]

For habitable rooms on Category II facades, the following example configuration would achieve compliance with internal noise levels. **Actual configurations and material options, once decided, should be assessed for acoustic performance.**

- Glazing with manufacturer attenuation of: STC/R_w: 38 and PSR (Perceived Sound Reduction): 55% (e.g. 24.4mm Laminated IGU 6.38mm / 12mm AS / 6mm or equivalent.)
- Glazing up to 60% of external wall area.
- Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals.
- Hinged doors with rubber seals recommended instead of sliding doors
- Mechanical Ventilation required in all habitable spaces.

In order to meet the internal noise levels, windows of all the habitable spaces need to be closed and hence mechanical ventilation is required for all areas in Category I. We would like to clarify that the windows may be openable, i.e. those are not necessarily fixed windows, but would need to achieve the above performance.

<u>Mechanical Ventilation</u>

Mechanical ventilation will be required in all habitable spaces of the subject apartments to meet ventilation requirements. There is no minimum requirement for glazing in non-habitable spaces such as garages and bathrooms.

<u>Glazed Doors:</u>

If sliding doors are required, assessment must be made of measured performance of glazed door system, in context of areas of glazing relative to wall and room sizes. Sliding doors with brush seals would not usually achieve the required level of performance.

We note that while some configurations may achieve the required performance for this Category of facades, these are usually bespoke and likely to be heavy to operate (e.g. rubber seals) in a residential environment. An example is 4mm/ 16mm AS /6.38mm with rubber seals.

As such, it is recommended that proposed glazed doors on Category II facades are either acoustically suitable hinged doors or if alternate configurations are proposed, these should be tested in-situ (e.g. sample site or custom built enclosure) to establish the attenuation characteristics of the system. Testing must be undertaken by a qualified and experienced acoustical consultant.

11.2.3 Category III – [LA_{eq} 60-67dB]

For habitable rooms on Category III facades, the following example configuration would achieve compliance with internal noise levels. **Actual configurations and material options, once decided, should be assessed for acoustic performance.**

- Glazing:
    - With manufacturer attenuation of: STC/R_w: 38 and PSR (Perceived Sound Reduction): 55% (e.g. 24.4mm Laminated IGU 6.38mm / 12mm AS / 6mm or equivalent.) with up to 90% of external wall area OR
    - With manufacturer attenuation of: STC/R_w: 31 and PSR (Perceived Sound Reduction): 25% (e.g. 24mm IGU 6mm / 12mm AS / 6mm or equivalent.) up to 70% of external wall area.
- Window suites / frames are required to match the STC ratings noted above, complete with compressible weather seals.
- Sliding glazed doors are available commercially, but would need to achieve STC 31. As per the following section covering sliding doors, we note that this would be at the upper end of what can be achieved with brush seals (e.g. 4mm/ v16mm AS /6.38mm.)
- Mechanical Ventilation required in all habitable spaces.

In order to meet the internal noise levels, windows of all the habitable spaces need to be closed and hence mechanical ventilation is required for all areas in Category I. We would like to clarify that the windows may be openable, i.e. those are not necessarily fixed windows, but would need to achieve the above performance.

<u>Mechanical Ventilation</u>

Mechanical ventilation will be required in all habitable spaces of the subject apartments to meet ventilation requirements. There is no minimum requirement for glazing in non-habitable spaces such as garages and bathrooms.

<u>Glazed Doors:</u>

If sliding doors are required, assessment must be made of measured performance of glazed door system as the required performance would be at the upper end of what is achievable with brush seals. Use of rubber seals required for higher performance may make sliding doors subjectively heavy and hard to operate in a residential setting.

11.2.4 Category IV– [Less than LA_{eq} 60dB]

For habitable rooms on Category IV facades, the following example configuration would achieve compliance with internal noise levels. Actual configurations and material options, once decided, should be assessed for acoustic performance.

- Sliding glazed doors would need to achieve STC 25. (e.g. 4mm/ v16mm AS /4mm.)
- Mechanical Ventilation required in all habitable spaces.

In order to meet the internal noise levels, windows of all the habitable spaces need to be closed and hence mechanical ventilation is required for all areas in Category I. We would like to clarify that the windows may be openable, i.e. those are not necessarily fixed windows, but would need to achieve the above performance.

Mechanical Ventilation

Mechanical ventilation will be required in all habitable spaces of the subject apartments to meet ventilation requirements. There is no minimum requirement for glazing in non-habitable spaces such as garages and bathrooms.

Glazed Doors:

Commercially available sliding doors can achieve the required performance for this category of facades.

11.3 Roof

Assessing against the frequency distribution of traffic noise, the following options yield internal noise levels in a representatively modelled bedroom at Category I and II areas, with 180mm Autex Greenstuff R3.2 Insulation:

- 0.6mm Longrun Steel Roofing, with internal ceiling lining of 2x13mm Noiseline Plasterboard: 40dBA
- 3mm Asphalt Shingles with internal ceiling lining of 1x13mm Noiseline Plasterboard: 40dBA
- 3mm Asphalt Shingles with internal ceiling lining of 2x13mm Plasterboard: 36dBA

Assessment against the criteria yields the following:

- For Category I and II areas, the use of long run steel roofing requires the addition of 2 layers of 13mm Noiseline plasterboard linings to the ceilings of habitable areas to achieve compliance.
- An alternative would be the use of Asphalt Shingle Roofing systems with either:
  - 1x13mm Noiseline (high density) Plasterboard; or
  - 2x13mm Plasterboard

Worth noting here that the use of Asphalt with 2x13mm Plasterboard would yield internal noise levels comfortably below the compliance levels. The other alternatives modelled would be just at compliance levels and have the associated risk of in-situ performance degradation from design levels.

It is required that penetrations for light fittings in the ceilings of habitable areas at the top floor are to be restricted to 1x130mm diameter recessed light in the ceiling per 2m^2 in order for sound insulation not to be adversely affected. The acoustic criterion also requires all penetrations to be acoustically sealed. **Actual configurations and material options, once decided, should be assessed for acoustic performance.**

11.4 Mechanical Ventilation

All habitable spaces in all units to be provided with mechanical ventilation and/or a cooling system to achieve the noise levels, design temperatures and air flows in Standard E25.6.10(3)(b)(i) and (ii) of the Auckland Unitary Plan.

11.5 Mechanical HVAC Plant

11.5.1 Noise

All mechanical plant shall be designed, selected, positioned and shielded to control noise at any receiver to within the required compliance standards. Furthermore, mechanical plant shall be mounted on suitable vibration isolation mounts to maintain vibration levels within the compliance levels. We note that the above can be achieved with commercially available solutions.

11.5.2 Vibrations

Mechanical plant shall be mounted on suitable vibration isolation mounts to maintain vibration levels within the compliance levels.

11.6 Internal Traffic

Based on noise prediction models for the subject site, and assuming all cars within the development transit within 1 hour, noise levels would still be compliant at the adjacent sites.

11.7 Waste Management

In order to assess waste management noise levels and any required mitigation measures, access locations and processes are required (e.g. truck path, bin movement, reversing or not)

Notwithstanding that, in order to comply with the AUP external noise levels at the adjacent sites, waste collection is generally recommended to only occur during daytime hours of 7am to 11pm, unless proposed to occur within the basement area.

11.8 Intertenancy

11.8.1 Walls and Floors - Airborne

It is recommended that all intertenancy walls and floors are designed at an STC rating of at least 60 to ensure that even with in-situ degradation, noise insulation would still be at FSTC 55 whereby privacy between units is maintained.

11.8.2 Floors – Impact

Similarly, if units have intertenancy floors, it is recommended that all intertenancy floors are designed at an IIC rating of at least 60 to ensure that even with in-situ degradation, noise insulation would still be at FIIC 55 whereby privacy between units is maintained. To achieve this, it is recommended that all intertenancy non-carpeted areas (i.e. tiles or timber flooring) include the use of appropriate vibration isolation underlay, to be confirmed as part of the design, in addition to best practice design measures for intertenancy floor impact.

11.9 Car Stackers

11.9.1 Noise

For the specific receivers:

- **Internal receivers:** Noise attenuation of the facades adjacent the carpark would need to be considered depending on the noise levels from the car stackers. This would generally apply to the first and second floors (within 6-9m of the parking area.) Occupancies abutting the carpark would need to have solid heavy weight facades (e.g. concrete)

- **31 Mauranui Ave** is at a sufficient distance for noise from the stackers to comply with the daytime limits. Compliance with night-time limits will depend on whether the noise generated is tonal (requires a +5dB correction or not)

- **82 Great South Rd** may require some level of shielding where there is line of sight to the car park. Depending on the planned structures at the boundary, this may be achieved with simple fencing with a surface density of at least 10kg/m^2 (e.g. blockwork, plywood)

In addition, a number of measures and accessories are usually available from manufacturers for reduction of noise from stacker operations. These should be considered in conjunction with planned locations and shielding effects of parking area structures.

11.9.2 Vibrations

Consideration must be given to the mounting and isolation of mechanical stacker equipment from floor structures and wall connections. We note that manufacturers provide optional accessories for vibration reduction. These should be considered where required in conjunction with planned locations of stackers.

In addition, and if required, vibration propagation can be attenuated by specific construction measures such as saw cuts isolating floor areas of stackers from the building structure. These should be considered in conjunction with manufacturer measures.

Glossary of Terms- Acoustics

Ambient Noise: the total noise, at a given place, a composite of sounds from many sources near and far.

Asymmetric: a waveform not identical on both sides of the mean or zero line, lacks symmetry.

Average: in acoustics where dB levels are extensively used, average may not mean adding up the values and then dividing by the number of samples.

Octave: a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 Hertz octave band contains noise energy at all frequencies from 707 to 1414 Hertz.

In acoustical measurements, Sound Pressure Level is often measured in octave bands, and the centre frequencies of these bands are defined by ISO - 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, 16 kHz to divide the audio spectrum into 10 equal parts.

The sound pressure level of sound that has been passed through an octave band pass filter is termed the octave band sound pressure level.

One-third Octave Bands, there are three similar bands in each octave band.

1/1, 1/3, 1/6, 1/12, and 1/24 octaves are all used in acoustics.

Background Noise: the noise at a given location and time, measured in the absence of any alleged noise nuisance sources, also known as Residual Noise.

Broadband Noise: also called wideband noise - noise whose energy is distributed over a wide section of the audible range as opposed to Narrowband Noise.

Class 1: precision grade sound level meters for laboratory and field use - also known as Type 1.

Continuous Spectrum: sound spectrum whose components are continuously distributed over a given frequency range.

Frequency Weighted Sound Levels: Frequency weightings correlate objective sound measurements with the subjective human response. The human ear is frequency selective; between 500 Hz and 6 kHz our ears are very sensitive compared with lower and higher frequencies.

A-weighting: the A-weighting filter covers the full audio range - 20 Hz to 20 kHz and the shape is similar to the response of the human ear at the lower levels

C-weighting: a standard frequency weighting for sound level meters, commonly used for higher level measurements and Peak - Sound Pressure Levels.

Z-weighting: Z for 'Zero' frequency weighting, which implies no frequency weighting. In reality the range is 10 Hz to 20 kHz ±1.5 dB.

dB Level: is the Logarithm of the ratio of a given acoustic quantity to a reference quantity of the same kind. The base of the logarithm, the reference quantity, and the kind of level must be indicated.

decibel: dB : a relative unit of measurement widely used in acoustics, electronics and communications. The dB is a Logarithmic unit used to describe a ratio between the measured level and a reference or threshold level of 0dB. The ratio may be Sound Power, Sound Pressure, voltage or Sound Intensity, etc.

Deltatron ®: trade name for IEPE - Integrated Electronics Piezoelectric.

FFT: Fast Fourier Transform : a digital signal processing technique that converts a time record into a narrow band constant bandwidth filtered spectrum. Measurements are defined by specifying the frequency span and a number of lines (or filters).

Frequency: f : the number of times that a Periodic function or vibration occurs or repeats itself in a specified time, often 1 second - cycles per second. It is usually measured in Hertz (Hz).

Frequency Analysis: analysing an overall broadband noise to identify the different contributions in different parts of the audio spectrum. Typically the analysis in made using 1/1-Octave, 1/3-Octave or narrow band (FFT) Analysis.

Frequency Band: a continuous range of frequencies between two limiting frequencies.

Hertz: Hz : the unit of Frequency or Pitch of a sound. One hertz equals one cycle per second.

Impact Sound: the sound produced by the collision of two solid objects. Typical sources are footsteps, dropped objects, etc., on an interior surface (wall, floor, or ceiling) of a building.

Infrasound: sound whose frequency is below the low-frequency limit of audible sound (about 16 Hz).

Integrating (of an instrument): indicating the mean value or total sum of a measured quantity.

kHz: kilohertz : 1 kHz = 1000 Hz = 1000 Hertz.

LA: A-weighted, Sound Level.

LA10: is the noise level just exceeded for 10% of the measurement period, A-weighted and calculated by Statistical Analysis.

LA90: is the noise level exceeded for 90% of the measurement period, A-weighted and calculated by Statistical Analysis.

LAn: noise level exceeded for n% of the measurement period with A-weighted , calculated by Statistical Analysis - where n is between 0.01% and 99.99%.

LAeq: A-weighted, equivalent sound level. A widely used noise parameter describing a sound level with the same Energy content as the varying acoustic signal measured - also written as dBA Leq

LAF: A-weighted, Fast, Sound Level.

LAFmax: A-weighted, Fast, Maximum, Sound Level.

LAFmin: A-weighted, Fast, Minimum, Sound Level.

LAIeq: A-weighted, Impulse, Leq, Sound Level.

LAmax: A-weighted, Maximum, Sound Level

LAS: A-weighted, Slow, Sound Level.

LASmax: A-weighted, Slow, Maximum, Sound Level.

LASmin: A-weighted, Slow, Minimum, Sound Level.

LC: C-weighted, Sound Level.

LCE: C-weighted, Sound Exposure Level

LCeq: C-weighted, Leq, Sound Level

LCF: C-weighted, Fast, Sound Level.

LCFmax: C-weighted, Fast, Maximum, Sound Level.

LCpeak: C-weighted, Peak, Sound Level.

Leq: Equivalent Sound Level

Lpeak: Peak Sound Level

LZ: Z weighted, Sound Level.

LZE: Z-weighted, Sound Exposure Level

LZeq: Z-weighted, Leq, Sound Level.

LZF: Z-weighted, Fast, Sound Level.

LZFmax: Z-weighted, Fast, Maximum, Sound Level.

LZFmin: Z-weighted, Fast, Minimum, Sound Level.

Multi-spectrum: a one or two-dimensional array of spectra, consisting of two or more spectra that were recorded during the same measurement

Narrowband Noise: noise which has its energy distributed over a relatively small section of the audible range.

Natural Frequency: the frequency at which a resiliently mounted mass will vibrate when set into free vibration. The frequency of oscillation of the free vibration of a system if no Damping were present.

Noise: any sound that is undesired by the recipient. Any sound not occurring in the natural environment, such as sounds emanating from aircraft, highways, industrial, commercial and residential sources. Interference of an electrical or acoustical nature.

Octave: a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 Hertz octave band contains noise energy at all frequencies from 707 to 1414 Hertz.

Octave Band analyser: an instrument that measures Sound Levels in octave bands.

Peak-to-Peak: the amplitude difference between the most positive and most negative value in a time waveform, that is, the total Amplitude.

Piezoelectric: PE : any material which provides a conversion between mechanical and electrical energy. Piezo is a Greek term which means 'to squeeze'. If mechanical stresses are applied to a piezoelectric crystal, then an electrical charge results. Conversely, when an electrical voltage is applied across a piezoelectric material, the material deforms.

Pitch: is a subjective auditory sensation and depends on the frequency, the harmonic content, and to a lesser extent on the loudness of a sound.

Spectrum: the description of a sound wave's resolution into its components of frequency and amplitude.

Third Octave Band: Octave bands sub-divided into three parts, equal to 23% of the centre frequency. Used when octave analysis is not discrete enough. Divides the audio spectrum into 33 or more equal parts with Constant Percentage Bandwidth filter.

Tone: sound or noise recognisable by its regularity. A simple or Pure Tone has one frequency. Complex tones have two or more simple tones, the lowest tone frequency is called the Fundamental, the others are Overtones.

Vibration: mechanical oscillations occur about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random.