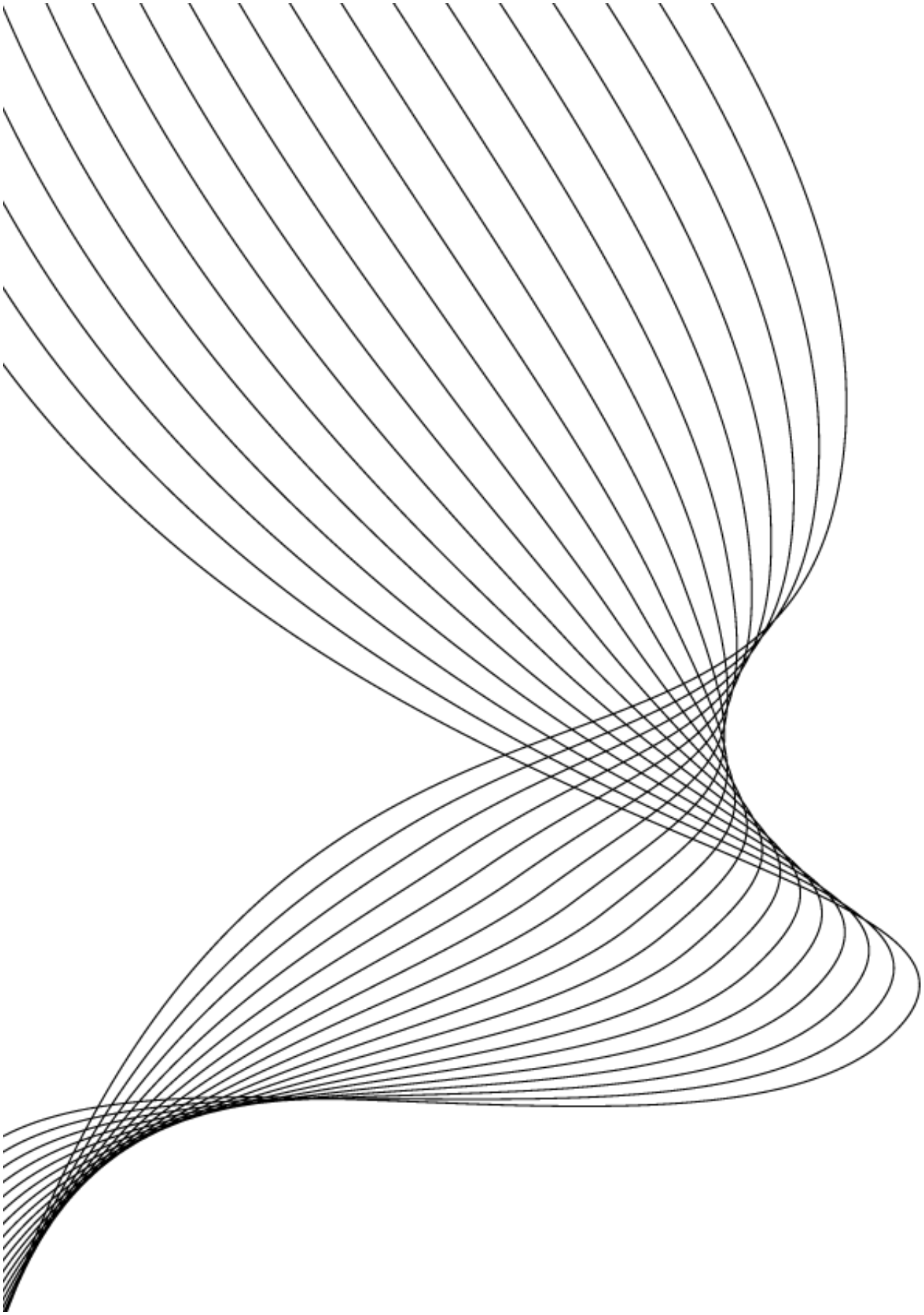
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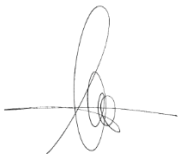
KSNPM

LRD Blackglen Road – Noise Impact Assessment

Issued



Client:	Site:	Project No:
KSNPM	LRD, Blackglen Road	3950

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Document History:

Revision:	Date:	Description:
0	23.06.2022	Issued
1	29.01.2024	Issued
2	09.05.2024	Minor Update
3	06.06.2024	Minor Update
4	10.06.2024	Minor Update
5	09.10.2024	Minor Update
6	26.11.2024	Minor Update
7	18.12.2024	Minor Update

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Executive Summary

This noise and vibration impact assessment report includes consideration of:

- Compliance with Dublin Agglomeration Noise Action Plan (2018-2023)
- Construction Phase
- Operational Phase
- Building Envelope Design

The findings of the report demonstrate that:

1. The development shall not be exposed to levels in excess of Dublin Agglomeration Noise Action Plan criteria.
2. Appropriate construction noise limits have been set and are not expected to be exceeded.
3. There are no adverse noise impacts associated with the operational phases of the proposed development.
4. A Good Acoustic Design methodology has been applied to ensure that the internal noise criteria will be satisfied with suitable glazing and ventilation performance criteria.

1.0 Introduction

The Proposed Development is a Large Scale Residential Development (LRD) on a site of approx. 3.86ha on lands at Blackglen Road, Sandyford, Dublin 18. This report assesses several elements with regard to the potential noise impact and the acoustic design including:

1. The noise and vibration impact during both the construction and operational phases will be identified and assessed.
   The construction phase will likely result in increased levels for a relatively short period whereas a small increase in traffic volumes associated with the development is likely to be the main impact source once operational.
2. The Acoustic Design Statement (ADS) methodology considers the external noise levels for day and night periods and the effectiveness of the building's design to meet the required internal noise criteria.

2.0 Description of Effects

In addition to the appropriate impact assessment criteria that will be set out in this chapter, the significance of effects of the proposed project shall be described in accordance with the Environmental Protection Agency (EPA) document *Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), 2022* (EPA Guidelines).

The EPA Guidelines do not however quantify the impacts in decibel terms. In the absence of such information, reference is made to *Guidelines for Environmental Noise Impact Assessment (2014)* from the Institute of Environmental Management and Assessment (IEMA Guideline). The IEMA Guidelines state similar terminology to the EPA Guidelines and quantifies the effect categories in decibel terms for various receptor categories, with residential receptors having the greatest sensitivity to noise.

Table 1 presents the categories for residential receptors with appropriate change in noise level ranges.

Table 1. Effects Description (EPA and IMEA Guidelines) and noise level change criteria.

EPA Description of Effect	IEMA Guidelines	Noise Level Change (dB)
Imperceptible	None / Not significant	Less than 2.9
Not Significant		
Slight	Slight	3.0 - 4.9
Moderate	Moderate	
Significant	Substantial	5.0 - 9.9
Very Significant	Very Substantial	Greater than 10.0
Profound		

3.0 Methodology and Guidance

The study has been undertaken using the following methodology:

- Baseline Noise monitoring and an Environmental Noise Survey has been undertaken across the development area to quantify the range of noise levels at varying locations.
- A review of the most applicable standards and guidelines has been conducted to set a range of acceptable noise and vibration criteria for the construction and operational phases of the proposed development.
- Predictive calculations have been performed to estimate the likely noise and vibration emissions during the construction phase of the project at the nearest sensitive locations (NSLs) to the site.
- Predictive calculations have been performed to assess the potential impacts associated with the operation of the development at the most sensitive locations surrounding the development site.
- A schedule of mitigation measures has been proposed, where relevant, to control the noise and vibration emissions associated with both the construction and operational phases of the proposed development.
- An Acoustic Design Statement has been prepared setting out the require acoustic performance of the glazing units.

This assessment has been prepared using the following guidance documents:

- BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Noise
- BS 5228-2:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Vibration
- BS 7385-2:1993 Guide for measurement of vibrations and evaluation of their effects on buildings.
- BS 4142: 2014: Methods for Rating and Assessing Industrial and Commercial Sound.
- BS 8233:2014 Guidance on Sound Insulation and Noise Reduction for Buildings.
- BS 6472-1 (2008) Guide to evaluation of Human Exposure to Vibration in Buildings - Vibration sources other than Blasting.
- BS 7385-1 (1990) Evaluation and Measurement for Vibration in Buildings - Guide for Measurement of Vibration and evaluation of their effects on buildings.
- BS 7385-2 (1993) Evaluation and Measurement for Vibration in Buildings - Guide to damage levels from Ground borne Vibration.

- ISO 1996: 2017: Acoustics - Description, Measurement and Assessment of Environmental Noise.
- Dublin Agglomeration Noise Action Plan (2018-2023)
- ProPG: Professional Practice Guidance on Planning & Noise. New Residential Development. May 2017.
- Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), 2022
- EPA Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)

3.1 Construction Phase (Noise)

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project.

To set appropriate construction noise limits for the development site, reference has been made to *BS 5228-1:2009 +A1 2014 Code of practice for noise and vibration control on construction and open sites - Noise*. This provides basic information on the prediction and measurement of noise from construction sites and operations such as mines and quarries. It also includes a large database of source noise levels for commonly used equipment and activities on construction sites.

The standard provides guidance on the 'threshold of significant effect' in respect of noise impact at dwellings. One suggested method for determining threshold noise levels is known as the 'ABC method'. This involves measuring existing ambient noise levels at noise sensitive locations and categorising them A, B or C accordingly, with the relevant threshold level derived from the category as set out in Table 1.

Table 2. BS 5228 - Example of significant effect at dwellings

Assessment category and threshold value period (L_{Aeq})	**Threshold value, in decibels (dB)**		
	Category A A)	**Category B** B)	**Category C** C)
Night-time (23.00−07.00)	45	50	55
Evenings and weekends D)	55	60	65
Daytime (07.00−19.00) and Saturdays (07.00−13.00)	65	70	75

NOTE 1 A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level.

NOTE 2 If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity.

NOTE 3 Applied to residential receptors only.

A)	Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.
B)	Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.
C)	Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.
D)	19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.

In general, the noise impact due to the construction phase will be from the specific items of plant used, the duration and phasing of the construction methods, the time of day that each plant will be used and their location.

At this stage of the planning for the proposed development however, a definitive construction plan is not yet formalised. Typically, a worse-case scenario is adopted whereby the plant associated for each phase e.g., site perpetrations, demolition, piling, general construction etc, is assumed to operate simultaneously. This can then inform the construction management plan and be refined as required.

3.2 Construction Phase (Vibration)

BS 5228-2:2009+A1:2014 - Code of practice for noise and vibration control on construction and open sites: - Part 2: Vibration, outlines several calculation methods for predicting vibration from construction works on open sites.

The standard references other guidance to set acceptable levels for:

- **Disturbance:**
  BS 6472-1 (2008) Guide to evaluation of Human Exposure to Vibration in Buildings, and;
- **Damage**
  BS 7385-2 (1993) Evaluation and Measurement for Vibration in Buildings.

3.2.1 Disturbance

BS 6472 requires that the estimated vibration dose value (eVDV) parameter be determined for the 16-hour daytime and 8-hour night-time periods. For vibration associated with construction sites however it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage. Furthermore, since many of the empirical vibration predictors yield a result in terms of PPV, it is necessary to understand what the consequences might be of any predicted levels in terms of human perception and disturbance. Some guidance is given in Table 2.

Table 3. Guidance on effects of vibration levels

Vibration Level	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

3.2.2 Building Damage

The response of a building to ground-borne vibration is affected by the type of foundation, underlying ground conditions, the building construction, and the state of repair of the building.

BS 7385 provides guidance on vibration measurement, data analysis and reporting as well as building classification and guide values for building damage.

Limits for transient vibration, above which cosmetic damage could occur, are given in Table 3.

Table 4. Transient vibration guide values for cosmetic damage.

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4Hz and above	50 mm/s at 4Hz and above
Unreinforced or light framed Structures Residential or light commercial buildings	15 mm/s at 4Hz[1] increasing to 20 mm/s at 15Hz	20 mm/s at 15Hz increasing to 50 mm/s at 40Hz and above
NOTE 1 Values referred to are at the base of the building. [1] At frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded		

Minor structural damage may occur at levels around twice the above limits and major damage can occur at levels around four times the above limits.

Both standards note that important buildings that are difficult to repair might require special consideration on a case-by-case basis but building of historical importance should not (unless it is structurally unsound) be assumed to be more sensitive. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground borne disturbance.

It should be noted that there is a major difference between the sensitivity of people in feeling vibration and the onset of vibration which caused building damage. Vibration in relation to construction sites therefore may result in short-term disturbance but rarely cause even cosmetic damage. For some construction sites e.g., during piling or rock-braking and with dwellings nearby, vibration monitoring at these locations may be prudent.

3.3 Operational Phase

3.3.1 Dublin Agglomeration Environmental Noise Action Plan (2018-2023)

Section 6.2.1 from the Dublin Agglomeration Noise Action Plan provides some discussion of external noise levels that are considered to be desirable high and undesirable low, as below:

a) *Undesirable High Sound Levels. Following a review of existing guidance as outlined in Chapter 2 and of the levels set out in the previous noise action plan, the following are the proposed threshold for undesirable high sound levels:*

   > 55 dB(A) L_{night}

   >70 dB(A) L_{day}

b) *Desirable Low Sound Levels. Again, following the same criteria as above, the following are the proposed threshold levels for desirable sound levels*

   <50 dB(A) L_{night}

   <55 dB(A) L_{day}

It should be noted that the above is relevant to any type of commercial, residential or industrial development and that the thresholds do not set external noise levels above which planning permission should not be granted for a development.

3.3.2 BS 8233:2014

To assess the building envelope design it is appropriate follow the guidance set out in BS 8233:2014 Guidance on sound insulation and noise reduction for buildings which is concerned with noise ingress into dwellings.

The recommended levels for indoor ambient noise in residential dwellings is summarised in Table 4.

Table 5. BS 8233:2014 Recommended internal noise limits.

Activity	Location	07:00 – 23:00 hours	23:00 – 07:00 hours
Resting	Living room	$L_{Aeq,16hr}$ 35dB	-
Dining	Dining room/area	$L_{Aeq,16hr}$ 40dB	-
Sleeping (daytime resting)	Bedroom	$L_{Aeq,16hr}$ 35dB	$L_{Aeq,8hr}$ 30dB $L_{AFMax,8hr}$ 45dB

3.3.3 ProPG

An Acoustic Design Statement methodology is set out in the Professional Practice Guidance on Planning and Noise (ProPG) which focuses on the adoption of Good Acoustic Design for dwellings when required as a result of high external noise levels.

ProPG also provides guidance on flexibility of the internal noise level targets set out in BS8233:2014. For instance, in cases where the development is considered necessary or desirable, then a relaxation of the internal L_{Aeq} values by up to 5dB can still provide reasonable internal conditions.

It also provides the following guidance regarding external noise levels for amenity areas in the development:

> *"The acoustic environment of external amenity areas that are an intrinsic part of the overall design should always be assessed and noise levels should ideally not be above the range 50-55dB LAeq,16hr."*

In addition, it offers flexibility on the amenity noise targets provided that residents have access to a quiet recreational environment.

3.3.4 External Noise Sources

The likely significant sources of noise associated with the operational phase of the proposed development are items of Electrical and Mechanical (M&E) plant and an increase to the local traffic.

3.3.4.1 M&E Plant

The noise impact associated with the plant and services associated with the development should be assessed following the procedures in BS 4142:2014

BS 4142:2014 describes a method for assessing the impact of a proposed or existing industrial or commercial sound source. Its principal uses are to assess noise from new or changed industrial or commercial premises, to accompany a planning application, or to assess noise which may be giving rise to complaints.

The standard is basic in principle, but the details can be complex. In the simplest terms, the procedure rates the noise levels from an operation (the 'Specific' noise) and compares it with the 'Background' noise levels in the absence of the

noise source(s) under investigation. The level difference is an indication of the impact that the operation might have.

If for example, if the 'Rated' noise level (the Specific noise + any penalties for particular noise characteristics) exceeds the Background noise by 10dB or more, it is likely to be an indication of a significant adverse impact. A difference of around 5dB indicates an adverse impact. If the level does not exceed the background, it is likely to have a low impact.

This however is dependent on the 'context' of the site and its environs e.g. time of day, nature of the neighbourhood, local attitudes to the development etc. There is also a degree of uncertainty applicable to the results e.g. for weather, instrumentation, measurement duration, calculation errors etc which ought to be considered.

3.3.4.2 Traffic

The increase in traffic numbers associated with the scheme's residences is a likely source of noise during the operational phase of the scheme.

The most appropriate criteria for assessing disturbance or annoyance from noise arising from the site would be related to the significance of perceived changes in noise levels.

The Institute of Environmental Management and Assessment's (IEMA) 'Guidelines for Noise Impact Assessment' gives appropriate impacts which have been summarised with relevant guidance in Table 5.

Table 6. Summary of appropriate impact for changes in traffic noise levels.

Change in Noise Level	Subjective Reaction	Magnitude of Impact	EPA Glossary of Effects[1]
0	No change	None	Imperceptible
0.1 to 2.9	Barely perceptible	Minor	Slight
3.0 to 4.9	Noticeable	Moderate	Moderate
5.0 to 9.9	Up to a doubling of loudness	Substantial	Significant
10+	More than a doubling of loudness	Major	Profound

A change in traffic noise of less than 2dBA is generally not noticeable to the human ear whilst a change of 3dBA is generally considered to be just perceptible. Changes in noise levels of 3 to 5 dBA would however be noticeable and, depending on the final noise level, there may be a slight or moderate noise impact. Changes in noise level in excess of 6dBA would be clearly noticeable, and depending on the final noise level, the impact may be moderate or significant.

However, a significant change in traffic volumes or traffic category i.e., increase in the use of a road by HGVs, would be required to result in such increases.

The UK Design Manual for Roads and Bridges (DMRB, Volume 11, Section 3, Part 7) states that a change in noise level of 1dB $L_{A10,18h}$ is equivalent to a 25% increase or a 20% decrease in traffic flow, assuming other factors remain

[1] EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports, (Draft August 2017)

unchanged and a change in noise level of 3dB $L_{A10,18h}$ is equivalent to a 100% increase or a 50% decrease in traffic flow.

3.3.5 Noise Ingress

The World Health Organisation (WHO) in their 2018 publication entitled Environmental Noise Guidelines for the European Region has proposed new guidelines for community noise. In this guidance, a L_{den} threshold daytime noise limit of 53dB is suggested to protect against adverse health effects. L_{night} Levels of 45dB or less are proposed at night-time to protect against adverse effects on sleep.

The operational phase of the development shall be assessed with regard to the 2018 WHO guidelines and appropriate acoustic design of residential units to ensure that they comply with the Department of the Environment, Building Regulations 2014, Technical Guidance Document E – Sound.

3.3.6 Noise Sensitive Location

The assessment criteria will apply to Noise Sensitive Locations (NSLs), the definition of which is given in the EPA NG4 document as:

> *"any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels."*

4.0 Receiving Environment

4.1 Development Description

Zolbury Ltd., intend to apply to Dun Laoghaire Rathdown County Council for permission for development for a Large-Scale Residential Development (LRD) on a site of approx. 3.86ha on lands at Blackglen Road, Sandyford, Dublin 18.

The development will consist of 192 no. residential units ranging from 2-5 storeys in height, associated resident amenity facilities, a childcare facility, all boundary treatment and landscaping works, site services connections and all site development works to include:

A. Construction of 192 no. residential units, in the form of 6 no. new apartment buildings (A1 – B4), 40 duplexes (C1, C2, C2A) and 14 houses (D1 & D2), to include 33 no. 1-beds, 84 no. 2 -beds, 61 no. 3-beds and 14 no. 4-beds as follows:

- Block A1 (4 storeys) comprising 15 no. apartments (3 no. 1 bed units, 6 no. 2 bed units & 6 no. 3 bed units); a crèche facility of approx. 378.2 sq. m with associated outdoor play space of approx. 170 sq. m; and resident amenity facilities of approx. 31.6 sq. m.
- Block A2 (3-4 storeys) comprising 26 no. apartments (2 no. 1 bed units, 20 no. 2 bed units and 4 no. no. 3 bed units) and resident amenity facilities of approx. 353.6 sq. m.
- Blocks B1 and B2 (2-5 storeys) comprising 51 no. apartments (15 no. 1 bed units, 29 no. 2 bed units, 7 no. 3 bed units).
- Blocks B3 and B4 (2-5 storeys) comprising 46 no. apartments (13 no. 1 bed units, 23 no. 2 bed units and 10 no. 3 bed units).

- Duplex Units C1 (4 storeys), C2 and C2A (3 storeys) comprising 40 duplexes (6 no. 2 bed units, 20 no. 3 bed units and 14 no. 4 bed units).
- House Units D1 and D2 (2 storeys) comprising 14 houses (14 no. 3 bed units).

B. Total Open space (approx. 10,854 sq. m) is proposed in the form of public open space (approx. 8, 686 sq. m), and residential communal open space (approx. 2,168 sq. m). Each residential unit is afforded with associated private open space in the form of a garden/terrace/balcony.

C. The development will be served via a new vehicular access via Blackglen Road. This will be designed as a priority junction with pedestrian and cycle crossings where required to tie in with the Blackglen Road Improvement Scheme.

D. A new toucan crossing is proposed across Blackglen Road just to the east of the new vehicular access. This toucan crossing has been designed as per TL607 of the Cycle Design Manual to allow crossing of pedestrians and cyclists to the northern side of Blackglen Road for improved public transport access.

E. Emergency access only is proposed via Woodside Road.

F. A dedicated wildlife corridor is proposed to the east/south-east side of the site and a public open space (approx. 307 m in length) tree trail to the west/north-west side of the site.

G. Basement/Podium car park areas are proposed below Blocks B1, B2, B3 and B4. A total of 226 no. car parking spaces are proposed, which includes 2 no. car club spaces, 12 no. accessible spaces and 47 no. EV charging spaces (198 no. long-stay spaces, 18 no. visitor space & 10 no. car parking spaces for creche use), in addition to 9 no. motorcycle spaces.

H. A total of 484 no. bicycle spaces are proposed in the form of 442 no. long stay bicycle spaces 42 short-term stay visitor parking.

I. 2 no. ESB substations at surface level.

J. Bin Storage areas for the Duplex blocks are proposed at ground level adjacent to the Duplex blocks.

K. All associated site and infrastructural works to include provision for water services; foul and surface water drainage and connections; internal roads, attenuation proposal; permeable paving; all landscaping works including green infrastructure zones; green roofs; and general plant areas; photovoltaic panels; landscaped boundary treatment; footpaths; public lighting; and electrical services.

The general site layout is presented in Figure 1.



Figure 1. Layout for the proposed development.

The site is boarded by the Blackglen Road to the north and Woodside Road to the south. The M50 motorway is approximately 700m to the north.

There are a number of existing residences surrounding the site considered as the nearest Noise Sensitive Locations (NSLs) for the purposes of this assessment.

4.2 Background Noise Survey

A baseline noise survey has been conducted at the site in order to quantify the existing noise environment. The survey was conducted in general accordance with *ISO 1996: 2017: Acoustics - Description, Measurement and Assessment of Environmental Noise* and followed the methodology contained in *EPA NG4*. Specific details are set out below.

2no. noise monitors were installed at the Noise Monitoring Locations (NMLs) shown in Figure 2 with GPS co-ordinates in Table 7.

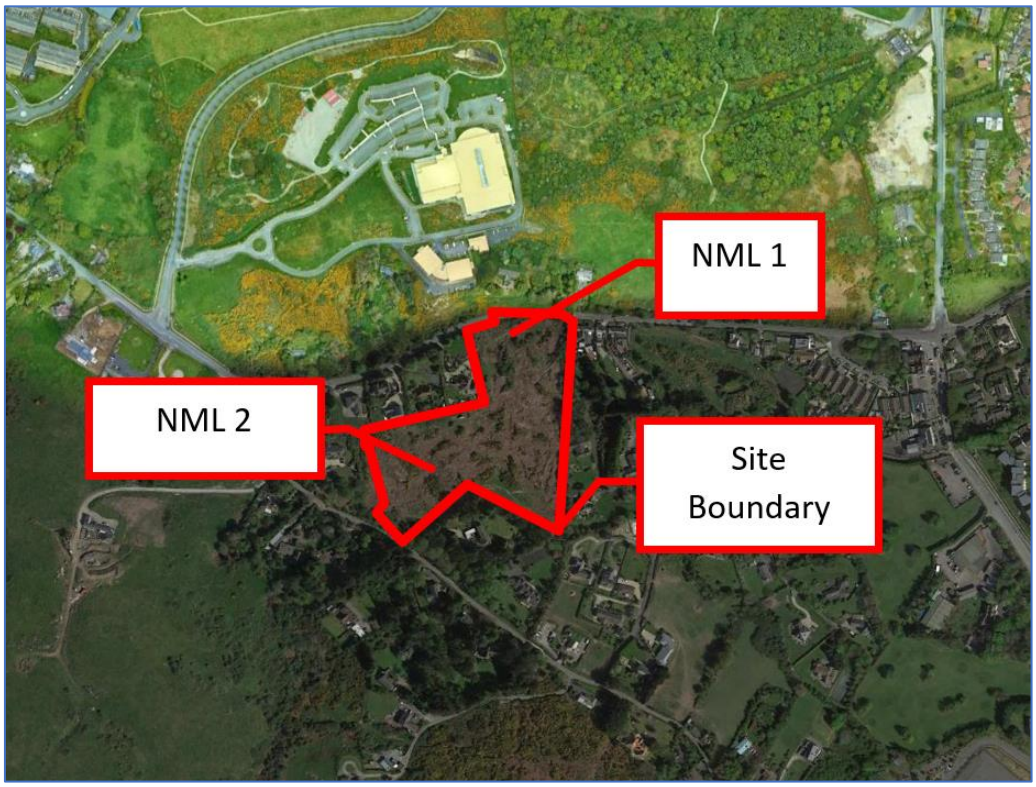


Figure 2. Noise Monitor Locations

Table 7. GPS co-ordinates

Location	GPS co-ordinates
NML1	53.265415, -6.236094
NML2	53.263667, -6.237833

The monitor at NML2 monitored noise levels from June 1-2, 2022. A second survey was conducted to capture the new road widening at Blackglen Road at NLM1 between January 25-26, 2024.

4.2.1 Measurements Parameters

The noise survey results are presented in terms of the following parameters[2]:

- $\mathbf{L_{Aeq}}$ is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period.
- $\mathbf{L_{A90}}$ is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing.

4.2.2 Survey Results

The noise data was analysed and complied into average values for Day (07:00 - 23:00) and Night (23:00 - 07:00) periods which are used in the acoustic design of the development. The results are given in Table 8 below.

[2] A full glossary of acoustic terminology can be found at: https://www.acoustic-glossary.co.uk/

Table 8. Summary of unattended noise monitoring results.

Location	Period	L_{Aeq} (dB)	L_{A90} (dB)
NML1	Daytime (07:00 – 23:00)	62	51
	Night-time (23:00 – 07:00)	53	43
NML 2	Daytime (07:00 – 23:00)	42	37
	Night-time (23:00 – 07:00)	38	33

5.0 Impact Assessment

The potential noise and vibration impacts associated with the construction and operational phases of the proposed development are discussed in the following sections.

5.1 Construction Phase

In the absence of specific information regarding the construction schedule, construction noise impacts cannot be fully quantified at this point. However, as a working hypothesis the assessment will assume typical phases of a construction site and associated plant.

The expected operational times of the construction sites are: 08-00 – 19:00 Mon-Fri.

5.1.1 Noise Limits at Noise Sensitive Locations

Following a review of the baseline noise survey results in Table 6 and the criteria detailed in Table 1, the day-time noise limit at the NSLs for construction noise are set out in Table 9.

Table 9. Defined Construction Noise Limits at Noise Sensitive Locations

Ambient Noise Level (Rounded to Nearest 5dB) L_{Aeq}	BS 5228-1 Category	Construction Noise Limit $L_{Aeq,\ 1hr}$
45dB	A	65dB

5.1.2 Construction Plan & Site Noise Limits

A variety of items of plant will be in use for site clearance and construction. The type and number of equipment will vary between the varying construction phases depending on the phasing of the works. There will be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for the generation of elevated levels of noise.

The closest noise-sensitive locations are the houses located immediately to the north-west on Blackglen Road, the closest of which range between approximately 35m to 50m to the site boundary.

BS 5228-1 gives a range of noise level for plant (e.g. excavators, loaders, dozers, concreting works, mobile cranes, generators etc) used for typical construction phases including; site clearance, building construction works and landscaping works. The noise levels range between 61dB to 86dB L_{Aeq} at a distance of 10m from each item of plant.

For this assessment, a combined sound power value of 119dB L_{AW} has been assumed for the purposes of construction noise calculations. This would include, for example, 5no. items of construction plant with a sound pressure level of 80dB L_{Aeq} at 10m operating simultaneously along the closest works boundary.

Given, that the type and number of construction equipment will vary throughout the construction phase, noise levels have been calculated at the closest noise-

sensitive locations assuming the typical construction noise levels and distances noted below. For the assessment, a standard site hoarding of 2.4m high has been assumed. The calculation also assumes that the equipment will operate for 66% of the working time and Table 10 summarises the results of this assessment.

Table 10. Indicative construction noise levels at Noise Sensitive Locations

Construction Phase	Examples (BS5228-1 item Refs.)	Calculated noise levels at varying distances, dB L_{Aeq}			
		35m	50m	100m	150m
Site Clearance	C2.28, C2.25, C2.13, C6.31, C8.20	68	65	58	54
General Construction	C2.30, C2.25, C3.19, C4.54, C4.76	63	59	52	49
Road Works and Landscaping	C5.30, C5.40, C5.20	59	56	49	46

The appropriate construction noise criterion has been set as 65dB $L_{Aeq, 1hr}$. The hypothetical assessment of the typical construction plan indicates that the criteria will be met at almost all of the nearby existing residential locations. However, the criterion may not be met for short periods during the site preparation phase at the few dwellings immediately adjacent to the site. Section **Error! Reference source not found.** sets out measures to mitigate the impact.

5.1.3 Construction Phase – Vibration

BS 5228-2:2009 Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration provides empirical vibration levels from various activities. Without a detailed construction plan, it is prudent to assess the likely vibration levels at the nearby dwellings from this most severe test as all other sources of vibration will be below this level.

The vibration limits are set out in Table 3 for Disturbance and Table 4 for Cosmetic Damage are 0.14mm/s ("just perceptible in the most sensitive situations") and 15mm/s respectively.

A review of the predicted vibration levels at the NSLs indicates that levels are expected to be well below a threshold that would cause disturbance to building occupants and there is also no risk of building damage. This assumes that no pile-driving or other highly impulsive construction activities occur.

5.1.4 Construction Phase – Traffic Noise

Consideration should also be given to the addition of construction traffic along the site access routes. Access to the development site for construction traffic will be via the adjoining roads.

It is possible to calculate the noise levels associated with passing vehicles using the following standard acoustic formula.

$$L_{Aeq,T} = L_{AX} + 10\log_{10}(N) - 10\log_{10}(T) + 10\log_{10}(r1/r2)dB$$

Where:

$L_{Aeq,T}$ is the equivalent continuous sound level over the time period T seconds.
L_{AX} is the "A-weighted" Sound Exposure Level of the event considered(dB).
N is the number of events over the course of time period T.

r1 is the distance at which L_{AX} is expressed.
r2 is the distance to the assessment location

The mean value of L_{AX} for truck moving at low to moderate speeds (i.e., 15 to 45km/hr) is of the order of 82dB at a distance of 5 metres from the vehicle.

It has been calculated that a maximum of 15 trucks per hour will results in a noise level at or below the existing level which will result in an imperceptible increase in noise levels at the NSLs.

The existing daytime noise environment is dominated by road traffic and the noise generated by construction traffic is not expected to change the character of the existing noise environment significantly.

5.1.4.1 Description of Effects

A summary of the effects associated with the construction phase is as follows:

Phase	Effect Magnitude	Effect Duration
Noise	Slight/Moderate	Short-term
Vibration	Imperceptible	Short-term
Traffic	Imperceptible	Short-term

5.1.5 Mitigation Measures

The impact assessment conducted for the construction activity during the construction phase has highlighted that the predicted construction noise levels are within the adopted criterion for almost all NSLs. However, the following mitigation measures may be considered during certain construction activities in order to further reduce the noise and vibration impact to nearby noise sensitive areas.

As part of these mitigation measures it is recommended that the Contractor should compile a Noise and Vibration Management Plan (NVMP) which will deal specifically with management processes and strategic mitigation measures to remove or reduce significant noise and vibration impacts, and cumulative noise and vibration impacts from the construction works. The Plan will also define noise and vibration monitoring and reporting. The NVMP will also include method statements for each phase of the works, the associated specific measures to minimise noise and vibration in so far as is reasonably practicable for the specific works covered by each plan and a detailed appraisal of the resultant construction noise and vibration generated.

Best practice noise and vibration control measures will be employed by the contractor during the demolition phase in order to control noise and vibration impacts at the nearest noise sensitive locations. All works on site shall comply with *BS 5228 2009+ A1 2014 (Parts 1 & 2)* which gives detailed guidance on the control of noise and vibration from construction activities. This includes guidance on several aspects of construction site mitigation measures, including, but not limited to:

- Selection of quiet plant;
- Noise control at source;
- Screening and;
- Liaison with the public.

The following key forms of noise control for the site are set out below:

- Site compounds will be located away from noise sensitive boundaries within the site constraints;
- For mobile plant items such as cranes, dump trucks, excavators and loaders, the installation of an acoustic exhaust and or maintaining enclosure panels closed during operation can reduce noise levels by up to 10dB. Mobile plant should be switched off when not in use and not left idling.
- For steady continuous noise, such as that generated by diesel engines, it may be possible to reduce the noise emitted by fitting a more effective exhaust silencer system and avoid idling of engines when not in use.
- For percussive tools, a number of noise control measures include fitting a muffler or sound reducing equipment to the breaker 'tool' and ensure any leaks in the air lines are sealed. Erection of localised screens around breaker or drill bit when in operation in close proximity to noise sensitive boundaries.
- The use of a high quality construction site hoarding will be included around all noise sensitive boundaries.
- For all materials handling, ensure that materials are not dropped from excessive heights, lining drops chutes and dump trucks with resilient materials.
- For all materials handling, ensure that materials are not dropped from excessive heights, lining drops chutes and dump trucks with resilient materials.
- All items of plant should be subject to regular maintenance. Such maintenance can prevent unnecessary increases in plant noise and can serve to prolong the effectiveness of noise control measures.
- All site staff shall be briefed on noise mitigation measures and the application of best practicable means to be employed to control noise.
- Use of electric vehicles and plant should be used where possible

The following key forms of vibration control for the site are set out below:

- Controlled drilling: If drilling is necessary, use controlled and engineered techniques to minimize the vibration impact. Precise timing and small charges can help reduce vibrations significantly.
- Modify construction techniques: Implement construction techniques that generate less vibration. For example, using different equipment or methods that create fewer vibrations can be beneficial.
- Construction sequencing: Plan the construction activities in a way that minimizes the impact on nearby receptors. For instance, schedule the noisiest and most vibration-intensive tasks at times when the receptors are least affected.
- Communication with neighbours: Keep nearby residents and stakeholders informed about the construction activities and potential vibrations. Address any concerns they may have promptly.
- Real-time adjustments: Based on the monitoring data, be prepared to make real-time adjustments to construction operations to keep vibrations within acceptable levels.

- Real-time adjustments: Based on the monitoring data, be prepared to make real-time adjustments to construction operations to keep vibrations within acceptable levels.
- Post-construction assessment: After the construction is complete, conduct a post-construction assessment of vibration data to ensure that no excessive vibration was generated

5.1.5.1 Monitoring

During the demolition phase, spot check noise monitoring may be required where the construction noise thresholds have the potential to be exceeded at noise sensitive locations. The monitoring shall be carried out by the contractor and used to inform the requirement for any control measures on site to reduce construction noise levels.

Noise monitoring will be conducted in accordance with the International Standard *ISO 1996-2:2017 - Description, measurement and assessment of environmental noise - Part 2: Determination of sound pressure levels*.

Where required, or requested by the local authority, unattended external noise monitoring will be undertaken at locations on the site boundary closest to sensitive locations. It is considered that it will be appropriate to amend the monitoring program and location as the works progress. Accordingly, monitors may be added, removed or relocated as necessary.

The noise monitoring terminals should provide the following at minimum:

- Logging at hourly intervals; and
- Remote access for information download.

Where required, or requested by the local authority, vibration monitoring will be installed at the site boundary to monitor Peak Particle Velocity parameter (PPV, mm/s) in the X, Y and Z directions, in accordance with *BS ISO 4866: 2010: Mechanical vibration and shock – Vibration of fixed structures – Guidelines for the measurement of vibrations and evaluation of their effects on structures*.

The mounting of the transducer to the vibrating structure will need to comply with *BS EN ISO 5348: 1998: Mechanical vibration and shock – Mechanical mounting of accelerometers*. In summary, the following ideal mounting conditions apply:

- The transducer and its mountings should be as rigid as possible;
- The mounting surfaces should be as clean and flat as possible;
- Simple symmetric mountings are best, and;
- The mass of the mounting should be small in comparison to that of the structure

5.2 Operational Phase

Operation phase noise sources may include:

- External mechanical and electrical plant equipment
- Additional traffic on the local road network.

There are no significant sources of vibration associated with the operational phase are expected.

5.2.1 Associated Traffic Noise

It is appropriate to consider the increase in traffic noise level that may arise as a result of vehicular movements associated with the development. However, in the absence of specific traffic information, as a working hypothesis it has been assumed that there is one car associated with each dwelling and 10% of these will be driving in any on hour period i.e. 24 additional vehicles.

It has been predicted that the change in noise level as a result of the additional traffic is <1dB.

5.2.2 Creche

Noise levels from the operation of the proposed creche facility are not expected to result in any adverse impact at the NSLs. The reasons being that firstly the noise from the children ought to be contained within the fabric of the building and secondly, the facility will only operate during the daytime period.

5.2.3 Operational M&E Plant

Details of the M&E plant and Ventilation equipment are given in Appendix B.

5.2.3.1 Stand-by Power Generators

2no. generator rooms are located on the ground floors of block B3 and block B2. The generator will only operate in the case of a power failure or during routine testing which will take place during normal working hours for a limit period (less then 30mis).

There is potential for noise break-out from inside the building where the generator is housed and the closest NSL is to B3, as indicated in Figure 3.

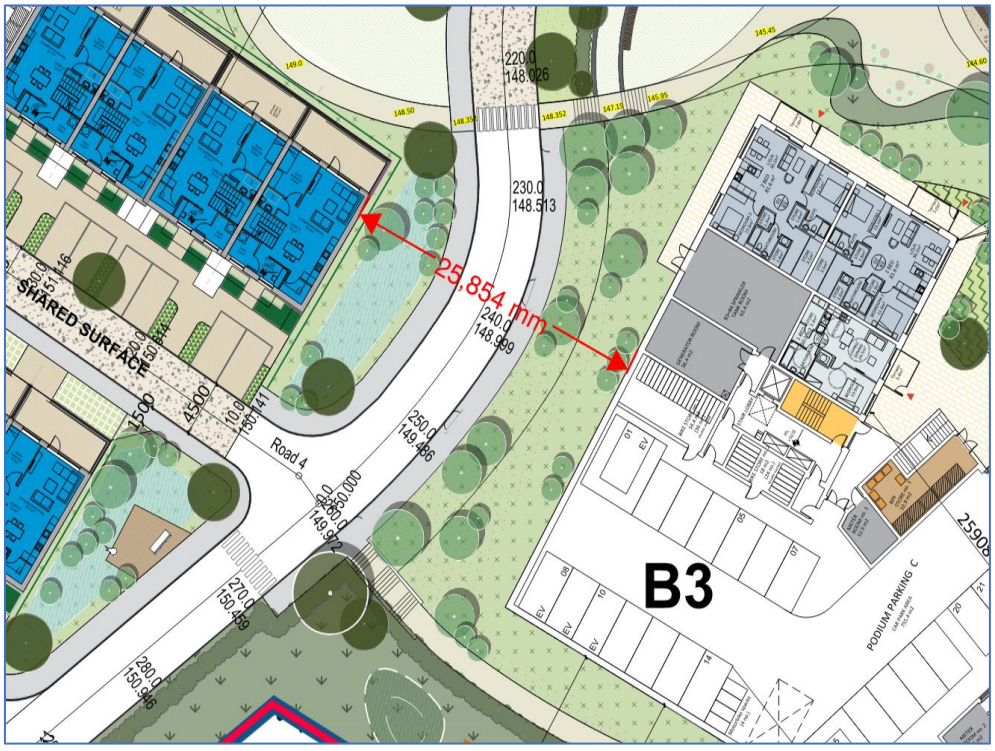


Figure 3. Generator room and nearest NSL

Acoustic calculations have predicted a noise level of 27dBA at the closet NSL which is below the existing background levels.

The noise break-out calculations are presented in Appendix A.

Notwithstanding this, the generator should only be tested during daytime hours at times that are least likely to cause disturbances.

5.2.3.2 Dwelling Ventilation Systems

Heating and ventilation is provided by a combination of Mechanical Ventilation Heat Recovery (MVHR) and Exhaust Air Heat Pumps (EAHP) units. These units are located internally to the dwellings and therefore there is no associated external noise impact.

5.2.3.3 Description of Effects

A summary of the effects associated with the operational phase is as follows:

Phase	Effect Magnitude	Effect Duration
Traffic	Imperceptible	Long-term
Creche	Imperceptible	Long-term
M&E Plant	Imperceptible	Long-term
Ventilation Systems	Imperceptible	Long-term

6.0 Building Envelope Specification

The Acoustic Design Statement of the building envelope should consider the external noise levels with a view to achieving the internal design goals as set out in Table 5.

The façade of the building includes several critical elements including glazing, walls, ventilation and roof/ceiling. By calculating the combined effect of these it's possible to predict the internal noise level based on the known external levels for a given building design.

The acoustic performance of the individual building element is usually rated in terms of the Weighted Sound Reduction Index (*Rw*) which is a number used to rate the effectiveness of a soundproofing system or material. Increasing the *Rw* by one translated to a reduction of approximately 1dB in noise level. Therefore, the higher the *Rw* number, the better a sound insulator it will be.

6.1 Acoustic Design Statement

By applying the guidelines in ProPG and BS8223, an Acoustic Design Statement (ADS) will provide the predicted interior noise levels based on the proposed construction and inform the building design. It will also present options to achieve the attenuation required should the predicted internal noise level exceed the required criteria.

The ADS does not consider the sound attenuation of internal elements such as walls and floor/ceiling or other acoustic topics; these are covered by Building Regulations, Technical Guidance Document, Part E.

6.2 Glazing System

Following the *ProPG & BS 8233:2014* guidelines, the noise ingress levels were estimated using the predicted noise levels and the acoustic performance specification of various elements. It was found that the internal daytime noise limit of L_{Day} 35dB from Table 5 is the most stringent due to the elevated daytime noise levels.

In this instance, using the minimum sound insultation performance as set out in Table 11 below is deemed suitable for the majority of apartments and houses under assessment to achieve an acceptable internal noise environment.

Table 11. Sound Insulation Performance Requirements for Glazing

Glazing specification	Minimum Required	Performance Indicator	Description of Typical Construction
Double Glazing	36dB	Rw	8 mm Glass - 16 mm - 5 mm Glass
Assumed: *Room volume = 45m3, Window area = 2.4m2, RT = 0.8s.*			

The glazing specification outlined in Table 11 is applicable to northern facing facades only as indicted in Figure 4 below.

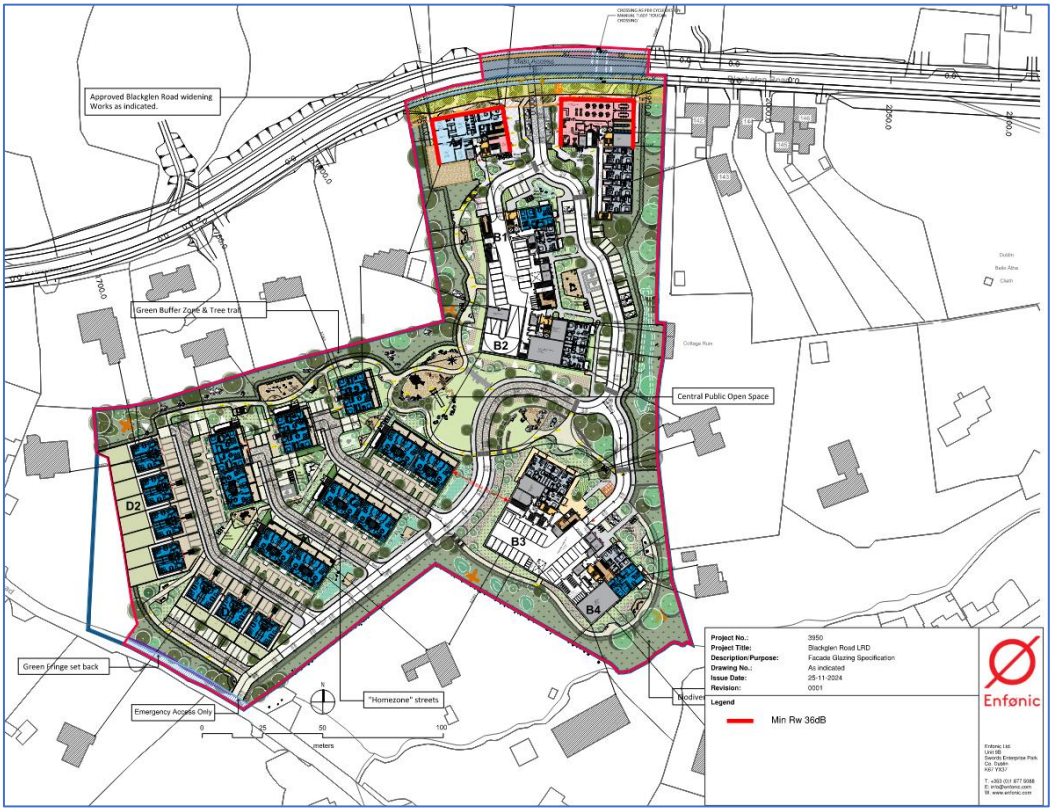


Figure 4. Glazing specification for northern facing facades

It is important to note that the acoustic performance specification detailed herein are minimum requirements that apply to the overall glazing systems. In the context of the acoustic performance specification the 'glazing system' is understood to include any of the parts that form part of the glazing element of the façade, i.e. glass, frames, seals, openable elements, etc.

6.3 Ventilators

To ensure compliance with the design criteria, ventilators located on the northern facades or roofs facing towards the M50 motorway as indicated in Figure 4 should achieve a minimum sound insultation performance of 45dB $D_{n,e,w}$.

6.4 Windows open

Opening a window will compromise the acoustic performance of the façade but it is a desirable feature or necessary to provide purge ventilation. Following the ProPG/BS5228 guidelines, we must first consider the performance of the façade with windows open.

The World Health Organisation (WHO) Environmental Noise Guidelines for European Region (WHO, 2018) document describes the typical reduction of an open window as being 15dB.

The criteria will be achieved with windows open for all facades apart from the northern facades immediately facing the Blackglen Road as indicated in Figure 4. For these dwellings, the design goal will however be achieved with a closed window and the option remains for the windows to be opened at the resident's discretion.

6.5 Wall Construction

In general, all wall constructions, i.e. block work or concrete, offer a high degree of sound insulation, much greater than that offered by the glazing systems set out in Section 6.2. Therefore, noise intrusion via the wall construction will be minimal. The calculated internal noise levels across the building façade have assumed a minimum sound reduction index of 51dB Rw for this construction.

6.6 Amenity areas

The amenity areas consist of outdoor spaces within the development. The maximum criteria of 55dB set out in ProPG will be satisfied for all gardens and the amenity space in the centre of the development.

7.0 Future Situation

7.1 M50 Upgrade

Due to the potential of a planned upgrade of the M50 with associated increase in traffic flows, a future scenario has been considered. It has been estimated that this will results in a +5dB increase in noise levels at the receivers.

The specified glazing will satisfied this increase.

The amenity area criteria will be met for all amenity areas

Appendix A

Noise Break-out Calculation from generator room

		Octave Band Centre Frequency (Hz)								Overall
		31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
Reverberant Source Level, L_1			88	92	82	85	87	83	80	70	95
Sound Reduction Index, R			-38	-37	-36	-43	-52	-59	-64	-64	
Area (m^2) (of wall)	16		12	12	12	12	12	12	12	12	
Distance (m) (from source to wa	25		-28	-28	-28	-28	-28	-28	-28	-28	
Geo spreading			-14	-14	-14	-14	-14	-14	-14	-14	
L_{2A}			20	25	16	12	5	-6	-14	-24	27
Toral Reduction:			-68	-67	-66	-73	-82	-89	-94	-94	

Appendix B

M&E Equipment Datasheets

1. Generator:

FG WILSON

P88-3

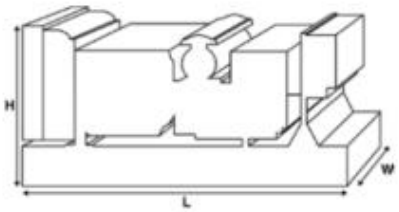
Optional Alternator

Output Ratings

Voltage, Frequency		Prime	Standby
400/230 V, 50 Hz	kVA	80	88
	kW	64	70.4
480/277 V, 60 Hz	kVA	90	100
	kW	72	80

Ratings at 0.8 power factor.
Please refer to the output ratings technical data section for specific generator set outputs per voltage.





Dimensions and Weights

Length	mm	1870 (73.6)
Width	mm	840 (33.1)
Height	mm	1333 (52.5)
Weight (Dry)	kg	972 (2143)
Weight (Wet)	kg	985 (2172)

Ratings in accordance with ISO 8528, ISO 3046, IEC 60034, BS5000 and NEMA MG-1.22.
Generator set pictured may include optional accessories.

Prime Rating

These ratings are applicable for supplying continuous electrical power (at variable load) in lieu of commercially purchased power. There is no limitation to the annual hours of operation and this model can supply 10% overload power for 1 hour in 12 hours.

Standby Rating

These ratings are applicable for supplying continuous electrical power (at variable load) in the event of a utility power failure. No overload is permitted on these ratings. The alternator on this model is peak continuous rated (as defined in ISO 8528-3).

Standard Reference Conditions

Note: Standard reference conditions 25°C (77°F) Air Inlet Temp, 100m (328 ft) A.S.L. 30% relative humidity.
Fuel consumption data at full load with diesel fuel with specific gravity of 0.85 and conforming to BS2869: 1998, Class A2.

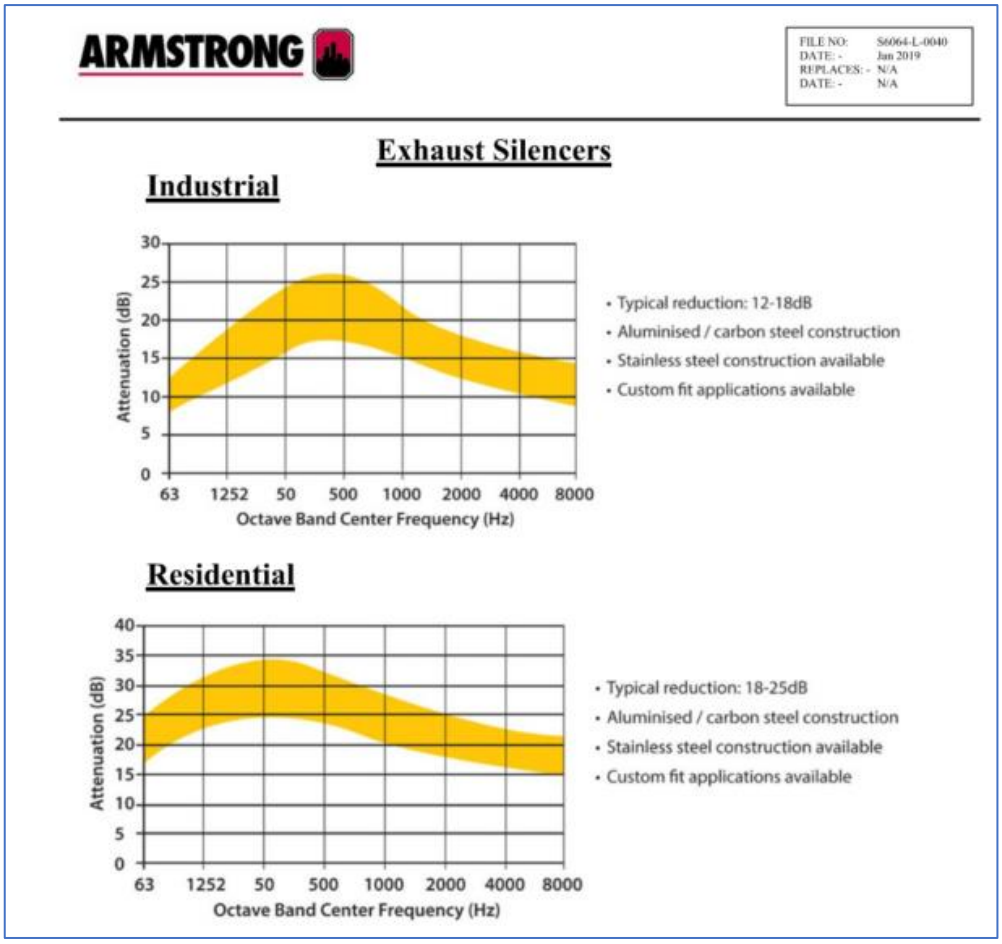
FG Wilson offer a range of optional features to allow you to tailor our generator sets to meet your power needs.
Options available include:

- Upgrade to CE Certification
- A wide range of Sound Attenuated Enclosures
- A variety of generator set control and synchronising panels
- Additional alarms and shutdowns
- A selection of exhaust silencer noise levels

For further information on all of the standard and optional features accompanying this product please contact your local Dealer or visit:

www.fgwilson.com

2. Generator's exhaust silencers:



ARMSTRONG

FILE NO:	S6064-L-0040
DATE: -	Jan 2019
REPLACES: -	N/A
DATE: -	N/A

Exhaust Silencers

Industrial

- Typical reduction: 12-18dB
- Aluminised / carbon steel construction
- Stainless steel construction available
- Custom fit applications available

Residential

- Typical reduction: 18-25dB
- Aluminised / carbon steel construction
- Stainless steel construction available
- Custom fit applications available

3. Internal Heat Pump:

Dimplex

Edel Hot Water Heat Pump



Product Description

Edel heat pump cylinders comprise of a stainless steel inner vessel with a hot water heat pump mounted on top. The heat pump produces hot water very efficiently by extracting heat from external air supplied via insulated ductwork, which is available as an accessory. This highly efficient cylinder reduces the dwelling emissions in SAP making it possible to pass using electric space heating and an Edel heat pump cylinder.

Key Features

- The Edel heat pump consumes 5 times less electricity than standard electric water heaters
- Helps to pass Part L building of the regulations whilst specifying electric heating
- Compact unit with 630mm diameter with options of 200L or 270L storage
- Stainless steel tank with 5 year UK guarantee and no requirement for a sacrificial anode
- Very quiet operation due to sound proof hood, variable speed fan and a high performance rotary compressor mounted on anti-vibration pads
- Patented high performance heat exchanger and defrost mode of operation in UK climates

Technical Details

Heat pump performance		Edel 200 UK	Edel 270 UK
Model code		EDL200UK-630	EDL270UK-630
Item Code		058621	058638
Nominal volume	L	200	270
Air operating range	°C	-7 to +35	
Achievable hot water temperature via heat pump	°C	60	
Max. electrical power input (heat pump AND immersion)	W	700 + 1200 = 1900	
Max. thermal power output from heat pump ONLY at 45°C	W	1300	
Max. power output from heat pump AND immersion at 45°C	W	1300 + 1200 = 2500	
Air flow	m^3/hr	320 to 400	
Sound pressure level at 2m	dB(A)	37 (Speed 1) / 40 (Speed 2)	
Refrigerant	/kg	R290/ 0.15	
Standing heat loss	kWh/24hr	1.61	1.77
Air ducting method		Separate inlet & outlet to exterior	
Heating time from cold (10°C)		7h15	9h48
Coefficient of performance		3.36	3.30
Dimensions & connections			
Dimensions	mm	630 x H 1460	630 x H 1780
Weight with packaging	kg	70	79
Weight without packaging	kg	56.5	63
Air duct diameter	mm	160	
Max. ducting pressure drop		220Pa at min. air flow rate 320m^3/hr	
Water connections	inch	M 3/4"	
Condensate tube	mm	18/24	
Electrical supply		230V - 50Hz - 8A	
IP rating		IPX4	
MCB type C	Amp	16	
Hot water cylinder			
Material		Stainless steel	
Insulation		45mm PU foam with PVC outer	
Refrigeration heat exchanger		Double walled separation from potable water	
Max. operating pressure	bar	6	
Max. condensate production	L/h	0.3	
Integrated electric immersion	W	1200	
Max. temperature with immersion heater	°C	65	
Approvals			
Water regulations		G3 KIWA approval to EN12897	
T&P valve		Factory fitted	
Accessories		Inlet group, tundish, expansion vessel	
Guarantee (UK)		5 years tank (2 years other parts)	

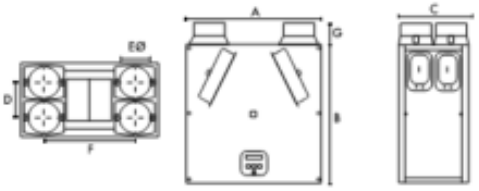
4. MVHR:

SEC Class

Model	SEC Class
Kinetic B1	A

Dimensions (mm)

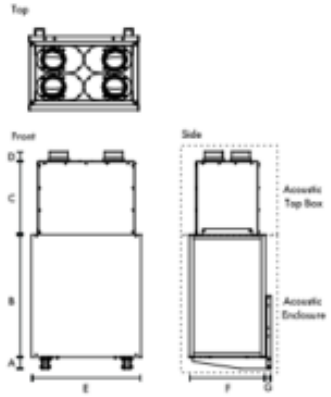
Unit



A	B	C	D	EØ	F	G
550	550	285	140	125	360	90

Weight: 15kg

Acoustic Solution

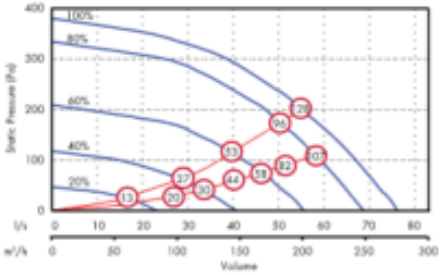


A	B	C	D	E	F	G	Acoustic Top Box kg	Acoustic Enclosure kg	Spigot
80	633	501	75	626	647	45	11	19	125

Performance

Fan speeds are fully adjustable within the performance range.

Vertical Spigots



Horizontal Spigots

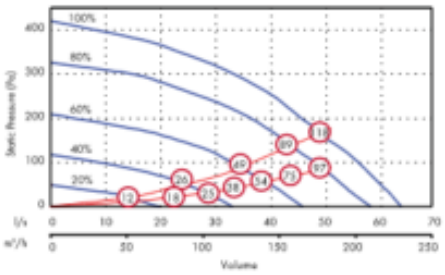


Figure relates to Wattage (both motors)

Sound Data (Unit)

Speed	Test mode	Octave band, Hz, dB SWL 63	125	250	500	1k	2k	4k	8k	LwA	SPL dB(A) @ 3m
20%	Supply	32.9	32.9	46.5	41.7	39.3	29.3	19.3	22.8	44.4	26.9
	Extract	50.7	41.9	37.4	34.5	29.8	17.7	17.4	22.7	35.7	18.2
	Breakout	36	34.5	33.6	34.3	33.8	27.2	22.2	25.3	37.2	16.7
40%	Supply	57.1	64.1	56.8	50.6	49.7	41.1	32.8	26.4	54.7	37.2
	Extract	55.2	50.3	44.9	43	38.3	27.7	19.8	22.9	43.8	26.3
	Breakout	43.5	41.7	40.4	41.3	41.7	36.1	27.8	26.2	44.7	24.2
60%	Supply	71.3	72.5	68.5	57.6	56.4	51.1	42.7	38.1	63.6	46.1
	Extract	60.2	56.3	52	48.8	44.8	35.5	26.9	24.4	50.2	32.7
	Breakout	50.7	47.8	47.7	47.7	48.3	44.9	36.7	30	51.8	31.3
80%	Supply	86.3	74.8	71.2	62.8	61	56.3	49.8	46.7	67.3	49.8
	Extract	63.8	59.4	57.6	53.8	49.2	41.2	33.5	29	55.0	37.5
	Breakout	54.4	52.7	54	52.7	53.5	50.3	43.6	37.7	57.2	36.7
100%	Supply	70.3	75.7	73.9	66.3	63.5	59.7	53.2	50.6	70.0	52.5
	Extract	66.6	63.9	60.9	56.5	51.2	44.2	36.8	32.6	57.9	40.4
	Breakout	59.1	55.2	56.8	55.6	56.1	53.5	47.1	41.6	60.1	39.6

Sound Data (Unit with Acoustic Solution)

Speed	Test mode	Octave band, Hz, dB SWL 63	125	250	500	1k	2k	4k	8k	LwA	SPL dB(A) @ 3m
20%	Supply	37.1	44.6	36.4	27.9	20.6	14.8	18.1	23.8	35.2	17.7
	Extract	54.4	40.1	29.6	22.2	17.5	14.5	17.8	23.5	31.1	13.6
	Breakout	37.5	33.8	29.1	22.9	17.0	14.0	17.8	23.6	27.7	7.2
40%	Supply	64.9	56.3	46.4	36.1	28.2	15.4	18.1	23.8	44.6	27.1
	Extract	60.2	46.8	35.7	28.2	21.9	14.8	18.1	23.7	36.6	19.1
	Breakout	46.0	43.6	36.3	30.4	23.9	15.9	18.1	23.6	33.5	13.0
60%	Supply	72.3	63.0	55.6	43.1	34.1	19.5	18.6	24.0	51.9	34.4
	Extract	61.4	53.3	43.4	34.7	27.2	15.5	18.1	23.8	41.4	23.9
	Breakout	52.2	50.5	44.4	38.2	33.5	23.8	19.3	23.8	41.0	20.5
80%	Supply	73.8	67.9	61.6	50.0	38.6	23.4	20.2	25.2	56.8	39.3
	Extract	68.6	58.2	50.5	40.5	31.1	17.2	18.2	23.9	47.5	30.0
	Breakout	65.6	55.5	50.5	43.8	39.7	32.7	24.9	24.0	47.4	26.9
100%	Supply	77.3	70.8	64.9	53.8	41.4	26.3	21.9	26.8	60.1	42.6
	Extract	71.5	60.6	53.5	42.9	33.4	19.1	18.5	24.0	50.5	33.0
	Breakout	69.0	58.4	53.4	47.1	43.0	37.5	29.9	24.9	51.1	30.6

Tested according to BS EN 13141-7:2010. Breakout quoted spherical. Supply and Extract quoted hemispherical. For in-duct data, end reflections are added based on the spigot size of the unit.