A Noise and Vibration Assessment For Rush Lane, Elsenham

On behalf of Rosconn Strategic Land

September 2023

resound acoustics

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Resound Acoustics Limited is a
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Appendices

1 INTRODUCTION

1.1 Rosconn Strategic Land has appointed Resound Acoustics Limited to undertake a noise and vibration assessment for a proposed development on land at Rush Lane, Elsenham, Essex.

1.2 Rosconn Strategic Land is intending to develop the site for residential purposes, with up to 40 no. dwellings proposed.

1.3 The noise and vibration climate at the site has been established by direct measurement and the suitability of the site for the proposed development considered against national and local planning policy, and guidelines on noise and vibration. Where necessary, mitigation measures have been recommended so that a noise and vibration climate suitable for residential development can be achieved.

1.4 Whilst reasonable efforts have been made to produce a report that is easy to understand, it is technical in nature. To assist the reader, an introduction to noise and vibration, and an explanation of the terminology used in this report are contained in Appendix A.

2 SITE DESCRIPTION

Existing Site Conditions

2.1 The site is located on the southern edge of Elsenham, Essex. The site is bounded by Rush Lane to the north and west, by Robin Hood Road to the north-east, and by the West Anglia mainline railway to the south-east. The M11 motorway lies approximately 350 metres to the west of the site, and Stansted Airport lies approximately 2km to the south.

2.2 The site is currently open grassland and slopes up from south-east to north-west.

2.3 A site location plan is included as Figure B.1 in Appendix B.

Proposed Site Conditions

2.4 Rosconn Strategic Land is seeking outline planning permission for up to 40 no. residential dwellings at the site.

2.5 An illustrative site layout that shows how the site may be developed is shown in the JCN architects' drawing *Development Layout* (reference BW289a-PL-02 Rev D, dated August 2023). This drawing is included as Figure B.2 in Appendix B.

2.6 As outline planning permission is being sought, the final site layout could be different to that in the illustrative site layout. However, it is understood that constraints in the form of a public footpath running along the south-eastern edge of the site and existing foul and surface water easements mean that no properties will be located closer to the West Anglia mainline railway than shown on the illustrative layout.

3 GUIDANCE

Local Authority Consultation

3.1 A consultation response was requested from the Environmental Health Department of Uttlesford District Council during the preparation of this assessment. However, at the time of issuing the report, no consultation response had been received.

National Planning Policy Framework

3.2 The Department for Communities and Local Government published the *National Planning Policy Framework* (NPPF) on 27th March 2012. The NPPF was most recently revised in September 2023 and issued by the Department of Levelling Up, Housing and Communities.

3.3 The general guiding principle in the NPPF is contained in Section 15 under the heading *Conserving and enhancing the natural environment*. Paragraph 174 states:

> *"Planning policies and decisions should contribute to and enhance the natural and local environment by:*
>
> *(e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans;"*

3.4 The noise planning policy is contained in paragraph 185, which also appears in Section 15 of the NPPF:

> *"Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:*
>
> *a) mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life;*
>
> *b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason;"*

3.5 A footnote to the point paragraph 185(a) refers to the *Explanatory Note of the Noise Policy Statement for England*, which defines both *"significant adverse impacts on health and quality of life"* and *"adverse impacts on health and quality of life."*

Noise Policy Statement for England

3.6 The Department for Environment, Food and Rural Affairs published the *Noise Policy Statement for England* (NPSE) in March 2010. The explanatory note of the NPSE defines the terms used in the NPPF:

> *"2.20 There are two established concepts from toxicology that are currently being applied to noise impacts, for example, by the World Health Organisation. They are:*
>
> *NOEL – No Observed Effect Level*
>
> *This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.*
>
> *LOAEL – Lowest Observed Adverse Effect Level*
>
> *This is the level above which adverse effects on health and quality of life can be detected.*
>
> *2.21 Extending these concepts for the purpose of this NPSE leads to the concept of a significant observed adverse effect level.*
>
> *SOAEL – Significant Observed Adverse Effect Level*
>
> *This is the level above which significant adverse effects on health and quality of life occur."*

3.7 The NPSE does not define the SOAEL numerically, stating at paragraph 2.22:

> *"2.22 It is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. It is acknowledged that further research is required to increase our understanding of what may constitute a significant adverse impact on health and quality of life from noise. However, not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available."*

3.8 There is no local or national guidance on how the three terms should be defined numerically.

3.9 There are three aims in the NPSE, two of which relate to the first bullet point in paragraph 185 of the NPPF:

> ***"The first aim of the Noise Policy Statement for England***
>
> ***Avoid significant adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.***
>
> *2.23 The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development (paragraph 1.8).*
>
> ***The second aim of the Noise Policy Statement for England***

Mitigate and minimise adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.24 The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development (paragraph 1.8). This does not mean that such adverse effects cannot occur.

The third aim of the Noise Policy Statement for England

Where possible, contribute to the improvement of health and quality of life through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.25 This aim seeks, where possible, positively to improve health and quality of life through the pro-active management of noise while also taking into account the guiding principles of sustainable development (paragraph 1.8), recognising that there will be opportunities for such measures to be taken and that they will deliver potential benefits to society. The protection of quiet places and quiet times as well as the enhancement of the acoustic environment will assist with delivering this aim."

Planning Practice Guidance

3.10 In March 2014, the Government released Planning Practice Guidance (PPG) on noise, titled *Noise*. This document sets out a number of principles in the form of questions and answers, and reinforces the guidance set out in the NPPF and the NPSE. The most recent version of this document was published in July 2019.

3.11 The noise PPG notes that:

"Noise needs to be considered when new development may create additional noise and when new developments would be sensitive to the prevailing acoustic environment (including any anticipated changes to that environment from activities that are permitted but not yet commenced)."

3.12 It goes on to note that:

"Plan-making and decision taking need to take account of the acoustic environment and in doing so consider:

- *whether or not a significant adverse effect is occurring or likely to occur;*
- *whether or not an adverse effect is occurring or likely to occur; and*
- *whether or not a good standard of amenity can be achieved."*

3.13 The noise PPG broadly repeats the NPSE definitions of the NOEL, LOAEL and SOAEL and it provides a summary table to explain how the terms relate to each other and to typical human reactions to sound. The table is replicated below in Table 3.1.

Table 3.1: Planning Practice Guidance summary of noise exposure hierarchy

Perception	Examples of Outcomes	Increasing Effect Level	Action
No Observed Effect Level			
Not present	No effect	No observed effect	No specific measures required
No Observed Adverse Effect Level			
Present and not intrusive	Noise can be heard, but does not cause any change in behaviour, attitude of other physiological response. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.	No observed adverse effect	No specific measures required
Lowest Observed Adverse Effect Level			
Present and intrusive	Noise can be heard and causes small changes in behaviour, attitude or other physiological response, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a small actual or perceived change in the quality of life.	Observed adverse effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level			
Present and disruptive	The noise causes a material change in behaviour, attitude or other physiological response, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep the windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant observed adverse effect	Avoid
Present and very disruptive	Extensive and regular changes in behaviour, attitude or other physiological response and/or an inability to mitigate effect of noise leading to psychological stress, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Unacceptable adverse effect	Prevent

3.14 It is noted that the text in paragraph 005 of the PPG for noise reiterates the point illustrated in Table 3.1, that there are degrees of adverse effect above the SOAEL. Table 3.1 defines two degrees of significant adverse effect: a significant observed adverse effect, which is deemed noticeable and disruptive, and an unacceptable adverse effect, which is deemed noticeable and very disruptive.

3.15 The distinction between these two degrees of significant adverse effect is expanded upon in the text in paragraph 005 of the PPG for noise:

> *"005 Increasing noise exposure will at some point cause the 'significant observed adverse effect' level boundary to be crossed. Above this level the noise causes a material change in behaviour such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present. If the exposure is predicted to be above this level the planning process should be used to avoid this effect occurring, for example through the choice of sites at the plan-making stage, or by use of appropriate mitigation such as by altering the design and layout. While such decisions must be made taking account of the economic and social benefit of the activity causing or affected by the noise, it is undesirable for such exposure to be caused.*
>
> *At the highest extreme, noise exposure would cause extensive and sustained adverse changes in behaviour and / or health without an ability to mitigate the effect of the noise. The impacts on health and quality of life are such that regardless of the benefits of the activity causing the noise, this situation should be avoided."*

3.16 The PPG is clear that a significant adverse effect, which lies above the SOAEL but below an unacceptable adverse effect, can be addressed (or 'avoided' in the terms of the PPG) through the provision of mitigation, including noise insulation; it is not until an unacceptable adverse effect is reached that the cause of the effect should be prevented.

3.17 The noise PPG provides advice on how to mitigate the effects of noise, noting that there are options to reduce noise at source, to optimise site layouts, to use planning conditions, and providing insulation within affected properties.

3.18 The noise PPG also notes that:

> *"The noise impact may be partially offset if the residents of those dwellings have access to:*
>
> - *a relatively quiet façade (containing windows to habitable rooms) as part of their dwelling, and/or*
> - *a relatively quiet external amenity space for their sole use, (e.g. a garden or balcony). Although the existence of a garden or balcony is generally desirable, the intended benefits will be reduced with increasing noise exposure and could be such that significant adverse effects occur, and/or*
> - *a relatively quiet, protected, nearby external amenity space for sole use by a limited group of residents as part of the amenity of their dwellings, and/or*
> - *a relatively quiet, protected, external publically accessible amenity space (e.g. a public park or a local green space designated because of its tranquillity) that is nearby (e.g. within a 5 minutes walking distance)."*

Local Planning Policies

3.19 Uttlesford District Council (UDC) is currently developing a new Local Plan. Until the new plan is adopted, planning decisions will be determined against saved policies in the *Local Plan 2005*.

3.20 Policy ENV10 – *Noise Sensitive Development and Disturbance from Aircraft*, states:

> *"Housing and other noise sensitive development will not be permitted if the occupants would experience significant noise disturbance. This will be assessed by using the appropriate noise contour for the type of development and will take into account mitigation by design and sound proofing features."*

ProPG

3.21 *Professional Practice Guidance on Planning and Noise* (ProPG) was released in May 2017. A joint publication by the Chartered Institute of Environmental Health, the Institute of Acoustics, and the Association of Noise Consultants, the document sets out a recommended approach for the management of noise within the planning system in England.

3.22 ProPG sets out a two-stage risk based approach for new residential development:

- **Stage 1:** initial noise risk assessment of the proposed development;
- **Stage 2**: a systematic consideration of four key elements:
  - *Element 1*: demonstrating a '*Good Acoustic Design Process*';
  - *Element 2*: observing internal '*Noise Level Guidelines*';
  - *Element 3*: undertaking an '*External Amenity Area Noise Assessment*'; and
  - *Element 4*: consideration of '*Other Relevant Issues*'.

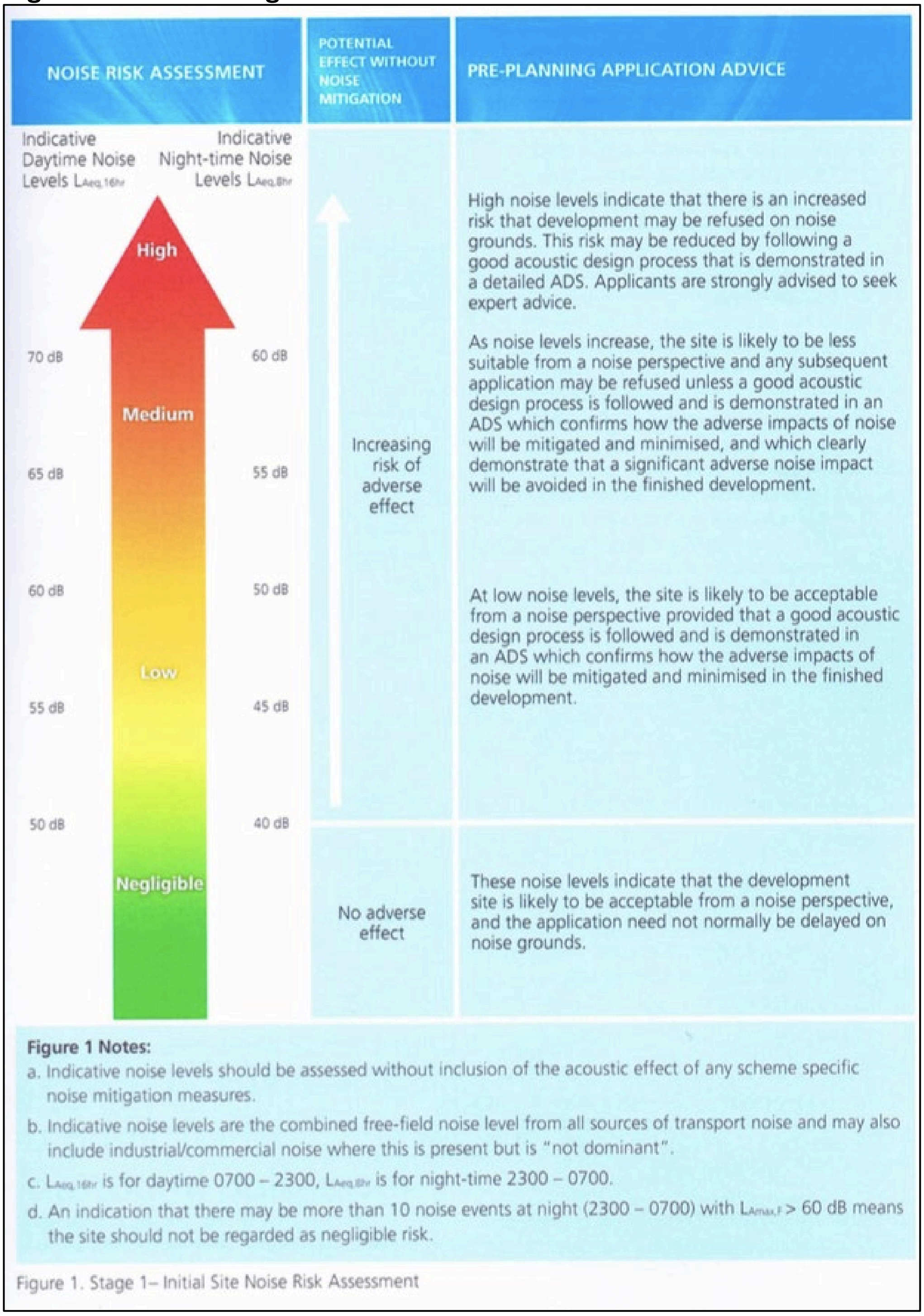
3.23 The Stage 1 initial noise risk assessment should provide an indication of the likely risk of adverse effects from noise should no mitigation be included as part of the development proposals.

3.24 ProPG provides an illustrative noise risk scale, derived from current guidelines values and experience. The scale suggests that the risks are negligible where noise levels are below 50dB L_{Aeq} during the daytime and 40dB L_{Aeq} during the night-time. The scale suggests that a site would start to tend from a medium to a high risk when noise levels are above approximately 70dB L_{Aeq} during the daytime and above approximately 60dB L_{Aeq} during the night-time. Between these values, the level of risk increases through low to medium as noise levels increase. These values are all stated as indicative in the ProPG.

3.25 The ProPG states that this initial noise risk assessment is intended to support wider Government planning and noise policies and guidance, i.e. the NPPF, NPSE and PPG-*Noise*.

3.26 Figure 1 of the ProPG, which is replicated here as Figure 3.1, presents the risk hierarchy, with indicative noise levels that broadly equate to the different risk categories.

Figure 3.1: ProPG Stage 1 Risk Assessment



3.27 The Stage 2 full assessment should consider good acoustic design, internal noise levels, external amenity area noise levels, and assessment of any other issues.

3.28 The ProPG states that good acoustic design should consider factors suggest as reducing noise at source, site layouts, and building orientation. Solely relying on the sound insulation of building fabric to achieve acceptable acoustic conditions is not considered good acoustic design. Noise control measures should be considered against other requirements, such as ventilation, fire regulation and cost.

3.29 The ProPG refers to the criteria set out in BS8233: 2014 and the World Health Organisation's *Guidelines for Community Noise* for internal noise levels and noise levels in external amenity areas. The ProPG notes that internal noise levels should always be considered alongside requirements for ventilation and overheating. Note 5 under Figure 2 in the ProPG, which sets out the internal noise level guidelines replicated from BS8233: 2014 and the WHO guidelines, states:

> *"Designing the site layout and the dwellings so that the internal target levels can be achieved with open windows in as many properties as possible demonstrates good acoustic design. Where it is not possible to meet internal target levels with windows open, internal noise levels can be assessed with windows closed, however any façade openings used to provide whole dwelling ventilation (e.g. trickle ventilators) should be assessed in the "open" position and, in this scenario, the internal L_{Aeq} target levels should not normally be exceeded, subject to the further advice in Note 7."*

3.30 It is clear that the internal noise guidelines should be met for 'whole dwelling ventilation' conditions, which are effectively background ventilation. 'Whole dwelling ventilation' is defined in Approved Document F of the Building Regulations 2010.

3.31 Note 7 under Figure 2 of the ProPG states:

> *"Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal L_{Aeq} target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved."*

3.32 The ProPG allows for the relaxation of the internal guideline noise levels by up to 5dB and the internal noise levels would still be regarded as reasonable.

3.33 For 'purge ventilation' conditions, the ProPG does not specify internal noise criteria, stating at paragraph 2.35:

> *"It should also be noted that the internal noise level guidelines are generally not applicable under "purge ventilation" conditions as defined by Building Regulations Approved Document F, as this should only occur occasionally (e.g. to remove odour from painting and decorating or from burnt food)."*

3.34 For thermal control, i.e. overheating conditions, ProPG states that the potential noise levels should be assessed, stating at paragraph 2.38:

> *"Where mechanical services are used as part of the ventilation or thermal comfort strategy for the scheme, the impact of noise generated by these systems on occupants should also be assessed."*

3.35 The ProPG goes on to state in paragraph 2.72(h):

> *"Reasonable steps should be taken to minimise overheating during summer months through good design. Where openable windows / ventilators are proposed to mitigate overheating and where the internal noise level guidelines are likely to be exceeded when they are open a more detailed assessment of the potential impact on occupants during the overheating condition should be provided in the ADS. This more detailed assessment may include: (i) the alternative design measures considered / applied to reduce noise impact on occupants, (ii) the expected internal noise levels when windows / ventilators*

are opened to provide relief from overheating, and (iii) an estimate of the amount of time that windows are likely to be open to provide relief from overheating."

3.36 Consideration of overheating issues is outside the scope of this noise assessment. However, it is clear that while the ProPG does require internal noise levels to be considered under thermal control conditions, no internal noise criteria are applied.

3.37 The ProPG states that other relevant issues include compliance with relevant national and local policies, magnitude of compliance with the ProPG itself, the likely occupants of the development, acoustic design against unintended adverse consequences and acoustic design against wider planning objectives.

AVO Guide

3.38 The Association of Noise Consultants published the Acoustics Ventilation and Overheating Residential Design Guide in January 2020 (known as 'the AVO guide'), which sets out the ventilation conditions that should be considered when assessing internal noise levels.

3.39 The over-riding principle is set out in paragraph 3.9 of the AVO guide, which states:

"It is suggested here that the desirable internal noise standards within Table 4 of BS 8233:2014 should be achieved when providing adequate ventilation as defined by ADF whole dwelling ventilation. However, it is considered reasonable to allow higher levels of internal ambient noise from transport sources when higher rates of ventilation are required in relation to the overheating condition."

3.40 The AVO guide is more explicit than the ProPG in stating that the internal noise level guideline values need only be achieved when considering 'whole dwelling ventilation'; as previously noted, this can be achieved with closed windows and appropriate trickle vents.

3.41 For purge ventilation, which is likely to require windows to be fully open, the AVO guide is again more explicit than the ProPG, stating:

"No specific acoustic criterion needs to be met in a room using purge ventilation for the purpose of rapidly diluting indoor pollutants."

3.42 As noted above, the AVO guide suggests that it is reasonable to allow higher levels of internal ambient noise from transport sources when windows are partially open to mitigate overheating. The AVO guide assumes a reduction of 13dB for a partially open window.

3.43 The AVO guide does not set specific guideline values for what are acceptable higher noise levels in the overheating condition.

3.44 However, Table 3-2 of the AVO guide suggests that where internal L_{Aeq} noise levels meet the 'reasonable' values in BS8233: 2014, which are set out later in this section of the report, an adverse effect is unlikely. This translates to external levels of 53dB $L_{Aeq,16hrs}$ during the daytime and 48dB $L_{Aeq,8hrs}$ during the night-time, with the assumed reduction of 13dB for a partially open window stated in the AVO guide.

3.45 Table 3-3 in the AVO guide suggests that internal daytime noise levels above 50dB $L_{Aeq,16hrs}$, internal night-time L_{Aeq} noise levels above 42dB $L_{Aeq,8hrs}$ are likely to cause a 'material change in behaviour'. Therefore, these values are considered to represent an upper limit of acceptable internal L_{Aeq} noise levels with windows open to mitigate overheating.

3.46 Note 4 to Table 3-2 of the AVO guide states that where external night-time maximum noise normally exceed 78dB L_{AFmax}, which translates to an internal value of 65dB with the assumed reduction of 13dB for a partially open window stated in the AVO guide, a Level 2 assessment is recommended. This suggests that where internal maximum noise levels are at or below 65dB, a Level 2 assessment is not required, and an adverse effect is unlikely. Table 3-3 of the AVO guide suggests that where internal night-time maximum noise levels normally exceed 65dB, a 'material change in behaviour' is likely.

3.47 The AVO guide notes that the overall potential for adverse effect will also depend on how frequently and for what duration the overheating condition occurs. Noise levels below the upper limits identified above may still result in an adverse effect if they occur for the majority of the time. The frequency and duration for which the overheating condition occurs is beyond the scope of this noise assessment and would need to be determined by an appropriate specialist as part of an overheating assessment.

3.48 Any advice provided in this report on ventilation is provided solely to contextualise the acoustic outcomes. Specialist advice on ventilation systems should be sought where it is required.

Approved Document O

3.49 Approved Document O (ADO) of the Building Regulations came into effect on 15th June 2022. Although compliance with the Building Regulations is typically assessed at the post-planning stage, the requirements of ADO are considered in this report as planning stage factors such as site layout may have implications for future compliance with ADO.

3.50 ADO requires that reasonable provision is made to limit unwanted solar gains in summer and to provide adequate means to remove heat from inside a building. ADO states that buildings should be constructed to meet the solar gain and overheating requirements using passive means as far as reasonably practicable, and that mechanical cooling should only be used as a last resort.

3.51 The document includes two methods to demonstrate compliance; a 'simplified method' and 'dynamic thermal modelling'.

3.52 The simplified method sets out maximum glazing areas to limit solar gain, and minimum free areas for openings to sufficiently remove excess heat, based on the building's overheating risk. The categorisation of overheating risk is broad, based on location in either a 'high risk' area (urban and some suburban parts of London) or 'medium risk' area (England excluding high risk parts of London).

3.53 Therefore, the simplified method and the maximum glazing areas and minimum free areas for openings stated in ADO may not accurately reflect site specific conditions, for example buildings that are shaded by neighbouring properties, structures, or landscapes.

3.54 Dynamic thermal modelling allows these factors to be considered, and alternative maximum glazing areas and minimum free areas for openings may be determined as appropriate. Where dynamic thermal modelling is undertaken, this should by an appropriate specialist.

3.55 ADO states that where a window open sufficiently to remove excess heat will result in night-time noise levels in bedrooms exceeding 40dB $L_{Aeq,8hours}$ or 55dB L_{AFmax} more than ten times per night, between 23:00 and 07:00 hours, then windows are likely to be kept closed by occupants to mitigate noise, and the overheating strategy should take account of this.

3.56 The required minimum free areas for openings in bedrooms stated in the 'simplified method' in ADO translate to an acoustic open area that is approximately 5% of the floor area for medium risk sites, and approximately 15% of the floor area for high risk sites. Based on typical bedroom dimensions and constructions, this results in an outside-to-inside level difference of approximately 9dB for medium risk sites and 4dB for high risk sites.

3.57 It is noted that this is different to the outside-to-inside level difference of 13dB for a window partially open to mitigate overheating stated in the AVO guide, which is understood to be based on an acoustic open area that is approximately 2% of the floor area.

British Standard 8233

3.58 The scope of British Standard (BS) 8233: 2014 *Guidance on sound insulation and noise reduction for buildings* is the provision of recommendations for the control of noise in and around buildings. It suggests appropriate guideline values for different situations, which are primarily intended to guide the design of new or refurbished buildings undergoing a change of use rather than to assess the effect of changes in the external noise climate.

3.59 BS8233: 2014 suggests suitable internal noise levels within different types of buildings, including residential dwellings, as shown in Table 3.2.

Table 3.2: BS8233 recommended internal noise levels, dB

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

3.60 BS8233 contains the following relevant guidance in footnotes to the above information:

> *"Note 4: Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$, depending on the character and number of events per night. Sporadic noise events could require separate values.*
>
> *Note 5: If relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level.*

Note 7: Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved."

3.61 Although Note 4 above refers to setting a guideline value for maximum noise levels, BS8233: 2014 does not provide any guidance on a suitable criterion.

3.62 Placing the BS8233: 2014 guidance into the context required by the NPPF and the NPSE, it is considered that where the internal noise levels meet the guideline values set out in Table 3.2, there is considered to be no observed effect.

3.63 Since BS8233: 2014 allows for a 5dB relaxation in the guideline values in Table 3.2 (Note 7 above), it is considered that internal noise levels up to 5dB above the guideline values in Table 3.2 may still be acceptable.

3.64 Section 7.7.3.2 of BS8233, titled *Design criteria for external noise* states:

"For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50dB $L_{Aeq,T}$, with an upper guideline value of 55dB $L_{Aeq,T}$ which would be acceptable in noisier environments."

3.65 BS8233: 2014 goes on to note that the upper guideline value may be exceeded in certain circumstances:

"However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited."

3.66 Achieving the lowest practicable noise levels in gardens is deemed acceptable in BS8233: 2014 in circumstances where development is needed in areas where the upper 55dB limit can not be achieved.

3.67 As BS8233: 2014 states that it is desirable that garden noise levels do not exceed 50dB $L_{Aeq,T}$, this implies some adverse effect above this level. Therefore, an external daytime noise level of 50dB $L_{Aeq,16hrs}$ can be defined as the LOAEL.

3.68 However, it would not be appropriate to equate the 55dB criterion with the SOAEL, since it is clear from BS8233: 2014 that 55dB is not a threshold that should never be exceeded. Equating the 55dB criterion to the SOAEL would mean that, in national policy terms, exceeding this threshold should be avoided, which is not what the standard requires.

World Health Organisation

3.69 The World Health Organisation (WHO) *Guidelines for Community Noise* (1999) also sets out guidance on suitable internal and external noise levels in and around residential properties. The guidance on internal and external noise levels is the same as set out in BS8233: 2014 in terms of L_{Aeq} values, but the WHO guidelines also provide guidance on night-time maximum noise levels, stating:

> *"For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{AFmax} more than 10-15 times per night."*

3.70 The WHO guidelines suggest the possibility of sleep disturbance if continuous noise in bedrooms exceeds 30dB $L_{Aeq.8hrs}$ during the night-time, and therefore internal noise levels above this value can be considered to be above the LOAEL. This internal value can be translated to an external value by the addition of 10dB, to account for the typical reduction through an open window. Therefore, external night-time noise levels of 40dB $L_{Aeq,8hrs}$ can be defined as the LOAEL.

3.71 The WHO published their *Night Noise Guidelines for Europe* in 2009. This document sets an external 'night noise guideline' (NNG) of 40dB. This is consistent with the LOAEL value determined above. The NNG also sets an interim target of 55dB in situation where the 40dB value cannot be met. Above 55dB the NNG notes that the situation is considered increasingly dangerous for public health. On the basis of the above, a free-field external value of 55dB $L_{Aeq,8hrs}$ is considered to be the night-time SOAEL.

3.72 The WHO published their *Environmental Noise Guidelines for the European Region* in 2018. The WHO state that this document supersedes the 1999 *Guidelines for Community Noise*; however, it recommends that all indoor guideline values in the 1999 document, and any values in the 1999 document not covered by the 2018 document, such as industrial noise, remain valid. The WHO also note that the 2018 document complements the 2009 *Night Noise Guidelines*.

Noise Insulation Regulations

3.73 The Noise Insulation Regulations for road and rail schemes set out conditions, which if satisfied, require the promoter of a new road or railway to offer affected residents sound insulation or a grant in respect of sound insulation.

3.74 Although legislation framed with reference to new roads or railways is not directly relevant to the proposed development considered here, the noise levels at which sound insulation must be offered provide an indication of what constitutes a significant level of noise from these sources; these values may be used to define the level at which significant adverse effects occur, i.e. the SOAEL.

3.75 *The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996*, which apply to new or amended railways, set out façade level thresholds for the daytime and night-time of 68dB $L_{Aeq,18hrs}$ and 63dB $L_{Aeq,6hrs}$ respectively.

3.76 The daytime value in the *Noise Insulation Regulations 1975 (as amended 1988)*, which apply to road schemes, is more stringent than the daytime value in the *Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996*, and this more stringent value has been used to inform the daytime SOAEL in this assessment, where the site may be subject to a mix of road and railway noise, even if railway noise is dominant.

3.77 There is no night-time value in the *Noise Insulation Regulations 1975 (as amended 1988)*, however the night-time value set out in the *Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996* is less stringent than the 55dB $L_{Aeq,8hrs}$ value adopted as the night-time SOAEL in this assessment, based on the WHO *Night Noise Guidelines for Europe*.

3.78 Since the *Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996* have not been used to derive a SOAEL in this assessment, all subsequent references to the Noise Insulation Regulations in this report are to the road-based version, the *Noise Insulation Regulations 1975 (as amended 1988)*.

3.79 The *Noise Insulation Regulations* indicate that sound insulation should be offered when, inter alia, road traffic noise exceeds a façade noise level of 68dB $L_{A10,18hrs}$. This value can be converted to a 16 hour L_{Aeq} to match the form of the guidance recommended in BS8233 by subtracting 5dB. This correction includes a -3dB correction to remove the façade correction, a further -3dB correction to convert the 18 hour L_{A10} noise level to an 18 hour L_{Aeq} noise level, and a +1dB correction to convert the 18 hour L_{Aeq} to a 16 hour L_{Aeq}. The resulting value of 63dB $L_{Aeq,16hrs}$ is considered to be the daytime SOAEL.

3.80 Since noise levels of 63dB $L_{Aeq,16hrs}$ can be controlled through the provision of appropriate ventilation, as required by the *Noise Insulation Regulations*, it is reasonable to suggest that the point at which an unacceptable adverse effect occurs is higher than this value.

3.81 The sound insulation package specified in the *Noise Insulation Regulations* is known to give a sound reduction of approximately 35dB. At external noise levels in excess of 70dB at night the internal noise levels will exceed the reasonable criterion in BS8233 of 35dB. A noise level 1dB below this value is therefore taken to be the upper limit of acceptability for residential properties at night.

3.82 This 69dB $L_{Aeq,8hrs}$ limit has been converted to a free-field value of 66dB to be consistent with the free-field values used elsewhere in this report.

3.83 On this basis, and in the absence of any local definition, the point at which night-time noise levels result in an unacceptable adverse effect is considered to be 66dB $L_{Aeq,8hrs}$.

BRE Research Paper

3.84 A Building Research Establishment (BRE) survey titled *The effectiveness and acceptability of measures for insulating dwellings against traffic noise* (Utley W et al, Journal of Sound and Vibration (1986) Vol 109(1), pages 1-18) found that the insulation package supplied under the Noise Insulation Regulations is inadequate for road traffic noise levels of 78dB $L_{A10,18hrs}$ and above at a façade.

3.85 This figure is equivalent to a free-field level of 75dB $L_{A10,18hrs}$; which in turn is equivalent to 73dB $L_{Aeq,16hrs}$. If mitigation specified under the *Noise Insulation Regulations* becomes ineffectual at 73dB $L_{Aeq,16hrs}$, it can be concluded that 72dB $L_{Aeq,16hrs}$ is the highest noise level at which the mitigation remains effective.

3.86 On this basis, and in the absence of any local definition, the point at which daytime noise levels result in an unacceptable adverse effect is considered to be 72dB $L_{Aeq,16hrs}$.

Calculation of Road Traffic Noise

3.87 Calculations of road traffic noise have been undertaken using the *Calculation of Road Traffic Noise* (CRTN), published in 1988 by the former Department of Transport and The Welsh Office.

3.88 CRTN sets out standard procedures for calculating noise levels from road traffic. The calculation method uses a number of input variables, including traffic flow volume, average vehicle speed, percentage of heavy goods vehicles, type of road surface, site geometry and the presence of noise barriers or acoustically absorbent ground, to predict the $L_{A10,18hrs}$ or $L_{A10,1hr}$ noise level for any receptor point at a given distance from the road.

3.89 The CRTN calculation algorithms have been used to extrapolate from measured road traffic noise levels.

Calculation of Railway Noise

3.90 Calculations of railway noise have been undertaken using the *Calculation of Railway Noise* (CRN), published in 1995 by the Department of Transport.

3.91 CRN sets out standard procedures for calculating noise levels from railways. The calculation method uses a number of input variables, including vehicle type, speed, site geometry and the presence of noise barriers or acoustically absorbent ground to predict a Sound Exposure Level (SEL) at the receiver point. The SEL is converted to daytime and night-time values by applying appropriate corrections and accounting for the number of trains within each time period.

3.92 In this instance, the calculation algorithms have been used to extrapolate from measured train noise levels.

British Standard 6472

3.93 British Standard (BS) 6472: 2008 *Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting* contains a method for assessing the human response to vibration in terms of the vibration dose value. The advice contained in Section 3.5 of BS6472: 2008 states:

> *"The effect of building vibration on the people within is assessed by finding the appropriate vibration dose. Present knowledge shows that this type of vibration is best evaluated with the vibration dose value (VDV).*
>
> *The VDV defines a relationship that yields a consistent assessment of continuous, intermittent, occasional and impulsive vibration and correlates well with subjective response"*

3.94 The vibration dose value is a single figure descriptor that represents the cumulative dose of transient vibrations, taking into account the frequency spectrum and duration of each event. The measured values are weighted to account for the way in which people perceive building vibration, which is dependent on various factors, including the vibration frequency and direction.

3.95 For occupants within buildings, the frequency-weighting curve is defined in British Standard 6841: 1987 *Measurement and Evaluation of Human Exposure to Whole-Body Mechanical Vibration and Repeated Shock*.

3.96 The vibration dose value is determined over a 16 hour daytime period or 8 hour night-time period, and the guidance in BS6472: 2008 is as shown in Table 3.3.

Table 3.3: Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings, $ms^{-1.75}$

Place and Time	Low probability of adverse comment[1]	Adverse comment possible	Adverse comment probable[2]
Residential buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Notes:
(1): Below these ranges adverse comment is not expected
(2): Above these ranges adverse comment is very likely

3.97 The above guidance relates to vibration measured at the point of entry into the human body, which is usually taken to mean the ground surface or at a point mid-span of an upper storey floor, rather than the point of entry into the building, for example a foundation element.

3.98 Where the vibration is measured at another location, BS6472: 2008 states that a transfer function should be applied; however, BS6472: 2008 does not itself contain any guidance on suitable transfer functions although it does reference other publications that contain transfer functions. Transfer functions are considered later in this report.

Summary

3.99 The suitability of the site has been assessed in the following ways:

- determining the external noise levels across the site, to compare with the LOAEL and SOAEL for residential sites, as defined above. For clarity, the LOAEL and SOAEL adopted for this site are shown in Table 3.4;
- calculating the sound reduction performances required of the external building fabric of any proposed properties, particularly the glazing units, so that suitable internal noise levels are achieved;
- assessing the sound levels against the guidance for external amenity areas set out in BS8233: 2014;
- assessing the vibration levels against the guidance in BS6472: 2008.

Table 3.4: LOAEL and SOAEL for this site

Effect	Daytime $L_{Aeq,16hrs}$ (dB)	Night-Time $L_{Aeq,8hrs}$ (dB)	Comments
No Observed Effect	< 50	< 40	The parts of the site that have noise levels below these values are considered acceptable for residential development without the need for further mitigation.
LOAEL	**50**	**40**	
Observed Adverse Effect	50-55	40-45	Although the parts of the site that have noise levels between these values are above the LOAEL, BS8233 suggests that they would be acceptable.
	55-63	45-55	The parts of the site that have noise levels between these values are above the LOAEL, and are considered broadly acceptable for residential development, although mitigation may be required.
SOAEL	**63**	**55**	
Significant Observed Adverse Effect	63-72	55-66	The parts of the site that have noise levels between these values are above the SOAEL but below the point at which an unacceptable adverse effect occurs. Planning policy states that Significant Adverse Effects should be avoided and the Noise PPG states that the planning process should be used to do this by use of appropriate mitigation.
Unacceptable Adverse Effect	> 72	> 66	The noise PPG states that this situation should be prevented; however, no indication is given of how to do this.

Notes:
Stated sound levels are free-field values.

3.100 It is considered that the above values can also be related to the levels of risk described in the ProPG:

- noise levels below the LOAEL, i.e. below 50dB $L_{Aeq,16hrs}$ during the daytime and below 40dB $L_{Aeq,8hrs}$ during the night-time, are considered to be a negligible risk;
- noise levels above the LOAEL but below the SOAEL, i.e. between 50dB $L_{Aeq,16hrs}$ and 63dB $L_{Aeq,16hrs}$ during the daytime and between 40dB $L_{Aeq,8hrs}$ and 55dB $L_{Aeq,8hrs}$ during the night-time, are considered to range from a low to medium risk;
- noise levels above 63dB $L_{Aeq,16hrs}$ i.e. the SOAEL, but below 72dB $L_{Aeq,16hrs}$ during the daytime, and above 55dB $L_{Aeq,8hrs}$, i.e. the SOAEL, but below 66dB $L_{Aeq,8hrs}$ during the night-time, are considered to range from a medium to high risk; and
- noise levels that result in an unacceptable adverse effect, i.e. above 72dB $L_{Aeq,16hrs}$ during the daytime and above 66dB $L_{Aeq,8hrs}$ during the night-time, are considered to be a high risk.

3.101 The lower and upper ends of these ranges, representing negligible and high risks respectively, accord with the advice set out the ProPG.

4 ENVIRONMENTAL SURVEYS

4.1 Sound and vibration surveys were undertaken to establish typical sound and vibration levels at the site. The measurements were taken between Tuesday 27th June 2023 and Thursday 29th June 2023.

4.2 The survey methods and results are set out below.

Sound Survey Method

4.3 The measurements were undertaken between 14:00 hours on Tuesday 27th June 2023 and 12:30 hours on Thursday 29th June 2023.

4.4 The equipment used during the survey is summarised in Appendix C. The sound level meters were calibrated immediately before and after the measurements using the listed acoustic calibrators and no significant calibration drifts were found to have occurred.

4.5 All of the equipment had been laboratory-calibrated to a traceable standard within the year preceding the survey.

4.6 Measurements were carried out at two positions, shown in Figure D.1 in Appendix D and described as follows:

- Position 1: approximately 15 metres from the northern-western site boundary; and
- Position 2: approximately 2.5 metres from the south-eastern site boundary, adjacent to the West Anglia mainline railway.

4.7 The measurements at both positions were taken at a height of 1.5 metres above local ground level, with the microphone in free-field conditions, i.e. at least 3.5 metres away from any reflecting surfaces other than the ground.

Sound Survey Results

4.8 The weather during the majority of the survey was suitable for noise measurement, it being dry with wind speeds of up to 5m/s. However, there was rain overnight between Wednesday 28th and Thursday 29th June 2023, with some surfaces remaining damp during the morning of Thursday 29th June 2023.

4.9 The dominant noise sources during the survey at both positions were trains on the nearby railway line and distant road traffic on the M11 motorway. Trains were audible to a greater degree at Position 2, with that location being closer to the railway line. Distant aircraft noise from planes taking off from and landing at Stansted Airport was also audible, along with natural sounds such as birdsong.

4.10 The trains noted during the survey included Class 720 *'Aventra'* electric multiple units (EMUs) and Class 170 *'Turbostar'* diesel multiple units (DMUs), which are both passenger trains. It is understood from timetabling information that the majority of passenger train services on the line are performed by the Class 720 EMU.

4.11 It is understood that freight trains also operate on the line on occasion, although these were not observed when Resound Acoustics staff were on-site at the start and end of the survey.

4.12 The noise survey results are summarised in Table 4.1 (Position 1) and Table 4.2 (Position 2) aggregated across the daytime (07:00 to 23:00 hours) and night-time (23:00 to 07:00 hours) periods. Full survey results are included in graphical form in Appendix E, in Figure E.1 for Position 1 and Figure E.2 for Position. The periods of rain resulting in damp ground surfaces on the night of Wednesday 28th and on Thursday 29th June 2023 are shown as 'adverse weather'. Full tabulated data are available on request.

Table 4.1: Summary of measured noise levels at Position 1, free-field dB

Date	Period	Duration, T	$L_{Aeq,T}$	$L_{A90,T}$ (1)	$L_{A10,T}$ (1)	L_{AFmax}
Tuesday 27th June 2023	Day	9 hours	54.0	49.9	54.8	59.8 to 72.0
	Night	8 hours	51.7	46.5	52.6	53.7 to 74.8
Wednesday 28th June 2023	Day	16 hours	53.7	48.6	53.4	55.4 to 79.2
	Night	8 hours	48.9	43.6	49.5	48.6 to 70.0
Thursday 29th June 2023	Day	5 hours	53.0	45.8	54.9	64.3 to 76.2

Note: (1) – The $L_{A90,T}$ and $L_{A10,T}$ values are the arithmetic means of the $L_{A90,15min}$ and $L_{A10,15min}$ measurements for each period.

Table 4.2: Summary of measured noise levels at Position 2, free-field dB

Location	Period	Duration, T	$L_{Aeq,T}$	$L_{A90,T}$ (1)	$L_{A10,T}$ (1)	L_{AFmax}
Tuesday 27th June 2023	Day	8.75 hours	55.4	46.2	50.6	56.2 to 88.0
	Night	8 hours	53.3	41.9	47.6	50.8 to 88.9
Wednesday 28th June 2023	Day	16 hours	55.5	44.5	49.2	50.7 to 89.0
	Night	8 hours	50.4	41.9	46.9	49.0 to 81.3
Thursday 29th June 2023	Day	5.5 hours	55.8	46.9	50.1	53.6 to 88.4

Note: (1) – The $L_{A90,T}$ and $L_{A10,T}$ values are the arithmetic means of the $L_{A90,15min}$ and $L_{A10,15min}$ measurements for each period.

Vibration Survey Method

4.13 Vibration measurements were carried out at Position 2 simultaneously with the sound measurements. The measurements were undertaken between 14:15 hours on Tuesday 27th June 2023 and 12:30 hours on Thursday 29th June 2023.

4.14 The equipment used during the survey is summarised in Appendix C and the vibration meter was laboratory-calibrated in the year preceding the survey.

4.15 The accelerometer was buried to a depth of approximately 20cm and the ground compacted around it.

Vibration Survey Results

4.16 The vibration survey results are summarised in Table 4.3. The vibration dose values have been aggregated across the daytime (07:00 to 23:00 hours) and night-time (23:00 to 07:00 hours) periods.

Table 4.3: Summary of vibration levels, Position 2, $ms^{-1.75}$

Day	Period	Duration, T	X-axis $VDV_{d,T}$	Y-axis $VDV_{d,T}$	Z-axis $VDV_{b,T}$
Tuesday 27th June 2023	Day	8.75 hours	0.004	0.005	0.026
	Night	8 hours	0.003	0.004	0.018
Wednesday 28th June 2023	Day	16 hours	0.005	0.006	0.032
	Night	8 hours	0.003	0.004	0.018
Thursday 29th June 2023	Day	5.5 hours	0.004	0.005	0.024

5 ASSESSMENT

Calculation Parameters

5.1 The sound levels across the site have been calculated using the CadnaA modelling package, implementing the calculation methods set out in CRTN for road traffic and CRN for the railway, based on the measured sound levels. The noise model takes account of the dominant sources at the site, these being the M11 motorway and the West Anglia Mainline railway.

5.2 As noted in Section 4 of this report, there was rain overnight between Wednesday 28th and Thursday 29th June 2023, with some surfaces remaining damp during the morning of Thursday 29th June 2023. Therefore, the assessment uses the noise data gathered during the full 16 hour daytime period on Wednesday 28th June 2023, and the full 8 hour night-time period on Tuesday 27th June 2023.

5.3 For Position 1, this results in a full 16 hour daytime L_{Aeq} value of 53.7dB $L_{Aeq,16hr}$ and an 8 hour night-time value of 51.7dB $L_{Aeq,8hr}$.

5.4 For Position 2, this results in a full 16 hour daytime L_{Aeq} value of 55.7dB $L_{Aeq,16hr}$ and an 8 hour night-time value of 53.3dB $L_{Aeq,8hr}$.

5.5 These values have been used to calibrate noise sources in the model representing the M11 motorway and the West Anglia Mainline railway.

5.6 The ground heights at and around the site have been modelled according to OS mapping information, LIDAR data obtained from the DEFRA website, and from on-site observations. The acoustic absorbency of the ground is modelled as 75% acoustically soft.

5.7 It is noted that Stansted Airport lies approximately 2km to the south of the site. However, the most recent noise contours maps for the airport, as shown in the Environmental Research and Consultancy Department (ERCD) report *Noise Exposure Contours for Stansted Airport 2022* (ERCD report reference 2303, dated May 2023), show that the site lies outside the lowest daytime contour of 51dB L_{Aeq} and outside the lowest night-time contour of 45dB L_{Aeq}. Therefore, noise from Stansted Airport is not considered to be a significant source compared to the road and rail traffic sources, and has not included in the noise model. For reference, the airport noise contours from the ERCD report are shown in Figures F.1 and F.2 in Appendix F.

Site Suitability - Noise

5.8 The calculated daytime sound contours at the site are shown in Figure F.3 in Appendix F and the night-time contours are shown in Figure F.4. The contours have both been calculated on the basis of an open site with no proposed development structures included. However, the illustrative site layout has been included as an underlay to the contours to provide context. It is understood that constraints in the form of a public footpath running along the south-eastern edge of the site and existing foul and surface water easements mean that in practice no properties will be located closer to the West Anglia mainline railway than shown on the illustrative layout.

5.9 The daytime contours have been calculated at a height of 1.5 metres above ground level and the night-time contours have been calculated at a height of 4 metres above ground level.

5.10 It can be seen from Figure F.3 that during the daytime, the south-eastern part of the site has sound levels between 55 and 63dB (blue area), which is the upper range of values considered to be above the LOAEL but below the SOAEL. It is noted that only the properties on the illustrative site layout closest to the railway fall into this range of values. The remainder of the site, further away from the railway, has sound levels between 50 and 55dB (yellow area), which is the lower range of values above the LOAEL but below the SOAEL. The majority of properties shown on the illustrative site layout fall into this range of values.

5.11 It can be seen from Figure F.4 that during the night-time, the majority of the site has sound levels between 45 and 55dB (blue area), which is the upper range of values considered to be above the LOAEL but below the SOAEL. A small strip along the south-eastern edge of the site is predicted to have sound levels of between 55 and 66dB (orange area), which is considered to be above the SOAEL, but not at the level at which an unacceptable adverse effect would occur. The strip of land is up to approximately 15 metres wide and the illustrative site layout does not propose properties within it.

5.12 In terms of the level of noise risk as described in the ProPG, it is considered that overall the site is a low to medium risk, as the majority of the site is subject to noise levels above the LOAEL but below the SOAEL, with only small areas along the south-eastern edge being above the SOAEL but not at the level at which an unacceptable adverse effect would occur. The illustrative site layout does not propose properties in the area above the SOAEL, and as previously noted there are constraints at the site that mean in practice no properties will be located closer to the West Anglia mainline railway than shown on the illustrative layout.

5.13 On the basis that the site is subject to sound levels above the LOAEL but below the level at which an unacceptable adverse effect would occur, and is considered to be a low to medium risk, the site is considered acceptable for residential use, subject to the incorporation of suitable mitigation, which is considered in the next section of this report.

Site Suitability - Vibration

5.14 The measured vibration levels have been assessed against the guidance contained in BS6472: 2008, to determine the likely response of future occupants of the development to railway vibration. The assessment has taken account of the location, size and construction of potential buildings at the site.

5.15 The daytime assessment period in BS6472: 2008 is 16 hours and the night-time assessment period is 8 hours. Although vibration measurement is less susceptible to adverse weather than noise measurement, the vibration assessment also uses data gathered during the full 16 hour daytime period on Wednesday 28th June 2023, and the full 8 hour night-time period on Tuesday 27th June 2023, to be consistent with the noise data.

5.16 The measured VDV values used in the assessment are shown in Table 5.1.

Table 5.1 Measured daytime and night-time vibration levels, $ms^{-1.75}$

Period	Duration, T	X-axis $VDV_{d,T}$	Y-axis $VDV_{d,T}$	Z-axis $VDV_{b,T}$
Day	16 hours	0.005	0.006	0.032
Night	8 hours	0.003	0.004	0.018

5.17 The guidance in BS6472: 2008 applies at the point of entry into a human receptor and not necessarily at the measurement position. It is therefore necessary to estimate the effect that any potential building will have on the magnitude of vibration at the point of entry to the human.

5.18 There are two key aspects to the effect that the building structure will have on measured vibration levels: the first is generally a reduction as the vibration passes into the foundations of a building; there is typically then amplification as the vibration propagates up the building to the upper storeys and across potentially suspended floors. Each of these factors is considered below.

5.19 The measurements were taken in unloaded soil, but the proposed houses are likely to have strip foundations. It is therefore necessary to determine a transfer function that represents the likely effect that the foundation would have on the vibration magnitude as it propagates into the building structure. In assessing the effect that the different foundations may have, guidance has been sought from the *Handbook of Urban Rail Noise and Vibration Control* (HURNVC), published by the Federal Transit Administration, USA, written by H J Saurenam, J T Nelson and G P Wilson.

5.20 The HURNVC sets out attenuation factors that can be applied to calculate the transfer function between vibrations measures on unloaded ground and vibration at a foundation. It notes that the multiplication factor for a strip foundation is approximately 0.5, based on the 31.5 Hz frequency band.

5.21 It has been assumed that the buildings will have strip foundations, so a multiplication factor of 0.5 has been used.

5.22 The vibration is likely to be amplified as it propagates up a structure and amplified again as it propagates across a suspended floor, as might be found in the upper storeys of buildings.

5.23 To extrapolate the measured vibration levels up the building to a suspended upper storey, an amplification factor of 2.8 has been used, based on figures presented in *Transmission of Ground-borne Vibration in Buildings* by Jorgen Jakobsen, Journal of Low Frequency Noise and Vibration, Vol. 8 No. 3, 1989.

5.24 The other factor that may affect the final vibration level within potential buildings, relative to the amount of vibration that has been measured on-site, is the separation distance between the buildings and the railway line.

5.25 The correction for the additional distance between the proposed properties and the railway line relative to the vibration measurement position is based on:

- the vibration energy being contained within a surface wave, which for a line source such as a railway, results in zero reduction over short distance; and
- frequency independent soil damping, based on the smallest rate of reduction set out in the HURNVC.

5.26 In this instance, the measurement position was located approximately 2.5 metres from the south-eastern site boundary, and approximately 11 metres from the nearest railway track.

5.27 The proposed planning application for the development is outline, and therefore any building could in theory be located directly on the site boundary closest to the railway, closer to a track than is shown on the illustrative site layout and closer than the measurement position.

5.28 However, it is understood that constraints in the form of a public footpath running along the south-eastern edge of the site and existing foul and surface water easements mean that in practice no properties will be located closer to the West Anglia mainline railway than shown on the illustrative layout.

5.29 The closest property on the illustrative layout is approximately 27 metres from the nearest railway track. To account for this different distance from the railway compared to the measurement position, a reduction factor of 0.5 has been applied.

5.30 Table 5.2 shows the vibration levels likely to occur within a room on the upper storey of a building at the section of the south-eastern site boundary closest to the railway. The figures presented in Table 5.2 equate to the highest measured vibration dose values amplified by an overall transfer function of 0.7, i.e. 0.5 for the strip foundation multiplied by 2.8 for the upper storey amplification multiplied by 0.5 for the distance correction.

Table 5.2 Calculated vibration levels in habitable rooms, $ms^{-1.75}$

Period	Maximum Measured VDV ($ms^{-1.75}$)	Resulting VDV ($ms^{-1.75}$)
Day	0.032	0.023
Night	0.018	0.014

5.31 The resulting daytime and night-time vibration dose values shown in Table 5.2 are significantly below the level that BS6472: 2008 suggests carries a low probability of causing adverse comment. Vibration is therefore not considered to be a material constraint at the site and it is not considered further in this report.

6 MITIGATION

6.1 The noise levels at the site are above the LOAEL but below the level at which an unacceptable adverse effect would occur, so the inclusion of mitigation measures should meet the requirements of the NPPF, NPSE and noise PPG.

6.2 There are typically three opportunities to reduce noise levels at a site such as this: at source, between the source and the receptor, or at the receptor.

6.3 In this instance, Rosconn Strategic Land cannot reduce the noise at source, i.e. by directly affecting road traffic on the M11 motorway or rail traffic on the West Anglia mainline railway. However, noise can be reduced between the source and the receptor, for example by installing an acoustic barrier along the south-eastern boundary of the site to screen the West Anglia mainline railway, or at the receptor, for example by adopting a layout that takes noise into consideration or by using appropriate building materials to control noise within the properties.

6.4 Consideration has been given to the site layout, the use of buildings and barriers to reduce noise levels, particularly in gardens, and the specification of building materials to control internal noise levels.

Site Layout

6.5 The sound level contours presented in Figures F.3 and F.4 in Appendix F show that the highest noise levels at the site are expected to be on its south-eastern edge, closest to the West Anglia mainline railway.

6.6 The illustrative site layout sets properties back from the railway line, and it is understood that constraints in the form of a public footpath running along the south-eastern edge of the site and existing foul and surface water easements mean that in practice no properties will be located closer to the railway line than this, even if the future layout differs from the illustrative layout. This distance buffer is an effective measure in terms of reducing noise levels from the railway incident on the properties themselves, with no properties in the parts of the site subject to noise levels above the SOAEL.

6.7 The illustrative site layout also orients the properties along the south-eastern edge of the site so that they screen their garden areas behind from the railway line. This is considered to be good acoustic design and it is recommended that the final site layout, should it differ from the illustrative layout, also adopts this approach.

Noise Barriers

6.8 Noise barriers can be effective in reducing noise levels, as they are a physical structure providing acoustic screening between a source and a receptor.

6.9 Barriers typically take the form of acoustic fences or bunds, although as previously noted, the properties themselves or ancillary structures such as garages can act as effective barriers to block sound.

6.10 At this site, the most effective location for a barrier is likely to be along the south-eastern site boundary, to screen the railway. However, the relationship between the site and the railway could limit the effectiveness of such a barrier; the railway is on a slight embankment as it passes the site, so that ground level at the site is lower than the railway line. Assuming a barrier cannot be located at the top of the embankment on land belonging to Network Rail, a barrier located at site level would need to be taller than would otherwise be needed if the railway were at grade with the site.

6.11 The exact height of a barrier would also depend on what the barrier was trying to achieve. For example, if the barrier was intended to reduce noise levels at upper floors of a property overlooking the railway, then it is likely to need to be at least 4 metres high to fully screen windows at this level. If the barrier was only intended to reduce noise levels in garden areas, then the required height is likely to be lower, as the receptor height is also lower.

6.12 Small plot-specific barriers, such as garden fences that act as noise barriers, may also be effective. As noted above, properties themselves can be used as barriers, oriented to screen gardens behind. The illustrative layout adopts this approach.

6.13 Any fences used as noise barriers erected at the site would need to be imperforate, sealed at the based, and have a minimum superficial density of at least 18kg/sq.m.

Internal Noise Levels

6.14 The sound reduction performance required of the external building fabric of the proposed properties has been determined, so that the noise levels within the properties meet the guideline values set out in BS8233: 2014 and the World Health Organisation's *Guidelines for Community Noise*.

6.15 The daytime and night-time L_{Aeq} noise levels have been calculated using the same noise model described previously, but this time including proposed properties, based on the illustrative site layout. The noise levels have been calculated at a number of representative locations across the site, as shown in Figure F.5 in Appendix F. The sound reduction performance requirements have been calculated at each of these locations so that the guideline values are achieved.

6.16 The daytime and night-time noise levels have been calculated at 4 metres above ground level to represent a first floor bedroom window or simply an upper storey.

6.17 To determine suitable maximum noise levels to use in the assessment, the night-time maximum sound level data at Position 1 have been analysed. Although this location was further from the railway line than Position 2, the measurement file from the sound level meter installed at this location allows the measured sound level data to be reprocessed into one minute intervals to better account for individual noise events, i.e. passing train, which were the dominant cause of maximum noise level events at the site during the night-time. Passing trains were clearly visible in the measurement trace for Position 1 and could be correlated with timetable information.

6.18 As noted in Section 4 of this report, there was rain overnight between Wednesday 28th and Thursday 29th June 2023, with some surfaces remaining damp during the morning of Thursday 29th June 2023. Therefore, the analysis only uses the maximum noise level data gathered during the full 8 hour night-time period on Tuesday 27th June 2023.

6.19 As the WHO guidelines state that noise levels within bedrooms should not exceed 45dB L_{AFmax} more than 10 to 15 times per night, the tenth highest 1 minute L_{AFmax} value of 67.7dB L_{AFmax} has been used.

6.20 This maximum sound level has been adjusted to take account of the differences in the distance between the railway and Position 1, and the distances between the railway and the receptor points.

6.21 The calculated sound reduction performance requirements apply to the whole external building fabric of the proposed properties. However, since windows are typically the weakest link in the external building fabric, in terms of acoustic performance, the values below will particularly apply to the windows.

6.22 The calculated noise levels and the sound reduction performances required of the external building fabric are shown in Table 6.1. The predicted noise levels have been rounded up to the nearest whole number to ensure that the calculated sound reduction performances are robust.

Table 6.1: Required sound reduction performances, dB

Location	Period	Target Noise Level	Calculated Noise Level	Required Sound Reduction Performance	Overall Performance Requirement
Plot 1	Day	35dB $L_{Aeq,16hr}$	45	10	21
	Night	30dB $L_{Aeq,8hr}$	43	13	
	Night	45dB L_{AFmax}	66	21	
Plot 3	Day	35dB $L_{Aeq,16hr}$	48	13	21
	Night	30dB $L_{Aeq,8hr}$	46	16	
	Night	45dB L_{AFmax}	66	21	
Plot 10	Day	35dB $L_{Aeq,16hr}$	50	15	26
	Night	30dB $L_{Aeq,8hr}$	47	17	
	Night	45dB L_{AFmax}	71	26	
Plot 17	Day	35dB $L_{Aeq,16hr}$	49	14	18
	Night	30dB $L_{Aeq,8hr}$	47	17	
	Night	45dB L_{AFmax}	63	18	
Plot 21	Day	35dB $L_{Aeq,16hr}$	50	15	22
	Night	30dB $L_{Aeq,8hr}$	48	18	
	Night	45dB L_{AFmax}	67	22	
Plot 25	Day	35dB $L_{Aeq,16hr}$	56	21	27
	Night	30dB $L_{Aeq,8hr}$	54	24	
	Night	45dB L_{AFmax}	72	27	
Plot 28	Day	35dB $L_{Aeq,16hr}$	55	20	24
	Night	30dB $L_{Aeq,8hr}$	54	24	
	Night	45dB L_{AFmax}	68	23	
Plot 30	Day	35dB $L_{Aeq,16hr}$	55	20	28
	Night	30dB $L_{Aeq,8hr}$	53	23	
	Night	45dB L_{AFmax}	73	28	
Plot 37	Day	35dB $L_{Aeq,16hr}$	51	16	25

Location	Period	Target Noise Level	Calculated Noise Level	Required Sound Reduction Performance	Overall Performance Requirement
	Night	30dB $L_{Aeq,8hr}$	49	19	
	Night	45dB L_{AFmax}	70	25	
Plot 40	Day	35dB $L_{Aeq,16hr}$	56	21	31
	Night	30dB $L_{Aeq,8hr}$	54	24	
	Night	45dB L_{AFmax}	76	31	

6.23 Windows do not reduce noise equally across the entire frequency spectrum, so the frequency content of the sound will influence the overall sound reduction performance of a given window, and by extension, the resulting noise levels within the property.

6.24 However, many glazing manufacturers test their products under laboratory conditions using a frequency spectrum source. The resultant measured noise attenuation, in dB, gives a very useful guide to in-situ sound reduction performance of the window for situations where a particular noise spectrum dominates. For an acoustic climate that includes road traffic noise and railway traffic at low speeds, as is the case at this site, the appropriate spectrum adaptation term is the C_{tr} term. The sound reduction requirements set out in Table 6.1 should be interpreted as R_w+C_{tr} values.

6.25 It can be seen from Table 6.1 that a sound reduction performance of up to 31dB would be required at Plot 40, which is the closest property to the West Anglia mainline railway.

6.26 An example of a glazing unit that should be capable of achieving a sound reduction performance requirement of 31dB R_w+C_{tr} is a Pilkington 10/12/6 *Insulight*™ unit, which comprises a 10mm pane of glass and a 6mm pane of glass, separated by an air gap of 12mm.

6.27 For those locations where the required sound reduction performance is 25dB or less, standard thermal double-glazing should be sufficient, as it typically provides a sound reduction performance of 25dB R_w+C_{tr}.

6.28 It is noted that the sound reduction performances stated as achievable by the identified glazing units are based on laboratory tests. In practice, the actual on-site performance may be lower, depending on the quality of the fitting. The sound reduction performances in Table 6.1 should be interpreted as in-situ sound reduction performances.

6.29 Glazing units other than that suggested may be suitable and it is the responsibility of the glazing manufacturer to recommend and provide appropriate systems. The above analysis demonstrates that a design solution is feasible at the site for the purposes of a planning application.

6.30 The detailed design of the proposed properties will also affect the required sound reduction performance and the consequent selection of glazing units. The aspects of the detailed design that are important are the layout, room dimensions, room finishes, window dimensions, and the sound reduction performance of non-glazing elements. Further detailed consideration of the glazing components will be required once the building designs are confirmed.

6.31 Internal noise levels should be considered in the context of room ventilation and overheating requirements. Where the sound reduction performance requirements are greater than 10dB, the windows will need to be closed to achieve the internal noise criteria.

6.32 Therefore, an alternative form of ventilation and/or cooling may be required so that occupants can retain access to fresh air and maintain thermal comfort without compromising their noise climate. The ventilation and/or cooling system chosen should be designed so that it does not compromise the sound insulation performance of the building fabric.

6.33 In this situation, the ProPG is clear that the internal target noise levels should be achieved when windows are closed with 'whole dwelling ventilation' provided that is assumed to be in the 'open' position. Approved Document F (ADF) of the Building Regulations notes that whole dwelling ventilation can be provided by 'background ventilators', and states these are most commonly trickle ventilators.

6.34 Occupants would still retain the option to open windows, for example for purge ventilation. Both the ProPG and the AVO guide suggest that the internal noise level guideline values are set aside in these conditions.

6.35 The AVO guide states that higher internal noise levels are also considered acceptable when windows are open to control overheating. The level of noise that occupants may consider acceptable depends on how frequently and for what duration windows need to be open to mitigate overheating. A higher internal noise level is more likely to be acceptable if windows only need to be open occasionally, and therefore occupants are only exposed to the noise for a short duration.

6.36 For this site, where windows are partially open, as defined in the AVO guide, to control overheating during the daytime, the daytime internal L_{Aeq} noise levels across the majority of the site, as represented by Plots 1, 3, 10, 17, 21 and 37 are predicted to meet the 'reasonable' values in BS8233: 2014, and therefore an adverse effect is unlikely.

6.37 At Plots 25, 28, 30 and 40 which represent the properties on the south-eastern edge of the site closest to the railway, the daytime L_{Aeq} noise levels are predicted to exceed the 'reasonable' values in BS8233: 2014, however, the margin of exceedance is only predicted to be between 1dB and 3dB, and internal noise levels would be clearly below the levels that the AVO guide suggests might lead to a material change in the occupants' behaviour.

6.38 It is noted that the overall potential for adverse effect will depend on how frequently and for what duration the overheating condition occurs. However, this is beyond the scope of this noise assessment, and would need to be determined by an appropriate specialist as part of an overheating assessment.

6.39 Approved Document O (ADO) sets out a simpler approach than the AVO guide, with absolute noise level thresholds applied irrespective of how often or how long the windows may be open to mitigate overheating. The thresholds in ADO only apply to bedrooms during the night and are more stringent than the upper limits for bedrooms in the AVO guide. As the fixed thresholds form part of the Building Regulations and are more stringent than those in the AVO guide, they are considered to be the appropriate thresholds against which to assess internal noise levels in the context of overheating during the night-time.

6.40 An assessment in accordance with the 'simplified method' in ADO, with the assumption that the site is a 'medium' overheating risk based on its location, shows that at all receptor locations except Plot 17, the required minimum free areas for openings cannot be met without either the L_{Aeq} or L_{AFmax} internal noise levels exceeding the stated thresholds.

6.41 Where the 'simplified method' cannot be used to demonstrate compliance, ADO states that 'dynamic thermal modelling' should be used. Dynamic thermal modelling takes account of site-specific conditions, and therefore it may be possible to confirm that smaller free areas for openings than those set out in the 'simplified method' are sufficient to mitigate overheating. This could in turn reduce the amount of acoustically open area, increasing the overall sound insulation performance of the building façade and reducing internal noise levels so that the internal noise level thresholds may no longer be exceeded.

6.42 However, detailed consideration of overheating is outside the scope of this report, and any overheating assessment should be undertaken by an appropriate specialist.

6.43 In practice, a range of ventilation options from background trickle ventilation through to full mechanically-assisted whole house systems should be capable of providing a suitable internal acoustic climate, subject to their own acoustic performance, and meeting the ventilation requirements of the Building Regulations.

6.44 Where windows open sufficiently to mitigate overheating result in the ADO thresholds being exceeded, then an alternative strategy for mitigating overheating during the night-time will be required.

Garden Noise Levels

6.45 The noise levels across the site have been calculated using the same noise model described in the internal noise level assessment, and compared against the guideline values for external amenity areas in BS8233: 2014. The resulting contours are shown in Figure F.6 in Appendix F.

6.46 It can be seen from Figure F.6 that, based on the illustrative site layout, the sound levels in all of the proposed gardens are predicted to meet the upper 55dB guideline value in BS8233: 2014 (green and yellow areas), with the majority of properties having sound levels that also meet the more stringent 50dB guideline value (green areas).

6.47 The illustrative site layout orients properties along the south-eastern edge of the site so that their gardens are behind them, screening them from the West Anglia mainline railway; this is effective in reducing noise from the railway line in gardens.

6.48 If any future layout does not adopt this same approach, and gardens are located to the south-east of any properties along the south-eastern edge of the site, facing the railway, then it has been calculated that 1.8 metre high garden fences that act as noise barriers will reduce noise levels in the garden to meet the upper 55dB guideline value in BS8233: 2014.

6.49 Any garden fences used as noise barriers should be imperforate, sealed at the base, and have a superficial density of at least 18kg/sq.m.

Summary

6.50 The illustrative site layout includes a number of measures that are considered to be good acoustic design and are effective in reducing noise levels at the site.

6.51 The incorporation of a distance buffer between properties and the West Anglia mainline railway reduces sound levels at the proposed properties. It is understood that constraints in the form of a public footpath running along the south-eastern edge of the site and existing foul and surface water easements mean that in practice this distance buffer will be retained and properties will be located no closer to the railway line than is shown on the illustrative layout, even if the final layout differs from the illustrative layout.

6.52 Glazing units with a higher sound reduction performance than standard thermal double-glazing are likely to be required. However, based on properties being located no closer to the railway line than shown in the illustrative layout, the sound reduction requirements would be no higher than those set out in Table 6.1 of this report.

6.53 Properties along the south-eastern edge of the site are also oriented so that they screen their garden areas from the railway. This is effective in reducing sound levels from the railway in gardens, and sound levels in all proposed gardens are predicted to meet at least the upper 55dB guideline value set out in BS8233: 2014, with noise levels in the majority of gardens also meeting the more stringent 50dB guideline value.

6.54 If any future layout does not adopt this same approach, and gardens are located to the south-east of any properties along the south-eastern edge of the site, facing the railway, then it has been calculated that 1.8 metre high garden fences that act as noise barriers will reduce noise levels in the garden to meet the upper 55dB guideline value in BS8233: 2014.

7 CONCLUSION

7.1 Rosconn Strategic Land has appointed Resound Acoustics Limited to undertake a noise and vibration assessment for a proposed development on land at Rush Lane, Elsenham, Essex.

7.2 Rosconn Strategic Land is intending to develop the site for residential purposes, with up to 40 no. dwellings proposed.

7.3 This assessment has shown that providing appropriate mitigation measures are incorporated into the final design of the site:

- sound levels within the proposed properties should meet the internal noise level guideline values set out in British Standard 8233: 2014 and the World Health Organisation's *Guidelines for Community Noise*; and
- sound levels within the gardens of the proposed properties should meet the requirements for external amenity areas set out British Standard 8233: 2014.

7.4 Vibration levels are significantly below the level that BS6472: 2008 suggests carries a low probability of causing adverse comment, and therefore vibration is not considered to be a material constraint at the site.

7.5 On the basis of this assessment, it is considered that noise and vibration does not pose a constraint to the proposed development.

Appendices

Appendix A – Introduction to Noise and Vibration and Glossary of Terminology

Noise is defined as unwanted sound. The human ear is able to respond to sound in the frequency range 18Hz (deep bass) to 18,000Hz (high treble) and over the audible range of 0dB (the threshold of perception) to 140dB (the onset of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting (filtering) mechanism is used. This reduces the importance of lower and higher frequencies, approximating the response of the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. Noise can be perceived to be louder or more noticeable if the source of the noise is observed; e.g. roads, trains, factories, building sites etc. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source. Various noise indices have been derived to describe the fluctuation of noise levels that vary over time. Usually, these noise indices relate to specific types of noise, and as such different noise indices are used to describe road traffic noise, background noise, construction noise, etc.

The weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement and the levels are denoted as dB(A) or L_{Aeq}, L_{A10}, etc, according to the parameter being measured.

Noise is measured on the decibel scale, which is logarithmic rather than linear. As a result of this, a 3dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3dB(A) is generally regarded as the minimum difference needed to perceive a change. Table A.1 sets out examples of noise levels typically experienced during everyday activities. Table A.2 sets out an explanation of the terminology used in this report.

Table A.1: Typical sound levels found in the environment

Sound Level	Location
0 to 10dB(A)	Threshold of hearing
10 to 20dB(A)	Broadcasting studio
20 to 30dB(A)	Quiet bedroom at night
30 to 40dB(A)	Living room during the day
40 to 50dB(A)	Typical office
50 to 60dB(A)	Inside a car
60 to 70dB(A)	Typical high street
70 to 90dB(A)	Inside a factory or noisy pub
100 to 110dB(A)	Burglar Alarm at 1m
110 to 130dB(A)	Pneumatic drill at 1m away
140dB(A)	Threshold of Pain

Vibration is defined as a repetitive oscillatory motion. Groundborne vibration can be transmitted to the human body through the supporting surfaces; the feet of a standing person, the buttocks, back and feet of a seated person or the supporting area of a recumbent person. In most situations, entry into the human body will be through the supporting ground or through the supporting floors of a building. Vibration from road traffic can also be airborne. Such airborne vibration is transmitted as a low-frequency sound wave and is often perceived when the sound wave causes windows or other objects to rattle.

Vibration is often complex, containing many frequencies, occurring in many directions and changing over time. There are many factors that influence human response to vibration. Physical factors include vibration magnitude, vibration frequency, vibration axis, duration, point of entry into the human body and posture of the human body. Other factors include the exposed persons experience, expectation, arousal and activity.

Experience shows that disturbance or annoyance from vibration in residential situations is likely to arise when the magnitude of vibration is only slightly in excess of the threshold of perception.

The threshold of perception depends on the frequency of vibration. The human body is most sensitive to vibration in the frequency range 1 to 80Hz and especially sensitive to vibration in the range 4 to 8Hz. As with noise, a frequency weighting mechanism is used to quantify vibration in a way that best corresponds to the frequency response of the human body. In general, vibration is only perceptible in residential situations when the building is close to a railway, construction site or very close to a road that carries large and heavy vehicles.

Table A.2: Terminology relating to noise and vibration

Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (Sound Level)	The sound level is the sound pressure relative to a standard reference pressure of 20μPa (20×10^{-6} Pascals) on a decibel scale.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s_1 and s_2 is given by $20 \log_{10} (s_1/s_2)$. The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20μPa.
A-weighting, dB(A)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
$L_{Aeq,T}$	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{max,T}$	A noise level index defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
$L_{90,T}$ or Background Noise Level	A noise level index. The noise level exceeded for 90% of the time over the period T. L_{90} can be considered to be the "average minimum" noise level and is often used to describe the background noise.
$L_{10,T}$	A noise level index. The noise level exceeded for 10% of the time over the period T. L_{10} can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise.
Free-field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5 metres
Façade	At a distance of 1 metre in front of a large sound reflecting object such as a building façade.
Fast Time Weighting	An averaging time used in sound level meters. Defined in BS EN 61672.
Displacement, Acceleration and Velocity Root Mean Square (r.m.s.) and Peak Values Peak Particle Velocity (PPV)	Vibration is an oscillatory motion. The magnitude of vibration can be defined in terms of displacement (how far from the equilibrium position that something moves), velocity (how fast something moves), or acceleration (the rate of change of velocity). When describing vibration, one must specify whether peak values are used (i.e. the maximum displacement or maximum velocity) or r.m.s. / r.m.q. values (effectively an average value) are used. Standards for the assessment of building damage are usually given in terms of peak velocity (usually referred to as Peak Particle Velocity, or PPV), whilst human response to vibration is often described in terms of r.m.s. or r.m.q. acceleration.
Root Mean Square (r.m.s.)	The r.m.s. value of a set of numbers is the square root of the average of the squares of the numbers. For a sound or vibration waveform, the r.m.s. value over a given time period is the square root of the average value of the square of the waveform over that time period.
Root Mean Quad (r.m.q.)	The r.m.q. value of a set of numbers is the fourth root of the average of the fourth powers of the numbers. For a vibration waveform, the r.m.q. value over a given time period is the fourth root of the average value of the fourth power of the waveform over that time period.

Appendix B – Site Plans

Figure B.1: Site location plan

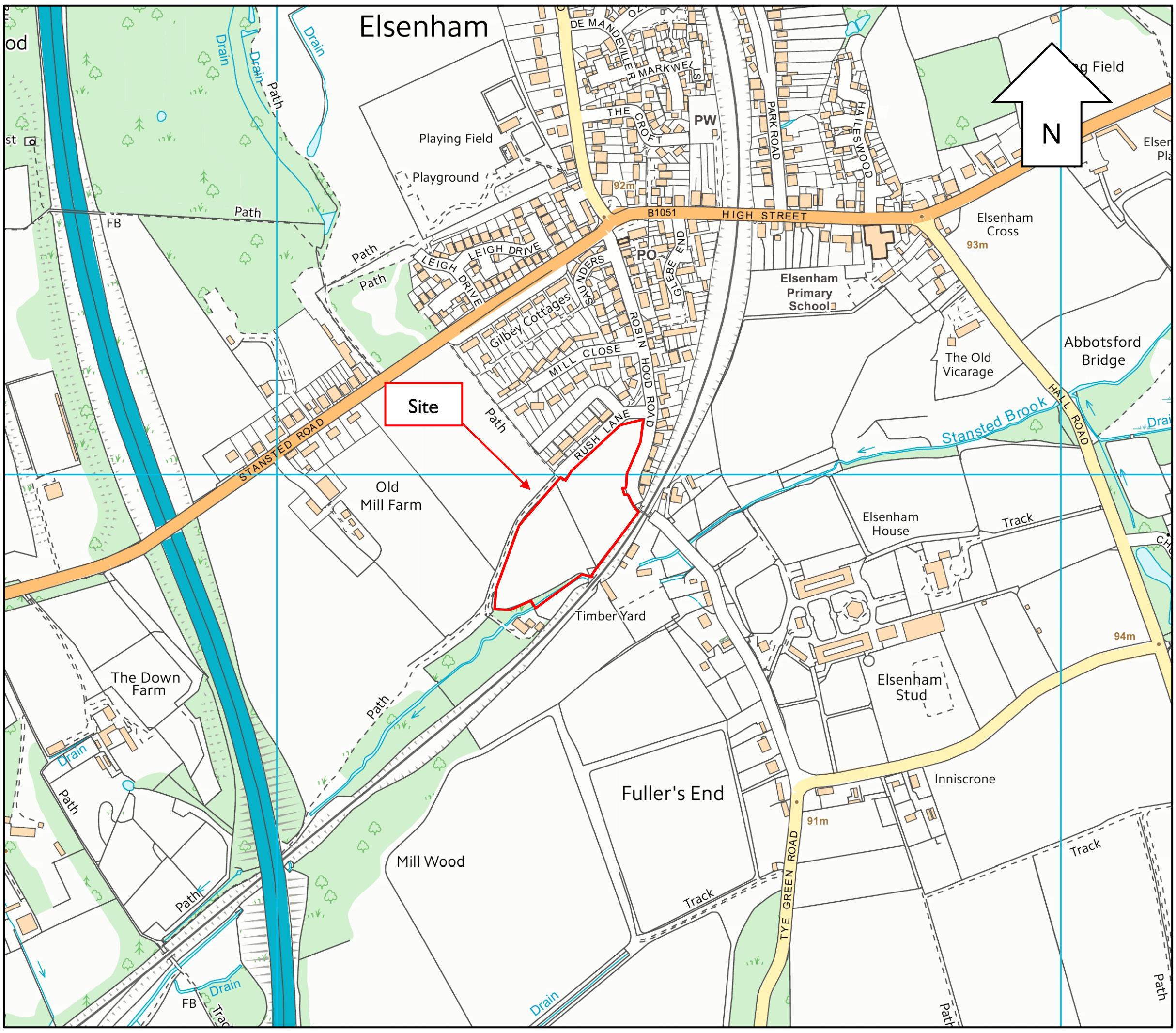


Figure B.2: Illustrative site layout

Appendix C – Monitoring Equipment

Table C.1: Noise monitoring equipment

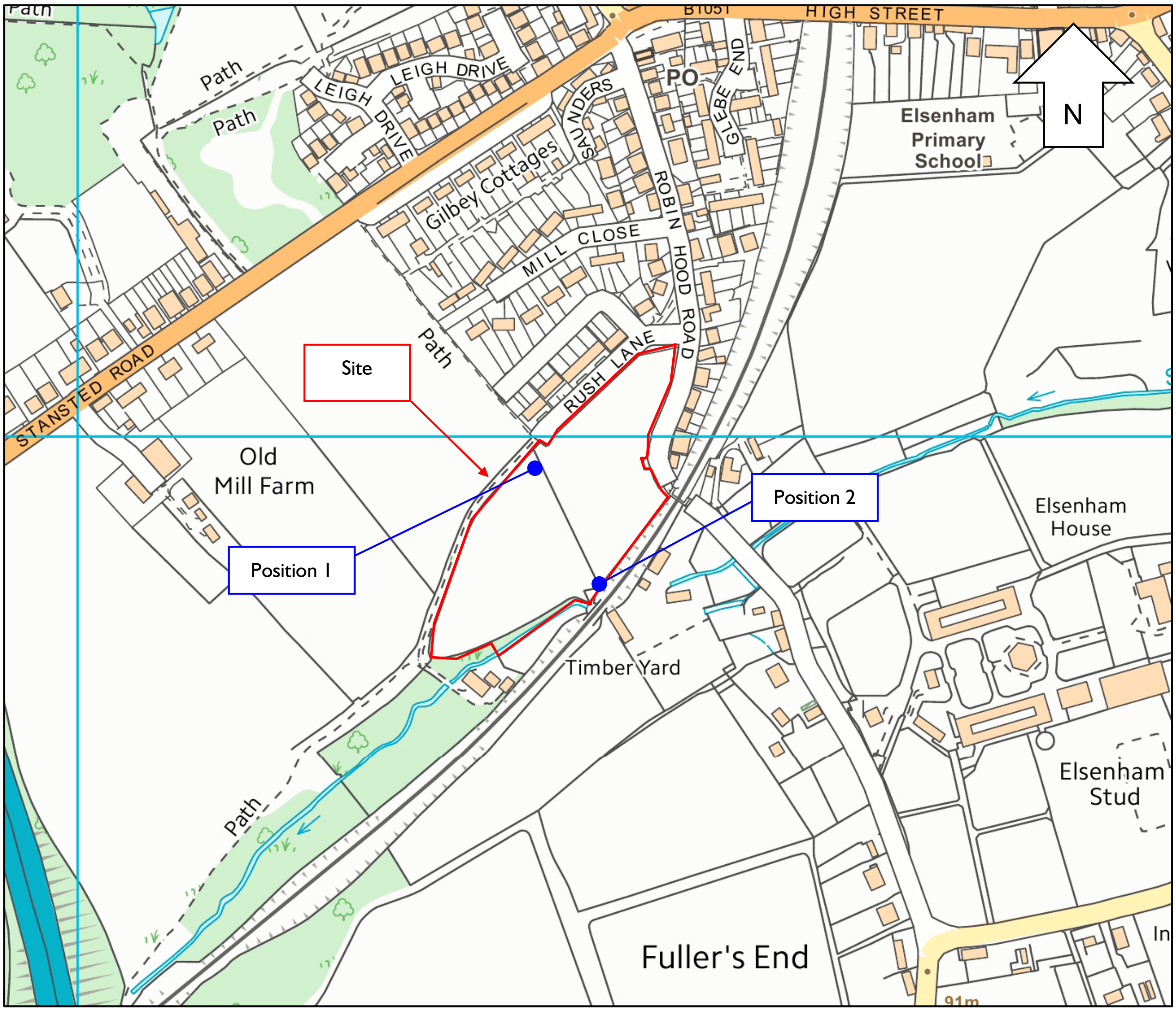
Position	Equipment	Serial Number	Calibration Date
1	01dB Blue Solo type 1 sound level meter	60582	09/01/2023
	01dB PRE21S pre-amplifier	13510	
	01dB MCE212 microphone	90416	
	01dB Cal01 acoustic calibrator	980058	09/01/2023
2	Rion NL-52 type sound level meter	00610205	06/02/2023
	Rion NH-25 pre-amplifier	10199	
	Rion UC-59 microphone	02547	
	Rion NC-74 acoustic calibrator	34494274	10/02/2023

Table C.2: Vibration monitoring equipment

Position	Equipment	Serial Number	Calibration Date
2	Rion VM-56 Tri-axial vibration meter	34390060	18/01/2023
	Rion PV-83D Tri-axial accelerometer	80032	

Appendix D – Measurement Positions

Figure D.1: Measurement positions



Appendix E – Full Survey Results

Figure E.1: Noise levels measured at Position 1, free-field dB

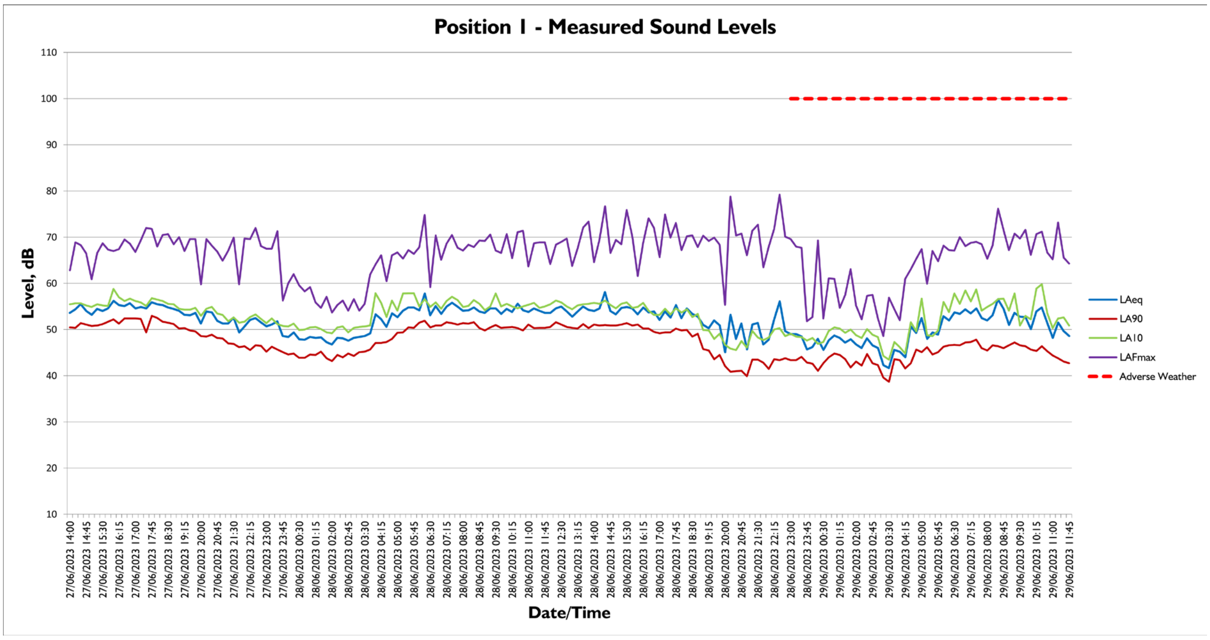
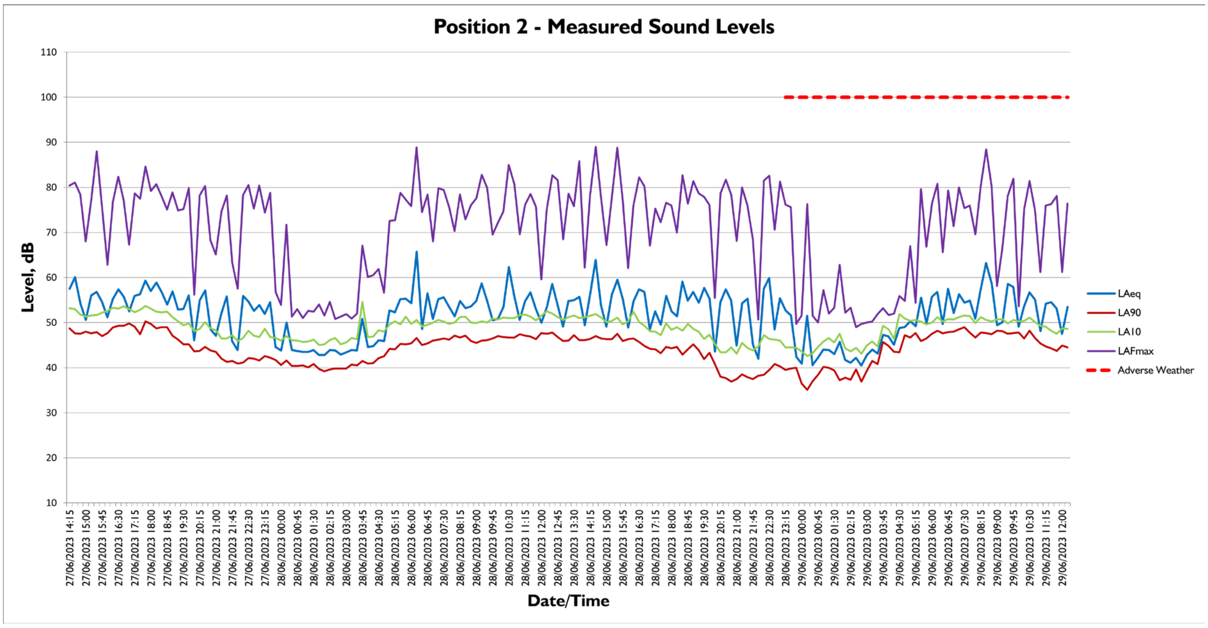


Figure E.2: Noise levels measured at Position 2, free-field dB



Appendix F – Assessment Figures

Figure F.1: Stansted Airport daytime noise contours

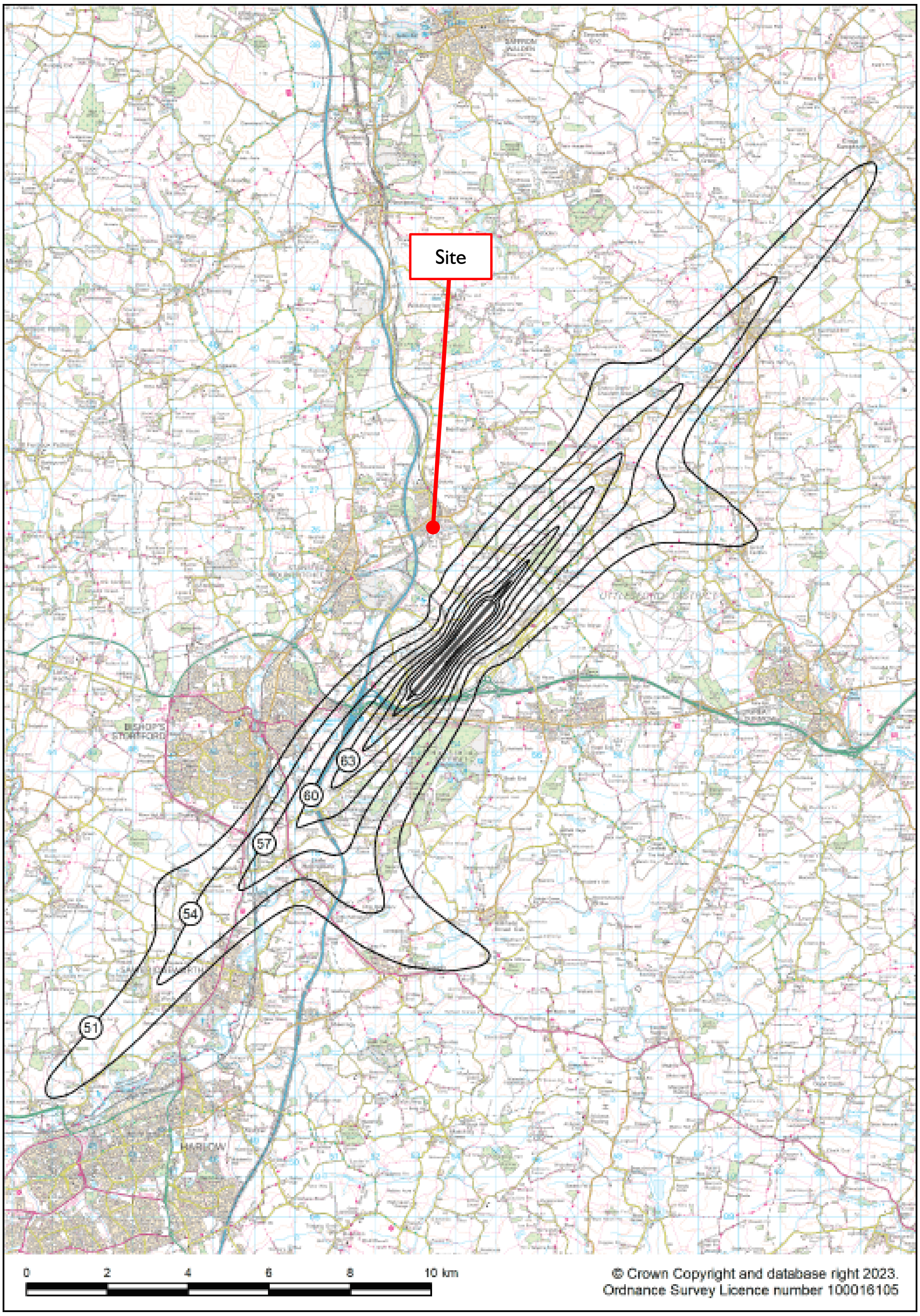


Figure F.2: Stansted Airport night-time noise contours

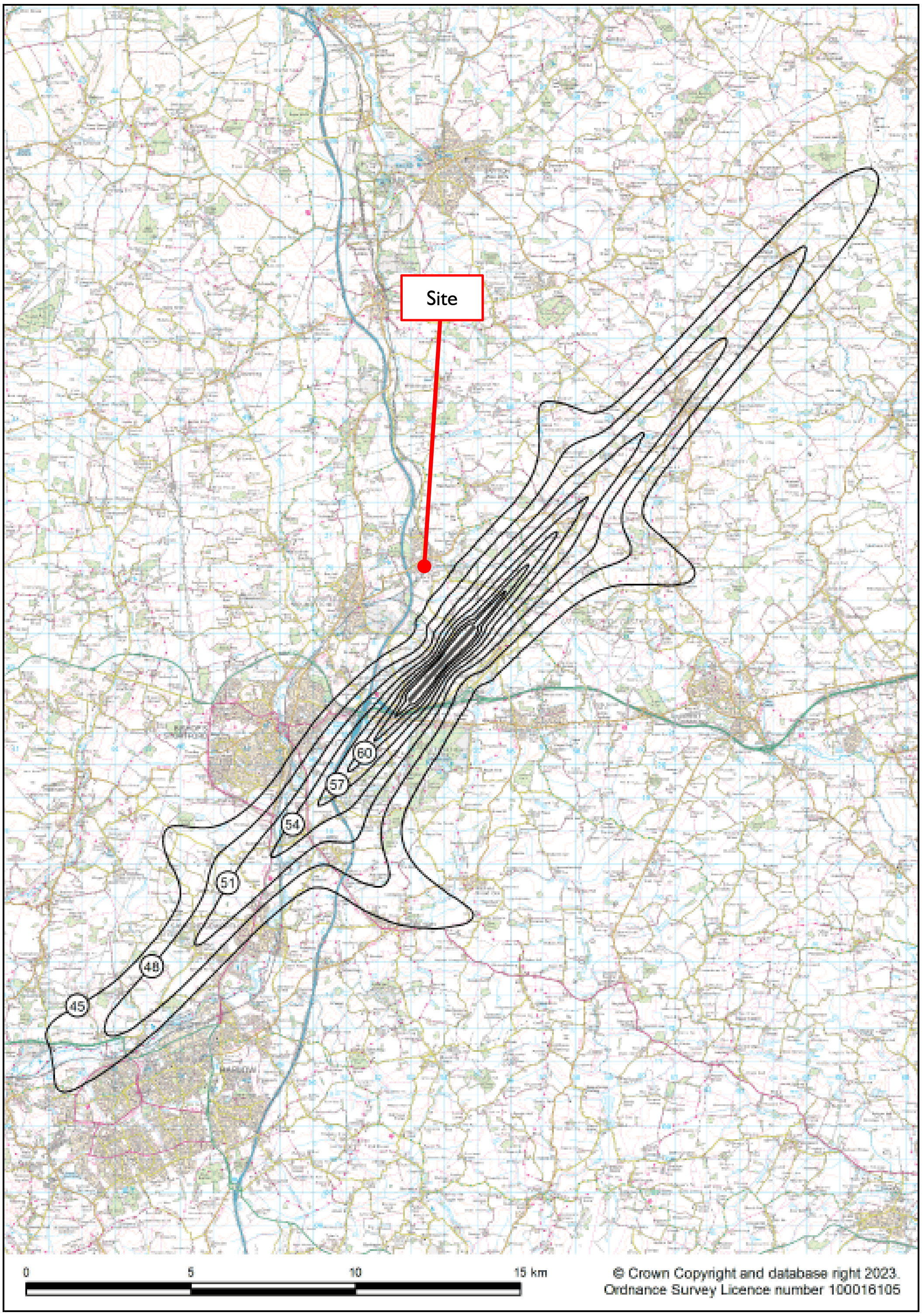


Figure F.3: Open site calculated sound contours - daytime

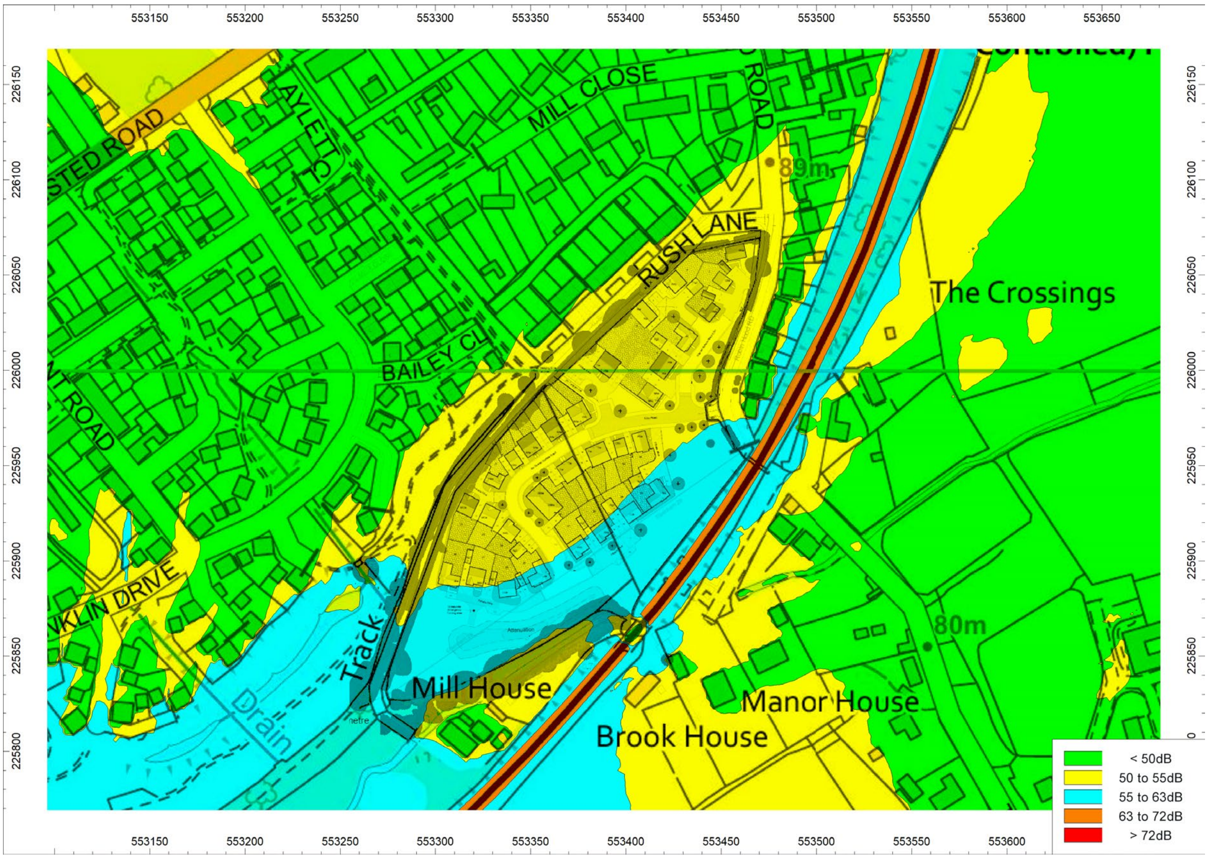


Figure F.4: Open site calculated sound contours – night-time

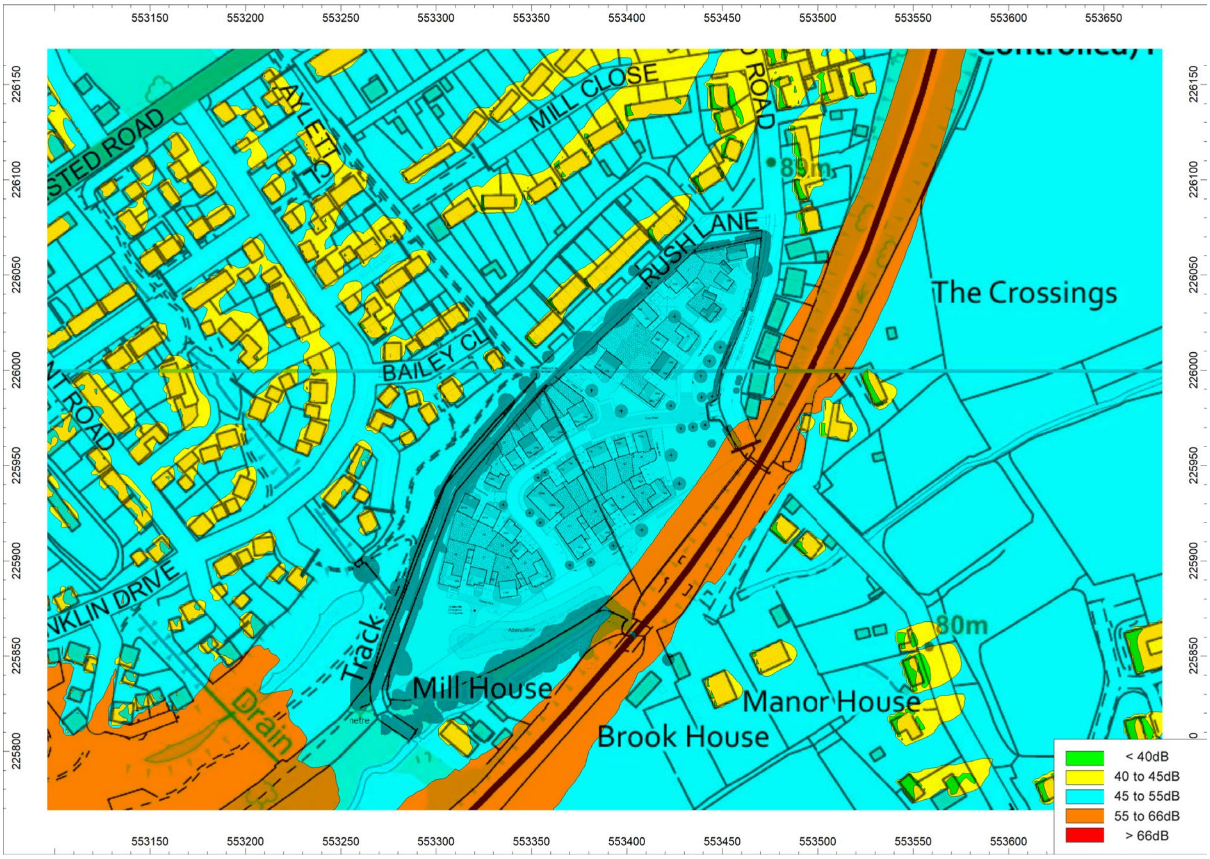
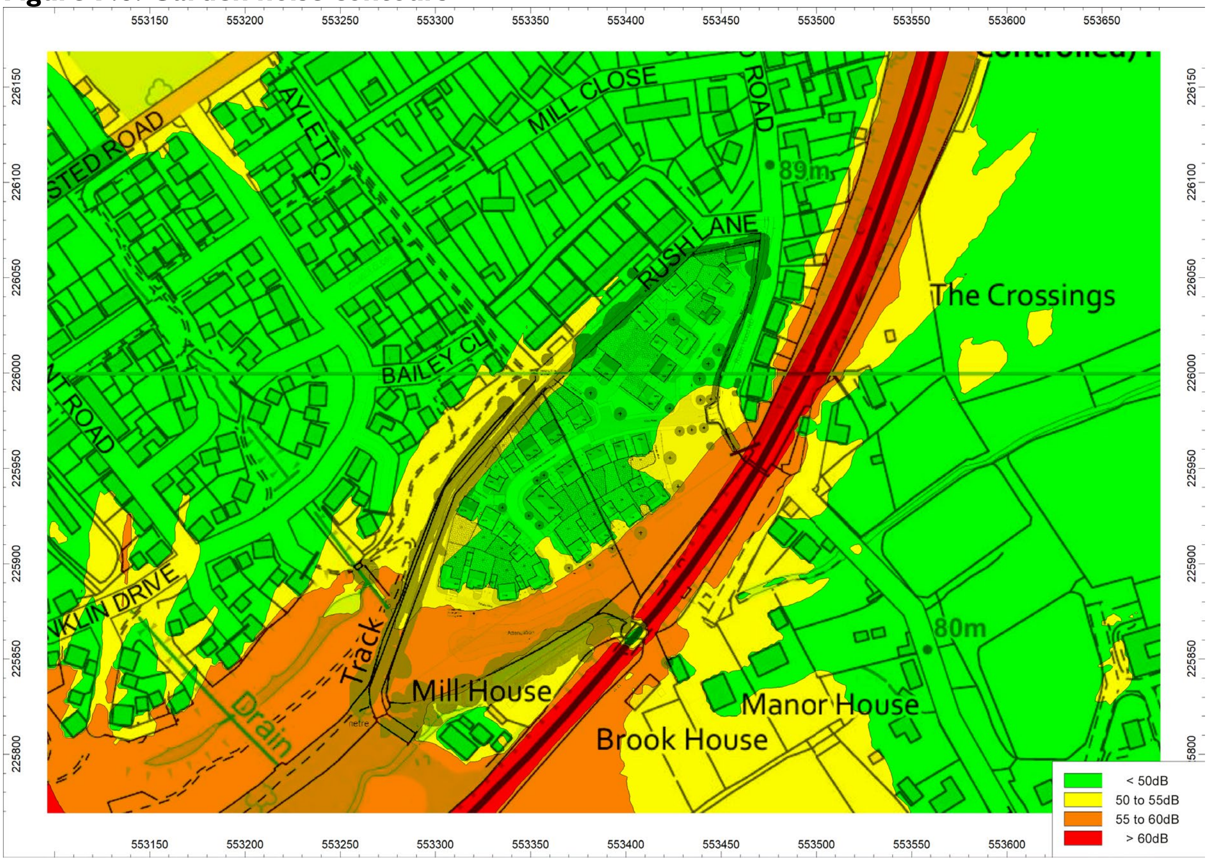


Figure F.5: Glazing assessment locations

Figure F.6: Garden noise contours



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