Institute of Environmental Management & Assessment

GUIDELINES FOR ENVIRONMENTAL NOISE IMPACT ASSESSMENT

VERSION 1.2 (NOVEMBER 2014)

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Foreword

It gives me great pleasure to welcome you to these Guidelines on Noise Impact Assessment. As many readers will know, these have taken a very long time to come to fruition. But they are published now and I would like to congratulate Graham Parry, Martin Broderick and the team of reviewers who have finally completed the task over the last few years.

Today these guidelines now provide a valuable new resource to assist in the assessment of the impact of potential new noise sources. In particular, the guidelines include advice on the various factors that should be considered, as well as information about the many facets of a noise assessment. The content of these guidelines apply equally to formal assessments required under legislation, such as the Town and Country Planning (Environmental Impact Assessment) Regulations 2011, as to noise assessments needed to support a routine planning application.

It is being increasingly recognised that no form of acoustic assessment can be reduced to just collecting a range of data, inserting them into a few algorithms and waiting for the answer to be provided (what some describe as the 'black box' approach). Instead, the outcome regarding the extent of the impact should take properly into account the various issues described in these guidelines, some of which will rely on judgement. Crucially, the assessor must be clear over how those judgements are made and to justify the decisions reached.

Over the years some of the concepts presented here have been anticipated in conference papers. It is noteworthy that some of these concepts can already be found in government policy documents including the Scottish government's Technical Advice Note: Assessment of Noise (published in 2011) and the English Planning Practice Guidance on noise published earlier this year.

Noise is an inevitable consequence of our mature and vibrant society – yet we know that noise can adversely affect health and quality of life. These guidelines will assist with the assessment of noise from new sources, and further enable the impacts to be properly understood and appropriately managed.

I commend these guidelines to you.

Stephen Turner, HonFIOA
Former chair of the IOA Environmental Noise Group
Former chair of the Noise Impact Assessment Guidelines Working Group

Due to an omission of the word 'rarely' in Section 7, Paragraph 7.11 of the original Guidelines for Environmental Noise Impact Assessment (October 2014) IEMA have issued Version 1.2 (November 2014)

Acknowledgements

The development of these guidelines is the culmination of many years of voluntary participation from a wide range of acoustic and impact assessment professionals. The original project to develop what has become this document began in the early 1990s, with an aim to produce guidance to advance the practice of environmental noise impact assessment. While practice has clearly advanced over this period, the same core aim has remained and been used to direct the finalisation process initiated by the Institute of Environmental Management & Assessment (IEMA).

Given the timescale for development, a wide range of thanks and acknowledgements are required for those who started the process, helped during the middle decade and those, new to the project and old hands, who brought it to completion. IEMA's thanks are offered to all parties who contributed to the document, from the most recent inputs to early contributory groups; in particular, the Institute recognises the earlier contributions of the Institute of Acoustics (IOA), which was previously a partner in the project.

Special praise and thanks go to both Stephen Turner and Graham Parry: without their immense contributions, time and effort over the years these guidelines would not have been produced.

OUR THANKS TO:

2013-14 Project Team

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2011 IOA Review Panel In 2011 an IOA review was undertaken by Colin English (Acoustic Consultant) and Bernadette McKell (AECOM) whose useful comments were used to help frame the finalisation of these Guidelines.

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We also acknowledge the contribution made by Barry Hankey of Caerphilly Council, during its initial meetings; the committee of the Environmental Noise Group of the IOA, and; Colin Grimwood (formerly with Bureau Veritas) during part of the process of preparing these guidelines.

The guidelines are variously the independent views of the principal writers, and the members of the steering group and the working party. The 2013-14 project team are indebted to all of those people who have been involved in contributing to the evolution of this guidance.

1. Now with the Department for Environment, Food and Rural Affairs.

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1.0 Introduction

1.1 Most new developments, regardless of their scale, will generate noise which has the potential to affect people in terms of their health and quality of life, their property, locations valued for their tranquillity or soundscape, historic buildings and wildlife. There is currently no specific guidance on how to undertake a noise impact assessment, and, although standards and guidance about noise are available [2,3], they have not been specifically developed to assist with the process of undertaking a noise impact assessment. The guidelines presented here are intended to fill that gap and to set current good practice standards for the scope, content and methodology of noise impact assessments, in order to facilitate greater transparency and consistency between assessments.

PURPOSE OF THE GUIDELINES

1.2 These guidelines address the key principles of noise impact assessment and are applicable to all development proposals where noise effects are likely to occur. The guidelines provide specific support on how noise impact assessment fits within the Environmental Impact Assessment (EIA) process. They cover:

- how to scope a noise assessment;
- issues to be considered when defining the baseline noise environment;
- prediction of changes in noise levels as a result of implementing development proposals; and
- definition and evaluation of the significance of the effect of changes in noise levels (for use only where the assessment is undertaken within an EIA).

1.3 The guidelines are intended for a wide audience, including:

- professionals who work in the field of acoustics and noise control;
- regulators, including environmental health officers, planners and others within local government and the various government agencies (e.g. PINS) responsible for reviewing noise impact assessments, whether they form part of planning applications or EIA.
- developers and those responsible for contributing to and managing projects, such as architects, planners and engineers, that require a noise impact assessment;
- politicians, amenity societies and other interested parties who are interested in the outcome of noise impact assessments; and
- academics and students of noise impact assessment, planning and EIA.

1.4 The guidelines define core methods and techniques, used within the noise impact assessment process, and endeavour to highlight their limitations, where relevant. They can be applicable to all stages of a project, from construction through operation to restoration and decommissioning. The principles in the guidelines are relevant to all types of project, regardless of size:

- small developments which are not screened as EIA development (even small developments can have the potential to cause potentially substantive local noise effects);
- EIA developments which are captured under the EIA Regulations 2011[4]
- Nationally Significant Infrastructure Projects (NSIP) captured under the Infrastructure Planning (EIA) Regulations 2009[5]; and
- Other major infrastructure subject to Parliamentary Hybrid Bills, Transport and Works Act, EIA Decommissioning Regulations (EIADR), etc.

2. P. Morris & R. Therivel (2009) Chapter 4 Noise, pg 73-82, Methods of EIA. 3rd Edition 3. B Carroll & T Turpin (2009) Chapter 3 Noise and Vibration, pg 52-60, Environmental Impact Assessment Handbook. 2nd Edition. 4. Town and Country Planning (EIA) Regulations, 2011 SI No. 1824; Town and Country Planning (EIA) Regulations Scotland, 2011. 5. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2009 as amended by the Infrastructure Planning (Environmental Impact Assessment) (Amendment) Regulations 2012 and the Consequential Amendments Regulations 2012 (Came into force 1 October 2009) SI No.2263.

1.5 The guidelines are applicable in all parts of the UK and EU, subject to the caveat that the nuances of the devolved administrations and other EU member countries, legislation, regulations, policy and advice, need to be factored in by practitioners in applying the guidance. However, while this document is not an 'approved' code of practice under Section 71 of the Control of Pollution Act 1974, it does provide examples of what can constitute good practice with regards to noise impact assessment. Compliance with these guidelines does not necessarily confer statutory immunity or provide a defence against legal action, or confirm compliance with legal duties. Conversely, variation from these guidelines does not confirm non-compliance with legal duties. It remains the responsibility of developers to make their own arrangements in compliance with their legal duties; and they are strongly advised to seek technical noise and vibration advice from suitably qualified specialists within the context of the circumstances of any individual development proposal.

1.6 It is important that the reader understands that policy and legislation may change over time, and it will always be good practice to ensure that the most up-to-date information is utilised in any form of noise impact assessment. This responsibility lies with the acoustic or noise professional(s) leading a specific noise impact assessment. It also should be noted that precise guidance on the degree of significance of the noise impact is not given in these guidelines. The nature of the effects of noise means that no two situations will be the same. These guidelines present current good practice methods and procedures to assist in determining the degree of significance of the potential noise impact from a proposal.

1.7 The guidelines are not intended to address the issues of occupational noise.

NOISE AND THE UK PLANNING SYSTEM

1.8 In the UK, planning and noise impact assessment takes place within a complex land use planning decision - making process. Planning attempts to mediate between conflicting interests in the use and development of land. UK planning is a complex system which is presently defined by:

- Legislation:

  - (TCPA 1990, Planning Act 2008, Localism Act 2011, Transport and Works Act 1992, Scotland[6], Wales[7], Northern Ireland[8]);

- Regulation and Orders:

  - (EIA Regulations, 2011, Infrastructure Planning EIA Regulations 2009, , EIA, Scotland Regulations, 2011.etc.);

- judicial and appeal precedence; and
- National policy and advice:

  - (NPPF, NPS and Planning Practice Guidance[9], NPF, PPW, SPSS).

  - Local policy and advice

1.9 The National Planning Policy Framework (NPPF) sets out the government's planning policies for England and how these are expected to be applied[10]. It sets out the government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.

1.10 In Scotland, the National Planning Framework (NPF[11]) sets the context for development planning in Scotland and provides a framework for the spatial development of Scotland as a whole. It sets out the Scottish Government's development priorities over the next 20-30 years and identifies national developments which support the development strategy. On March 18, 2014, the Scottish Parliament debated the committee reports and agreed that they, plus the Official Report of the debate, should form the Parliament's response to Proposed NPF3. Scottish Planning Policy is Scottish Government policy on how nationally important land use planning matters should be addressed across the country. It carries significant weight in the preparation of development plans and is a material consideration in planning decisions[12].

6. The Planning etc. (Scotland) Act 2006, the Town and Country Planning (Development Planning) (Scotland) Regulations 2008 and the Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008.
7. TCPA, 1990 8. 2011/C.25. Planning Act (Northern Ireland) 2011. 9. Planning Practice Guidance Noise 6 March 2014.
10. National Planning Policy Framework 27 March 2012 DCLG. 11. Scotlands Third National Planning Framework - Proposed Framework January 2014.
11. Scotlands Third National Planning Framework - Proposed Framework January 2014. 12. Scottish Planning Policy, A statement of the Scottish Government's policy on nationally important land use planning matters 2010.

1.11 In Wales, Planning Policy Wales (PPW)[13] sets out the land use planning policies of the Welsh Government. It is supplemented by a series of Technical Advice Notes (TANs, listed in the Annex). Procedural advice is given in circulars and policy clarification letters.

1.12 In Northern Ireland the draft Strategic Planning Policy Statement (SPPS)[14] sets out the government's regional planning policies for securing the orderly and consistent development of land in Northern Ireland under a reformed two-tier planning system.

1.13 Planning law requires that applications for planning permission must be determined in accordance with the development plan, unless material considerations indicate otherwise. The NPPF/NPF/PPW are material consideration in planning decisions. Planning policies and decisions must reflect, and where appropriate promote, relevant EU obligations and statutory requirements.

1.14 On 6 March 2014 the previous planning guidance documents in England were replaced by the new Planning Practice Guidance. The guidance supports the National Planning Policy Framework and provides useful clarity on the practical application of policy.

1.15 The NPPF/NPF/PPW/SPSS do not contain specific policies for nationally significant infrastructure projects for which particular considerations apply. These are determined in England and Wales in accordance with the decision-making framework set out in the Planning Act 2008 and relevant national policy statements for major infrastructure, as well as any other matters that are considered both important and relevant (which may include the National Planning Policy Framework). National policy statements form part of the overall framework of national planning policy, and are a material consideration in decisions on planning applications.

1.16 Noise impact assessment is addressed in England as follows:

I. The National Planning Policy Framework (NPPF)[15] states the following:

The planning system should contribute to and enhance the natural and local environment by:

- preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability; … Planning policies and decisions should aim to:

- avoid noise from giving rise to significant adverse impacts[16] on health and quality of life as a result of new development;

- mitigate and reduce to a minimum other adverse impacts[17] on health and quality of life arising from noise from new development, including through the use of conditions;

- recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established[18]; and

- identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

II. The National Policy Statement, NPS EN-1[19] states:

"Excessive noise can have wide-ranging impacts on the quality of human life, health (for example owing to annoyance or sleep disturbance) and use and enjoyment of areas of value such as quiet places and areas with high landscape quality. The Government's policy on noise is set out in the Noise Policy Statement for England[20] "

Noise resulting from a proposed development also can have adverse impacts on wildlife and biodiversity.

It promotes good health and good quality of life through effective noise management. Similar considerations apply to vibration, which also can cause damage to buildings. In this Chapter, in line with current legislation, references to "noise" below apply equally to assessment of impacts of vibration.

III. Planning Practice Guidance[21] states:

Noise needs to be considered when new developments may create additional noise and when new developments would be sensitive to the prevailing acoustic environment… neither the Noise Policy Statement for England[22] nor the National Planning Policy Framework (which reflects the Noise Policy Statement) expects noise to be considered in isolation, separately from the economic, social and other environmental dimensions of proposed development.

13. Planning Policy Wales, 6 Edition, February 2014. 14. Draft Strategic Planning Policy Statement For Northern Ireland (SPPS), February 2014. 15. NPPF, 2012.
16. Explanatory Note to the Noise Policy Statement for England (Department for the Environment, Food and Rural Affairs). 17. Ibid. 18. Subject to the provisions of the Environmental Protection Act 1990 and other relevant law.
19. Overarching National Policy Statement Energy EN-1 July 2011; the other NPSs provide similar noise policy advice in regard to the types of development they cover.
20. Noise Policy Statement for England. DEFRA March 2010. 21. Planning Practice Guidance DCLG 6 March 2014. 22. Ibid.

NOISE POLICY STATEMENT FOR ENGLAND

1.17 In March 2010, the Noise Policy Statement for England (NPSE) was published. Its stated aim is to:

"provide clarity regarding current policies and practices to enable noise management decisions to be made within the wider context."

1.18 It describes a Noise Policy Vision and three Noise Policy Aims, and states that these vision and aims provide:

"the necessary clarity and direction to enable decisions to be made regarding what is an acceptable noise burden to place on society."

1.19 The policy statement includes phrases that are similar to those found in these guidelines. However, some care is needed, because although the words may be the same or very similar, the meaning is not necessarily identical. In relation to these guidelines, the NPSE does provide some assistance in two areas:

1. when making the judgement about the size of the noise impact of a proposal; and

2. for the decision maker, whether or not the noise impact is an acceptable burden to bear in order to receive the economic and other benefits of the proposal.

NOISE POLICY ADVICE ELSEWHERE IN THE UNITED KINGDOM

1.20 The devolved administrations within the United Kingdom variously have their own noise policy and guidance documents.

- **Scotland:** Planning Advice Note PAN1/2011 'Planning and Noise' provides specific advice in respect of the role of the planning system in helping to prevent and limit the adverse effects of noise. The Scottish Government has developed its own advice in respect of noise: ' Advice Note – Technical Assessment of Noise, which also includes a number of calculation tools to assist in carrying out the assessment of the noise impacts of a range of development schemes which includes roads and industrial projects.

- **Wales:** Technical Advice Note (TAN) 11: Noise (1997) provides advice on how the planning system can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development.

- **Northern Ireland:** There is no explicit technical advice document for noise.

1.21 It is important to understand that while policy may dictate the level of detail required in a noise impact assessment, the principles described in these guidelines are independent of policy. It is the role of the acoustics professional to relate the outcomes of the assessment to the policy context, which is generally undertaken during the later stages of the process.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

1.22 Noise impact assessment needs to be viewed within the context of the UK planning system and UK Environmental Impact Assessment (EIA) Regulations which implement the EU EIA Directive (2011/92/EU).

1.23 Environmental Impact Assessment (EIA) is an assessment process applied to both new development proposals and changes or extensions to existing developments that are likely to have significant effects on the environment. The EIA process ensures that potential effects on the environment are considered, including noise. EIA provides a mechanism by which the interaction of environmental effects resulting from development can be predicted, allowing them to be avoided or reduced through iterative design and the development of mitigation measures. As such, it is a critical part of the planning and decision-making process. The EIA Directive (2011/92/EU) forms the basis of UK EIA practice and was amended in May 2014 (2014/52/EU); however, these amendments are unlikely to be transposed into the UK's EIA Regulations before spring 2017.

1.24 All proposals for projects that are subject to the European Environmental Impact Assessment (EIA) Directive (2011/92/EU) as amended, must be accompanied by an Environmental Statement (ES). The Directive specifically refers to effects on human beings, fauna and flora, soil, water, air, climate, the landscape/seascape, material assets and cultural heritage, and the interaction between them. Assessment of the likely significant effects of the proposed project on the environment should cover effects related to any stage of the project that are:

- direct
- indirect, secondary, cumulative
- short, medium and long-term
- permanent and temporary
- positive and negative.

1.25 The assessment should also set out the measures envisaged for avoiding or mitigating significant adverse effects. Developers must ensure they consider both intra-project and inter-project cumulative effects. IEMA's 2011 report – The State of EIA Practice in the UK – found that 92% of a representative sample of 100 UK, Environmental Statements submitted during 2010 included a noise impact assessment. Therefore noise is an important environmental effect because:

- there are few developments which do not generate noise either during operation, construction or decommissioning; and

- most developments in the UK tend to be located close to receptors which are sensitive to noise, i.e. human beings.

1.26 In the UK, EIA has been implemented through secondary legislation, in the form of Regulations that link into a number of existing development consent regimes; with nearly two - thirds of all EIA undertaken in relation to applications for planning permission. As the EIA Regulations are mainly procedural, a failure to comply with the process can leave a development open to challenge through the courts.

1.27 The effects of noise on humans are usually the predominant consideration in assessing noise impacts, but noise can be an important contributor to other environmental effects acting either directly, indirectly or in combination. For example:

- noise may disturb wildlife – the effects on sensitive bird species or populations can be of particular concern;

- the level and type of noise can have a potentially significant effect on the character of a landscape or the setting of buildings and other features of historical interest; and

- air overpressure, e.g. from blasting activities, can cause structural damage.

STRUCTURE OF THE GUIDELINES

1.28 The guidelines commence with a description of some fundamental principles of noise (Chapter 2), explaining the objective and subjective nature of the discipline and examining the relationship between these two areas. The derivation of noise standards from social surveys and laboratory tests is outlined, together with an indication of the limitations of the available evidence as it applies to a noise impact assessment.

1.29 The main steps of a noise impact assessment are then considered (Chapters 4–9). These are scoping: baseline studies; noise prediction; assessment; mitigation and reporting.

1.30 The assessment of vibration also could be a requirement for a development project, and this work is often carried out by the specialist conducting the noise impact assessment. Furthermore, in some legislation noise is defined as including vibration. However, these guidelines only address the topic of airborne noise, although some of the principles outlined here can be applied to both groundborne noise and vibration assessments. Further guidance in respect of vibration can be found in the Association of Noise Consultants Guidelines: 'Measurement and Assessment of Groundborne Noise and Vibration'.

1.31 It is important to understand that the guidelines do not seek to be prescriptive as to how a noise impact assessment should be carried out. The intention is to provide sufficient guidance to assist acousticians in carrying out noise impact assessments which are both proportionate and fit for purpose. The guidelines should also allow other professionals and decision makers to understand the processes utilised in noise impact assessments. In this respect any noise impact assessment, whether for an Environmental Impact Assessment or smaller development project, will include elements of scoping, baseline studies, noise prediction, assessment, mitigation and reporting to a greater or lesser degree.

2.0 Noise

INTRODUCTION

2.1 Noise in the environment can affect human beings and other sensitive receptors (e.g. wildlife). At one extreme, noise can be loud enough to feel physically uncomfortable (e.g. in a very noisy night club), and, if persistent enough, can lead to some deterioration in auditory health (e.g. noise-induced hearing loss[23]). At the other extreme, noise may be only just perceptible, yet intensely annoying: e.g. the throb of a distant generator. In between, conversation can be disrupted (e.g. during an aircraft flyover), and at night, if there is too much noise, sleeping can be adversely affected. Besides sleep disturbance, other health effects related to noise can emerge, and there is on-going research into these effects. Therefore, noise must be considered, whether in determining the design and layout of new developments: or deciding where a new noise making development should be located; and this means that the designers need the effect of noise on sensitive receptors to be quantified and assessed.

2.2 When approaching noise measurement, the various features of the noise that are likely to affect the subjective reaction must be considered. These include:

- the type of noise: for example, is it continuous at a constant level, or continuous but fluctuating in level, or is it intermittent?;
- the frequency content of the noise: is it broad band, or is there a prominent frequency (that is, a tonal quality); and
- the time of day and/or day of the week it occurs.

2.3 Ideally, to be of practical use, any method of description, measurement and assessment of environmental noise should be related to what is known about human beings and other sensitive receptors response to noise. Many adverse consequences of environmental noise increase with increasing noise level, but the precise exposure–response relationships involved continue to be the subject of scientific research. In addition, it is important that all methods used should be practicable within the social, economic and political climate in which they exist. For these reasons, there is a large range of different indicators and methods of assessment currently in use.

PHYSICAL SOUND INDICATORS

2.4 Sound is energy propagated through the air (and other materials) via pressure fluctuations. These pressure fluctuations can be detected by the ear and microphones. A sound level meter uses the electrical output from a microphone to measure the magnitude of sound pressure fluctuations as a sound pressure level.

2.5 The human ear can detect a very broad range of sound pressure levels that is far too large to be described conveniently in simple pressure units. It is also found that the hearing mechanism responds to changes in pressure on a logarithmic scale. For these reasons, sound is usually measured on a logarithmic scale using decibels. The decibel is not an absolute measure but a ratio (comparison) between a measured quantity and a reference level.

2.6 For sound pressure level, the reference pressure is 20 μPa[24], which is generally accepted as approximating to the threshold of hearing at 1kHz[25]. Sound Pressure Level is measured in decibels (dB) and is defined as 10 times the logarithm (to the base ten) of the ratio of the sound pressure squared to the reference sound pressure squared.

2.7 Measuring in decibels means that a 3 dB increase is equivalent to a doubling of the sound energy, and a 10 dB increase is a tenfold increase in energy. For broad band sounds which are very similar in all but magnitude, a change or difference in noise level of 1 dB is just perceptible under laboratory conditions, 3 dB is perceptible under most normal conditions, and a 10 dB increase generally appears to be twice as loud. These broad principles may not apply where the change in noise level is due to the introduction of a noise with different frequency and/or temporal characteristics compared to sounds making up the existing noise climate. In which case, changes of less than 1 dB may be perceptible under some circumstances.

23. Exposure only to environmental noise is unlikely to lead to noise-induced hearing loss.
24. μPa means micro-pascal. Pascal is the international unit for pressure, and one micro pascal equals 0.000001Pa.
25. kHz is kilohertz. Hertz is the international unit of frequency and is identical to 'cycles per second'. One kilohertz equals 1000 Hz.

2.8 A healthy human ear is also sensitive to a large range of frequencies (approximately 20 Hz to 20,000 Hz[26]), and varies in sensitivity depending on the frequency. This important frequency effect is often reflected in noise measurement by means of an electronic filter incorporated into the sound level meter. The filter most commonly used in environmental noise measurement is the "A weighting", which aims to reflect the frequency response of the ear[27].

2.9 A measurement using this weighting is termed the A-weighted sound pressure level (or A-weighted sound level). Results are expressed as dB(A) to make it clear that the A-weighting filter has been used during the measurement. Some British and International standards (e.g. BS4142) require the use of "A-weighting" to be indicated as part of the subscript of the measurement indicator - (for an example, see paragraph 2.12)

2.10 Sounds rarely remain constant in level over a period of time and the frequency content may also change with time. These changes may occur in some predictable pattern or may be completely random. Much noise measurement and quantification is concerned with the effect of noise which varies significantly with time, e.g. the sound heard as an aircraft or vehicle passes. When considering environmental noise, it is necessary to consider how to quantify the existing noise environment to account for these moment-to-moment variations. Consequently, the science of acoustics has developed a range of noise metrics that provide a more readily-understood, single-figure description of a complex rapidly varying noise climate over a defined time period. When considering changes in the level of a noise metric due to the introduction of a new noise source or the duration or number of existing noise events, the general descriptions of perceptibility as described in paragraph 2.7 above may not be applicable, and the matters described later in this guidance will need to be considered.

2.11 There is a choice of standardised time weightings that can be used to measure the sound pressure level, depending on the characteristics of the noise. These include:

• "S" weighting which has high damping, giving a slow display movement, and has an effective averaging time of approximately 1 second. It is most appropriately used for noise which is fairly constant or varies only slowly.

• "F" weighting has low damping giving a more rapid display movement and has an effective averaging time of approximately 0.125 second. This weighting will follow most fluctuating noise levels and is, in most cases, the closest to human perception.

• "I" weighting has a very fast rising time constant that results in the display responding very quickly to a sound level increase. It also has a very slow falling time constant so the display responds more slowly to a sound level decrease. Normally, this weighting is only used for specific sound sources such as gunfire.

2.12 It will often be of interest to measure the maximum sound level during an event or measurement period. What is actually recorded is the maximum average level reflecting the time weighting employed. Therefore, it is important to note whether the time weighting is F or S, and to describe the maximum value as $L_{max,F}$ or $L_{max,S}$ as appropriate. If the sound being measured is also A-weighted, the maximum value is denoted as $L_{Amax,F}$ or $L_{Amax,S}$.

2.13 On some sound level meters, the time weighting "P" is available. This denotes the Peak value of the fluctuating sound pressure as opposed to the maximum average sound level (L_{max}). The 'P' time weighting is used mainly in connection with occupational noise assessment and only features in environmental noise assessment in particular circumstances, (e.g. in the evaluation of air overpressure arising from blasting).

26. The ability to detect frequencies at the upper end of this range reduces with age.
27. This weighting was originally devised to account for the ear's differing sensitivity to sound over the audible frequency range for low noise levels. However, it is now widely used when measuring sound at all levels of magnitude.

2.14 As indicated above, many units and indicators have been developed for the purposes of characterising one or more attributes of environmental sound. Some indicators in common use include:

$L_{Amax,F}$/ $L_{Amax,S}$ The A weighted maximum sound pressure level during the event or measurement period

$L_{A10,T}$ The A weighted sound pressure level exceeded for 10% of the measurement period, T. This indicator provides a measure of the higher sound pressure levels that occur during the measurement period. In particular, it is used when assessing certain aspects of road traffic noise.

$L_{Aeq,T}$ The equivalent continuous A weighted sound pressure level which contains the same sound energy in the period, T, as the actual (usually varying) sound over the same time period. This indicator describes the average sound energy, but with a bias towards the noisier events that occur during the measurement period. For sources that comprise identical specific events, the $L_{Aeq,T}$ will increase by 3 dB(A) if:

- the source level increases by 3 dB(A); or
- the number of events double; or
- if the duration of each event doubles in length.

$L_{Aeq,T}$ is often used in many areas of environmental noise assessment.

$L_{A90,T}$ The A weighted sound pressure level exceeded for 90% of the measurement period, T. This indicator provides a measure of the lower sound pressure levels that occur during the measurement period. It is sometimes defined as the background noise level.

More details and other indicators can be found in standard acoustic textbooks (e.g. Acoustics and Noise Control, Peters, Smith & Hollins, Third Edition, 2011).

2.15 In addition, the following terminology is used in this guidance:

• *Ambient (total) noise* includes all sounds occurring at a particular location, irrespective of the source. It is the sound that is measured by a sound level meter in the absence of a dominant specific noise source[28].

• *Specific noise* is the noise generated by a specific source. It is one component of the ambient noise. A sound level meter will effectively measure the specific noise if the specific noise sufficiently dominates the ambient noise level.

• *Residual noise* is the remaining noise when the specific noise is subtracted from the ambient noise.

At any particular location, all these different noise descriptors can be measured by any of the indicators given in paragraph 2.14, either singly or in combination, although specific indicators are used in some standards.

2.16 When assessing noise it is important to consider what sensitive receptors hear. The magnitude of a sound is not the only important feature to consider; the sound's character, quality and information content can also play a key role in its effects on individuals. Simple and limited objective indicators for tonal features and impulsive features exist, but further work is continuing into developing more sophisticated indicators.

28. In some documents the word 'ambient' is used generically and, in the context of those documents, can refer to a limited number of sources.

THE EFFECTS OF NOISE

2.17 Many different effects of noise have been identified and sensitive receptors[29] experience each of them to different degrees. Although there is no standard classification of effects, they can be divided into:

- behavioural indicators of well-being showing how noise may interfere with normal living; and
- physiological/medical indicators of chronic health effects, such as noise-induced hearing loss or other similar symptoms that may be caused by noise.

2.18 There is a complex web of cause–effect relationships. These can be simplified by breaking them down into different stages to aid explanation. One approach[30] that has been previously adopted is shown in Figure 2-1.

2.19 In the model shown above the first level of behavioural reaction, noise disturbs human activity, by causing distraction or by physically interfering with it. Grouped together under the general heading of disturbance, these effects can be classified as:

- detection/distraction;
- speech interference;
- disruption of work/mental activity, and
- sleep disturbance.

2.20 The second level of behavioural reaction, sometimes viewed as an indirect response to disturbance of different kinds, is:

- annoyance.

2.21 A third level response is:

- overt reaction, including complaints.

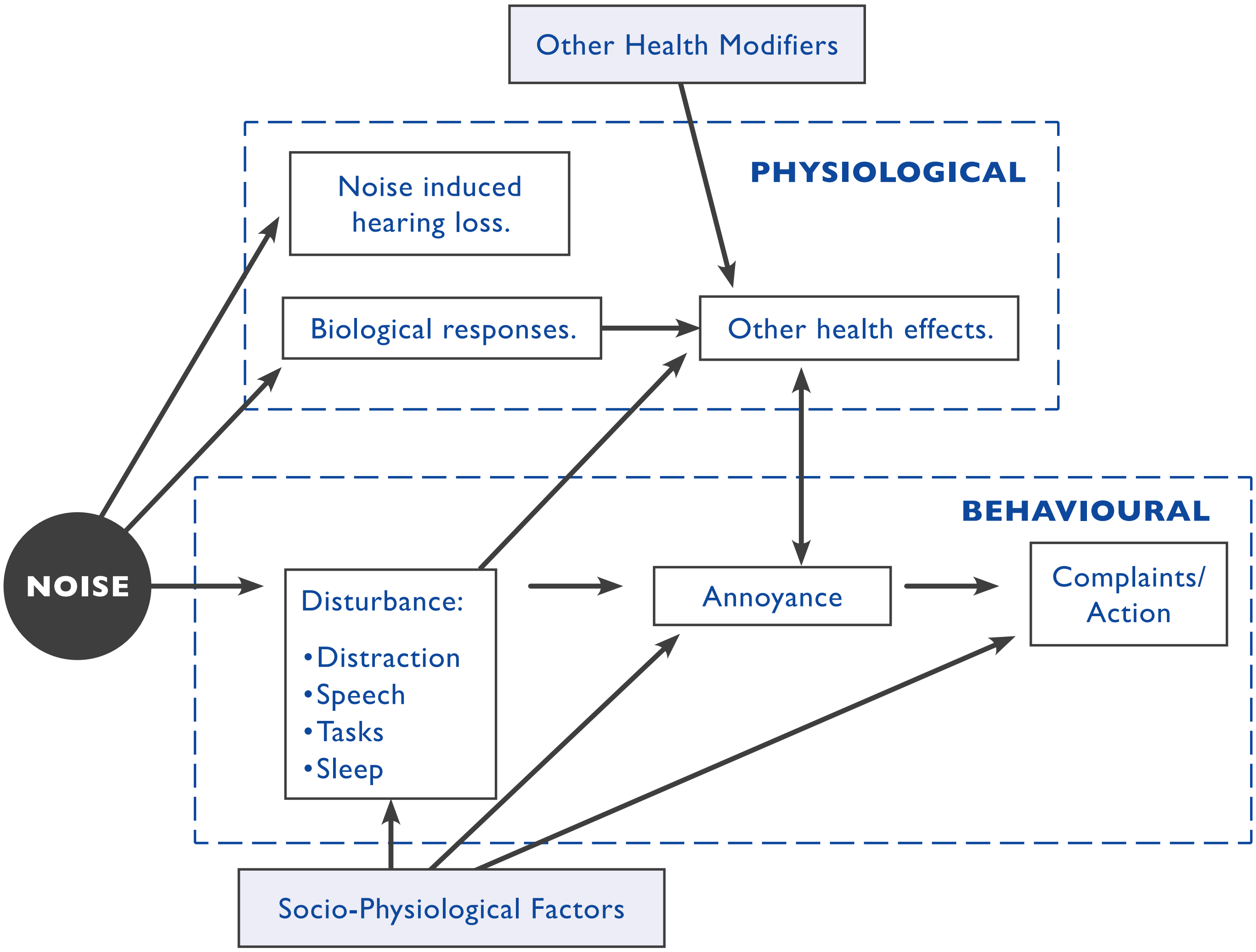
2.22 Two physiological effects are shown:

- auditory health effects (e.g. noise-induced hearing loss), and
- non-auditory health effects (e.g. stress and other health effects).

2.23 The issue of auditory effects is widely recognised and well-documented. The nature of non-auditory effects is much less certain; it is known that noise can cause a variety of biological reflexes and responses referred to as stress reactions. There is emerging evidence of a link between long-term exposure to environmental noise and an increased risk of heart attacks[31]. The possibility that severe annoyance might itself induce stress is shown as a link between the two effects branches in Figure 2-1[32].

29. Effects in human beings are understood much better than those in wildlife.
30. This approach is taken from a model developed by John Ollerhead and is described in paragraphs 2.19 to 2.27.
31. W.Babisch, Updated exposure–response relationship between road traffic noise and coronary heart diseases: A meta-analysis; Noise & Health, 2014, Volume 16, Issue 68, Pages 1–9
32. Further information about the effects of noise on health can be found in the European Environment Agency Technical Report No 11/2010: Good Practice Guide on noise exposure and potential health effects (EEA, 2010) and Night Noise Guidelines for Europe, World Health Organization, 2009.

FIGURE 2-1 CAUSE/EFFECT RELATIONSHIP



2.24 Some of the behavioural indicators, including annoyance, are essentially subjective and, although quantifiable, can be very sensitive to non-acoustic socio-psychological factors such as location, activity, state of well-being, familiarity with the noise, environmental expectations and attitudes to the noise makers. In the same way, physiological indicators can be sensitive to health modifiers such as genetics, other stressors and risk factors. The effects of such modifying factors dramatically weaken correlations between noise and response indicators by masking or confounding their dependency on noise. Such relationships are further obscured by variations in noise exposure over time and space, because individuals move around and experience different noise exposures, and engage in activities with different noise sensitivities.

2.25 Obvious physical factors include time and situation, which govern intrusions into activities. For example, for most, sleep disturbance occurs primarily at night and speech interference during the day. Furthermore, the effect of a particular noise (e.g. an aircraft flyover) is dependent on the activity being undertaken. The event is likely to be much more noticeable and potentially intrusive if the individual is reading quietly at the time of the event. Conversely, if the individual is listening to loud music, the aircraft flyover may not even be heard.

2.26 Equally important are those factors which control attitudes and susceptibilities; whether or not a particular noise annoys may depend very much upon the message it carries. Concerns about the sources of noise can influence annoyance reactions more strongly than physical noise exposure itself. Figure 2-1 shows the influence of these modifying factors and how they interact at each level of response, becoming increasingly important by comparison with the noise exposure. Thus the probability of overt reaction, including complaints, is sometimes governed only weakly by the actual noise exposure.

2.27 The extent to which a noise source causes different degrees of effect depends on many factors, but it is commonly assumed that increases in the noise level cause an increase in effects. The effects of noise are not limited to people relaxing at home but also can affect people at work, including the operation of machinery, as well as domestic and wild animals.

2.28 For each type of sensitive receptor it is possible to define an ascending order of noise effects ranging from negligible to physically destructive (see Tables 7-7 and 7-9).

2.29 As noted above, effects are not related to sound levels alone. For example, annoyance may arise as a result of relatively low levels of noise at night, especially if the sources are long-term or permanent, and give rise to perceived difficulties with sleeping. Speech interference also may occur at comparatively low sound levels in some environments.

2.30 At the lower end of the range of effects, a noise source may be noticeable but most people would not regard it as intrusive or disturbing to any material extent. Although behaviour may be modified as a result of the noise, this may occur instinctively, even unconsciously, and the noise becomes accepted as a normal part of the environment. This effect is known as habituation to noise and can account for the short-term and long-term impacts of noise.

2.31 Qualitatively, the next stage in adverse effect is when behaviour or performance is affected to a significant degree. In the case of human beings, this could mean that a conscious adaptation to the interfering noise must be made. The subject begins to consider the noise as an intrusion or an undesired change in living conditions (for example, keeping windows closed to exclude the noise) must be adopted. At a physiological level, sleep disturbance may be expected although not necessarily awakening. In other words, there may be effects on sleep that could be measured by factors such as changes in EEG[33] patterns, but of which the person would not necessarily be aware[34]. Therefore, care must be exercised in ascribing significance to changes at a physiological level that may occur as a result of noise impacts, but which may in fact be part of the normal response, and do not necessarily reflect significant pathological effects.

2.32 Higher levels of effect may be judged to arise when the noise has reached a clearly unacceptable or intolerable level. Typical effects would be high levels of annoyance, direct disruption of activities or regular perceived or actual sleep disturbance.

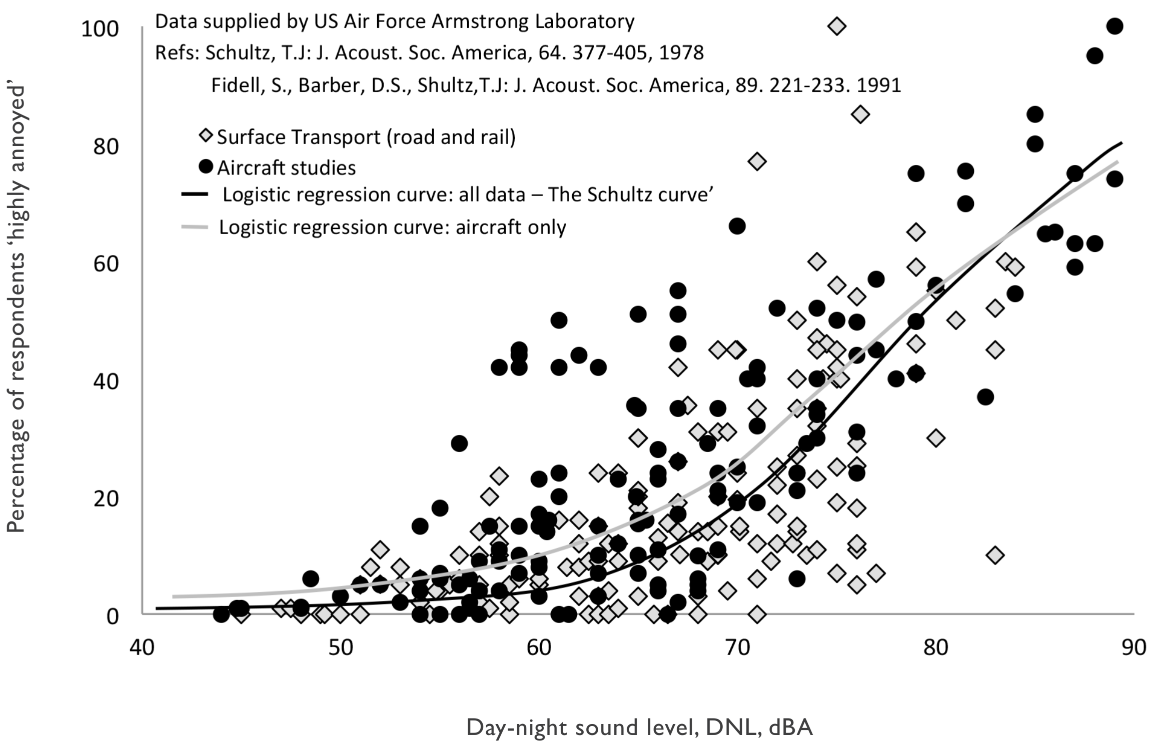
2.33 At the very highest levels of noise actual auditory physical harm may be caused. In humans, this commonly means noise-induced hearing loss. Such situations do not tend to occur solely as a result of being exposed to environmental noise[35].

33. EEG stands for Electroencephalogram. 34. More information on the effects of noise on sleep and sleep patterns can be found in 'Night Noise Guidelines for Europe' published by the World Health Organization (2009).
35. There is also the potential for lengthy and/or frequent exposure to high noise levels in the course of leisure activities to cause permanent hearing damage in the absence of protective measures.

SUBJECTIVE RESPONSE TO NOISE

2.34 Figure 2-2 depicts the response to noise from different sources of transport expressed as the percentage of respondents who described themselves as 'highly annoyed' by the noise[36]. This demonstrates that the response to noise is in some way dependent on an exposure–effect relationship (a dose–response function). Subjective response to noise is extremely complex and shows considerable variability in the response to a given noise exposure, both between and within different exposed populations. More recent research by HME Miedema et al[37] has derived further dose–response relationships for specific sources, although Figure 2-2 remains useful in illustrating the typical spread in population response to noise.

FIGURE 2-2 EXAMPLE OF GENERAL RESPONSE TO NOISE



36. Schultz, T.J. Synthesis of social surveys on noise annoyance, Journal of the Acoustical Society of America, 64(2), August 1978.
37. Miedema HM1, Vos H. Exposure–response relationships for transportation noise. J. Acoust. Soc. Am. 1998 Dec;104(6):3432–45.

2.35 Much research has been conducted on optimising the relationship between objective measures of the physical aspects of sound and the related subjective response. A commonly quoted example is the Schultz curve, which uses questionnaires to relate statistically the noise level to the percentage of population that is highly annoyed. Consequently, these relationships are based on typical, if not average, human response rather than individual responses. On the other hand, the psychophysical quantities characterising the effects of noise on human beings cannot be measured directly. Instead, subjective response to sound is evaluated through controlled listening tests and jury judgements, where the amount of exposure can be controlled and the associated response measured[38].

2.36 Any point on a dose–response curve, such as the one above, represents the typical response, not that of an individual. Furthermore, it can be seen that there is no point at which the noise clearly ceases to be "acceptable or tolerable" and instead becomes "intolerable". It can be seen from Figure 2-2 that there is no step change effect in response to noise, and it will be noted that there is a percentage of the population who remain highly annoyed despite the fact that they are exposed to relatively low noise levels. Thus, any standards that have been set have tended to represent a compromise between reducing the level of annoyance to zero, and economic, social and political constraints.

2.37 It also must be borne in mind that the dose–response curves mentioned above are based on the steady state situation: i.e. they are based on surveys of many people each exposed to different noise levels, rather than people experiencing changes in noise level. There is some published research[39] which indicates that relatively higher levels of disturbance are experienced in the short term immediately after a change in noise has occurred.

2.38 Noise can result in wider health effects associated with disturbance, cardiovascular effects and impairment to the learning capabilities in school children. These issues are considered briefly below and should be considered, if appropriate, in a noise impact assessment.

DISTURBANCE TO SLEEP

2.39 Besides annoyance and disturbance from noise it is important to understand that noise can result in health effects associated with disturbance to sleep. In this respect it is not just actual awakening but also changes to the pattern and quality of sleep that need to be considered.

2.40 Variability in normal sleep patterns, between individuals is high, and the reactions of sleeping humans to noise events are non-specific. In other words, the reactions observed when noise disturbs sleep are also observed during natural sleep undisturbed by external stimuli. Reactions observed during a noise event cannot be differentiated from spontaneous (non-noise-disturbed) reactions using objective measures of sleep disturbance. Consequently, reactions induced by noise are investigated by calculating the probability of a reaction during a noise event compared to the probability of reactions that normally would occur in the absence of noise.

2.41 Where there is an increase in the probability of EEG awakenings over and above those which occur naturally, the increase can be attributed to noise. In this way, it is possible to define the threshold or level at which noise starts to disturb sleep. The level and character of the noise is important, and the probability of an awakening in response to the Lmax of an event will depend upon the particular characteristics and features of the different types of noise event.

2.42 Basner et al have presented results from a field study in respect of aircraft noise, and they established a curve that gives the probability of awakening as a function of L_{Amax} with a model that assumed a background noise level just prior to the aircraft noise event of 27 dB(A). The L_{Amax} threshold for noise-induced awakenings was found to be about 35 dB(A). Above this threshold the probability of noise-induced awakenings increases up to roughly 10% at 73L_{Amax}. If the level of a noise event is below the sleep disturbance threshold, then it will not disturb sleep. Above this threshold the probability of a noise-induced EEG awakening increases at higher event noise levels.

38. Figure 2-2 was developed from CAP 725: CAA Guidance on the Application of the Airspace Change Process (Civil Aviation Authority 2007).
39. DMRB Volume 11, Section 3, Part 7. HD213/11, 2011.

CARDIOVASCULAR EFFECTS

2.43 It has been shown that long-term exposure to road traffic noise may increase the risk of heart disease, which includes myocardial infarctions. Both road traffic noise and aircraft noise also have been shown to increase the risk of high blood pressure.

2.44 Van Kempen and Babisch carried out an extensive review and synthesis of epidemiological studies in order to derive a quantitative exposure–response relationship between road traffic noise exposure and the prevalence of hypertension. Laszlo et al have highlighted the uncertainties at lower levels of exposure and the problems associated with establishing the Lowest Observable Adverse Effect Levels for both hypertension and heart disease. Notwithstanding the uncertainties, it is clear that individuals exposed to higher levels of noise are exposed to the greater risk. Additional useful information in respect of health effects is found in the Night Noise Guidelines for Europe[40].

COGNITIVE IMPAIRMENT TO SCHOOL CHILDREN

2.45 A World Health Organization document on Burden of Disease[41] references three European studies on cognitive impairment in school children from transport noise. There is evidence from the Munich[42] and RANCH[43] studies of an association between aircraft noise exposure and cognitive performance in school children (reading comprehension and recognition memory), but the same association was not seen for road traffic noise. Neither aircraft noise nor road traffic noise affected sustained attention, self-reported health or mental health.

40. World Health Organization (2009), Night Noise Guidelines for Europe.
41. World Health Organzsation (2011) Burden of disease from environmental health.
42. Proceedings of Internoise, (1996), Book 5, pg 2189–2192, Hygge S et al.
43. Lancet (2005) June 4–10, 365, Stansfeld et al.

3.0 The Process of Assessing Noise Impacts

INTRODUCTION

3.1 Many development proposals need a noise impact assessment. The early involvement of a competent noise assessor provides the opportunity to influence the design of the project and potentially eliminate or reduce the noise impact. This could result in overall cost and time savings to the project.

3.2 As will be seen from these guidelines, noise assessment is a complex issue and to be undertaken properly, it needs to involve qualified and experienced practitioners. In the UK, normally these will be qualified acousticians who are corporate members of the Institute of Acoustics. They should be experienced in the measurement and prediction of noise and have a good understanding of the issues involved in the assessment of noise.

3.3 In addition, early consultation during scoping (Chapter 4) with the key stakeholders, particularly the local planning authority, should be undertaken to understand their attitude to the proposals and any concerns they may have, so that the noise impact assessment can focus upon the key areas. Such consultation should continue throughout the noise impact assessment process, and should co-ordinate with other engagement activity related to the development proposal and, where relevant, its EIA.

3.4 Care must be taken with the terminology used in a noise assessment. In this document, the following definitions apply.

Noise Impact The difference in the acoustic environment before and after the implementation of the proposals (also known as the magnitude of change). This includes any change in noise level and in other characteristics/features, and the relationship of the resulting noise level to any standard benchmarks[44].

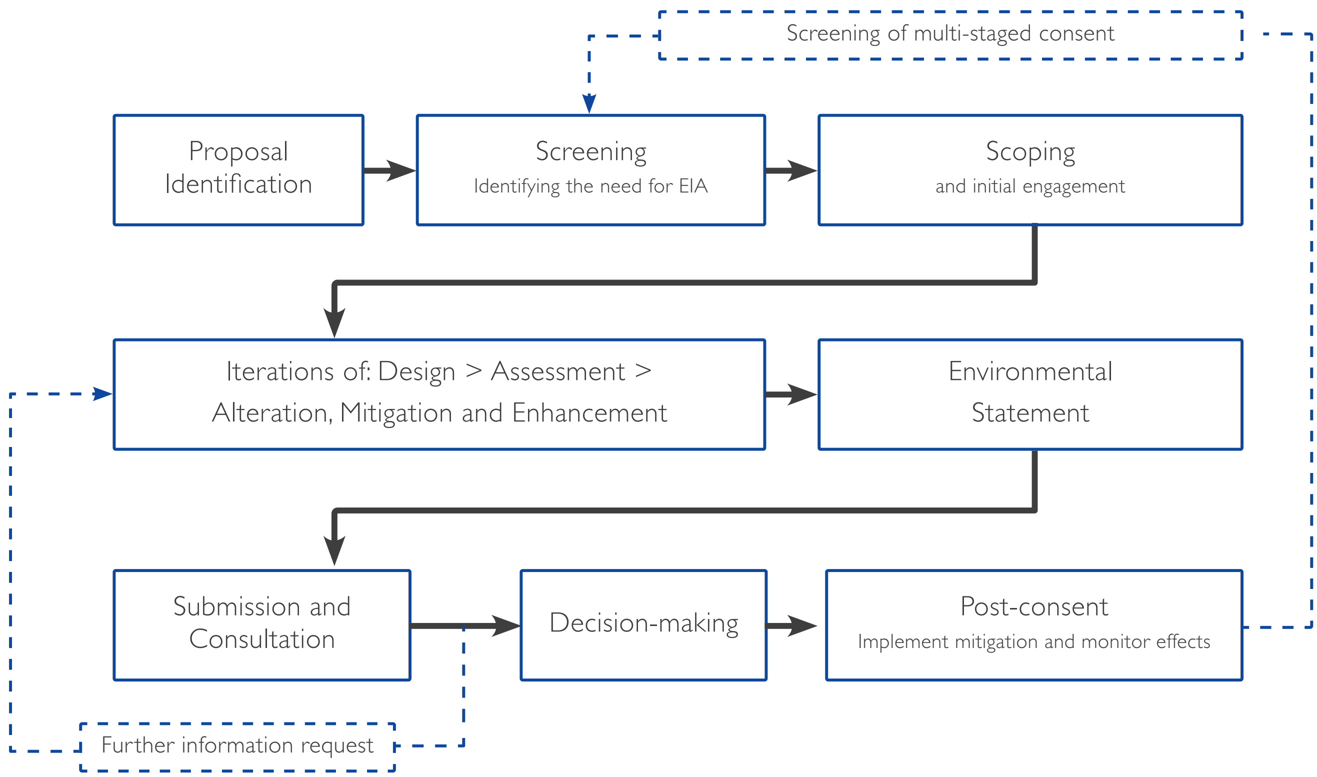
Noise Effect The consequence of the noise impact. This may be in the form of a change in the annoyance caused, a change in the degree of intrusion or disturbance caused by the acoustic environment, or the potential for the change to alter the character of an area such that there is a perceived change in quality of life. This will be dependent on the receptor and its sensitivity.

Significance of Effect The evaluation of the noise effect and, particularly if the noise impact assessment is part of a formal EIA, deciding whether or not that impact is significant[45].

3.5 The process of noise impact assessment is similar to the EIA process. EIA is an iterative process in which there are multiple feedback loops. This means that while there are a series of commonly accepted and well-understood steps within EIA practice, their application will vary between individual assessments including noise. The EIA process is set out in Figure 3-1, which identifies a number of regulatory feedback loops as well as the iterative nature of the assessment process. The process is well understood and some form of each stage can be seen to be universally applied in practice. Where these Guidelines are applied in relation to the noise component of an EIA they should be considered to sit within the over-arching process. Hence, those leading the noise impact assessment must ensure that they work closely with the EIA co-ordinator to deliver a proportionate output in a style that endeavours to fit within the EIA's approach.

44. The change could be an increase or a decrease.
45. Noise impacts may be both increases and decreases, hence the effect may be negative or positive.

FIGURE 3-1 THE EIA PROCESS[46]



It requires the following elements to be completed:

1. Scoping of issues to be addressed in the noise impact assessment;
2. An understanding and description of the existing noise environment, including the identification of sensitive receptors – the baseline condition;
3. Prediction of the noise that is expected to be generated by the proposals – impact identification;
4. Assessment of the significance of the expected noise impact at the sensitive receptors that might be affected - effect description;
5. Evaluation of the effects to determine their significance [**only formally required within an EIA**] – significance evaluation;
6. Identification of mitigation measures in order to reduce the extent of the noise impact. (The outcome of this element may also mean that steps (3) and (4) will need repeating); and
7. Monitoring of noise effects post-consent.

46. IEMA Special Report: The State of EIA Practice in the UK. 2011.

SCOPING THE NOISE IMPACT ASSESSMENT

3.6 Scoping is the process of identifying the content and extent of the Environmental Information to be submitted to the Competent Authority under the EIA process. Additionally, it can be a simple process of understanding the noise aspects of any project impact assessment at whatever scale.

3.7 Before undertaking a noise impact assessment, it is important that the assessor has a thorough understanding of the project and its context. This would involve:

- understanding the nature of the development and identifying the potential sources of noise;
- understanding the nature and character of the prevailing noise environment;
- identifying all the potential new noise sources that will arise from the proposals, during the construction, operation and, if appropriate, decommissioning;
- understanding the nature of the new noise sources that will arise from the proposal, including such features as tonal characteristics, intermittency, duration and timing (diurnally and seasonally);
- identifying potential noise-sensitive receptors; and
- understanding the policy context of the proposal, including central and local government policy, relevant international and national guidelines, British Standards, etc.

3.8 Having considered these issues in the scoping process together with the outcome of consultation with relevant stakeholders, the noise assessor is then able to define the detailed scope of the assessment, or even, determine whether a noise study is necessary.

3.9 The noise assessor/competent expert will need to liaise closely with other specialists who are involved in developing and evaluating the proposals, for example:

- to provide an assessment of cumulative and in-combination effects;
- the designer will be able to advise on the practicalities of possible mitigation measures;
- the operator can assist on the scope for using process management to limit the noise impact;
- the ecologist is likely to be able to provide advice on the extent to which noise will affect any sensitive wildlife receptors; and,
- the archaeologist is likely to provide advice on whether noise will affect the setting of archaeological and cultural heritage assets.

3.10 Furthermore, it must be remembered that measures taken to mitigate one impact may create an indirect impact for another environmental parameter: e.g. the creation of a bund or barrier for noise mitigation could be visually intrusive or have ecological implications. Further guidance on how to determine the baseline conditions is provided in Chapter 4.

CHARACTERISING THE EXISTING NOISE ENVIRONMENT

3.11 It is necessary to have a clear understanding of the existing situation. Usually, this will require the measurement of baseline noise levels at times of the day, night, week, season or year when the project is likely to have an impact. In some instances where detailed baseline data are available, e.g. traffic flow data, it may be appropriate to define the baseline noise environment by prediction. Further guidance on how to determine the baseline conditions is provided in Chapter 5.

PREDICTION OF THE NEW NOISE LEVELS LIKELY TO BE GENERATED

3.12 The level of noise expected to be generated by the different activities associated with the project must be predicted. Further guidance on the prediction of noise is provided in Chapter 6 and Annex A.

ASSESSMENT OF THE NOISE IMPACTS

3.13 Using information about the expected noise levels arising from the proposals and the existing noise environment, an assessment must be made of the nature and extent of the noise impact. In addition to the simple change in noise level, other factors or features of the change might need to be taken into account to determine the extent of any effect and its significance. Further guidance on this aspect is set out in Chapter 7.

3.14 In determining the extent of the noise impact, it must be remembered that considering the change in noise level and the other features is simply a means of assisting in the determination of the effect that the noise change would cause on the sensitive receptors.

IDENTIFY MITIGATION

3.15 Consideration should be given to mitigation measures that can be included in the proposals, especially when significant impacts have been identified. Further guidance can be found in Chapter 8.

REPORTING

3.16 Once the assessment has been completed, the results must be reported. The noise assessment report needs to balance the level of detail with the need to be accessible to the reader. A proportionate approach should be taken that provides a sufficient quantity and detail of information to satisfy the needs of those who will be making a decision regarding the overall merits and dis-benefits of the proposal.

3.17 The report will state whether or not there are any noise impacts, what action will be taken to eliminate or reduce any significant effects from the noise impacts, and come to an overall conclusion about the degree of the residual noise impact and effect of the proposals. Guidance on reporting is given in Chapter 9.

REVIEW AND FOLLOW-UP MONITORING

3.18 Once the planning application, together with the noise impact assessment report (potentially with an Environmental Statement), has been submitted to the decision-making authority, there is often a need for the assessment to be reviewed and, once the decision is made, other follow-up issues to be addressed. These are described in Chapter 10.

PRINCIPLES OF ASSESSMENT

3.19 A noise impact assessment can be effective in achieving the objective of informing decision-making and influencing project design only if the information generated is credible and reliable. As a consequence, it is important that an assessment conforms to certain principles of good practice, which are outlined below[47, 48]: For a project subject to a formal Environmental Impact Assessment, some of these principles are a statutory requirement.

3.20 A noise impact assessment reflecting good practice should:

- **Be transparent**. The process and the results of the assessment should be reported clearly in a format understandable to the non-specialist. The terminology used in the assessment should be clearly defined. The methods used in the assessment should be described, and any deficiencies or limitations of data including any uncertainties, techniques or resources that may have constrained the assessment should be acknowledged;

- **Be focused** through the identification of key issues. Scoping should be used to ensure that noise sources that can cause significant effects are not ignored;

- **Be practical.** The assessment should produce information that is sufficient, relevant and reliable for use in decision-making. Consistent with this, the assessment should impose the minimum cost burden on project proponents and other participants in the process. Data collection and analysis should be achievable within the limits of available data, time, resources and methods considered as robust and tested;

- **Be participative.** Ideally, the assessment should include consultation with a range of stakeholders throughout the process, although in some circumstances this may not be possible. The stakeholders should be provided with the opportunity to have their concerns addressed by the assessment;

47. Principles based on Guidelines for Environmental Impact Assessment (IEMA 2004).
48. B Carroll & T Turpin (2009) Environmental Impact Assessment Handbook. 2nd Edition.

- **Be credible.** The assessment should be objective, impartial, rigorous, balanced, fair and ethical;

- Include an assessment of alternatives, when appropriate. A range of alternatives for a proposal should be assessed and reported. Consistent with the alternatives being practicable they should include alternative sites, design, technology and mitigation measures. The no-action alternative and the least environmentally damaging alternative should be considered;

- Include an assessment of a worst-case situation (should consent be granted), when appropriate. In identifying a potential worst-case situation to examine, consideration should be given to an outcome that might occur without the need for further planning consent. However, rather than exploring an extreme worst case that could occur, the worst case to be tested should be reasonably likely. Furthermore, it must be physically possible for the worst-case situation to occur. Any such assessment should make clear the assumptions upon which it is based;

- Where appropriate the assessment should consider any uncertainty inherent in the process which might include determination of the baseline noise climate, or the prediction of noise levels at sensitive receptors;

- Result in follow-up. Ideally follow-up should form part of the process in order to confirm that the any noise control measures either proposed by the developer, or imposed through planning conditions, are properly implemented.

4.0 Scoping

INTRODUCTION

4.1 Scoping is the process of identifying the content and extent of the Environmental Information to be submitted to the Competent Authority under the EIA process. Before undertaking a noise impact assessment, it is important that the assessor has a thorough understanding of the project and its context. This involves having an understanding of the nature of the development and identifying the potential sources of noise. It is also important to understand the nature and character of the prevailing noise environment (see Chapter 5). The identification of all the potential new noise sources that will arise from the proposals, during the construction, operation and, if appropriate, de-commissioning needs to be established at the scoping stage. The nature of the new noise sources that will arise from the proposal, including such features as tonal characteristics, intermittency, duration and timing (diurnally and seasonally) needs to be established. It should be noted that the scoping process is not unique to the EIA process. It is relevant to all types of noise assessment and will only differ in its scale and the extent to which consultation is required, either formally or informally.

4.2 The policy context of the proposal, including central and local government policy, relevant international and national guidelines, British Standards etc. should be established at the scoping stage.

CONSULTATION

4.3 Unless there are commercial or other reasons for confidentiality, it is recommended that the competent authority[49] be consulted at an early stage when defining the scope of the baseline study. Consultation with the competent authority (in particular, the authority having responsibility for Environmental Health functions) has the following advantages:

- particular local concerns and receptors can be identified;
- data on existing noise levels may be available;
- specific monitoring or prediction requirements (e.g. noise indicator) can be identified;
- agreeing the spatial and temporal scales for the assessment; and
- assistance with surveys may be provided (e.g. in arranging access or protecting non-secure monitoring sites).

4.4 At the least, it may be possible to agree suitable receptor locations. Furthermore, contact with those living and working in the area also may highlight any local concerns[50].

SELECTION OF RECEPTORS

4.5 Sensitive receptors may include uses other than dwellings, and animals other than human beings. Normally, the objective is to identify those locations most sensitive to or likely to be adversely affected by the proposed development. (It should be noted that not all of these receptors would necessarily have the same degree of sensitivity. This variation would need to be taken into account during the assessment process described in Chapter 6.) Possible receptors that may need to be considered when determining the baseline noise levels include:

- Dwellings;
- Schools/Colleges;
- Hospitals;
- Especially sensitive commercial/industrial installations;
- Commercial premises;
- Community facilities (including libraries, surgeries, health centres);
- Places of worship;
- Retail premises;
- Open air amenities;
- Cemeteries;
- Light industrial sites;
- Farms, kennels;
- Wildlife sites; and
- Vacant land (classify according to potential future use where possible. Consult planning consents, relevant planning strategies and similar local development documents, etc).

4.6 "Open air amenities" covers a wide range of receptors and sensitivities. Sites such as those of special historic interest, nationally recognised footpaths and areas of landscape value should be considered as particularly sensitive[51].

4.7 In circumstances where the development proposal or elements of the scheme are noise-sensitive, it may be necessary to treat them as potential receptors in order to appraise the impacts and effects of noise from existing sources on the scheme itself.

49. Note that although a local authority may have environmental health functions, that body may not be the relevant planning authority.
50. This can be very important, as much time can be spent at Public Inquiry debating the merits or otherwise of specific noise monitoring locations.
51. This category includes both nationally and locally designated sites, but also might include locations that are valued locally, even though they have no formal designation.

5.0 ESTABLISHING THE BASELINE

INTRODUCTION

5.1 This chapter considers the purposes for which baseline noise levels are required, the means of determining them and the factors that influence the method used. It also sets out a systematic approach to presenting the baseline information that is applicable to an Environmental Statement for a major project, or part of a stand-alone noise report forming a planning submission.

5.2 The objective is to enable a practitioner to prepare the baseline information to an appropriate level of detail, proportionate to the development in question and the sensitivity of its proposed location. It also should assist anyone reviewing a baseline study to assess whether it follows good practice[52]. The chapter is structured as follows:

- definition and function of baseline;
- methodology for determination of the baseline; and
- presentation of the baseline information.

5.3 This part of the Guidelines also contains detailed information and advice on the factors that can affect determination of the baseline.

BASELINE: DEFINITION AND FUNCTION

DEFINITION

5.4 Baseline noise refers to the noise environment in an area prior to the construction and/or operation of a proposed (or new) development that may affect it.

5.5 Baseline noise levels may be required for different years. In many cases the year in which the study is carried out will be relevant, and these baseline noise levels may be referred to as existing (or current). However, there may be occasions when baseline data are required for other years (see paragraphs 5.7 and 5.8).

FUNCTION

5.6 Baseline noise levels can serve several purposes in the assessment process:

- They provide context for the noise levels predicted to arise from the proposed development against which they may be appraised;
- They may be required as a formal part of the noise assessment process;
- They may demonstrate that the noise environment is already unsatisfactory.

RELEVANT TIME

5.7 In order for baseline noise levels to fulfil any of these functions, they must be the values expected at the relevant time for the phase of the proposed development being considered. This may be at some future date either because the development will not be operational for several years, or because its noise emissions will change during its operating life.

5.8 For example, an industrial development may take several years to be planned, a year or more to be constructed, and may be designed to have further production lines coming on-stream in the years after it is first operating. In such circumstances, different baseline years may be relevant for the construction and operating phases, and neither of them will be the same as the situation at the time that the assessment is conducted. Although it is possible to measure noise levels at the time an assessment is conducted, this may not be the relevant time for which the baseline noise levels are required. baseline noise levels may be determined by direct measurement, by prediction, or by a combination of these methods. When considering future baseline noise levels it is considered good practice not to include the influence of the scheme itself; although 'organic' changes due to sources that are not associated with the scheme can be taken into account.

TEMPORAL CONSIDERATIONS

5.9 Table 5-1 provides information regarding the temporal aspects of a baseline study.

52. When possible, it is good practice to seek agreement on the proposed methodology with the relevant competent authority in advance.

TABLE 5-1 TEMPORAL ASPECTS OF BASELINE STUDY

Factor	Comment
Relevant Years	The first consideration is whether there are reasons to determine the baseline for years other than the year of the study. In the case of transport projects, there is usually a requirement to consider what noise levels in the area would be in the future if the proposals go ahead, and if they did not proceed. For example, for a road scheme, baseline noise is often determined for the year of opening and 15 years later. In fact, the baseline should be determined for whichever year in the 15 years after opening is predicted to lead to the highest noise level from the new road. Normally, this will be the 15th year, which is known as the design year. These two future years are important for two reasons. First, because there is typically a period of several years between a road scheme being proposed and opened: and second because traffic flows (and hence the noise emitted) are often expected to increase during the 15 years after the road opens. Thus, in considering any development proposals, these factors should be considered: • the delay before construction could start; • the construction period, and hence the delay before the project could be operational; and • whether there are expected or planned changes in the operation during its lifetime that will lead to a change in noise output (e.g. a power station with more phases coming on-stream later).
Time of Year	Seasonal variations in baseline noise levels may occur as a result of differences in the typical meteorological conditions at different times of the year, or with seasonal variations in the presence or strength of existing noise sources. However, it is not normally practicable to carry out baseline studies for environmental statements and planning submissions in more than one season. Therefore, a typical approach is therefore to attempt to measure in neutral weather conditions (e.g. low or no wind, absence of temperature inversion). This should result in a conservative, i.e. low value, for the baseline noise levels, but in some circumstances it may over estimate or underestimate the typical values. An exception would be the case of wind farm developments, when baseline measurements should occur for all relevant wind conditions, and for which specific guidance exists[53].
Day(s) of Week	The baseline determination should reflect the day(s) of the week when the proposed development is operating, and the day(s) of the week when the sensitive receptors are being used: i.e. schools, churches, etc.
Time(s) of Day	The baseline determination should reflect the time of day when the proposed development is operating, and the time of day when the sensitive receptors are being used: i.e. hours of operation and hours of use of schools, churches, hospitals, etc.
Variable Baseline Conditions	In some circumstances, the noise environment at a location may vary depending on a range of factors. For example, locations already affected by aircraft noise may have a very different noise environment depending on the operational mode of the airport. Similarly, the wind direction (and speed) may affect the level of noise at the receptor from an existing busy road some distance away.

53. A Good Practice Guide to the Application of ETSU-R-97. The Assessment and Rating of Wind Turbine Noise. Institute of Acoustics, May 2013, and IOA Good Practice Guide to Implementation of ETSU-R-97 and Supplementary Guidance Notes.

5.10 It should be remembered that different receptors may be relevant at different day(s) of the week and at different times of the day.

5.11 Similarly, care must be taken to ensure that appropriate locations are considered for both the construction and operating phases. Different receptors may be relevant or critical for these two phases of a project.

DEFINING AND OBTAINING THE DATA

NOISE INDICATOR

5.12 In order to describe fully the baseline, it is usually necessary to determine the noise climate in terms of a number of indicators. As will be seen from Chapter 6, the assessment process will consider a number of features of the noise expected from the proposed development, and often it will be necessary to compare those features with any relevant features that exist in the baseline.

5.13 Although some official documents may prescribe a particular indicator to use in the assessment of some sources of noise, this does not preclude the use of other indicators in order to provide a full assessment. Therefore, it is often helpful to describe the baseline in terms of more than just the prescribed indicator. Whichever noise indicators are utilised, it will be important to justify their use either by reference to good practice or any guidance documents, British Standards, etc.

TIME PERIOD

5.14 In terms of the baseline description, there are three elements of time period that need to be considered:

1. How the baseline is described – is the indicator to be averaged over, for example, one-hourly periods or over a different period?

2. Even if a longer averaging period is to be used, can the measurements be made over shorter periods and subsequently extrapolated to obtain the longer period value?

3. Can the measurements themselves be carried out for just one period during a day (or even part of a period), or should the noise measurements be over several days or longer in order to represent the baseline?

For (2) and (3) the assessor needs to be certain that any shorter measurement periods are properly representative of the desired baseline descriptor, or that they can be used in such a way as to adequately inform the overall baseline noise climate.

INDICATOR AVERAGING PERIOD

5.15 A decision must be made regarding the averaging period to use for the indicators recorded. These could range from as little as 1 minute up to 24 hours. When the L_{Amax} or Single Event Level (SEL) indicators are used, a similar decision is needed regarding the time periods over which the events associated with these indicators are determined.

MEASUREMENT PERIOD

5.16 It is good practice, where appropriate, to measure over shorter time periods even though the required indicator is to be averaged over a longer period. However, care is needed with any statistical indicators: the value over a longer period does not necessarily equal the average of the values for shorter periods that aggregate to the longer period. Thus, if the desired indicator is the $L_{A90,1h}$, this cannot be obtained by averaging the 12 $L_{A90,5min}$ values that make up the hour of interest. The desired indicator can be strictly obtained only with an hourly measurement. However, it should be noted, that in most circumstances the numerical difference between these two approaches is likely to be small.

MEASUREMENT DURATION

5.17 There are two main approaches to noise monitoring: short-term attended and medium to long-term unattended, using automatic logging equipment. Each of these methods has advantages and disadvantages which are outlined below.

5.18 The objective of the survey is to obtain baseline data that are reliable and representative of particular circumstances. Thus it may be necessary to establish either the typical noise environment or the noise levels arising under certain prevailing conditions (or both). Consequently, it is important to undertake baseline surveys during the relevant conditions of interest.

5.19 In the case of attended short-term measurements, less data are normally acquired at a given location than would be obtained from monitoring over 24 hours or a week. Conversely, short-term attended monitoring, if undertaken by a competent operator, can yield data about the weather conditions and the sources of noise being recorded – information that is not normally available from unattended longer, term monitoring without otherwise very detailed analysis techniques which may include audio recording.

5.20 On the other hand, long-term monitoring can provide results for a wider range of conditions and enable a more comprehensive description of the baseline to be obtained. However, some care must be exercised in interpreting these data. For example, long-term monitoring may coincide with a period when the weather conditions are inappropriate. It is important to identify when such conditions have occurred, although it may be difficult to do so. A combination of both short-term and long-term monitoring may be appropriate.

MEASUREMENT OR PREDICTION

5.21 Generally, some measurement should be undertaken unless there is reason to believe that the existing levels will change significantly before construction or completion. Even where significant changes are expected, measurement coupled with extrapolation should be considered as an appropriate method. However, in some cases it may be necessary or preferable to calculate the baseline noise levels rather than measuring them.

5.22 For example, where road traffic noise is under consideration, the existence of a detailed standard procedure for calculation may justify its use for current as well as future noise levels. This has the advantage of ensuring that the comparisons are made on the same basis. Ideally, some check on actual noise levels should still be made, to guard against there being any anomalies which might cause the existing levels to deviate substantially from the calculated values. This also has the advantage of providing confidence in any noise predictions.

5.23 In other cases, it may be necessary to calculate the baseline because measurement is not possible. In any event, even when calculation of the baseline is the only meaningful approach, it can be beneficial to carry out some measurement of the existing noise environment. However, the relevance of the measurements in such circumstances may need careful explanation and interpretation in the noise impact assessment report.

5.24 Some assistance may be gained from any noise maps that may have been produced for the area of interest[54]. However, the assessment should not rely solely on these sources of information, and great care should be exercised in ensuring that the maps are fully understood, including the limits of the quality of the data used to derive the maps and the declared accuracy of the maps. In most cases, the main benefit of noise maps is to distinguish between the relative degree of noise at different locations, rather than the precise noise level any at particular location.

54. For example, in connection with the implementation of Directive 2002/49/EC on the Assessment and Management of Environmental Noise.

INSTRUMENTATION

5.25 Most modern sound level meters can log all the commonly used noise indicators simultaneously. In most cases it will be useful to include all relevant indicators and rating systems in the baseline data, and to explain the reasons for the choice of the indices or rating systems used in the assessment of impact.

5.26 A suitable averaging period will depend on the nature of the proposed source, the existing baseline noise pattern and any requirements of the appropriate official guidelines, but intervals between 5 minutes and 1hour are the most likely to be required (but see para 5.16). The choice of interval should be explained. It also will be necessary to determine, where appropriate, the necessary time weighting for the instrument.

5.27 As a minimum, the instrumentation should be a Sound Level Meter (SLM) of an appropriate standard, capable of recording L_{Amax}, L_{Aeq}, L_{A10}, L_{A90} as a minimum. The meter should be calibrated before and after use. However, for extended measurement periods, additional calibration should be considered. SLMs and their calibrators should be certified to appropriate recognised standards at intervals set out in British Standards, or by other competent bodies.

5.28 For capturing frequency information, an appropriate frequency analyser should be used. Audio recordings also may be useful for frequency analysis. Such additional equipment should be checked, serviced or certified at appropriate intervals.

REPRESENTATIVE NOISE LEVELS

5.29 Relatively little has been published on what constitutes representative noise measurements. Where data have been published, the choice of indicators and measurement periods and the types of sites surveyed, generally vary from study to study. Although some general qualitative factors do emerge, a statement of precise, consistent values for the likely variation cannot be presented here from the current depth of knowledge available. Each specific description of variation below is summarised from a single publication, while the qualitative factors are more commonly reported.

QUALITATIVE FACTORS

5.30 The following qualitative factors should be noted:

- Quiet sites tend to show greater variation in ambient noise levels than inherently noisy sites;
- Atmospheric influences can give rise to the greatest variations; and
- Atmospheric influences increase as the distance from the source increases.

EXAMPLES OF SPECIFICALLY REPORTED VARIATIONS

5.31 For a quiet site, it is reported that 90% of the L_{A90} values for any specific hour of a weekday (taken to include evenings) will be within 5 dB of the long-term mean for the same hour, but the night-time values are more variable[55].

5.32 One study in a rural area, lying 1 to 3 km from several major roads and a railway, found that in order to achieve a standard deviation of no more than 2 dB compared to the mean taken over several weeks, L_{A90} values for the day time period (including weekends) would need to be averaged over at least six days. For the same accuracy, the study found that night-time values would require averaging over at least five nights, but evening values were much less consistent, and over a period of 21 evenings the standard deviations for L_{A90} did not fall below about 5 dB[56].

5.33 In another study, 95% of single 18-hour L_{A10} or 24-hour L_{Aeq} weekday values for a variety of locations were found likely to be within 3 dB of the long term average, with 60 % being within 1 dB[57].

5.34 Atmospheric factors can cause variations of up to 10 or even 20 dB(A) over long distances[58].

55. J.W. Sargent 'Measuring the Change in Noise Climate caused by the Introduction of a New Source', Building Research Establishment, 69/5/1, Internoise 88 pp 1607–1610, 1988.
56. PS Evans & RA Hood 'Variability of Noise Indices', IOA Conference, November 1991.
57. LC Fothergill 'The Variation of Environmental Noise Outside Six Dwellings Between Three Seasons', Building Research Establishment, A 69/8/12, Applied Acoustics 1977 10,3 pp 191–200.
58. Ibid.

5.35 A change in wind direction to, or from, a significant source (in this case, a motorway at 400 metres distance) has been found to change measured 18-hour (assumed to be 06:00 to 24:00) L_{A90} values by up to 7 dB(A). L_{A10} and L_{Aeq} values were less affected – up to 4 or 5 dB(A).[59] Normally upwind conditions – i.e. the wind is blowing from the receptor to the source – can produce a much greater reduction in noise propagation compared to the smaller increase in noise propagation likely under downwind conditions: i.e. the wind is blowing from the source towards the receiver.

5.36 Long-term variations in ambient noise levels can be 10 dB(A) or more[60].

5.37 Therefore, it can be seen that there is some evidence that evenings show more variability in ambient noise levels in terms of L_{A90} than during the daytime or night, at least during weekdays. Values of L_{A10} and L_{Aeq} may be more consistent than L_{A90} values.

5.38 In addition, the inherent accuracy limits, as specified in the relevant British Standard for the grade of sound level meter used, should be borne in mind.

IMPLICATIONS FOR BASELINE STUDIES

5.39 Most of the above studies are concerned with the ability of single or limited periods of measurement to represent a long-term average. However, when establishing a baseline against which to assess a specific noise impact, a typical value such as the mode average (the most commonly occurring noise level), or where a value biased towards worst case is desired, the mean average -1 standard deviation normally should be used. It is not often appropriate to use the absolute worst case or lowest measured value.

5.40 If only a limited set of measured baseline noise values is available, it should be borne in mind that lower levels might occur that have not been captured. The reliability of the measured values in establishing the baseline conditions must be considered as being reduced where the number of measurements is limited to periods of less than several days. Such uncertainty should be made clear in the baseline information within the noise impact report/ES chapter.

5.41 Estimates of the likely variability of the data should be used when comparing different sets of data for the same location, either to reconcile any differences (as being within the expected margins of accuracy), or to highlight genuine discrepancies that need further investigation.

5.42 Predictions and calculations are also subject to errors. These comprise both those intrinsic to the methodologies themselves and to the source data on which the calculations are based. Such errors should not be overlooked, but often cannot be quantified and may have to be estimated based on professional judgement.

5.43 Whenever possible, known effects such as wind direction should be taken into account directly by estimating their specific influence on the measured data, rather than simply including them in a general error margin. An example of such methods can be found in this reference[61].

5.44 The estimates of likely errors should not be applied uncritically, as they themselves are subject to potential error, being based on limited data in most cases[62].

59. J.W. Sargent, op cit.
60. PS Evans & RA Hood 'Variability of Noise Indices', IOA Conference, November 1991.
61. Planning Advice Note 50: Controlling the Environmental Effects of Surface Mineral Workings, Scottish Office Development Department, 1996.
62. A Good Practice Guide on the Sources and Magnitudes of Uncertainty Arising in the Practical Measurement of Environmental Noise, University of Salford, October 2001.

EFFECTS OF METEOROLOGY

5.45 In general, monitoring should be avoided when the wind speed exceeds 5 m/s, unusual temperature conditions are occurring, or when there is significant precipitation unless these are the normal conditions for the area. Care should be taken to ensure that the equipment is capable of operating satisfactorily (as set out in the instrument's handbook) under the prevailing conditions – in particular, ensuring that the calibration is not compromised under cold or wet conditions.

5.46 If less than ideal conditions are unavoidable, periods of poor conditions should be clearly indicated in the data records, and account taken of their effects in describing the baseline. The more detailed the weather records, the better, but it will be rarely practicable to set up automatic logging weather monitors to accompany the noise loggers, although such monitoring tends to occur as a matter of course for studies associated with wind farms. Wind speed and direction also can be highly localised near buildings, and care is needed in locating monitors to avoid misleading data being collected. Often, it will be more practicable to make a reasonable estimate of the effects of different weather conditions rather than attempt to measure them.

5.47 Where unattended monitoring is used, weather records may have to be obtained from sources such as the Meteorological Office. Such information will strictly apply only to the location of the weather station. Furthermore, the topography of the area can affect local meteorological conditions.

5.48 If the effects of noise propagating over long distances are being considered, it will be especially important to consider weather and atmospheric effects.

PRESENTATION OF BASELINE INFORMATION

5.49 A suggested order of presentation of the information is shown in Table 5-2. It also gives guidance about the matters to cover and the degree of detail. Further useful information can also be found in the ANC Guidelines, 'Environmental Noise Measurement Guide, 2013'.

TABLE 5-2 PRESENTATION OF BASELINE INFORMATION

Topic	Guidance and Key Issues
BASIC INFORMATION This should identify the sources from which the main information used in preparing the chapter was obtained.	Details of those undertaking the survey and the main consultees should be included.
LOCATION OF RECEPTORS Reasons for selection of the receptor locations should be given.	Any particular local concerns and noise sensitive receptors should be identified on a suitably scaled map and described. Whenever possible, noise-sensitive receptor locations should be agreed with the Competent Authority and other consultees. Photographs showing the specific siting of the measuring equipment can convey a great deal of helpful information regarding the measurement conditions.
PERIOD OF BASELINE STUDY The year(s) and time(s) of day and week for which the baseline has been determined.	Reasons for choosing short-term attended or long-term unattended monitoring (or both) should be outlined. The baseline should be capable of representing conditions which are relevant to the period of construction, operation and decommissioning. An explanation should be provided, detailing how the survey meets this requirement. An explanation of why the periods have been chosen should be included. If the study is more limited, it is important to explain why.
METHODOLOGY A description of how the baseline noise levels have been determined.	It should be reported whether data on existing noise levels were already available. Specific requirements should be identified: for example, noise indicators. Report and justify whether noise levels have been determined by measurement, calculation or a combination of both. The basis of any calculations and the choice of indices should be explained. In the case of measured values, the dates and times of monitoring, instrumentation and monitoring periods should be included. Baseline assessment may be an iterative process. Where a preliminary survey, or the predictions of noise from the project itself, has led to the need to carry out further baseline studies, this should be made clear and fully justified.

Topic	Guidance and Key Issues
BASELINE NOISE LEVELS This should present the results of the measurements and/or predictions.	In the case of large amounts of data, a summary should be provided – it is normally more helpful to include detailed information in an appendix. Ranges of noise levels should be included as the maximum, average and minimum recorded at each measurement location. In addition to noise levels, it is essential to report qualitative observations from site visits: in particular the source(s) of existing noise (or those expected to be present when the proposed development is under construction or operating) and the weather conditions.
RELIABILITY OF DATA Indicate any factors which may have affected the measured or calculated values.	For example: poor weather, untypical conditions or sources or difficulties in obtaining reliable data for calculations.
SUMMARY Summarise both the baseline data and the implications for the project design.	Include qualitative as well as quantitative assessments of the most significant findings.
RECOMMENDATIONS Highlight any issues identified by the baseline study.	For example: a need for further measurements nearer the time of construction, or suggestions for changes to the design of the project where the baseline study has identified especially sensitive receptors.

6.0 PREDICTION OF NOISE LEVELS

INTRODUCTION

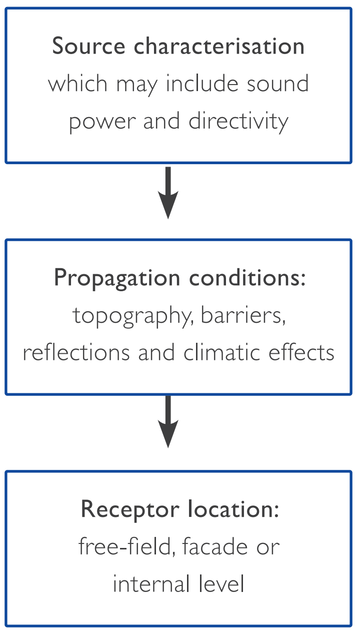
6.1 Prediction is a very important part of noise impact assessment. When a development is in the planning stage, it is the only way of quantifying the likely noise impact.

6.2 The prediction of noise for impact assessment requires consideration of both the way sound travels from source to receptor, and analysis of the changing character of the noise during the various phases of the scheme to be assessed. Different predictions and prediction methods may be necessary during site preparation, construction, operation and decommissioning. For example, when planning for surface mineral working or waste disposal sites, consideration needs to be given to site preparation, fixed plant noise, mobile plant noise, site restoration and vehicle movements (both within the site and on the local road network).

PREDICTION PROCEDURE

6.3 The basic prediction procedure involves consideration of the nature and noise level of the sources, the propagation along the paths between sources and receptors and the location of the receptors, as shown in Figure 6-1.

FIGURE 6-1 SOURCE, PATHWAY, RECEPTOR



6.4 Any noise prediction requires information about the sound power of the source or the sound pressure due to the source at a reference distance. The level of noise received from any source depends not only on the sound power frequency spectrum of the source, but on the type and size of the source, the distance between source and receptor, the intervening topography and climatic conditions, and the location of the receptor. Consideration also should be given to whether the predictions are intended to give internal or external levels. If external levels are to be predicted, it should be decided whether they are the levels at a building facade, or those free from the influence of vertical reflecting surfaces near to the receptor (free-field). Often, this will be determined by the requirements of any formal modelling or assessment methods which may apply to the situation being appraised. In addition, reference should be made to the discussion of receptors in Chapter 5, Baseline, for suggestions about the locations that should be included.

6.5 The spreading of sound waves as they travel from a source causes the sound level to reduce with distance from the source. However, this basic mechanism is influenced by the presence of the ground, absorption in the atmosphere, natural or artificial barriers, reflections from surfaces and meteorological conditions. An acoustically hard surface such as concrete, sealed asphalt or water tends to reflect the sound that impinges on it. Acoustically soft surfaces such as grassland, fields, or other vegetation attenuate the sound passing over them (ground effect).

6.6 Wind and temperature gradients affect the way that sound travels from the source to the receptor. Furthermore, the ground effect is reduced by atmospheric turbulence, which in turn depends on the wind and temperature gradients. Downwind from a source, sound levels will be higher than those upwind, everything else being equal. Temperature inversions, which generally occur between dusk and dawn under calm conditions, tend to increase the lateral propagation of sound in all directions from a source compared with normal propagation. The effect of wind direction and temperature inversion becomes more pronounced as the distance from the source increases. Meteorological effects also influence the performance of barriers, such that the predicted barrier attenuation might not be achieved in all atmospheric conditions.

6.7 Many prediction methods are source-specific and empirical. In the UK the formal models currently used for road traffic noise and railway noise are Calculation of Road Traffic Noise (CRTN)[63] and Calculation of Railway Noise (CRN)[64]. While BS 5228:2014 provides a method of predicting noise from construction and open sites, the international standard (ISO 9613-2)[65] sets out a general scheme that is intended, primarily, for fixed industrial sources[66], but its propagation element can be found in several models used in Europe. For noise from aircraft in the air, the UK Civil Aviation Authority use a model known as ANCON 2[67] for the designated airports, but this is not available for use by others. An alternative is the US Federal Aviation Authority's Integrated Noise Model (INM)[68], which is widely available. Apart from these, there are various proprietary schemes (for example, CONCAWE[69], developed for petro chemical sources, although often utilised for other types of noise source). These and other computational methods are increasingly found on various software platforms within proprietary programs that are able to model large areas comprising different types of noise source.

6.8 Prediction schemes vary in their complexity by taking greater or lesser account of meteorological and ground conditions, and source characteristics. They also differ in whether they give overall A-weighted sound levels or indices, or require calculations in octave frequency bands. Many source specific models are empirical. More complex general models offer ways of predicting the propagation, using either ray-based methods or numerical full-wave methods, or a mixture of both.

6.9 It is important to strike a balance between the convenience of a simple model and the need for accurate predictions[70]. In some cases, simplified prediction models, taking account of only geometrical spreading and air absorption, may be sufficient. This would be true, for example, when ground and other losses are balanced by downwind meteorological enhancement. However, this is likely to be appropriate only under very strong wind-induced downward refraction of sound and conditions of high turbulence, or when the source and/or the receptor are elevated. It should be noted that some of the standard computational methods, including CRTN, CRN and ISO 9613-2, are intended to provide predictions for moderate downwind conditions, but do include ground effects.

6.10 Meteorological and ground effects are particularly important when predicting noise over long distances. In such conditions, consideration should be given to whether the appropriate prediction is for typical or acoustically neutral meteorological conditions, long-term averages or a specific case. Formulae for the effects on noise levels of such propagation can be found in standard texts.

6.11 Certain noise generation and propagation factors are specific to given noise sources. For example, in the case of road traffic noise, the nature of the road surface and gradient of the road need to be included. There may be a case for using in situ measurements as the basis of a site and source-specific empirical prediction scheme, where the circumstances are complex or are not represented well by any existing prediction method. In any case, it is recommended that:

- The methods and factors used for prediction are specified in detail;
- Predictions are made for relevant scenarios;
- Enough information is included to enable calculations to be validated as part of the review process, and to enable an assessment of accuracy and limitations to be made; and
- The time period and meteorological conditions for the prediction are specified.

6.12 Further technical details regarding the issues to be considered when predicting noise levels can be found in **Annex A** to this document.

63. Calculation of Road Traffic Noise (Department of Transport, 1988, HMSO). 64. Calculation of Railway Noise (Department of Transport, 1995, HMSO). 65. ISO 9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation (ISO, 1996). 66. In the UK, BS 5228-1:2009 +A:2014 provides a methodology for predicting noise from construction and demolition activities. 67. The CAA Aircraft Noise Contour Model: ANCON Version 1 (Civil Aviation Authority DORA Report 9120, 1992) and the UK Civil Aircraft Noise Contour Model ANCON: Improvements in Version 2 (Civil Aviation Authority R&D Report 9842, 1999). 68. Available from the FAA. 69. CONCAWE, The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighbouring Communities (Report 4/81, 1981). 70. It should be noted that complex models do not necessarily give more accurate results. This is because such models require more complex input data which may not always be available and may not have the appropriate accuracy.

7.0 ASSESSMENT

INTRODUCTION

7.1 The ultimate aim of any noise assessment is to determine the effect of the expected change in the acoustic environment arising from the proposed development. Previous chapters of these Guidelines have described how information regarding the expected noise change (impact) can be acquired. The baseline and future noise levels at residential properties, schools, hospitals or in amenity areas, etc. will have been determined, and it is from this information combined with any other relevant information, that the consequential effect on the receptor and an overall conclusion regarding the significance or otherwise of the change in the acoustic environment must be drawn. In the context of EIA, it is the 'likely **significant** effects' that must be identified and reported, Where the scheme may affect the health of people, then the health effects of the scheme will need to be included within the scope of the assessment.

GUIDANCE

7.2 For some particular situations, guidance does exist that can assist with the assessment process, but generally there is no precise guidance that is available regarding determining the overall significance of the noise impact. For residential properties, for example, the baseline and future noise level information will lead to each property (and effectively those living within it) being assigned with a certain noise level or noise change as a result of the proposals. Most likely, this will be expressed in terms of a particular noise indicator. From such an analysis a range of results for a project could occur, for example::

- One dwelling will experience an increase of 15 dB(A); or
- 100 dwellings will experience an increase of 1 dB(A); or
- 10 dwellings will experience an increase of 10 dB(A), and 100 properties will experience a reduction of 1 dB(A).

7.3 The overall noise impact of a project may fall between highly beneficial at one extreme, and severely adverse at the other. In the case of a development that requires a formal EIA, there needs to be an evaluation regarding whether or not the effects of these impacts are significant. The evaluation of the significance of the noise effects should be carried out for each environmentally sensitive receptor (ESR) or group of receptors. With this information, the final decision maker will be able to add it to similar information about other effects of the proposals (e.g. on air quality, landscape, economics), to reach an overall decision about the development.

7.4 For each one of the cases mentioned in paragraph 7.2 above, the decision maker will want to have an understanding of the overall noise impact and the significance of the associated effects. Reaching that conclusion, however, is not something that can be undertaken following a standard protocol. While objectivity, with its implied reproducibility, is desirable, it is only of value if the methodology has a reliable basis. The assessment of environmental noise does not have the detailed understanding necessary to enable a reliable, precise, objective protocol to be defined for every situation.

7.5 In some circumstances, the magnitude of the noise change, i.e. the noise impact, may be described in terms of a long established noise indicator; but it is possible that basing the judgement on that comparison alone will be insufficient[71]. Other indicators might need to be examined and other relevant factors should be taken into account, e.g. health effects. The difficulty that exists is that not enough is known about the detailed interaction of the various factors to enable a purely objective systematic approach to be defined. the assessor must, show that all the relevant factors have been taken into account, and demonstrate that a holistic approach has been taken in the assessment process.

7.6 In some situations, the conclusion about the degree of the impact will be clear and straightforward; but in others it is likely that, ultimately, a professional judgement will have to be made by the assessor. It must be remembered that the effects of noise are primarily subjective, and while it is desirable to include as much objectivity as possible into the assessment process in order to obtain consistency, there should be no concern in allowing professional judgement to come in the final analysis. However, the basis for the judgement made must be clearly set out so that it is clear how the conclusion has been reached.

71. Although such an approach is usually appropriate when evaluating scheme options at an initial stage.

7.7 In the remainder of this chapter, guidance will be given on how that professional judgement can be made, and how the various factors that might influence that judgement can be taken into account. The guidelines are applicable in all parts of the UK and EU, subject to the caveat that the nuances of the devolved administrations and other EU member countries, legislation, regulations, policy and advice, need to be factored in by practitioners in applying the guidance. Figure 7-4, at the end of this chapter summarises the process. However, it is important to note that the subjective response to noise cannot include the underlying health effects of noise for which there are guidelines and emerging research[72].

7.8 As described in Chapter 3, the assessment of environmental noise has required the measurement of that noise as a means of determining the corresponding subjective reaction. Over the years, legislation, standards and guidance have been prepared which uses as their basis the relationship between a measure of the noise and the consequent community response, usually described in terms of the annoyance caused by the noise. Examples include the $L_{A10,18h}$ indicator for road traffic noise and the $L_{Aeq,16h}$ indicator used for aircraft noise.

7.9 Using this approach, the result of the noise assessment at a particular dwelling or group of sensitive receptors might be as follows:

TABLE 7-1 NOISE LEVEL CHANGE

CASE	LEVEL
Before	A
After	B
CHANGE	**B minus A**

7.10 The judgement that is required is whether or not the change in level of B – A i.e. the noise impact, causes a noise effect – and if so, the degree of that effect and, when related to an EIA, whether or not that effect is significant. Typically, that judgement has been made solely on the basis of that difference (B – A), deciding:

- Whether the noise change is small enough such that it is likely to be unnoticeable or barely noticeable; or
- Whether it is large enough to be noticed and hence cause a noise impact but not so large as to cause that impact to be significant; or
- Whether it is so large that the noise impact causes a significant noise effect.

7.11 Despite previous established practice, the noise impact and the consequential effect can only rarely be properly determined solely by the simple numerical difference in the value of a particular noise indicator. Instead, the following issues should also be considered.

7.12 Determining the simple numerical change of a particular noise indicator is only a starting point in describing the consequential effect on a receptor, and where relevant, evaluating the significance of that effect. When identifying the noise impact and the degree of the consequential effect, it is also necessary to consider, in qualitative terms, what might be the effect of any differences between the future and existing situations in either:

- the type of noise source, or
- the nature of the change, or
- other factors

on the question of whether or not the conclusions initially drawn from the numerical change in noise level remain valid.

71. Although such an approach is usually appropriate when evaluating scheme options at an initial stage.
72. Good Practice Guide on Noise Exposure and Health Effects, EEA, 2010; Night Noise Guidelines for Europe, WHO, 2009.

7.13 It is only by taking account of these factors that the magnitude of the effect of a given noise impact on sensitive receptors can be properly identified.

7.14 The various factors that have been identified as influencing this process are:

- Averaging period;
- Time of day;
- Nature of the noise source (intermittency, etc.);
- Frequency of occurrence;
- Spectral characteristics;
- Absolute level of the noise indicator; and
- Influence of the noise indicator used.

These factors are described and considered further in Table 7-2.

TABLE 7-2 ASSESSMENT FACTORS

Factor	Issue
Averaging Period	Is the averaging time so long that it might mask a greater impact at certain times, or does the noise change occur for such a small proportion of the time that it therefore can be considered of little consequence?
Time of Day/Night/Week	Is the change occurring at a time that might increase or reduce its effect from that implied by the basic noise change?
Nature of the Noise Source	Is there a change in the nature of the noise source which might alter the effect?
Frequency of Occurrence	How does the frequency of the occurrence of the noise source affect the effect?
Spectral Characteristics	Is there a change in the spectral characteristics which might affect the effect?
Noise Indicator	Has the indicator(s) which best correlates with the specific effect been correctly identified? (i.e. does the change in level as described by the indicator used adequately reflect the change that would be experienced by those exposed to it and could be affected by it?)
Absolute Level (Benchmark)	How does the change relate to any applicable published guidance?

AVERAGING TIME PERIOD

7.15 For some noise sources, the period over which the noise indicator is averaged for the purpose of quantifying the impact is set out in standards and guidance documents. Noise indices such as the $L_{A10,18h}$ and the $L_{Aeq,16h}$ can be used to describe noise exposure over a period of time. However, if the noise change is confined to a period that is shorter than the adopted averaging period, the change in the noise index is likely to be very small. The longer the averaging time period of the indicator, the more likely it is that a small change in it could be masking a larger and potentially substantial change that only occurs for a short part of the averaging period.

7.16 For example, a particular proposal may simply cause a four-fold increase in traffic between 22:00 and 23:00 hours, with no change at any other time of day. Using the $L_{A10,18h}$ indicator only to describe the change is likely to give rise to at most a few tenths of a decibel increase. At first sight, this would not appear to be significant. Yet, such an increase in traffic, and hence noise, at that time of the evening could lead to a substantive effect on residential receptors. Thus although legislation and other guidance may point to the use of the $L_{A10,18h}$ indicator for the assessment of traffic noise, the sole use of that indicator may not adequately describe the impact that will occur, and lead to the effect being underestimated.

7.17 In this example, only a small change in the $L_{A10,18h}$ indicator would occur, but this might not reflect a noise impact which should be taken into consideration. However, assessing the $L_{A10,1h}$ indicator for each of the 24 hours of the day would identify the hour with the four-fold increase in traffic. Thus, in this case, trying to determine the noise impact solely from the change in $L_{A10,18h}$ may be considered to be misleading, because the long averaging time is masking a potentially significant effect. Conversely, it can be argued that if the four-fold increase only occurs during one short period in the day, and the increase over the rest of the day is not significant, there is less of an impact than if the four-fold increase had occurred over the whole day.

7.18 A similar argument exists for any source where the established assessment method involves the use of an indicator averaged over a long period. Furthermore, it may be necessary to take account of any seasonal variations which may occur and which may be masked through the use of a noise indicator that is averaged over a year.

TIME OF DAY

7.19 It has long been recognised that a given level of noise is generally likely to cause different effects in terms of annoyance or disturbance depending on the time of day that the noise occurs, and the activity being undertaken at that time. For a long time planning guidelines have distinguished between daytime and night-time noise levels when setting criteria for residential premises. Current guidance and practice has continued that distinction, defining day as the 16-hour period between 07:00 and 23:00 hours, and night as 23:00–07:00 hours[73].

7.20 Time-of-day sensitivity is related to the activity being undertaken by the individual affected by the noise. Consequently, it could be considered that night becomes more sensitive because people are generally trying to fall asleep, are asleep or trying to fall back asleep. Noise can disturb these activities and if a noise event occurs towards the end of the night, there is a chance of the individuals being awakened prematurely. Therefore, the key effect is sleep disturbance, and annoyance about noise at night generally cannot occur without sleep disturbance having first occurred.

7.21 It also can be argued that within the 16-hour period, the evening period (19:00–23:00 hours) is relatively more sensitive than the remaining 12-hour period[74]. This is also activity-related, since during the evening people are generally at home relaxing, and children will be going to bed during this time.

7.22 For other noise-sensitive premises, different times of day may be important. In the case of schools, the sensitive times are during school hours, although these might extend into the evening if adult education courses or other noise-sensitive activities are held there. For churches and other places of worship, it is the times of the services that can be particularly sensitive.

73. For example, BS8233:2014.
74. The 1999/2000 National Survey of Attitudes to Environmental Noise (BRE), February 2002.

7.23 In addition to such diurnal considerations, there may be variations in sensitivity between:

- weekdays and weekends;
- Saturdays and Sundays;
- normal weekdays and public holidays; and
- different times of the year.

(It must also be remembered that some of these variations may affect the values used in defining the baseline.)

NATURE OF THE NOISE SOURCE

7.24 For a given level of noise, it is often considered that a source which emits a continuous noise level is less annoying or disturbing than a source that is intermittent enough to attract attention. This approach means that the nature of the noise source and how its nature changes needs to be taken into account.

7.25 Consider two situations: In Case 1 a noise source currently operates (without complaint or apparent disturbance) at a constant level, continuously for one hour (10:00–11:00) and then switches off for one hour (11:00–12:00), and continues with this pattern until 16:00 hours, as shown in Figure 7-1. (When the noise source is off, other noise in the area results in a level of 30 dB(A).)

7.26 Suppose that a change is proposed whereby the noise source would operate at a constant level and continuously between 10:00 and 16:00, as shown in Figure 7-2.

FIGURE 7-1 CASE 1 – THE EXISTING NOISE ENVIRONMENT

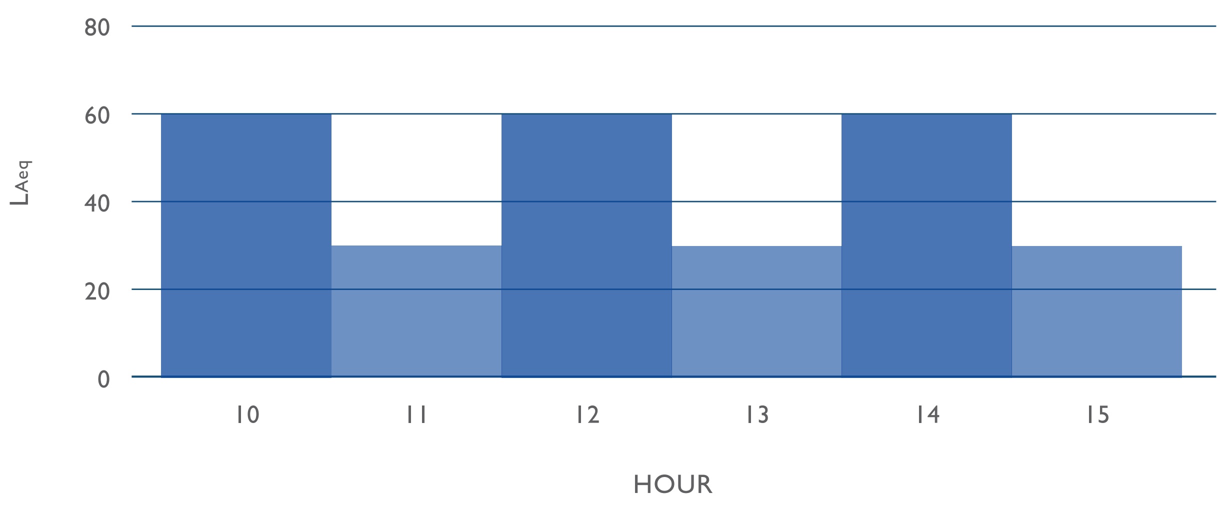
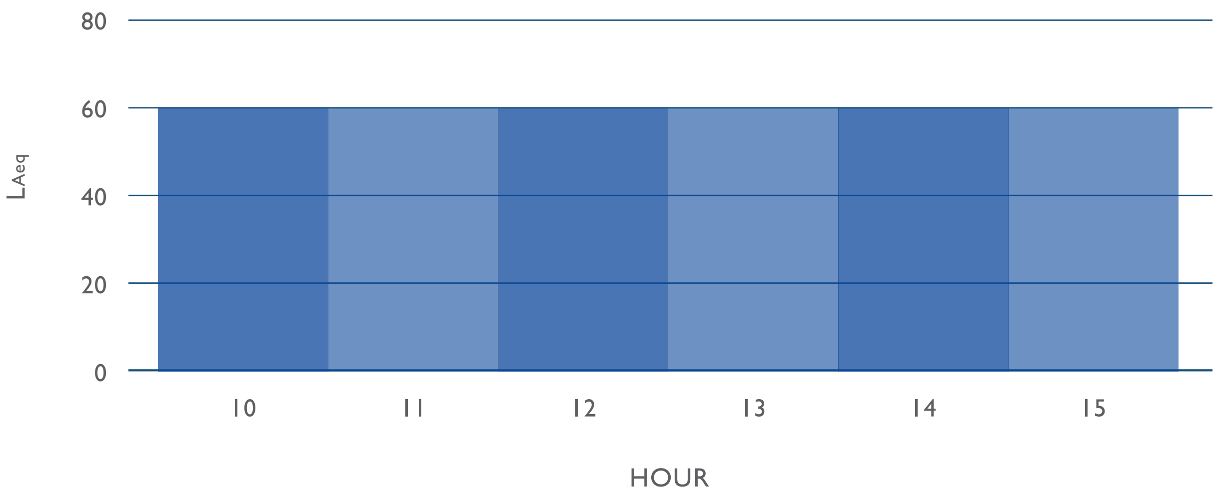


FIGURE 7-2 CASE 2 – THE FUTURE NOISE ENVIRONMENT



7.27 A simple assessment of Case 1, considering the L_{Aeq} averaged over the period 10:00–16:00 hours, would show the noise levels in Table 7-3.

TABLE 7-3 CASE 1 – NOISE LEVEL CHANGE FOR $L_{Aeq,\,6h}$

CASE	$L_{Aeq,\,6h}$
Before	57
After	60
CHANGE	**+3**

7.28 Consider now Case 2, in which the existing noise source currently operates continuously at a level of 57 dB(A) (without complaint or apparent disturbance) over the period 10.00–16.00 hours, and the proposal would increase that level to 60 dB(A) (continuously over the same time period). The question is whether the consequential effect on the receptor differs between these two cases.

7.29 For both cases, there is a 3 dB(A) increase in $L_{Aeq,6h}$, but the nature of the increase is different.

7.30 There is not a straightforward answer. Issues that the assessor may wish to take into account would include the following:

- The 3 dB(A) increase in Case 2 may only just be perceptible;
- There is an increase of 30 dB(A) during the new hours of operation in Case 1;
- In both cases the existing operation is occurring without complaint or apparent disturbance, even though, in Case 1, the source is 30 dB(A) above ambient when it occurs, and in Case 2 is 27 dB(A) above ambient.

7.31 In addition, it should be remembered that evidence from surveys of the subjective response to various noise sources indicates that, for a given level of noise exposure, a different degree of reaction may be expected, depending on the source.

7.32 Similarly, where a proposal involves receptors being affected by more than one type of source, there is the potential for a combined impact from the various sources that is different from that indicated by the combined basic noise change. There is limited research data available to determine how such impacts do combine, but it is important for the assessor to consider how the combined impact will affect the receptors, as set out in Table 7-7.

FREQUENCY OF OCCURRENCE

7.33 Development proposals may include noise sources that do not occur every day. It has been established that the frequency of occurrence of a source affects the annoyance and disturbance caused. Thus a single event, occurring just on one day, producing a certain L_{Aeq} averaged over a 12 or 16-hour period, is likely to cause less annoyance or disturbance than if it is repeated on, say, 12 days during the year.

7.34 This principle can be found in published guidance[75] where the recommended guideline limit or threshold depend in part on the frequency of occurrence of the events. Furthermore, it is noted in that guidance that the pattern of occurrence also influences the reaction. For example, 12 events, occurring once a month during one year, are likely to produce less disturbance than if the 12 events occurred over a period of just one month every year.

FREQUENCY SPECTRAL CHARACTERISTICS

7.35 If a new noise source is expected to exhibit a very different frequency spectral shape from the baseline noise, there may be a difference in effect beyond that suggested by the simple difference expressed in dB(A).

7.36 It is not possible to give any more precise guidance because there is virtually no research on the effect of a change in frequency spectrum. In some guidance[76] those noise sources which have a distinct tonal content are penalised, and elsewhere some assistance can be found in defining tonal in terms of the spectral shape[77].

7.37 Furthermore, relying only on changes in dB(A) when the noise source contains a bias towards the low frequency end of the spectrum may mislead the assessment. There is some evidence that such a spectrum produces relatively more annoyance or disturbance than a noise source with the energy more evenly distributed across the spectrum[78, 79].

7.38 While it is usually possible to define the frequency spectrum of the baseline situation by measurement, sufficient information may not be available to predict the expected future spectrum. Therefore, it may be necessary to estimate the spectrum in order to determine whether the frequency characteristics are likely to affect the assessment.

THE INFLUENCE OF THE NOISE INDICATOR

7.39 It has already been shown that the use of standard noise indicators may fail to reveal adequately the actual noise impact of the proposals. A further aspect which needs considering is whether the impact that is indicated by the noise change between before and after situations, when using a standard indicator, adequately reflects the change that would be heard or the effect on the receptor or resource that is being assessed.

7.40 Consider, for example, a single property located very close alongside a minor road. The traffic which uses that road causes the $L_{A10,18h}$ at the most affected facade to be 65 dB(A). A six-lane motorway is proposed to be built about 150 m away from the property, and at the most affected facade the predicted noise level is 60 dB(A), $L_{A10,18h}$ from the motorway alone. There is no change expected in the traffic using the minor road, so the new total noise level is 66 dB(A)($L_{A10,18h}$). The impact in terms of $L_{A10,18h}$ is (Table 7-4).

75. Code of Practice on the Control of Noise from Concerts, The Noise Council, 1995.
76. BS 4142. 77. BS 7445. 78. Low frequency noise and annoyance, Noise Health (2004), Apr-June 6 (23) pg 59–72, Leventhall HG.
79. Low Frequency Noise Annoyance, Infrasound and Low Frequency Vibration, ME Bryan and W Tempest (1976).

TABLE 7-4 NOISE LEVEL CHANGE FOR $L_{A10,\,18h}$

CASE	$L_{A10,\,18h}$
Before	65
After	66
CHANGE	+1

7.41 However, this analysis does not take into account the change in noise character. The traffic on the minor road is intermittent, whereas the noise from the motorway would be likely to be continuous. Using the arguments described in paragraph 7.25, moving from an intermittent noise to a more continuous noise may alter the conclusion regarding the effect that otherwise may be drawn from the numerical noise change. If anything, therefore, a conclusion might be drawn that the impact may not be as great as even the 1 dB(A) increase might indicate. But would that conclusion be correct? What is the change in the noise that residents would hear?

7.42 Although both the existing and the new noise sources are road traffic, arguably, it is not appropriate to combine them, as was done in Table 7-4, because the character of each is so different. It is likely that the impact perceived would be the sound of the motorway compared with what could previously be heard in between the sound of the vehicles using the minor road. This effect is not shown by the comparison in Table 7-4.

7.43 Therefore, it is necessary to be sure that the indicators used to describe the noise environment, and the change in it, do so adequately. For most situations this can be achieved by examining the following indicators:

- L_{Amax} An indication of the maximum sound level heard;
- L_{Aeq} An indication of the average level of noise heard (L_{A10} can be used for road traffic in specified situations);
- L_{A90} An indication of the minimum noise level heard;
- N The number of distinct events in a certain time period.

7.44 In the example considered above, the likely change in these indicators would be as in Table 7-5.

TABLE 7-5 LIKELY CHANGE IN INDICATORS RESULTANT FROM THE PROPOSAL

INDICATOR	CHANGE
L_{Amax}	No Change (L_{Amax} still dominated by the minor road)
L_{Aeq}/L_{A10}	Slight Increase (as shown in Table 7-4)
L_{A90}	Large Increase (dominated now by the virtually continuous noise from the motorway)
N	No Change (no new discrete events)

7.45 Thus the impact identified by the $L_{A10,18h}$ comparison can provide only part of the answer. There would almost certainly be a large change in the L_{A90}, and it is this change which would probably be noticed by the affected residents, potentially resulting in a noise effect (e.g. a change in behaviour).

7.46 Illustrations of the changes that might occur in some other situations are given in Table 7-6. Example 1 has been discussed above (paragraphs 7.40–7.42).

7.47 For Example 2, consider a new railway added to an existing noise environment dominated by a minor road. In most cases the L_{Amax} would remain unchanged or increase, depending on the relative distances. The L_{Aeq} would be likely to increase, but the L_{A90} would remain unchanged, because there would still be gaps between both the traffic using the minor road and the train movements such as to leave the L_{A90} unaffected, unless the rail service was very frequent.
The number of discrete noise events would increase.

7.48 For Example 3, in which a new railway is added to a rural environment, the L_{Amax} would probably increase as a result of the train events. The L_{Aeq} would also increase because of the railway. The L_{A90} would not change because this would still be influenced by the gaps between the rail events, unless the rail service was very frequent. The number of discrete events would increase.

7.49 Example 4 considers an industrial development in a rural environment. In this case, both the L_{Amax} and the L_{Aeq} might remain unchanged, although the L_{Aeq} might rise as a result of the new industrial noise. If the industrial noise is continuous, the L_{A90} is likely to increase, but if the industrial noise contains no discrete events, N would not change.

7.50 In Example 5, a railway is added to an area affected by aircraft noise. The L_{Amax} may not change since this might still be dominated by the aircraft events. The L_{Aeq} might not appear to change if the aircraft noise is dominant, or it might increase slightly. There would still be gaps between the two types of noise event, so the L_{A90} would not alter. N would increase because of the greater number of discrete events.

7.51 What is being examined by this approach is whether the established relationship between effect (which is usually defined in terms of annoyance) and the standard noise indicator would continue to hold in the situation being considered.

7.52 In Example 1, the large change in L_{A90} could significantly affect the quality of life or amenity of the residents of the property, and that might affect their attitude to, and annoyance with, the road traffic noise. The small increase in $L_{A10,18h}$ suggests only a small increase in annoyance, but this may not reflect what will actually occur. Conversely, concentrating solely on the likely change in L_{A90} could overestimate the adverse impact. The main problem is that not enough is known about what occurs in this type of situation. for any assessment, it is essential that all these issues are addressed and a view taken about them.

7.53 Similar arguments exist with regard to sources made up of discrete events (e.g. Examples 5), and whether the change in $L_{Aeq,T}$ over-or underestimates the change in disturbance or intrusion from the change in the noise environment which could occur as a result of the change in the number of events.

TABLE 7-6 SUMMARY OF POSSIBLE CHANGES IN NOISE INDICATORS FOR A VARIETY OF SITUATIONS

Example	Existing Source	Future Source	L_{Amax}	L_{Aeq}	L_{A90}	N
1	Minor road	Motorway	None	Slight Increase	Large Increase	None
2	Minor road	Railway	None/ Increase	Slight Increase	None	Increase
3	Rural	Railway	Increase	Increase	None	Increase
4	Rural	Industrial	None	None/ Increase	Increase	None
5	Airport	Railway	None	None/ Increase	None	Increase

N.B: These changes will depend on the relative sound powers of the different sources and the relative distances between the sources and the receptor.

THE INFLUENCE OF THE ABSOLUTE LEVEL

7.54 Relying solely on the change in noise level is not appropriate because it risks ignoring the context of the noise change. It also gives scope for what is often called 'noise creep'. This is the gradual increase in the noise level in an area as a result of a succession of small increases in noise level which, taken individually, might not be regarded as having a noticeable effect, but cumulatively lead to a noticeable effect which could be considered to be significant. Of course, the converse can be true. A succession of small decreases in noise might not be significant in themselves, but cumulatively could result in perceived benefits.

7.55 To address this issue, consideration also must be given to the absolute levels being encountered and how they compare with any relevant standards, guidance or relevant research. There are two aspects to this element:

- How the existing or before noise level compares with the appropriate guideline; and
- How the final noise level relates to any relevant guidance.

7.56 A development proposal which would cause an increase in an existing level that is already well above an existing guideline should probably be regarded as worse than if the existing level were below the guideline. If the existing noise environment is already at a level where there might be significant risk of adverse quality of life and health effects, then almost any increase in noise level, regardless of how small, is an impact which should be taken into account in the assessment.

7.57 Similarly, but at the other end of the scale, for an area which is valued because of the soundscape, a relatively small impact could be considered as having a potentially substantive effect if the quality of the noise environment were to be eroded. This particularly relates to tranquil, quiet or calm areas.

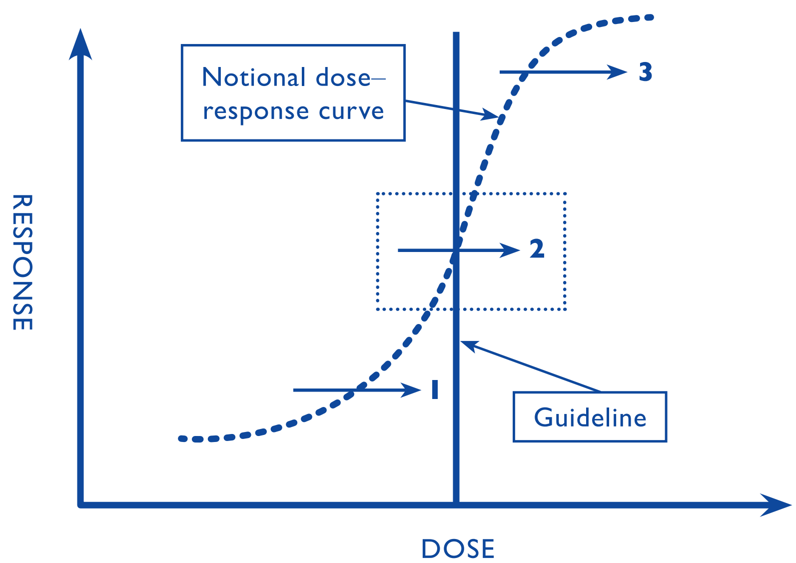
7.58 In relation to any relevant standards and guidance, a noise increase arising from a development falls into one of three categories (depicted in Figure 7-3):

1. The existing level and the future level are below the relevant guideline;

2. The existing level is below the guideline but the future level is above the guideline; and

3. Both the existing and future level are above the guideline.

FIGURE 7-3 THREE EXAMPLES OF POTENTIAL NOISE CHANGES



7.59 If it is accepted that the relationship between the noise change and the guideline level influences the extent of the impact, then, for the same noise change, situation (1) is likely to have the least effect, unless the starting point is a relatively low-noise area. Situation (3) has a greater effect because the guideline level is already exceeded and the proposal is worsening the situation.

7.60 this distinction is based more on a common-sense approach than on a firm scientific acoustic basis. If the guideline noise level has any relevance, increasing the noise level, but keeping it below the guideline value, is clearly more acceptable than increasing the noise level when it is already above the guideline.

7.61 Consider now superimposing a typical acoustic exposure–response curve (Figure 2-2), (see Chapter 2). In this example, it can be seen that the gradient of the curve is similar at both extremes, and so the increase in annoyance/disturbance that would be expected in situation (3) is no more than that which would be expected in situation (1). Nevertheless, custom and practice supports the assertion that situation (3) is worse than (1).

7.62 Situation (2) displays similar complexities. If the guideline noise level is exceeded as a result of the proposed change, this could be regarded as a significant impact. In which case, situation (2) is worse than either situation (3) or (1). To an extent this conclusion can be supported in this example because the slope of the dose–response curve is at its steepest in this region (see Figure 7-3). Thus situation (2) could generate the largest change in the subjective response for a given change in noise level.

CHANGES CLOSE TO THE GUIDELINE

7.63 In most cases, an increase just either side of the guideline is likely to produce a similar change in annoyance/disturbance as the same change which happens to cause the guideline to be breached (see Figure 7-3). All three changes illustrated would be expected to cause acoustically similar effects, but only in one of the cases does the change breach the guideline. Arguably, therefore, there is no greater significance with a change that causes the guideline to be exceeded, compared with the same changes just on either side of it. Nevertheless, when presented with a guideline or limit of, say, 65 dB(A), decision makers often seem to regard 64.9 dB(A) as being quiet and peaceful, and 65.1 dB(A) as very loud and unacceptable. Clearly such an approach must be ill-conceived, as both noise levels when rounded are 65dBA and the difference between them would be imperceptible. For this reason, while it may be important to determine any change in noise level to the nearest 0.1 of a decibel, it is equally important to understand and communicate what the noise change means with respect to annoyance, disturbance and health effects.

7.64 In certain cases, there is government endorsed guidance which defines what are considered to be acceptable noise thresholds e.g. ETSU-R-97 for wind turbines, below which the government states that the situation is acceptable. This does not mean, however, that there would be no effect (consequences) and it is important to acknowledge any impact (change in noise level) that is identified even if the government limit or guideline value is not exceeded. Conversely, if a guideline is already being exceeded or is just exceeded by the noise change, there may not be an effect (any consequences) if the expected noise change is not noticeable (see Table 7-7). However, the fact that the guideline is exceeded as a result of the proposal should be reported.

7.65 On balance, after taking account of all of these issues it is clear that there is no simple answer and professional judgement will be required in both describing the likely effect of the noise impact and, in EIA, when going on to evaluate the effect's significance.

7.66 When relating the changes to the absolute levels and corresponding guidelines, care must be taken not to double count factors such as time of day when making the overall assessment. Noise guidelines for evening and night periods are often lower than their daytime equivalent and thus effectively already take account of the time of day factor.

IMPACT AND ASSESSMENT OF EFFECTS

7.67 When the impact of a scheme has been suitably described and assessed, it is then necessary to assess the effect of a development on the receptors and resources likely to be impacted and, in the case of EIA development, to determine whether the effect is significant or not. Exposure to noise is already prevalent within the UK (UK Noise Incidence Study[80]) and, in the absence of any impacts resulting from a proposed scheme, the occupants of buildings may already be exposed to varying levels of noise. In some cases, the occupants of buildings may have already made adaptations to the use and occupation of the building in response to existing levels of noise, or incorporated noise insulation or other protection measures to make occupation of a particular building suitable.

7.68 Once all these factors have been taken into account, the assessor is in a position to form a view about the magnitude of the impact and, where necessary, the significance of the effect. Table 7-7 sets out a generic scale for describing a range of noise effects on a receptor.

80. The National Noise Incidence Study 2000, P Wright, C Grimwood, BRE Client Reports Nos 203938f and 206344f.

TABLE 7-7
GENERIC RELATIONSHIP BETWEEN NOISE IMPACT (MAGNITUDE) AND NOISE EFFECT (MAGNITUDE + SENSITIVITY), INCLUDING THE EVALUATION OF EFFECT SIGNIFICANCE

MAGNITUDE (Nature of Impact)		DESCRIPTION OF EFFECT (on a specific sensitive receptor)	SIGNIFICANCE (as required within EIA)
Substantial	BENEFICIAL	**Receptor perception = Marked change** Causes a material change in behaviour and/or attitude, e.g. individuals begin to engage in activities previously avoided due to preceding environmental noise conditions. Quality of life enhanced due to change in character of the area.	**More Likely to be Significant** (Greater justification needed – based on impact magnitude and receptor sensitivities – to justify a non-significant effect) ↕
Moderate	BENEFICIAL	**Receptor perception = Noticeable improvement** Improved noise climate resulting in small changes in behaviour and/or attitude, e.g. turning down volume of television; speaking more quietly; opening windows. Affects the character of the area such that there is a perceived change in the quality of life.	
Slight	BENEFICIAL	**Receptor perception = Just noticeable improvement** Noise impact can be heard, but does not result in any change in behaviour or attitude. Can slightly affect the character of the area but not such that there is a perceived change in the quality of life.	(Greater justification needed – based on impact magnitude and receptor sensitivities – to justify a significant effect) **Less Likely to be Significant**
Negligible		N/A = No discernible effect on the receptor	**Not Significant**
Slight	ADVERSE	**Receptor perception = Non-intrusive** Noise impact can be heard, but does not cause any change in behaviour or attitude, e.g. turning up volume of television; speaking more loudly; closing windows. Can slightly affect the character of the area but not such that there is a perceived change in the quality of life.	**Less Likely to be Significant** (Greater justification needed – based on impact magnitude and receptor sensitivities – to justify a significant effect) ↕
Moderate	ADVERSE	**Receptor perception = Intrusive** Noise impact can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; closing windows. Potential for non-awakening sleep disturbance[81]. Affects the character of the area such that there is a perceived change in the quality of life.	
Substantial	ADVERSE	**Receptor perception = Disruptive** Causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion. 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 character of the area.	(Greater justification needed – based on impact magnitude and receptor sensitivities – to justify a non-significant effect) **More Likely to be Significant**
Severe	ADVERSE	**Receptor perception = Physically Harmful** Significant changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Significant

81. Further information on the effects of noise on sleep can be found in the World Health Organization's Guidelines on Community Noise (WHO, 1999) and Night Noise Guidelines for Europe (WHO, 2009).

7.69 As indicated above, the potential impacts described in Table 7-7 and their consequential effect in terms of attitude, behaviour and quality of life primarily refer to individuals in and around their homes. The principles behind the range of impacts and effects in Table 7-7 also can be applied to people at other noise-sensitive receptors, e.g. schools, hospitals, places of worship and amenity areas, although the detailed changes in attitude and behaviour may be different.

7.70 In the case of amenity areas, for example, a non-intrusive noise impact may mean that people still use the amenity area as often as they did before, even though new noise can be heard. At the other extreme, the effect of a disruptive impact may mean that people no longer use the amenity because of the new noise intrusion spoiling their enjoyment of that area.

7.71 To determine an effect on human receptors, the assessor must form a view regarding the extent of the impact that the proposed development is likely to cause, and any consequential change in attitude, behaviour and health effects.

TABLE 7-8
GENERIC SCALE OF NOISE IMPACTS ON FAUNA

DESCRIPTION OF MAGNITUDE OF IMPACT	EFFECT	SIGNIFICANCE OF EFFECT (if required, e.g. as part of EIA)
Negligible	**No reaction**	Not significant
Slight	Noise causes a reaction, either physiological or behavioural, but fauna returns to pre-exposure conditions relatively quickly and without continuing effects.	**Less Likely to be Significant** (Greater justification needed – based on impact magnitude and receptor sensitivities – to justify a significant effect) ↕ (Greater justification needed – based on impact magnitude and receptor sensitivities – to justify a non-significant effect) **More Likely to be Significant**
Moderate	Noise causes a reaction, either physiological or behavioural, but cause more permanent changes that do not readily allow individuals or communities to return to pre-exposure conditions. Can include temporary nest abandonment.	
Severe	Noise causes demonstrable harm, either injury or death, or causes situations such as permanent nest abandonment.	**Significant**

7.72 One of the principal health effects is that related to sleep quality where the maximum level of noise, the number of events and character of the noise source are all important. The actual test of significance will depend upon the circumstances and will need to be justified according to the particular merits of each scheme. Where it is practicable to do so, it is recommended that a risk assessment for new infrastructure projects be undertaken using available dose–response relationships, in line with the WHO Night Noise Guidelines publication and any other relevant research, when the noise is expected to be above adverse effect threshold levels. Such an approach has been utilised to justify the criteria used to assess the effect of HS2 on sleep, and is usefully described in a paper specifically related to high–speed railways[82].

7.73 Another type of receptor that may have to be considered is the noise impact on fauna. Table 7-8 sets out a scale describing a range of noise impact on fauna.

7.74 Having taken account of the various factors, the assessor must consider the noise impact at each sensitive receptor and evaluate how it relates to the categories shown in Tables 7-7 or 7-8. When considering different types of receptor, it is important to understand that not all sensitive receptors are equally sensitive. Accordingly, because of the difference in species and the way in which they variously react to different sources and levels of noise, it will be important to obtain input to this part of an assessment from a qualified ecologist.

7.75 To demonstrate how this method differs from the more traditional approach, consider as an example, a proposal that is expected to give rise to a continuous (broad band) noise that would cause a 5 dB(A) increase in the night-time $L_{Aeq,8h}$ from 37 dB(A) to 42 dB(A). In many cases, previously, the judgement regarding the magnitude of the impact would have been based solely on the noise level difference. However, other factors need to be considered. So, account should be taken of the fact that the noise will occur continuously, at night and has no distinguishing characteristics. Note that when compared with relevant guidelines, good acoustic standards would still be achieved inside a dwelling even if windows were partially open for ventilation. Consequently, in terms of the descriptors in Table 7-7, no material change in behaviour would be expected; so although it would be expected that the noise change would be noticeable, it would not be expected to be intrusive or result in a change in behaviour and, in the context of a formal EIA, is not a significant effect.

7.76 Consider, on the other hand, a proposal that is expected to cause an increase in $L_{Aeq,16h}$ (07:00–23:00) of 0.5 dB(A). At first sight, this appears to be a very small change. However, suppose that this change results solely from an increase of 6 dB(A) in the hour between 07:00 and 08:00 each day. It is occurring at a time of day when typically the dwelling would be occupied and, at weekends, at a time when residents might still want to rest and sleep. Therefore, depending on the absolute level, the noise could be intrusive and could cause changes in behaviour. If this was considered to be the case, according to Table 7-7, the effect would be noticeable and intrusive, and, in the context of a formal EIA, significant.

7.77 Following the publication of the draft guidelines in 2002[83], there was evidence of some confusion over their application. At no time did these guidelines confirm that a certain noise level change equated to a certain semantic description of the magnitude of the noise impact. As indicated above, the assessor must form a view about the appropriate descriptor, taking account of the objective evidence of the expected noise change, and making a professional judgement regarding the effect of the noise impact.

NOISE EFFECT OF THE SCHEME

7.78 Having undertaken the assessment for the various receptors and resources, consideration has to be given to the presentation and reporting of the assessment that will promote good decision-making and inform judgement on the overall noise effect of the project. As with most planning decisions, noise is one of several, if not many, considerations to be taken into account which include the social and economic merits of the specific development proposal. What the decision makers and other stakeholders and interested parties need is information that is accessible and which allows the overall noise effect of the scheme to be considered in the context of other effects on aspects of environmental assessment such as air quality, landscape and visual intrusion, etc. For example, a noise assessment may produce results, as in Table 7-9.

82. ICBEN 2014, Marshall T, Greer R, Cobbing C; Evaluating the Health Effects of Noise from High Speed Railways.
83. Consultation Draft: Guidelines for Noise Impact Assessment (IEMA/IOA – March 2002).

TABLE 7-9 OVERALL NOISE EFFECT OF THE PROPOSAL

Scale of Noise Effects	Dwellings	Schools	Places of Interest	Amenity Areas	Fauna
Severe Adverse Effect	5	0	0	2 km^2	0
Substantial Adverse Effect	10	0	0	6 km^2	0
Moderate Adverse Effect	20	3	0	6 km^2	2 habitats
Slight Adverse Effect	30	1	0	10 km^2	0
No Effect	100	4	2	30 km^2	0
Slight Beneficial Effect	50	1	2	4 km^2	1 habitat
Moderate Beneficial Effect	4	0	1	0	0
Substantial Beneficial Effect	0	0	0	0	0
Major Beneficial Effect	0	0	0	0	0

7.79 There is a case for saying that noise assessments should finish with such a table, because it is likely that no two people would draw the same conclusion from it regarding the severity or otherwise of the overall noise effects. However, the decision maker has to make that judgement so that it can be added to similar judgements about other effects of the proposals (e.g. air quality, landscape, economics etc.), to reach an overall decision about the acceptability or otherwise of the development. Hence, it is often incumbent on the assessor to provide some guidance on what that judgement should be, and the assessor may be encouraged to do so by both the planners and the decision maker. Although there is much information that will have been included in the noise assessment, the decision maker is likely in the end to have to summarise the overall degree of the noise impact of the proposal by a single description, using the terminology shown in Table 7-9. For larger schemes, liaison will have to occur with other disciplines to check that the descriptors used attract an equal weight and describe similar degrees of effect. In this respect the scales used for the magnitude of the impact and the sensitivity of the receptors need to be considered carefully as to what can be reasonably justified.

7.80 In reaching a conclusion about the overall scale of the noise impact and its significance, the assessor should clearly set out the evidence which has been relied upon. In addition, it is important to highlight any receptors that would be expected to suffer a noise effect, even if the overall conclusion is that the proposals produce only a slight adverse effect. This would enable the decision maker to be aware of the particular receptors that are likely to experience adverse noise effects, and provide the opportunity for additional mitigation to be considered for those receptors.

7.81 There is also a view that the size of the project should be taken into account in any judgement of the overall severity of the noise impact. For example, a proposal for a new car wash might result in one property receiving a substantial adverse noise impact. Should the conclusion in terms of overall noise effects be the same as that from a proposed new airport which gives rise to exactly the same result, i.e. one property receiving a substantial adverse noise impact? It could be argued that the promoters of the airport would have been very successful in mitigating its effects if that were the total impact, and that this success should be reflected in the judgement of the overall noise effects. Using this approach, the overall noise effects from the car wash are likely to be regarded as being worse than the overall effects from the airport proposal. However, it is important to stress that any conclusion about the overall acceptability of a scheme, when considered in relation to the social and economic benefits/disbenefits of the proposals, are for the decision maker to determine.

7.82 An alternative view is that the noise impact should be assessed solely by reference to the effects arising from the noise change, i.e. how many receptors are affected by the proposals and to what extent? For the car wash and the airport in the example given above, the impact is identical, and both should be judged to give the same overall noise impact. It is further on in the environmental impact assessment process that differences between the two schemes will emerge (primarily, probably, because of differences in the economic benefits). It is at that point that the fact that the airport only causes a substantial noise impact at one property allied with its economic benefit would put it ahead of the car wash, if a comparison was being made. Thus, the scale of the project should not affect the judgement regarding the severity of the noise impact.

7.83 The noise arising from the construction phase also

needs to be considered, even though it is of finite duration. The principles described above should be used with appropriate account being taken of the expected duration of the construction works. For some projects there also might be a de-commissioning phase that requires assessment using the above principles.

RESIDUAL EFFECT

7.84 This term effectively describes the resulting noise effect of the proposal that would remain once any mitigation has been implemented. It is the noise effect that is described by the type of data set out in Table 7.9 above. The term 'residual effect' (and residual impact) tends to focus on the adverse effects that remain (rather than any beneficial effects), and its function is to ensure that the remaining adverse effects are not overlooked – even if the overall conclusion is that the proposal produces a net noise benefit, or the scheme is permitted because of other economic or social benefits.

CUMULATIVE AND IN-COMBINATION EFFECTS

7.85 We define cumulative effects as:
"those that result from additive impacts caused by other past, present or reasonably foreseeable actions together with the plan, programme or project itself and synergistic effects (in-combination) which arise from the reaction between impacts of a development plan, programme or project on different aspects of the environment[84]".

7.86 There can be situations when separate, independent proposals are put forward at about the same time and which are going to impact on the same receptors. The various proposals need to be assessed independently, but at some point, there should be liaison between the projects to consider the cumulative impact on the sensitive receptors of all the proposals. The cumulative impact is likely to be of concern for the local planning authority and, of course, those affected by the proposals are unlikely to differentiate between the noise from the different developments. They are simply going to perceive the total change to their noise environment, should all the developments be implemented.

MONETISATION OF NOISE EFFECTS

7.87 Approaches are emerging that attempt to assign monetary values to changes in noise level arising from large development proposals. These are currently confined primarily to new road and rail schemes, although some attempt is being made to cost the impact of changes in aircraft noise. There is debate over the robustness of these approaches, but in any event, they do not affect the determination of the nature and extent of the noise impact. Instead, this type of approach is likely to be found in any overall economic valuation of the development.

84. RUK July 2013. Guiding Principles for CIA in Offshore Wind Farms.

EXAMPLE APPROACHES TO NOISE IMPACT ASSESSMENT FROM RECENT PROJECTS

7.88 Current Practice: example based on traffic generated onto highway network by development

This approach represents a detailed methodology which has been adopted for a number of development proposals, including housing, where noise from traffic generated onto the existing highway network is the principal consideration. It relies on an understanding of the sensitivity of the receptor and the change in noise level exposure (Table 7-10).

TABLE 7-10 SENSITIVITY OF RECEPTOR TO NOISE LEVEL EXPOSURE

	Large	Medium	Small	Negligible
Relative change	Greater than 10 dB(A) change in sound level	5 to 9.9 dB(A) change in sound level	3 to 4.9 dB(A) change in sound level	2.9 dB(A) or less change in sound level
Absolute change – Adverse daytime	If b<50 dB $L_{Aeq,16hr}$ and f ≥55 dB $L_{Aeq,16hr}$ If f triggers entitlement to statutory sound insulation	If b < 50 dB $L_{Aeq,16hr}$ and 50≤f<55 dB $L_{Aeq,16hr}$ If 50≤b<55 dB $L_{Aeq,16hr}$ and f≥55 dB $L_{Aeq,16hr}$		
Absolute change – Adverse night-time	If b<45 dB $L_{Aeq,16hr}$ and f ≥45 dB $L_{Aeq,16hr}$ If b<60 dB L_{Amax} and f ≥60 dB L_{Amax} If b≥60 dB L_{Amax} but does not exceed 85 dB L_{Amax} more than twice in a one-hour period and f≥85 dB L_{Amax} more than twice in a one-hour period	If b> 85 dB L_{Amax} though not regularly and f exceeds 85 dB L_{Amax} more than twice in any one-hour period		
Absolute change – Beneficial daytime	If b≥55 dB $L_{Aeq,16hr}$ and f <50 dB $L_{Aeq,16hr}$	If 50≤b<55 dB $L_{Aeq,16hr}$ and f <55 dB $L_{Aeq,16hr}$ If b≥55 dB $L_{Aeq,16hr}$ and 50≤f <55 dB $L_{Aeq,16hr}$		
Absolute change – Beneficial night-time	If b≥45 dB $L_{Aeq,16hr}$ and f <45 dB $L_{Aeq,16hr}$ If b≥60 dB L_{Amax} and f <60 dB L_{Amax}			

7.89 Finally, to determine the overall noise impact, the magnitude and sensitivity criteria are combined into a Degree of Effect matrix as shown in Table 7-11, with the corresponding descriptors in Table 7-12.

TABLE 7-11 DEGREE OF EFFECT MATRIX

		IMPORTANCE/SENSITIVITY OF RECEPTOR			
		High	Medium	Low	Negligible
MAGNITUDE/SCALE OF CHANGE	Large	Very Substantial	Substantial	Moderate	None
	Medium	Substantial	Substantial	Moderate	None
	Small	Moderate	Moderate	Slight	None
	Negligible	None	None	None	None

TABLE 7-12 EFFECT DESCRIPTORS

Very Substantial	Greater than 10 dB L_{Aeq} change in sound level perceived at a receptor of great sensitivity to noise
Substantial	Greater than 5 dB L_{Aeq} change in sound level at a noise-sensitive receptor, or a 5 to 9.9 dB L_{Aeq} change in sound level at a receptor of great sensitivity to noise
Moderate	A 3 to 4.9 dB L_{Aeq} change in sound level at a sensitive or highly sensitive noise receptor, or a greater than 5 dB L_{Aeq} change in sound level at a receptor of some sensitivity
Slight	A 3 to 4.9 dB L_{Aeq} change in sound level at a receptor of some sensitivity
None/Not Significant	Less than 2.9 dB L_{Aeq} change in sound level and/or all receptors are of negligible sensitivity to noise or marginal to the zone of influence of the proposals

MORE RECENT APPROACH – BASED ON APPLICATION OF LOAEL SOAEL 7.90 The Noise Policy Statement for England presents an approach to defining noise levels at which the lowest observed adverse effect level (LOAEL) and the significant observed adverse effect level (SOAEL) would occur. An example of this approach is shown Table 7-13.

TABLE 7-13 NOISE EFFECT LEVEL FOR PERMANENT RESIDENTIAL BUILDINGS FROM OPERATIONAL NOISE (Source: HS2 Phase 1 Environmental Statement)

Day	Time (hours)	Lowest Observed Adverse Effect Level (dB)	Significant Observed Adverse Effect Level (dB)
Any day	07:00 - 23:00	50 L_{pAeq}	65 L_{pAeq}
Any night	23:00 - 07:00	40 L_{pAeq}	55 L_{pAeq}
Any night (more than 20 train passbys)	23:00 - 07:00	60 L_{pAFMax} (at the facade)	80 L_{pAFMax} (at the facade)
Any night (20 or less train passbys)	23:00 - 07:00	60 L_{pAFMax} (at the facade)	85 L_{pAFMax} (at the facade)

7.91 Additionally, forecast operational sound levels from a Proposed Scheme that site between the respective LOAELs and SOAELS (i.e. between 50 dB and 65 dB daytime, or 40 dB and 55 dB night-time) may be perceived as a change in quality of life for occupants of dwellings or a perceived change in the acoustic character of an area. When considered collectively for groups of dwellings and their shared community open areas, such effects may be significant. An example of how the impact arising from a change in sound levels could be evaluated is presented in Table 7-14.

TABLE 7-14 IMPACT FROM THE CHANGE IN SOUND LEVELS (Source HS2 Phase 1 Environmental Statement)

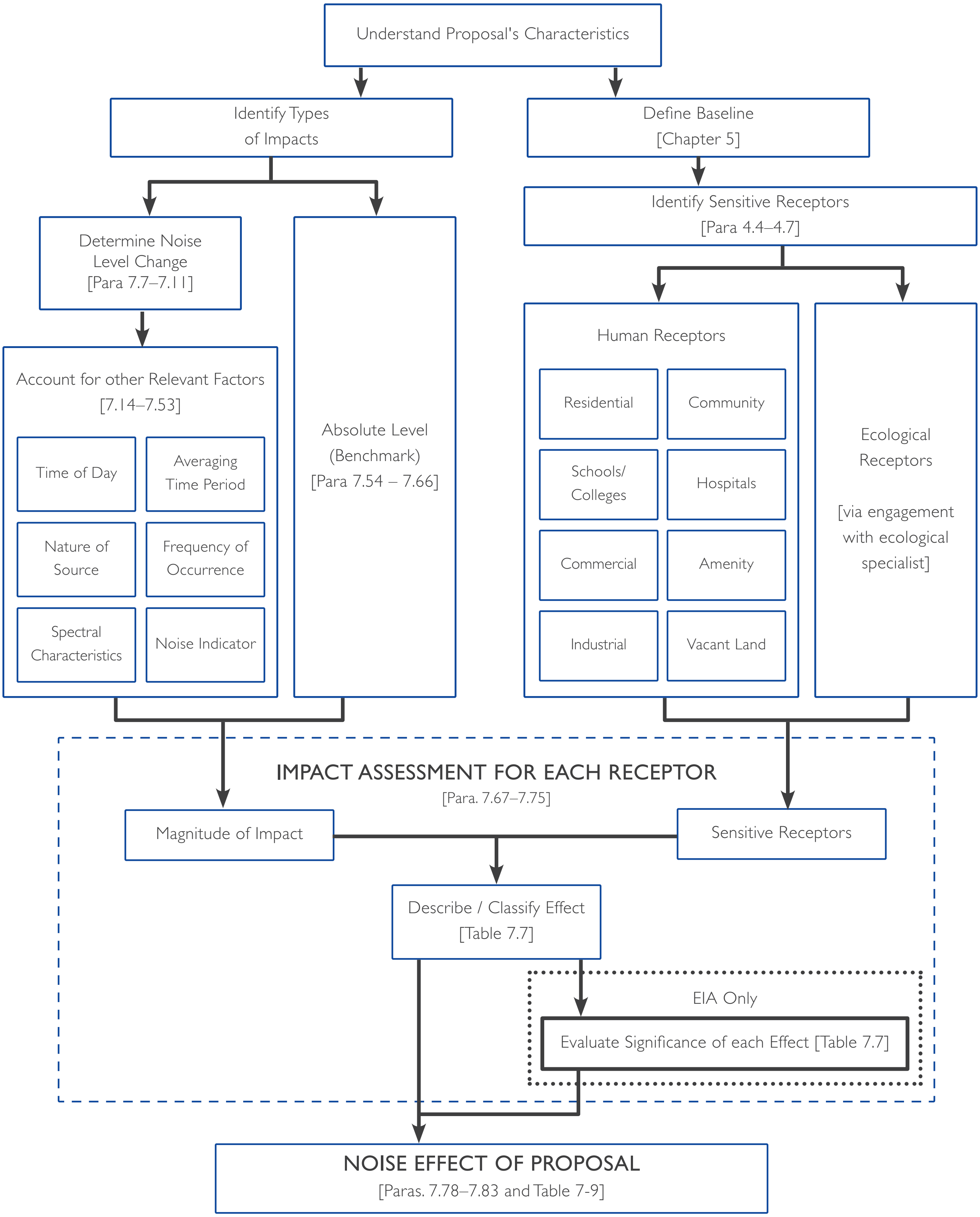
Long-term Impact Classification	Short-term Impact Classification	Sound level change dB L_{pAeqT} (positive or negative) T = either 16hr day or 8hr night
Negligible	Negligible	≥ 0 dB and < 1 dB
	Minor	≥ 1 dB and < 3 dB
Minor	Moderate	≥ 3 dB and < 5 dB
Moderate	Major	≥ 5 dB and < 10 dB
Major		≥ 10 dB

7.92 It is important to reiterate that Tables 7-7 to 7-14 are included in the guidelines to portray concepts, and cannot necessarily be transposed over to any other development scheme. The use of any of the impact assessment criteria must be fully justified in the noise impact assessment report/ ES chapter, as was the case with the above examples, where sourced from external material.

CONCLUSION

7.93 This chapter has sought to define an approach to noise assessment which ensures that **all** of the relevant issues are addressed. The subjective nature of noise, together with the many gaps that exist in the detailed understanding of the effects of noise, mean that it is not possible to set out a detailed structure and precise methodology. Inevitably, therefore, the assessment will have to include a degree of professional judgement based on the relevant factors. Examples of noise impact assessment have been provided for a large-scale housing development and a recent transportation corridor. The two examples are provided in order to demonstrate the difference in approach that is utilised between different schemes and assessors. As such, while the approaches used could be fully justified and have certain merits, it is not suggested within this guidance that the methodologies can be slavishly followed. The most important point is that any assessment must adequately justify the approach that has been carried out, and is not just done because the particular approach was used on recent or previous schemes of a similar nature.

FIGURE 7.4 SUMMARY OF THE NOISE IMPACT ASSESSMENT PROCESS



8.0 MITIGATION

INTRODUCTION

8.1 Mitigation may be defined as any process, activity or design feature whose purpose is to avoid, reduce or remedy adverse environmental impacts and effects likely to be caused by a development project. All adverse effects should be considered for mitigation (see paragraph 1.16), and specific measures should be applied where practicable, although in this chapter the adverse effects are limited to those produced by noise. It is important that mitigation should not be merely an addendum to a project, but an integral part of the design process which is applied at all stages, and which secures the long-term environmental acceptability of the project.

HIERARCHY OF MITIGATION

8.2 The types of mitigation which might be employed may be classified, in order of importance and preference, as:

- Avoidance;
- Reduction; and
- Compensation.

8.3 For an industrial development, the first category includes the initial choice of plant or technology, which should be consistent with BAT [85] (Best Available Techniques) principles. The site layout, building design and the operational management also can significantly affect potential noise impacts. Consequently, the initial avoidance of potential noise impacts and effects by plant selection, mode of operation and layout should be sought wherever possible.

8.4 Similar avoidance principles can be applied to transport developments, by careful selection of road or rail alignments to minimise the sensitive areas affected, or by careful location and route design for aviation developments. In addition for railways and airports, constraints could be placed on the noise generated by individual train units or aircraft either through the use of specific criteria, or by making use of national or international noise emission standards.

8.5 Avoidance can also be achieved by:

- controlling the hours of operation;
- limiting the duration of operation;
- limiting the number of events; or
- limiting the number of different sources operating concurrently.

8.6 Reduction for industrial developments means adopting noise reducing methods such as enclosures, screening or fitting silencers to noisy plant. Such detailed acoustic/engineering design would be normally undertaken by a noise consultant or specialist engineer, to achieve a given noise criterion or to minimise the noise impact.

8.7 The same principles can be applied to transport developments, with the use of landscaping or noise barriers for road and rail links or along airport taxi-ways, and the use of noise-reducing surfaces on roads or resiliently mounted rails, rail dampers, etc.

8.8 Compensation may include measures applied outside of the development area, such as fitting double/secondary glazing to affected premises. In certain cases, legislation provides for financial compensation for the loss of value of properties affected by noise. It also may be possible to offer compensation in the form of the provision of alternative or additional community facilities. Liaison with the relevant local authority or affected community groups might assist in identifying a suitable form of alternative compensation.

8.9 For projects that involve changing an existing development, such as an industrial extension, it may be possible to upgrade or improve the existing plant by replacing equipment with newer, less noisy, models. For road widening schemes it may be possible to add to, improve, or enhance existing noise screening, or to provide a low-noise surface for the whole carriageway.

85. Directive 2010/75/EU on industrial emissions (Integrated Pollution Prevention and Control).

8.10 Although mitigation should feature in the noise impact assessment, the mitigation identified should be confined to those measures that will be definitely included in the design. Speculating about other measures which might be adopted in the future can lead to expectations being raised which are not fulfilled, and to the belief that (in their absence) the best practicable package of mitigation measures has not been adopted. However, it may be helpful to mention mitigation measures that had been considered during the design process but are not to be pursued. The reason for rejecting the measures must be stated.

8.11 The various construction phases of a project such as site clearance, construction, commissioning and operation will generate very different noise environments, depending on the nature and extent of the equipment used and the working hours adopted. The same mitigation principles described above apply, including the use of compensation in the form of double/secondary glazing for large projects. In some circumstances, the offer of temporary relocation of those badly affected during the noisiest phases of the construction might be considered. Further guidance on this can be found in BS5228: Part 1: 2014[86]. Specific examples of major projects which have introduced set criteria for sound insulation and rehousing as a result of construction noise include the railway projects Crossrail and Thameslink.

8.12 Most developments with a potential noise impact consist of a number of individual noise sources. Each source needs to be identified as early in the design stage as possible, so that consideration can then be given to the best arrangement of the development to minimise the noise emissions and protect sensitive properties or amenity areas. This may be achieved by using some or all of the following principles:

- maximising the separation distance between the noise source and noise-sensitive areas;
- on industrial sites, locating noise sources within substantial buildings or acoustic enclosures;
- carefully considering noise sources which are at elevated height, as measures to mitigate the effects of noise emissions from these sources can be difficult to achieve;
- maximising the use of existing ground contours or landscaping as barriers;
- using self-shielding, for example, by buildings acting as a barrier between noisy areas, such as those where external activities occur, and noise sensitive premises or areas;
- arranging buildings such that there are no acoustically weak areas in the facades facing noise-sensitive premises or areas;
- locating site access roads and site entrances away from noise-sensitive areas;
- selecting the quietest equipment, plant and methods for both construction and operation; and
- optimising the hours of operation to avoid potential noise impacts.

8.13 Often, there will be requirements to landscape the project site to minimise the visual impact of the development. This often takes the form of mounds and areas of planting both within and around the site, or along the line of the road or railway. The mounds can form effective noise barriers, particularly if they are located either close to the noise source or receptor. Trees and shrubs have a negligible effect in reducing noise in themselves, unless they cover a large area with a considerable distance between the source and receptor, and contain a high density of mature plants. such planting may have a psychological value by removing the noise source from direct vision.

8.14 In some cases, the provision of a high mound or an acoustic barrier could be considered to constitute a visual intrusion. Such potential conflicts need to be considered and resolved at an early stage in the design process.

8.15 Should the layout of the development and the landscaping proposals fail to deliver the necessary amount of protection against noise to areas beyond the site boundary, then the provision of additional acoustic barriers may be needed.

86. Code of Practice for Noise and Vibration control on Construction and Open Sites.

8.16 In general, the following principles should be observed in the design of a barrier:

- prevent line of sight between the source and receptor;
- position the barrier as close to the noise source or the receptor as possible;
- use materials with an appropriate mass as recommended in the relevant standard (see Technical Annex paragraphs A24–A27);
- avoid using reflective barriers where this might result in increased noise at noise-sensitive receptors located opposite the barrier on the same side as the source;
- allow no gaps or other acoustically weak areas.

8.17 Management of the industrial site or development and the hours of operation offer further methods for mitigating the effect of noise. Noisy operations should be restricted to less sensitive times of the day, and if they are scheduled to take place regularly, good liaison with the local community will be beneficial. The times of the day that are most sensitive to noise impacts depends upon local circumstances, but would normally be considered to be the early evening and night-time. However, in some city centres where there are no residential units, the daytime might be considered to be more sensitive because of the potential effects of noise on people working in the area.

8.18 Methods of working, particularly on open sites such as mineral extraction or waste disposal sites, can have a large impact on the noise levels at neighbouring properties. However, on extraction sites, working behind the extraction face provides additional barrier attenuation. Similarly, in waste disposal sites it is better to work behind the tip face.

8.19 Where shift working is a part of the operation, consideration needs to be given to the effect of noise from traffic entering and leaving the site during the shift changes. Alterations to the times of the shifts, or staggering of start times for the workforce, may need to be introduced to reduce the noise impact on surrounding receptors.

8.20 Consideration needs to be given to the timing and duration of particularly noisy operations. For example, during the construction phase, local residents may prefer a higher level of noise to be generated for a shorter time, rather than for a particular operation to produce a slightly lower noise level but over a longer period. Good public relations with local residents will assist in finding the correct compromise between efficient working and the minimum reduction in amenity.

8.21 Noise can be controlled through the use of conditions in planning permissions. Some examples of relevant noise planning conditions and the general principles that should apply are available in various guidance documents. The recommended model conditions include those that limit the hours of working, the type of equipment, the form of building construction or the location of noisy equipment. Other conditions can be used, but in all cases it is essential that the conditions can be shown to be necessary, relevant, enforceable, precise and reasonable[87].

8.22 Similar arrangements can be made during the construction phase through seeking either formal or informal agreements with the local authority over hours of operation, construction methods, the use of temporary barriers and noise limits.

8.23 The benefits to be achieved from mitigation should be quantified wherever possible, and the methods employed should have the full commitment of the developer. Clearly, the methods should be feasible and effective and should be enforceable by a programme of inspection or monitoring.

8.24 In some instances the proposed development may result in improvements to the noise environment in an area. This may be as the result of the replacement of old noisier equipment, the relocation of internal roads or the re-routing of traffic to and from the site, the enhancement of barriers or the removal of noise sources from a particular area. Improvements also may be achieved by locating the proposed development in a position where it can effectively screen an existing noise source.

87. Planning Practice Guidance for England – Use of Planning Conditions March 2014 (web-based resource).

8.25 It is possible that these various measures may be sufficient to produce a positive enhancement of the local environment, compared with the original state. This positive aspect of project design is often insufficiently emphasised in an assessment and, if applicable, the environmental enhancement brought about by the proposed development should be clearly stated.

8.26 Enforcement of the mitigation methods themselves may occur through the use of planning consent conditions and their implementation may be monitored by simple physical inspection. Alternatively performance criteria, such as noise limits, may be set and monitored.

8.27 The need for on going monitoring (see Chapter 9) in addition to inspection both during and after project commissioning should be considered. The nature and extent of such monitoring will be dependent on the project scale, and the economic and practical limitations. However, such ongoing monitoring is important to enable the detection of any degradation of the mitigation schemes occurring over time.

9.0 REPORTING AND MONITORING

INTRODUCTION

9.1 The manner in which the noise impact assessment of a proposed development is reported is likely to depend on the nature of the project. For smaller projects the assessment is likely to be reported in a self-contained document. If, however, the assessment is part of a larger scheme that requires a formal EIA, the results are likely to form part of both the non-technical summary and the Environmental Statement (ES). It also may be necessary to present the results of the noise assessment in a form suitable for public consultation, possibly by way of displays or other easily accessible information.

9.2 The noise assessment report needs to provide a sufficient quantity and detail of information to satisfy the needs of those who will be making a decision regarding the overall merits and disbenefits of the proposal. For a small proposal it may be appropriate to include all relevant information in one document. However, for a large project or where noise is considered as part of an ES, a Technical Appendix may be required. This would contain all the technical information that would not necessarily be required by the decision maker or stakeholders/members of the public, but would assist people with a technical background to evaluate the noise assessment in more detail.

9.3 The information that should be contained in the noise assessment report is set out below, together with a brief description of the scope of each topic.

DESCRIPTION OF PROJECT

9.4 This should consist of a description of the project, but recognising that it is likely to have been described in detail elsewhere or by others. When that is the case, the project description in the noise report or chapter should refer to those other documents for the general description and focus on the potential sources of noise. Qualitative descriptions of proposed noise sources may be included together with proposed times and levels of operation. A qualitative description of existing noise sources on the site also may be included, together with any particular restrictions or development orders affecting such sources. Any landscape or other designation of the site should be included, together with its effect on noise aspects of the potential development. A separate description of any construction and decommissioning element associated with the proposed development may be required but, again, remembering that it is likely to have been described in detail elsewhere.

SCOPE OF THE NOISE ASSESSMENT

9.5 This should cover the potential noise impacts associated with the proposed development. It should include all potential noise sources, including those from any construction or decommissioning element of the proposed development, on and off-site activities, and the area over which a possible impact could be experienced. The extent to which each of these is considered within the assessment should be stated. Any particular local concerns should be highlighted, together with the extent to which these have been incorporated as part of the assessment. Liaison with local planning or environmental health officers in formulating the assessment should be described, along with any preliminary public consultation which may have occurred.

STANDARDS AND OTHER GUIDANCE

9.6 This should describe the relevant standard(s) and other guidance document(s) that have been used in considering the noise impact of the proposed development. Full technical references to the documents should be included (e.g, title, author, publisher, and date). The relevant parts of any standards or documents relied upon in the assessment should be quoted in full here without requiring the reader to turn to a separate references chapter. Only quote those parts of the standards that were used in the assessment and do not refer to standards that were not used. (See also paragraph 9.16.)

ASSESSMENT PROCEDURE

9.7 The method of assessment, and relevance to the standard(s) or other guidance covered above, should be clearly stated, together with the noise indicators used. Where a criterion has been specially developed for a particular impact assessment, then this should be described as required.

DESCRIPTION OF BASELINE

9.8 Qualitative descriptions of the existing area, including noise sources, should be included together with information about any relevant features that may affect the noise aspects of the potential development.

9.9 A brief description of the baseline measurement and/or calculation procedure used to characterise the baseline situation should be given. The locations for which noise levels were measured or calculated should be described and shown on a plan. For some projects there will be a number of baseline scenarios, and these should be reported and their context with respect to the development project fully explained.

9.10 The results should be reported and the relevance to the potential noise impact of the scheme described. This quantitative description may be a summary or a considered appraisal of the raw data obtained from the baseline measurements, taking into account the advice contained in these guidelines. It is often useful to present the data in graphical rather than tabular form, as this allows a useful overview of any trends; although data used for comparison with, for example, predicted levels may need to be presented numerically.

NOISE LEVELS FROM PROPOSED DEVELOPMENT

9.11 The results of the noise predictions will need to be presented in a form appropriate to the particular development. Predicted noise levels at specific locations where assessment is to be carried out will need to be included. Normally, separate predictions will normally be required for different phases of any construction or decommissioning elements of the proposed development. Contours also may be useful to show the spread of predicted noise levels in the area. Care should be taken to specify the conditions for which the predictions apply, together with any local effects that should be taken into account. Variation in noise with operating conditions should be included where such variation exists. This may be illustrated graphically or numerically, or by some combination of the two methods. A brief description of the methodology by which such levels were obtained also should be included and any source noise data should be fully referenced. In describing the prediction process, it may be necessary to refer to a Technical Appendix. (See paragraph 9.17.)

IMPACT ASSESSMENT

9.12 The noise impact should be described by considering the baseline noise levels, the predicted noise levels and the method of assessment and criteria that were described in the preceding chapters, including any mitigation that has been incorporated in the proposals. A summary of the severity of impact should be included here for all receptor locations defined within the Scope chapter. When the scale or complexity of the proposals merit it, noise impacts should be shown on a plan, and would probably take the form of coloured bands showing the impact descriptor, or noise contours, depending on the assessment methodology adopted.

9.13 Additional plans may be required for different time periods, particularly during the construction period when the impact may vary with different phases of the work. Sometimes, the same plans also can be used to show the location of any measurements carried out in the baseline assessment (see above). The chapter should include a comparison of the results with any specific local requirements or other pertinent criteria. It should conclude with a comment on the overall severity or otherwise of the noise impact, based on the assessment which has been carried out. Reference also should be made to the residual impact (see paragraph 7.82) and any cumulative impact issues (see paragraph 7.83).

MITIGATION

9.14 This chapter should describe the mitigation measures that will be incorporated in the development, together with their likely effectiveness. An indication should be given of the scope for further mitigation which could have been included to reduce further the potential impact, and why it has been rejected. The practical, economic and other implications associated with such mitigation should be described., The scope for noise impact to be controlled using planning conditions, or similar measures, should be discussed, together with the possible practical implementation of such conditions or agreements. The necessity for noise monitoring during the various phases of the project also should be discussed, including possible requirements for routine monitoring, monitoring which would only take place if complaints occur, or in relation to planning conditions or agreements imposed. The practical, economic and other implications of such monitoring should be noted.

9.15 Mitigation measures developed as the project design has progressed might become an integral part of the proposals rather than a distinct element. The benefits of such integrated mitigation should be reported.

CONCLUSIONS

9.16 The conclusions should summarise the results of the impact assessment, their relevance to existing standards, criteria or other guidance, together with proposed measures to ensure that the described impacts are not exceeded. The conclusion should include commentary about the overall severity or otherwise of the noise impacts, once all these factors have been taken into account.

TECHNICAL APPENDIX

9.17 If it is appropriate to produce a Technical Appendix, it should contain any relevant additional information that would aid a more detailed evaluation of the noise assessment report by a technically competent person. Thus it may include more detailed explanation of why (or why not) certain indicators and standards were used, and why and/or how the assessment criteria were chosen. It should give full details of the noise levels that were measured, both for the baseline and those to enable predictions of future noise levels to be made. It should give details of the calculations that have been undertaken, although if these have been carried out using a standard methodology, this may not be necessary.

PUBLIC CONSULTATION

9.18 Although the noise impact assessment report or environmental statement would be usually made available to interested members of the public, it also may be necessary to provide information for a public meeting or so to be displayed at council offices or other public buildings. The results of the noise assessment should be presented in this case in an easily accessible form. This may need to include a brief introduction to the noise assessment process, together with pertinent information about the proposed development and the data that the decision makers will be using to assess the project. Similar considerations will be needed for any initial public consultation that may have occurred.

10.0 REVIEW AND FOLLOW UP OF THE NOISE IMPACT ASSESSMENT

INTRODUCTION

10.1 At its most basic level, a review of a noise impact assessment provides a check of the content of the noise assessment. The purpose of a review is normally to:

- check compliance with relevant regulations;
- check the scope and methodology of the baseline studies;
- evaluate the completeness and accuracy of the impact predictions;
- check the appropriateness of the assessment method , the criteria used to assess the magnitude of the impacts and the significance of the effects;
- check that mitigation measures are proposed to reduce the significant adverse effects and to evaluate their effectiveness; and
- check for the need for any additional mitigation or monitoring measures.

10.2 The noise impact assessment should be reviewed by the determining authority, using someone with the appropriate skills and experience. For example, this may involve close liaison between the departments responsible for planning and environmental health. In addition, the determining body might employ a professional acoustician to review the noise chapter, particularly when an application is being considered for a project with unusual, complex or potentially significant noise impacts.

10.3 An important component of the review can be played by the public. Their comments may provide valuable input to the determining authority's response.

10.4 If the review identifies that insufficient information has been provided, the determining authority should ask the developer to supply additional information before a decision on a project is made. In the case of a formal ES, Regulation 22, of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 2011 (as amended) may be used. The EIA Regulations also require that such 'further information' must be made available for public consultation prior to the decision being made.

10.5 In determining the planning application the decision-making authority will take account of the information contained in the noise impact assessment report and the outcome of the review work. In making the decision, it is likely that many factors in addition to the noise impact, will be taken into account, including prevailing national and local policies. The authority may think it appropriate only to grant consent subject to certain conditions being applied to exercise an appropriate level of noise management. The nature of any such conditions will depend on the type of proposal being made, but such conditions will have to follow the principles contained in relevant government guidance documents[88].

IMPLEMENTATION AND FOLLOW-UP

10.6 Once planning consent has been granted the following issues would need to be addressed:

- The developer should ensure that all mitigation measures that were promised and included in the noise impact assessment are properly implemented;
- The developer should ensure that all consent conditions relating to noise management are discharged at the appropriate time;
- The local planning authority should satisfy itself that all promised mitigation measures have been properly implemented, and that all relevant consent conditions have been discharged at the appropriate time.

10.7 If time and resources permit, there is a good case for checking:

- the resulting noise levels to ascertain whether the outcome was as expected (i.e. the predictions were correct); and
- whether or not the degree of impacts occurring is as expected.

10.8 The dissemination of such follow-up studies would provide helpful lessons for future noise impact assessments.

88. NPPF, NPS, NPF and new Planning Practice Guidance.

TECHNICAL ANNEX (TO CHAPTER 6)
PREDICTING NOISE LEVELS

INTRODUCTION

A1 This annex builds on the content of Chapter 6 by setting out more information regarding the issues that need to be considered when predicting noise levels. The data set out here are not exhaustive, and reference should be made to standard acoustic textbooks and other similar material for further information.

SOURCE CHARACTERISATION

Sound Power

A2 To make a prediction, it is essential to have some information about the sound output of the sources of interest. The sound power level of a source may be available from manufacturers. If not, and since it is not straightforward to measure sound power directly, it would be necessary to calculate it from measured sound pressure levels under specified conditions. Such measurements should be at fairly close range, depending on the source size and ideally over hard ground and under free-field conditions. However, for some specific noise sources, the source terms are derived from other input data that form an inherent part of the calculation procedure.

Source Classification

A3 The rate at which sound will decrease with distance from a source is affected by its type. Fixed noise sources may be classified as point, line or plane sources. Mobile sources, for example vehicle movements, may be represented as moving point sources, but, if there are sufficient vehicle movements, a steady stream of vehicles can be regarded as a line source. Alternatively, a long train may be a moving line source when close to it, but a moving point source further away.

Propagation Factors

A4 The reduction in level, or attenuation, with distance from a point source corresponds to expansion of the sound wave as though it is a surface of a sphere with increasing radius. The area of the spherical surface increases with the square of the radius, so that the sound power or intensity decreases with the square of the distance and results in a sound pressure level reduction of 6 dB per doubling of distance. This is known as the inverse square law. The corresponding attenuation from a line source is 3 dB per doubling of distance. There may be circumstances, close to a radiating wall, for example, where neither of these rates apply. It is difficult to give a general rate for the decrease in level with distance close to such a source. However, at a large enough distance, any plane source will appear to be a point source.

A5 Deviations from these simple relationships can occur for a variety of reasons, including proximity to a large source, the effects of absorption and reflection from the ground and from nearby buildings and meteorological effects outdoors. Despite these effects, it is generally found that the decrease in measured sound levels is proportional to the logarithm of distance. The rate of decay may be significantly different from the 6 or 3 dB per doubling of distance rate that applies to an ideal point or line source respectively, but a simple proportionality is usually found.

Directionality

A6 In addition to the sound power and propagation condition, it is important to take account of the source directionality. Directionality may arise:

- because the source is inherently directional; or
- because of the location of the source on a hard surface or against hard vertical surfaces, such as a wall or building.

A7 If the source is located on sound-reflecting surfaces, there is an effective increase in the sound power of the source of 3–6 dB, depending on the geometry of the surfaces at the source.

Ground Effect

A8 Attenuation in excess of that due to geometric divergence and atmospheric absorption occurs when sound travels across acoustically soft ground. Such additional attenuation is known as excess attenuation. Sound reflected from the ground surface can cancel sound travelling directly to the source, as a consequence of differences in phase. Over acoustically hard ground the difference in phase is due only to the difference in the lengths of the direct and ground reflected rays, hence the effect is limited. Over acoustically soft ground, the difference in phase occurs at a wider range of frequencies due to the absorptive nature of the surface. The shallower the angle at which the sound is reflected from the ground, the higher the cancellation frequencies will be.

A9 For a given source height, the reflection angle depends upon the horizontal distance between source and receptor. The greater the distance, the shallower the angle. For a heavy goods vehicle source (at about 1m height), a receptor at a height of about 1.2 m to 1.5 m and a separation distance of the order of a few metres, the cancellation can occur in an important part of the audio frequency range. On the other hand, if the source and receptor are both close to a hard ground surface, or the separation is above 20 m, the cancellation tends to occur at frequencies that are too high to be useful for noise control. However, over acoustically soft ground, the cancellation frequencies will occur in a band between 200 and 800 Hz, for a wide range of source receptor geometries and lead to attenuation that is significantly greater than that due to geometric spreading alone.

A10 When plotted against frequency, the excess attenuation spectrum of ground effect over acoustically soft ground shows maxima and minima corresponding to reinforcement and cancellation of the direct sound by ground reflected sound. The reinforcement can be as much as 6 dB (corresponding to a pressure doubling over hard ground), and at the reinforcement frequencies the excess attenuation is negative. The excess attenuation or ground effect is greatest usually at the frequencies where the direct and reflected sounds cancel each other. The ground effect near the first such frequency is most important. Excess attenuation over acoustically soft ground can be higher than 25 dB for distances of 1000 m and source and receptor heights of about 1.5 m.

A11 Empirical expressions for excess attenuation over soft ground in octave bands are suggested in ISO 9613 and the CONCAWE scheme. Similar expressions in terms of A weighted sound level can be found in CRTN and CRN for the relevant noise sources. The theory of ground effect has advanced considerably in recent years. Consequently, along with advances in readily available computational facilities, it is possible to make predictions based on theory, rather than empirical observations, assuming the ground and prevailing meteorological data are available with sufficient accuracy.

METEOROLOGICAL EFFECTS

A12 Outdoor sound propagation is influenced by wind speed, temperature gradients, turbulence, (which depends on wind speed and temperature gradients), and air absorption, (which depends on temperature and humidity). Typically, during a day when there is sunshine, temperature decreases with height, and such conditions are referred to as adiabatic lapse or simple lapse rate conditions. Lapse rate conditions imply upward refraction of sound, and give rise to shadow zones at receptor points sufficiently far from the source and close to the ground. When the temperature increases with height, as sometimes happens between dusk and dawn under calm conditions, inversion effects occur, and these tend to concentrate and enhance noise levels near the ground. The influence of these factors is frequency dependent.

Atmospheric Absorption

A13 Atmospheric absorption depends on frequency, relative humidity, temperature and atmospheric pressure. The attenuation of sound in the atmosphere results from dissipation of the sound energy within the oxygen and nitrogen molecules and depends on moisture content. At high enough frequencies, the viscosity and thermal properties of airflow play a part. The resulting dependence of attenuation on frequency is fairly complicated. The attenuation is very small below 500 Hz, but the attenuation per wavelength passes through several peaks as the frequency increases. The overall attenuation increases with frequency.

A14 It should be noted that atmospheric absorption increases linearly with distance, but non-linearly with frequency. The relatively high attenuation at high frequencies and long ranges are of particular importance to aircraft noise predictions. Very little attenuation is found for low values of relative humidity or temperature. However, monthly and diurnal variations in relative humidity and temperature can introduce large variations in atmospheric absorption. Usually, relative humidity reaches its diurnal maximum soon after sunrise and its minimum in the afternoon, when the temperature is highest. The diurnal variations are usually greatest in the summer.

A15 A detailed method for calculating atmospheric absorption as a function of the various meteorological parameters is found in ISO 9613-1. Mean values of atmospheric absorption are tabulated for use with a more general prediction method in ISO 9613-2. This standard states that:

"For calculation of environmental noise levels, an average atmospheric attenuation coefficient should be used, based on the values determined by a range of ambient weather which is relevant to the locality."

A16 It should be noted that use of (arithmetic) mean values of atmospheric absorption may lead to overestimates of attenuation when attempting to establish typical worst-case exposures for the purposes of noise impact assessment. Investigations of local climate statistics, for example, hourly means over one year, should lead to more accurate estimates of lowest absorption values.

Atmospheric Refraction

A17 If the temperature decreases with height, as in lapse conditions, then the following effects are observed:

- the sound speed also decreases with height;
- the direction of propagation is upwards;
- a shadow zone is formed around the source.

A18 In the shadow zone, the sound level can be much less than at locations not affected by these conditions. However, although differences of greater than 20 dB can occur, they have been encountered very rarely, probably as a result of energy being scattered into the shadow zone by turbulence.

A19 As well as inducing the formation of a shadow zone, upward reflection tends to reduce the frequency dependence of the attenuation and its sensitivity to the nature of the ground surface. Deep into the shadow zone, sound pressure levels can be 30 dB less, even when A-weighted, than they would be under isothermal, windless atmospheric conditions. When a wind is present, the combined effects of temperature lapse and wind will tend to enhance the shadow zone upwind of the source, since wind speed tends to increase with height. downwind of the source, the wind will counteract the effect of temperature lapse and the shadow zone will be destroyed. An acoustic shadow zone is never as complete as an optical zone because of diffraction and turbulence. Nevertheless, shadow zones can be areas in which there is significant excess attenuation, so it is important to be able to locate their boundaries approximately. Formulae for doing so are available in the standard texts[89].

A20 Down wind and during temperature inversions, sound rays are bent towards the ground and noise levels may be enhanced. In fact, in these conditions, the first maximum in the excess attenuation spectrum due to ground effect is shifted to a lower frequency, and the resulting influence on overall sound level will depend on the source spectrum.

A21 In discussing the effects of meteorology on sound levels, the ISO 9613-2 scheme suggests that predictions for conditions favouring propagation from source to receptor may be the most appropriate for use in determining noise limits that should seldom be exceeded. Indeed, the formulae in the standard are intended to give downwind predictions. That is, the following conditions:

- Wind direction within $\pm 45^0$ of the direction connecting the centre of the dominant sound sources and the centre of the specified receptor region, together with wind speeds of between 1 ms^{-1} and 5 ms^{-1}.

(N.B. CRTN and CRN both assume "moderate" or "mild" downwind conditions.)

A22 ISO 9613-2 goes on to suggest that when a long-term sound pressure level, $L_{Aeq,T}$(Long Term), perhaps covering several months, is required, then this quantity may be as much as 5 dB less than the value of $L_{Aeq,T}$ deduced entirely for downwind conditions.

89. Standard texts may be available through most libraries, but the library at the Institute of Acoustics should be able to assist. http://www.IOA.org.uk/

Pasquill Stability Classes

A23 A practical measure of atmospheric stability, and hence of meteorological conditions, is the Pasquill Stability class. There are six stability classes, A–F. Class A represents a very unstable atmosphere with strong vertical air transport and mixing. Class F represents a very stable atmosphere, with weak vertical air transport. Class D represents a meteorologically neutral atmosphere with a logarithmic wind speed profile and a zero temperature profile. Note that this is not the same as an acoustically neutral atmosphere, since it includes a wind velocity gradient. In a stable atmosphere, the temperature increases with height and the wind speed gradients are larger than is usual for a meteorologically neutral atmosphere. In an unstable atmosphere, the temperature decreases with height and wind speed gradients are smaller than usual for a meteorologically neutral atmosphere. Usually, the atmosphere is unstable (Classes A, B, C and D (relating to "very unstable" to "neutral")) by day and stable (Classes D, E and F (relating to "neutral" to "very stable")) by night.

TOPOGRAPHICAL EFFECTS

Barriers

A24 Non-porous barriers of sufficient mass can result in appreciable noise reduction if located between the source and receptor, such that there is no direct line of sight. Noise reduction results from the fact that sound can primarily reach the receptor only by diffraction around or over the barrier[90].

A25 When the barrier is close to the source, and when the receptor is in the shadow of the barrier, the sound would appear to be coming from a line along the top of the barrier. The strength of this effective source line will be proportional to the strength of sound arriving at the top of the barrier. The fact that the top of the barrier acts as though it is the sound source, means that the effective mean propagation height of sound between the source and receptor is increased, and consequently, the ground effect is diminished[91]. When excess attenuation due to a barrier is to be included, it is safest to ignore excess attenuation due to ground effect. However, if the barrier effect is achieved by means of a cutting, with ground falling from the receptor to the edge of the cutting, the ground effect could still be included. This is because the effective source is still close to the ground. However, some standard prediction methods do not take account of this situation.

A26 Downwind conditions and scattering into the shadow zone by turbulence tend to reduce the effectiveness of outdoor noise barriers. The performance of roadside and rail-side noise barriers can be adversely affected by reflections from high-sided vehicles. Some calculation methods do take this effect into account because of their empirical nature.

A27 While many noise barriers are rigid and non-porous (for example, brick walls and timber noise barriers), there is also an increasing use of absorptive barriers, (i.e. absorbent covered with a non-porous core) which utilise a range of materials (for example, earth berms, wood/concrete panels etc.). It has been found that these absorptive barriers, when close to the source of the noise, have reduced the adverse effect of reflections by up to 3–4 dB.

Reflections from Vertical Surfaces

A28 Typically, the presence of vertical surfaces, close to a receptor will increase the sound level for receptors on the same side of the surface as the source. In CRTN and CRN, the presence of vertical surface within lm of the receptor increases the level by 2.5 dB(A). In ISO 9613-2 it assumes that there is a 3 dB increase in the presence of a sufficiently large acoustically hard vertical or near vertical surface.

A29 ISO 9613-2 also includes formulae for calculating the effects of various other types of surface with different absorption coefficients and of various sizes.

90. British Standard 5228 states that a barrier must have a mass of at least 7 kg/m2. A rough practical guide appears in BRE Digest 186 which states that where A is the full potential screening correction:

For A between 0 dB(A) and –10 dB(A)	M = 5 kg/m2
For A between –10 dB(A) and – 15 dB(A)	M = 10 kg/m2
For A between – 15 dB(A) and – 20 dB(A)	M = 20 kg/m2

Where M is the desirable mass per unit area of the barrier. (Note, the required mass is also dependent on the frequency spectrum of the source).

91. If the ground is snow covered, then the introduction of a barrier has been found to result in higher sound levels at reception points behind the barrier from the source.

Total Attenuation

A30 The attenuation of sound outdoors may be calculated by adding to the attenuation due to distance (geometric spreading) alone (A_{div}), the various additional factors due to:

a) atmospheric absorption (A_{atm})
b) absorbing ground (A_{ground})
c) atmospheric refraction ($A_{refraction}$)
d) diffraction by barriers ($A_{barrier}$)
e) reflection from nearby vertical surfaces ($A_{reflection}$)
f) other miscellaneous factors, (A_{misc}).

A_{misc} represents the "miscellaneous" effects of meteorological conditions (other than refraction or absorption), trees and shrubs and buildings or elements of buildings.

A31 Therefore, total attenuation may be calculated from
$A = A_{div} + A_{Atm} + A_{ground} + A_{refraction} + A_{reflection} + A_{barrier} + A_{misc}$

A32 The effect on the sound level due to the presence of nearby reflecting surfaces at the receptor will in fact be an enhancement (i.e. a negative $A_{reflection}$), rather than an attenuation. $A^{refraction}$ also may be negative in inversion conditions.

A33 It is important to note that many prediction models have only been validated up to certain distances from the source, and therefore, extrapolation beyond the indicated range may introduce errors or uncertainties into the methodology.

A34 Table A1 sets out the features of some models available for predicting noise from particular sources.

TABLE A1 SUMMARY TABLE OF PREDICTION SCHEMES, THEIR SCOPE AND FACTORS INCLUDED[92]

Source	Prediction Scheme	Factors Included
Road	Calculation of Road Traffic Noise	AA, BE, GS, GE, GR, RS
Rail	Calculation of Railway Noise	AA, BE,GS, GE, RS
Aircraft	CEAC.ECAC Document 29[93]	AA, BE,GS, GE
Industry	CONCAWE, ISO 9613-2	AA, AR, BE, GS, GE, NB, AA, BE, GS, GE
Construction	BS 5228[94]	BE, GS, GE

KEY

AA = Atmospheric absorption
AR = Atmospheric refraction
BE = Barrier effects
GS = Geometrical spreading
GE = Absorbing ground effect
GR = Road gradient
NB = Narrow band
RS = Road/Rail surface

92. Work has been carried out in the European Union on harmonised prediction methods for road, rail, aircraft and industry based on a numerical prediction model. The HARMONOISE project has addressed road and rail and the IMAGINE project took the HARMONOISE work and extended it to aircraft and industry. The next stage is the development of the Common Noise Assessment Methods (CNOSSOS – EU) by the European Commission and the European Environment Agency for road, railway, aircraft and industrial sources. This work is in progress (2011). 93. Report on Standard Method of Computing Noise Contours around Civil Airports (European Civil Aviation Conference 3rd Edition 2005). 94. BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise (BSI 2009)

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