VOLUME 11 ENVIRONMENTAL ASSESSMENT

SECTION 3 ENVIRONMENTAL ASSESSMENT TECHNIQUES

PART 7

HD 213/11

NOISE AND VIBRATION

SUMMARY

This Standard provides guidance on the assessment of the impacts that road projects may have on levels of noise and vibration. Where appropriate, this standard may be applied to existing roads.

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THE HIGHWAYS AGENCY



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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Noise and Vibration

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NOISE AND VIBRATION

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1. INTRODUCTION

Background

1.1 Although the previous version of this Advice Note was published in August 2008, this update has been necessary in order to clarify some aspects of the guidance. These include:

- updates on the assessment methodologies and reporting including night-time assessment;
- clarifications on which façade of a sensitive receptor to undertake the assessment;
- slight revisions to the additional guidance for the use of the Calculation of Road Traffic Noise (CRTN) (Ref 10); and
- revised tables to describe the magnitude of an impact. In addition, the structure of the Advice Note has been changed to fit with revised Highways Agency guidance.

Scope

1.2 This Standard sets out the requirements to be adhered to in undertaking noise and vibration assessments, as well as providing guidance on the appropriate level of assessment to be used when assessing the noise and vibration impacts arising from all road projects, including new construction, improvements, operation and maintenance. This Section should be read in conjunction with the Design Manual for Roads and Bridges (DMRB), Volume 11, Sections 1 and 2, which set out the overall framework for the environmental assessment process. A full description of the technical terms used in this Section is given in Annex 2. A description of the general terms used during environmental assessment is provided in Volume 11, Section 2.

1.3 The second chapter of this document covers how noise and vibration relates to the UK Highways, including legislation. Chapter 3 covers a brief overview of the assessment process. Advice on design and mitigation is given in Chapter 4 and guidance on the management of environmental effects is presented in Chapter 5. Chapter 6 covers the monitoring and evaluation of noise impacts. The requirements for reporting are given in Chapter 7, with the full assessment methodology described in Annex 1.

Purpose

1.4 The purpose of this document is to provide guidance for those undertaking noise and vibration assessments of impacts from road projects, such that all assessments are undertaken in an appropriate and consistent manner using best practice, which is compliant with requirements of the relevant legislation.

Mandatory Sections

1.5 Sections of this document containing mandatory requirements are identified by being contained in boxes. These requirements must be complied with or a prior agreement to a Departure from Standard must be obtained from the Overseeing Organisation. The text outside boxes contains advice and explanation, which is commended to users for consideration.

1.6 While this Standard provides a series of general methods for assessing potential impacts on the noise and vibration environment, it is inevitable that there will be unique situations where a requirement of the Standard is inappropriate or that an aspect is not covered by the Standard. GD 01 (Introduction to the Design Manual for Roads and Bridges) provides further details on the process of applying for a Departure from Standard.

Equality Impact Assessment

1.7 This guidance seeks to improve the noise and vibration environment and, in turn, should benefit all human users. Any adverse or beneficial impacts that result from the introduction and adoption of this guidance are not expected to discriminate against any defined group in society. No equality impact assessment has been carried out in the development of this Standard as it is not considered relevant.

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Devolved Administration Issues

1.8 This document covers England, Wales, Scotland and Northern Ireland. The method used for assessment is the same for all countries. However, some aspects of legislation are different, and these are detailed in Chapter 2. The users of this document should always check if other differences exist.

1.9 The Environmental Noise Directive 2002/49/EC relates to the assessment and management of environmental noise in EU member states. The implementation of this Directive, through subsequent Regulations, is dealt with differently by each country. During an assessment, reporting and subsequent interpretation of results, any specific requirements of the relevant Regulations should be considered.

Implementation and Feedback

1.10 The Standard must be used forthwith on all road projects for the assessment of noise and vibration impacts associated with construction, improvements, operation and maintenance associated with motorways and trunk roads (and roads designated by the Overseeing Organisation in Northern Ireland) except where the procurement of works has reached a stage at which, in the opinion of the Overseeing Organisation, its use would result in significant additional expense or delay progress (in which case the decision must be recorded in accordance with the procedure required by the Overseeing Organisation).

Feedback

1.11 Attention is drawn to the requirements of DMRB Standard GD 03/08 for Designers to use the Standards Improvement System (SIS) to generate feedback reports to help improve the performance of standards.

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2. NOISE AND VIBRATION – UK HIGHWAYS

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Definition of Noise and Vibration

2.1 Traffic noise is a general term used to define the noise from traffic using the road network. A traffic stream is made up of a variety of vehicle types which have their own individual noise sources. Close to a road individual vehicles can be distinguished in the traffic stream, but further from the road the influence of individual vehicles is lost and the noise becomes a continuous drone.

2.2 A road project has the potential to cause both increases and decreases in traffic noise on an existing road by altering the traffic composition. In the case of a new road, for example a bypass, a completely new noise source can be created.

2.3 The impact of a road project at any location can be reported in terms of changes in absolute noise level. In the UK the standard index used for traffic noise is the $L_{A10,18h}$ level, which is quoted in decibels.

2.4 The effect on people from a road project can also be reported in terms of nuisance or annoyance. The World Health Organisation (WHO) define annoyance as 'a feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them' (Ref 34). This displeasure can be caused by the overall level of noise or by a change in noise level. The WHO also provide guideline values for noise levels for specific environments and times of the day.

2.5 The assessment of nuisance in this document is based on the average percentage of people who were interviewed at home and had expressed a considerable degree of annoyance at the level of external noise. This measure of community annoyance has been correlated with the standard index used for traffic noise ($L_{A10,18h}$). It should be noted that this definition of nuisance is not the same as that used in some statutory documents.

2.6 The construction process of a road project also has the potential to cause noise impacts. The impact of construction activities is usually reported in terms of changes in absolute noise level using the L_{Aeq} index, although the maximum noise level, often referred to as the L_{Amax}, from any one activity may also be assessed.

2.7 A road project also has the potential to cause annoyance and physical damage through vibration. Vibration is a low frequency disturbance producing physical movement in buildings and their occupants. These impacts can happen during the operation of an existing or new road, during the improvement or maintenance of an existing road, and also during the construction of a new road. Vibration is usually measured in terms of Peak Particle Velocity, or PPV, which is measured in terms of movement in mm/s.

Legislative Framework

2.8 Article 3 of Directive 85/337/EEC (as amended) requires Member States to assess the effects of noise from projects. This legislation provides the basis for the assessment process. In addition, there are several sets of legislation that provide the means to redress the adverse impacts of traffic noise and vibration resulting from the construction and use of new and improved roads on both land and people. These are set out in paragraphs 2.9 to 2.22.

New and Improved Roads – Operation

Land Compensation Act 1973
Land Compensation (Scotland) Act 1973

2.9 Part I of the Land Compensation Act provides a means by which compensation can be paid to owners of land or property which has experienced a loss in value caused by the use of public works, such as new or improved roads. Noise and vibration are two of the factors which would be considered in any claims for compensation, but the claim should consider all changes and effects, including betterment.

2.10 Claims can be made under Part I of the Act from 1 to 7 years after the opening of a road project. However, consideration of the likely extent of claims may be made during the design phase of a road project following the completion of statutory processes.

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The Noise Insulation Regulations 1975 (as amended 1988)
The Noise Insulation (Scotland) Regulations 1975

2.11 The Noise Insulation Regulations were made under Part II of the Land Compensation Act 1973 and the Noise Insulation (Scotland) Regulations 1975 made under the Land Compensation (Scotland) Act 1973.

2.12 Regulation 3 imposes a duty on authorities to undertake or make a grant in respect of the cost of undertaking noise insulation work in or to eligible buildings. This is subject to meeting certain criteria given in the Regulation.

2.13 Regulation 4 provides authorities with discretionary powers to undertake or make a grant in respect of the cost of undertaking noise insulation work in or to eligible buildings, subject to meeting certain criteria given in the Regulation. Advice on the use of this discretionary power should be sought from the Overseeing Organisation.

2.14 It is noted that in Scotland, for the assessment of eligibility under the Noise Insulation Regulations, the use of the methodology provided in The Memorandum to Regulations 3 and 6 of the Noise Insulation (Scotland) Regulations should be used. This differs from England, Wales and Northern Ireland, where the methodology contained within CRTN should be used when calculating entitlement under the relevant Noise Insulation Regulations.

The Highways Noise Payments and Movable Homes (England) Regulations 2000 (as amended 2001)
The Highways Noise Payments (Movable Homes) (Wales) Regulations 2001

2.15 The Highways Noise Payments and Movable Homes (England) Regulations 2000 and The Highways Noise Payments (Movable Homes) (Wales) Regulations 2001, provide highway authorities with a discretionary power to provide a noise payment where new roads are to be constructed or existing ones altered. The relevant regulations set out the criteria which should be applied in assessing eligibility for making such payments. Advice on the use of this discretionary power should be sought from the Overseeing Organisation. It is noted that there is no similar Regulation in Scotland.

New and Improved Roads – Construction and Maintenance

The Noise Insulation Regulations 1975 (as amended 1988)
The Noise Insulation (Scotland) Regulations 1975

2.16 Regulation 5 provides relevant authorities with discretionary powers to undertake or make a grant in respect of the cost of undertaking noise insulation work in or to eligible buildings with respect to construction noise. This is subject to meeting certain criteria given in the Regulation. Advice on the use of this discretionary power should be sought from the Overseeing Organisation.

Control of Pollution Act 1974

2.17 The Control of Pollution Act 1974 Section 61 sets out procedures for those undertaking works to obtain 'Prior Consent' for construction works within agreed noise limits.

2.18 Applications for such consent are made to the relevant local authority and contain a method statement of the works and the steps to be taken to minimise noise. Under Section 60 of the Act, the local authority has powers to attach conditions to, limit or qualify any consent to allow for changes and limit the duration of any consents. It is noted that although it is generally for those undertaking the works to decide whether or not to seek such consent, this is also dependent on the custom and practice of the local authority. Some local authorities request demonstration of best practicable means rather than formal 'Prior Consent' applications.

2.19 For the control of noise and vibration at construction sites, BS 5228: 2009 (Ref 9) (Code of Practice for noise and vibration control on construction and open sites – Part 1: Noise & Part 2: Vibration) provides guidance for predicting construction noise and also provides advice on noise and vibration control techniques.

Environmental Protection Act 1990

2.20 Under Part III of the Environmental Protection Act 1990 local authorities have a duty to investigate noise complaints from premises (land and buildings) and vehicles, machinery or equipment in the street. It does not apply to road traffic noise but may be applicable to some construction activities. The Noise and Statutory Nuisance Act 1993 amended Part III

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of the Environmental Protection Act 1990 by placing additional definitions in the list of statutory nuisances in Section 79 of the Environmental Protection Act. The definitions relate to nuisance caused by vehicles, machinery and equipment in the road.

2.21 If a local authority's Environmental Health Officer is satisfied that a complaint amounts to a statutory nuisance then the authority must serve an abatement notice on the person responsible or in certain cases the owner or occupier of the property. The notice could require that the noise or nuisance must be stopped altogether or limited to certain times of the day.

Other Legislation and Policy

The Environmental Noise (England) Regulations 2006 (as amended 2008, 2009)
The Environmental Noise (Northern Ireland) Regulations 2006
The Environmental Noise (Scotland) Regulations 2006
The Environmental Noise (Wales) Regulations 2006 (as amended 2009)

2.22 The above Environmental Noise Regulations have been introduced into the UK to implement the Assessment and Management of Environmental Noise Directive 2002/49/EC. This Directive relates to the assessment and management of environmental noise in EU member states. At the time of publication of this standard and in the future, Noise Action Plans and additional guidance may be available to those carrying out noise and vibration assessments that might need to be taken into account during the assessment of road projects. One such published example is Scotland's Draft Transportation Noise Action Plan. Advice should be sought from the Overseeing Organisations to establish the relevant information and guidance which needs to be considered during the assessment process.

National Noise Policy

Noise Policy Statement for England, DEFRA

2.23 DEFRA released the Noise Policy Statement for England (NPSE) in March 2010. The NPSE vision is to promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development. To achieve this vision the NPSE sets out the following aims for the effective management and control of environmental, neighbour and neighbourhood noise with in the context of Government policy on sustainable development:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to improvement of health and quality of life.

Advice should be sought from the Highways Agency to establish the extent to which the NPSE should be considered during the assessment process. For projects involving the other Devolved Administrations, advice should be sought from the Overseeing Organisation as to the application of the relevant noise policy.

Key Issues

2.24 Traffic noise is a major source of complaint and the release of the Assessment and Management of Environmental Noise Directive (2002/49/EC) is part of a strategy to address this. The implementation of this Directive into national law via Regulations given at Cl 2.22 and the production of action plans provides a framework to manage environmental noise, including traffic noise.

2.25 One of the issues to consider during an assessment of noise and vibration is the impacts upon people. This relates to people in their homes, their gardens and also outside in recreation areas. The impact upon other sensitive receptors and the enjoyment of these receptors is also important.

2.26 There is a growing body of evidence concerning the adverse effect noise can have on health and general quality of life. Current evidence indicates that prolonged exposure to high levels of noise can lead to mental health and physiological symptoms; however, further research is necessary to define noise level exposure parameters for such symptoms. (Ref 34 & 35))

2.27 Impacts on the noise climate from climate change are relatively unknown, but these could become an issue as this topic is better understood.

2.28 For a road project that involves introducing a new noise source into an area, a key consideration is the change in the level of nighttime noise. In the

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WHO's 'Night Noise Guidelines for Europe' (2009) a night noise guideline (NNG) of 40 dB $L_{night,outside}$ is recommended. This façade noise level is considered by WHO to protect the public, including most of the vulnerable groups such as children, the chronically ill and elderly, from the adverse health effects of night noise. WHO also recommends an interim target (IT) of 55 dB $L_{night,outside}$ for situations where the achievement of NNG is not feasible in the short term. The guidance considers that this IT can be temporarily considered by policy-makers for exceptional local situations. No timescale is recommended to achieve these noise levels, only that Member States are encouraged to gradually reduce the proportion of the population exposed to level over the IT within the context of meeting wider sustainable development objectives.

2.29 The use of congestion management schemes is becoming widespread, and the effect these have on the noise climate is still relatively unknown.

Interactions with Other Assessment Topics

2.30 During the assessment of a road project, the impact from noise and vibration may need to be considered by other environmental topic areas. Although most non-dwelling sensitive areas will be included in the noise assessment, some other environmental topics may require additional information on noise and vibration impacts in order to undertake their assessments (e.g. Nature Conservation).

2.31 Noise is one characteristic that determines the level of tranquillity. This is considered further within the Landscape and Visual Effects topic, and therefore, information may need to be provided to assist with the landscape chapter assessment.

Project Objectives

2.32 The design objectives of the road project should always be understood by those undertaking an assessment. This could include how the noise and vibration assessment fits into any wider design objectives.

2.33 If there are any design objectives set specifically for noise then those undertaking the assessments should fully understand the reasons for this requirement and the objective that has been set. Any wider government objectives or strategies should also be considered.

2.34 Any local or legal requirements should also be understood before an assessment is undertaken.

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3. PROCEDURE FOR ASSESSING IMPACTS

Overview of Process

3.1 The following guidance describes the assessment process for potential noise and vibration impacts arising out of road projects involving new construction, improvements, operation and maintenance. Methods are provided in Annex 1 which should be used to predict the potential impact of proposed road projects.

3.2 The general principle of DMRB Volume 11 Section 2 allocates an assessment method according to risk and the assessment of noise and vibration impacts follows the same process. This process uses three levels of assessment:

i) scoping;

ii) simple;

iii) detailed.

3.3 The level of assessment reached will depend upon the potential for impacts to occur, and this will in turn depend upon the scale of the proposed road project, the site and local circumstances, and the location of sensitive receptors. Determining the appropriate level of assessment is dependant upon threshold criteria being met. The threshold criteria used for traffic noise is a permanent change in magnitude of 1 dB(A) in the short term (i.e. on opening) or a 3 dB(A) change in the long term (i.e. between opening and future assessment year). These noise changes should also apply for the consideration of nighttime noise impacts but only where an $L_{night,outside}$ greater than 55 dB is predicted in any scenario. The threshold criterion for traffic induced vibration is a PPV rise to above a level of 0.3 mm/s, or an existing level above 0.3 mm/s is predicted to increase.

3.4 A Simple Assessment would normally be appropriate where sensitive receptors are present but neither of the threshold values (i.e. noise and vibration) are expected to be exceeded. A Detailed Assessment would be appropriate in situations where sensitive receptors are present and either or both of the threshold values are expected to be exceeded, for example where a new road is proposed. Where a Simple Assessment demonstrates that either or both threshold values are expected to be exceeded it will be appropriate to move to a Detailed Assessment.

3.5 Where sensitive receptors are identified during the Scoping Assessment at which exceeding the threshold values for noise or vibration are possible at such an early stage, it may be appropriate to move directly to a Detailed Assessment. However, caution should be applied to such an approach as at the Scoping Assessment sufficient data may not always be available to make this decision. Before such an approach is adopted, the Overseeing Organisation should be consulted.

3.6 The objective of an assessment is to gain an appreciation of the noise and vibration climate both with and without the road project, referred to as the Do-Something and Do-Minimum scenarios respectively. These scenarios need to be assessed for a baseline year and also a future year. The baseline and future assessment years for construction and operational effects are as follows:

- For an assessment of temporary noise and vibration impacts (i.e. from construction or maintenance activities), the baseline year is taken as that immediately prior to the start of works. The future assessment year would be a year during the period of construction/ maintenance works.

- For an assessment of permanent noise and vibration impacts, the baseline year is taken as the opening year of the road project. This is considered to be the year which is most representative of the situation immediately before a road project opens to traffic. It is noted that the baseline year used for this assessment could be different to the year used when predicting the Prevailing Noise Level for any calculations undertaken for the relevant Noise Insulation Regulations. The future assessment year for operation is typically the 15th year after the opening year of the road project, but in some circumstances this may occur before the 15th year. Inspection of the traffic model outputs will be necessary to establish whether the greatest traffic flows will occur in the 15th year.

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3.7 During the assessment process at Simple and Detailed, comparisons are made between scenarios in the baseline year and the future assessment year. At Simple stage, the following two comparisons are made in order to determine the impact of the road project in the short term, and the long term.

i) Do-Minimum scenario in the baseline year against Do-Something scenario in the baseline year (short term).

ii) Do-Minimum scenario in the baseline year against Do-Something scenario in the future assessment year (long term).

3.8 At the Detailed stage, the following three comparisons are made in order to better understand the impact of the road project.

i) Do-Minimum scenario in the baseline year against Do-Minimum scenario in the future assessment year.

ii) Do-Minimum scenario in the baseline year against Do-Something scenario in the baseline year.

iii) Do-Minimum scenario in the baseline year against Do-Something scenario in the future assessment year.

3.9 The assessment of noise and vibration should be based on the project with permanent mitigation as agreed by the Overseeing Organisation. In Scotland and Wales, an assessment of noise and vibration should also be undertaken without permanent mitigation in place. Any temporary mitigation installed (e.g. environmental barriers which will be removed after the construction phase) should only be included during the assessment of temporary impacts which the temporary mitigation will affect.

Temporary impacts

3.10 Temporary noise and vibration impacts are normally those that occur between the start of advance works and the end of the road project construction period. The term 'disruption due to construction' is commonly used to describe such temporary impacts which occur on both people and the natural environment. In addition to the impacts due to the construction of the road project itself, disruption can arise from advance works, for example to divert utilities, and these works may extend well beyond the road construction site. Where material needs to be transported to or from the construction site, the impacts of the additional traffic along access routes should be considered.

3.11 Although construction-related impacts are temporary, they may nevertheless be sufficient to require mitigation. Typical construction impacts might include a localised increase in noise, vibration, and a loss of amenity due to the presence of construction traffic.

3.12 Ground-borne vibration caused by the activities of heavy construction plant can become perceptible in dwellings and cause nuisance (Ref 21). People often express concern that vibrations they feel will cause structural damage to their dwelling. However, it has been shown that vibrations that can be felt indoors and which often cause occupants anxiety are an order of magnitude smaller than would be needed to activate pre-existing strains and cause cracks to propagate. It should be borne in mind that superficial cracks in plaster around openings such as doors and windows can often appear during the life of a building.

3.13 As there is an expectation that disruption due to construction is a temporary issue, the area in which it is considered to be a nuisance is generally more localised than where the impacts of the road project are likely to be a cause of concern once it has opened to traffic. It has been shown (Ref 4) that the impact of construction nuisance in one form or another, diminishes rapidly with distance.

3.14 Certain projects may require the use of temporary diversion routes and receptors located in proximity to such routes may experience increased levels of noise and vibration. The duration of the temporary diversion is important when considering the potential impacts.

3.15 For on-line projects, e.g. carriageway widening, where temporary diversion routes are not viable, a restriction on road traffic speed is often implemented for reasons of safety allowing construction works to occur adjacent to a traffic stream. Such decreases in traffic speed can lead to temporary reductions in noise levels for nearby receptors. This should be taken into account when considering the potential public response following the opening of the project when traffic speeds are increased following project completion.

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Permanent impacts

3.16 The noise arising from a stream of traffic has two main components. The first component is generated by the engine, exhaust and transmission systems of vehicles and is the dominant source of noise when traffic is travelling at fairly low speeds, or in a low gear. Engine noise from heavy vehicles is commonly the dominant source of low frequency noise. Engine and exhaust noise levels are closely related to engine speed, and transmission noise depends more on the relationship between road speed and engine speed than on vehicle speed.

3.17 The second component of traffic noise is generated by the interaction of tyres with the road surface and this is the dominant noise source when traffic is flowing freely at moderate to high speeds. Tyre noise contributes a significant proportion of high frequency noise, especially in wet weather. Tyre noise levels depend on the tyre characteristics and the road surface roughness, but always increase with vehicle speed in this speed range.

3.18 The noise level from a stream of traffic is an aggregate of the noise emitted by many vehicles. For a continuous flow of traffic, it is generally reasonable to consider this complex source as a single line with uniform emission characteristics, from which the noise level at a specified distance can be estimated.

3.19 The main factors influencing the noise level close to a road comprising freely flowing traffic is the traffic volume, speed and composition (% heavy vehicles), and the road gradient and surface characteristics. At a distant reception point the noise level is attenuated by a number of additional factors, including the distance from the noise source, the nature of the intervening ground surface and the presence of obstructions.

3.20 The total noise level from several sources cannot be combined by simply adding them together since noise levels are calculated as a function of the logarithm of sound pressure. A procedure for combining traffic noise levels is described in the Technical Memorandum Calculation of Road Traffic Noise (CRTN) (Ref 10), which provides a graphical illustration of how the stronger of two sources will have a dominant effect.

3.21 It is widely believed that a given level of traffic noise is more annoying at times when people are resting, especially at night. Historically, the fact that there is much less traffic at night has meant that nighttime noise assessments have not been undertaken as part of the DMRB assessment process. However, due to the increasing use of strategic networks by long distance goods traffic during nighttime hours and the potential to increase the level of noise and the perception of nuisance at night, a nighttime noise assessment should now be considered as part of the assessment process.

3.22 While traffic levels are generally lower at night their resultant noise impacts may be similar to those during the day. It is also noted that people tend to be more sensitive to nighttime noise (Ref 34). As noise during the night (11pm to 7am) is only covered slightly by the 18 hour measure used for assessing noise in this document, a separate quantitative assessment is required.

3.23 The TRL report 'Converting the UK traffic noise index $L_{A10,18h}$ to EU noise indices for noise mapping' (Ref 3) provides a technique for predicting nighttime noise levels (L_{night}). It presents three methods, with the applicable method dependent on the detail of traffic information available. The preferred technique is through the use of Method 1 which relies on the provision of hourly traffic flows. Method 2 allows for the prediction of nighttime noise levels where the traffic flow for that period is available. Using daily traffic flow data, Method 3 converts predicted day-time noise levels ($L_{A10,18hr}$) to nighttime noise levels. Where Method 3 is used it should be ensured that diurnal traffic pattern from the given road scheme is typical, otherwise erroneous forecasts may be given.

3.24 The conversion methods contained within the TRL report to predict nighttime noise levels were derived through investigating the correlation between measured levels of $L_{A10,1hr}$ and $L_{Aeq,1hr}$ at 76 different urban sites. A good correlation was shown between these noise parameters where high noise levels were measured; however, a greater variance is shown where at lower noise levels. The report considers that this is due to non-traffic noise sources affecting measured L_{Aeq} values more than L_{A10} values as the traffic flow reduces. Therefore, caution should be applied when using the TRL conversion formulae to predict nighttime noise levels away from major trunk roads and motorways. Despite this caution, the conversion methods contained within the TRL report are deemed the most suitable pending further research in this area.

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3.25 Traffic vibration is a low frequency disturbance producing physical movement in buildings and their occupants. Vibration can be transmitted through the air or through the ground. Airborne vibration from traffic can be produced by the engines or exhausts of road vehicles and these are dominant in the audible frequency range of 50-100 Hz. Groundborne vibration is often in the 8-20 Hz range and is produced by the interaction between rolling wheels and the road surface (Ref 30).

3.26 Vibration can be measured in terms of Peak Particle Velocity, or PPV (i.e. the maximum speed of movement of a point in the ground during the passage of a source of vibration). For vibration from traffic, a PPV of 0.3 mm/s measured on a floor in the vertical direction is perceptible (Ref 32) and structural damage to buildings can occur when levels are above 10 mm/s (Ref 8). The level of annoyance caused will also depend on building type and usage, however, a building of historic value should not (unless it is structurally unsound) be assumed to be more sensitive (Ref 8).

3.27 Occupants of hospitals, educational establishments and laboratories or workshops where high precision tasks are performed may well be affected to a greater extent than residents of dwellings.

3.28 PPVs in the structure of buildings close to heavily trafficked roads rarely exceed 2 mm/s and typically are below 1 mm/s. Normal use of a building such as closing doors, walking on suspended wooden floors and operating domestic appliances can generate similar levels of vibration to those from road traffic (Ref 30).

Cumulative impacts

3.29 The impact from noise and vibration can contribute to the overall cumulative impact of a road project in three ways.

3.30 Cumulative impacts from a single road project may arise from the combined action of noise or vibration and a number of different environmental topic-specific impacts upon a single receptor/resource. For example, a new road may increase noise at a dwelling, which may also be subject to a deterioration in air quality. Where there is an impact from the road project on a single receptor/resource from the combined action of noise and vibration, this should be treated as a cumulative impact. The forms of cumulative impact are discussed further in Section 2, Part 5, Chapter 1, with advice on how to consider the certainty of outcome and the probability of the predictions.

3.31 Cumulative impacts may arise from the combined action of a number of different road projects, in combination with the proposed road project, on a single receptor/resource. For example, the road project may be on a route where further road projects are scheduled for opening. These road projects may result in changes in traffic flow when each road project is completed and hence increase or decrease noise at dwellings. The traffic flows supplied for the noise and vibration assessment undertaken in accordance with Chapter 3 would normally consider the changes in traffic on the wider network and from other road projects. Hence, the information required to assess this type of cumulative impact may be readily available (e.g. from wider strategic studies), without the need for a further assessment. This should be clarified with the traffic consultant.

Magnitude of Impact

3.32 Section 2 of Volume 11 includes HA 205/08. This provides a method for the classification of the magnitude of impact and the significance of an effect in order to arrive at an overall level of significance. Currently, a methodology has not yet been developed to assign a significance according to both the value of a resources and the magnitude of an impact. However, the magnitude of traffic noise impact from a road project should be classified into levels of impact in order to assist with the interpretation of the road project. Therefore, for the assessment of traffic noise that is covered by this document, a classification is provided for the magnitude of impact.

3.33 A change in road traffic noise of 1 dB(A) in the short term (e.g. when a project is opened) is the smallest that is considered perceptible. In the long term, a 3 dB(A) change is considered perceptible. The magnitude of impact should, therefore, be considered different in the short term and long term. The classification of magnitude of impacts to be used for traffic noise is given in Table 3.1 (short term) and Table 3.2 (long term).

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Noise change, $L_{A10,18h}$	Magnitude of Impact
0	No change
0.1 – 0.9	Negligible
1 – 2.9	Minor
3 – 4.9	Moderate
5+	Major

Table 3.1 – Classification of Magnitude of Noise Impacts in the Short Term

Noise change, $L_{A10,18h}$	Magnitude of Impact
0	No change
0.1 – 2.9	Negligible
3 – 4.9	Minor
5 – 9.9	Moderate
10+	Major

Table 3.2 – Classification of Magnitude of Noise Impacts in the Long Term

3.34 Research into the response to change in road traffic noise is largely restricted to daytime periods. Until further research is available Tables 3.1 and 3.2 should be used to consider the magnitude of noise change at night. However, given the caution with predicting nighttime noise levels away from main roads as highlighted above, only those sensitive receptors predicted to be subject to a $L_{night,outside}$ exceeding of 55 dB should be considered. The $L_{night,outside}$ of 55 dB corresponds to the Interim Target level specified in the WHO Night Noise Guidelines for Europe.

3.35 Methods are available for evaluating the significance of construction noise. These methods are described in Annex E of BS 5228 (Ref 9) and should be used unless an alternative method is agreed with the Overseeing Organisation.

3.36 Tables 3.1 and 3.2 should be used in the assessment of noise impact associated with construction traffic on the local road network and from temporary diversion routes resulting from construction of the road project.

3.37 The level of vibration at sensitive receptors has the potential to increase and decrease. If the level of vibration at a receptor is predicted to rise to above a level of 0.3 mm/s, or an existing level above 0.3 mm/s is predicted to increase, then this should be classed as an adverse impact from vibration.

Uncertainty and validity

3.38 During an assessment of the impacts from noise and vibration, the uncertainty associated with input data is an important factor in determining how confident the Overseeing Organisation's supply chain can be with the assessment results. As the road project progresses, the quality and accuracy of the assessment should normally improve. This in turn will influence the accuracy of designed mitigation measures, for example the height and positioning of any barriers. The most up to date scheme design and traffic flow information should be used in the final assessment.

3.39 For the prediction of road traffic noise the methodology given in the CRTN should be used. Annex 4 provides additional guidance on the use of CRTN.

3.40 The method used to assess noise nuisance in this guidance is based on data that is at least 15 years old. The surveys which provided the basis for this method of assessing nuisance were conducted at sites where road traffic was the dominant noise source. The noise exposure at those sites ranged from 65 to 78 dB $L_{A10,18h}$, with the changes in traffic noise being up to 10 dB $L_{A10,18h}$ at dwellings up to 18m from the roadside kerb. On this basis this method should be used with caution and further guidance and requirements are given in Annex 4.

3.41 For the prediction of vibration from an existing road, the methodology given in Watts 1990 (Ref 30) could be used to predict the maximum vertical PPV at the foundations of a building. However, this methodology requires detailed knowledge of the ground type which may only be available at advanced stages of assessment. If this methodology is to be used for the prediction of expected vibration levels from a new road, then the Overseeing Organisation should first be consulted and the proposed use agreed.

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3.42 The method to assess airborne vibration nuisance in this guidance was restricted to dwellings within 40m of the carriageway where there were no barriers to traffic noise. There should be caution when using this guidance to make predictions of disturbance caused by airborne vibration where the receptors are screened or are not sited within 40m of the road, since this is outside the range of the data on which the method is based.

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4. DESIGN AND MITIGATION

4.1 A road project should be designed in order to fulfil the objectives from the project brief. This brief may include noise and vibration related objectives. As far as practicable the mitigation of impacts should be addressed through optimising horizontal and vertical alignments to achieve the necessary mitigation. However, this optimisation may be insufficient to achieve or address some or all principal objectives, and thus additional measures may be necessary.

4.2 Some examples of design and mitigation techniques to address noise and vibration impacts are described below. Except where noted, they will help to mitigate both noise and vibration impacts.

i) **Horizontal alignment** – By moving a route away from sensitive receptors.

ii) **Vertical alignment** – Keeping a route low within the natural topography to exploit any natural screening and enhancing this by the use of cuttings and, in exceptional circumstances, sub surface and surface tunnels.

iii) **Environmental barriers** – These can be in the form of earth mounding or acoustic fencing of various types, or a combination of the two. Conventional environmental barriers are not effective in reducing ground borne vibration and may be only partially effective against airborne vibration. They should, therefore, be ignored in assessing vibration nuisance unless tests show benefits from the design proposed. The use of reflective and absorptive barriers could also be considered. Further advice on how the assessment can consider such barrier types in the modelling process is given in Annex 4.

iv) **Low-noise surfaces** – The principal benefit of low-noise surfaces is the reduction in mid and higher frequencies of noise generated by tyres at speeds in excess of 75 km/hr. They are less effective in reducing noise at low speeds where engine noise particularly from heavy vehicles is more dominant. These surfaces also create a relatively smooth running surface that in some cases can help to eliminate ground borne vibration.

v) **Speed and volume restrictions** – The effect of the speed of vehicles on noise level is one of the most fundamental in the noise prediction process. Above 40 km/hr, noise level increases with the speed of the vehicle and a reduction in speed will normally cause a reduction in noise level. In a similar way, the volume and composition of traffic has a direct influence on the noise level.

4.3 The potential benefits of mitigation measures vary widely according to circumstances. For example, environmental barriers can provide reductions of 10 dB or more for well-screened locations relatively close to the source. But at further distances, and especially where the barrier provides only a small deflection of the transmitted sound waves, actual noise reductions may only be 1 or 2 dB. Beyond 200-300m, the effects are often zero as ground attenuation becomes the most significant factor.

4.4 The use of shrubs or trees as a noise barrier has been shown to be effective only if the foliage is at least 10m deep, dense and consistent for the full height of the vegetation (Ref 16, 29). The effect on noise from the removal of such foliage density will require consideration when undertaking any predictions as this may lead to an elevation of noise level. Guidance from the Overseeing Organisation should be sought in considering the potential effects of foliage on noise.

4.5 The benefits of adjusting alignments are difficult to determine without complex calculations; a horizontal realignment can often take advantage of natural screening or provide opportunities to create landscaped features. Lowering a road into cutting may be more attractive than erecting noise barriers and may generate extra fill which can be used for earth mounding to enhance the screening effect.

4.6 Although putting a road into a tunnel will eliminate the noise from the enclosed section, there is potential for reverberant noise to be emitted at either end of the tunnel and increase the noise from traffic on the approaches. Noise may also be exacerbated by reflections between the flanking retaining walls. Noise absorptive surfaces within the entrance of the tunnel and on the retaining walls can help to reduce this if it is a problem.

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4.7 CRTN cannot deal with the effects of partial reflections or with 3D effects and there may be need for a sophisticated analysis of noise if there are sensitive receptors in close proximity to the end of a tunnel. Work has shown that the reflection effects at a tunnel portal are localised, and possibly only noticeable within 100m of the portal.

4.8 The presence of movement joints in structures and carriageways may lead to adverse response from nearby sensitive receptors. Noise emitted from vehicles passing over movement joints can emanate from a number of paths including, tyre interaction with the joint and associated vibration, particularly of a structure. Although the noise emissions can be perceptible against that of general traffic flow noise, particularly at night, due to the variation in the noise spectrum resulting from these events, it is unlikely that measured levels of L_{A10} would be affected by their presence. However, the potential public response to noise emanating from movement joints should be considered where new joints are proposed or where they currently exist but the carriageway is being replaced by a surface with a lower road surface influence (RSI).

4.9 Reducing the noise and vibration impact from a road is just one of the factors to be considered in design, and conflicts can exist. Consideration should be given to cases where such conflict may exist, e.g. an acoustic barrier may introduce unacceptable visual intrusion or safety implications. In addition, any mitigation measure should perform to an acceptable level in traffic, road safety, economic and other environmental terms.

4.10 The impact from construction noise can be mitigated to a certain extent both by applying powers within the relevant Land Compensation Act or by imposing contractual working restraints. The Land Compensation Act allows for temporary re-housing when the disruption is of such an extent that continued occupation is not reasonably possible. Regulations made under Part II of the Act also permit the insulation of eligible buildings against construction noise where that noise seriously affects, for a substantial period of time, the enjoyment of the building. This is independent of any requirement for noise insulation resulting from traffic noise. However, where houses are eligible for insulation from traffic noise, the insulation work could be carried out early enough for the recipients to benefit during the construction period.

4.11 Contractual working restraints are important where the natural environment needs to be protected against potentially adverse impacts caused by particular construction methods. For example, restrictions can be written into the contract documents that prevent the storing of borrow or surplus material in particular areas. Contract conditions can also be used to limit noise from the construction site, to control working hours (especially for potentially disruptive operations), to prevent access to sensitive areas, to restrict construction traffic to suitable haul routes, and to ensure that such routes are cleaned or swept regularly. It is important that contractual working restraints are discussed in advance with the local authority Environmental Health Officer. Monitoring of conditions noise and vibration may be necessary during construction.

4.12 Nuisance from construction vibration can be reduced by the use of specialised equipment. Martin (Ref 22) gives further guidance on mitigation measures to reduce vibration and describes a method of predicting vibration levels. In considering possible methods of mitigating adverse impacts during the construction period, it will be necessary to balance the severity of an impact with its duration. For example, it may be acceptable if greater disruption occurs over a short period than lesser disruption over an extended period.

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5. MANAGEMENT OF ENVIRONMENTAL EFFECTS

5.1 It is important to note the conclusion of noise and vibration assessments may depend on mitigation features built into the design, e.g. noise barriers or low noise surfacing. The validity of these conclusions will depend on these mitigation features being maintained as fit-for-purpose and this is the assumption that is made during the compiling of the assessment such that the road project should deliver the objectives over the assessment period. This will include the managing of any proposed mitigation in order to deliver any predicted benefits.

5.2 For noise, the long term effectiveness of any low-noise surfaces and noise barriers is important in achieving any claimed benefits. This process starts with the choosing of an appropriate surface or barrier, through the installation period and then during the operation of the road project.

5.3 The effectiveness of low-noise surfaces is dependant upon wear to the surface and clogging of the surface, with the noise reducing properties of the surface becoming less due to clogging. A possible measure to manage the low-noise surface is to clean the surface to avoid clogging. Cleaning can be undertaken by a variety of means, although each has disadvantages associated with cost, time, and the potential need to close lanes to traffic.

5.4 The effectiveness of a noise barrier is dependant upon its ability to prevent sound passing through, over, or around it. Following installation, this can be managed by undertaking regular inspections to ensure that there is no significant degeneration in its construction.

5.5 For vibration, imperfections in the road surface are the main cause of vibration. The monitoring of surface condition is an important part in preventing traffic induced vibration.

5.6 An important part of the management of the noise and vibration impacts from a road project is the management of stakeholder expectations. Exhibitions and consultations will usually be held to inform stakeholders of the potential impacts and associated mitigation The Overseeing Organisation's supply chain should ensure that the noise and vibration impacts and any mitigation are correctly conveyed. The management of temporary impacts from construction can be particularly important as these can often involve a sudden change in noise level.

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6. MONITORING AND EVALUATION

6.1 Although there is currently no general requirement for noise and vibration monitoring following the completion of a road project, the Overseeing Organisation's supply chain should check whether any monitoring requirements have been written into the design specification. This may be required if an objective of the road project is to reduce noise.

6.2 Monitoring during construction may be required and the scope of this would usually be covered by agreements with the local Environmental Health Officer.

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7. REPORTING OF ASSESSMENTS

7.1 When reporting the potential impact of noise and vibration, completed tables A1.1, A1.2, A1.3 and A1.4 should be supported by the results of the assessment methods as well as other technical and qualitative information sufficient to provide a transparent decision-making process. The results of the assessments may be intended for inclusion in an Environmental Statement and to document and support decision making. The results should be capable of bearing public scrutiny and debate and should, therefore, be robust enough to withstand such scrutiny. Records of assessments, consultations, analyses and conclusions should be comprehensive, meticulous and consistent. For further general guidance on reporting potential effects DMRB 11.2 'General Principles of Environmental Assessment' should be consulted. In particular, HD 48/08 'Reporting of Environmental Impact Assessments' gives guidance on reporting the results of the processes described in the standard.

7.2 The assessments will produce reports in various formats for different purposes. Technical reports on data collection or fieldwork may often be stand-alone documents, but they should be prepared bearing in mind that certain aspects may contribute to the environmental plans or management plans (or equivalent) for the road project.

7.3 Reports should conform to the Overseeing Organisation's preferred style or formatting, and observe any protocols for the presentation of electronic documents or data.

7.4 Reports should be prepared including the results of all assessments, whether at Scoping, Simple or Detailed stage, taking account of the level of detail required for the particular stage in road project delivery and the decision making process associated with the road project.

7.5 Any recommendation given in assessment reports to proceed to a formal Environmental Impact Assessment should be agreed with the Overseeing Organisation and that agreement confirmed in writing by the Overseeing Organisation.

7.6 Annex 1 of this guidance details the approach for the assessment of noise and vibration for new road projects.

Scoping

7.7 For the report at Scoping, the indicative layout for the specialist topics given in HD 48/08 (Table 2.1) should be followed unless directed otherwise by the Overseeing Organisation. The noise and vibration scoping report should also report the following for each option under consideration:

- A description of the road project objectives, define and display the study area and the main sources of noise and vibration in the area;
- Whether there is likely to be a change in noise level of 1dB or more at any sensitive receptors within the study area;
- Whether there is likely to be an increase in the level of groundborne vibration at any sensitive receptors within the study area to above a level of 0.3 mm/s, or an existing level above 0.3 mm/s is predicted to increase;
- The outcome from any consultations and also any known noise levels;
- The data sources used to gain information for assessment. This should also include an indication of whether or not (and why) a site visit has been undertaken;
- A view on the likely impact and if the assessment should proceed to either Simple or Detailed and the reasoning for this;
- Any limitations in the data used or assumptions made during the assessment process.

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Simple

7.8 The report for a Simple Assessment should be written in accordance with any instructions from the Overseeing Organisation, and should also report the following:

Reporting of permanent impacts

- A description of the road project objectives, define and display the study area, and the main sources of noise and vibration in the area.
- The results from the assessment (Table A1.1 and A1.2) including potential nighttime noise impacts.
- Provide a list of predicted noise levels at all sensitive receptors used in the assessment, including the associated magnitude of change. Where a large number of sensitive receptors exist it may be suitable to include these in an Annex to the main report.
- The results from the BNL comparisons. A qualitative entry can be given to describe any potential impacts at sensitive receptors further than 50m from any affected link.
- Any possible cumulative impacts.
- Any possible vibration impacts or results from surveys.
- The results from any noise surveys.
- The outcome from any further consultations.
- A view on the likely impact and whether or not (and why) an assessment at Detailed is recommended.
- Noise change contour maps showing any areas where noise change of 1 dB(A) or greater occur in the base year.
- Any limitations in the data used or assumptions made during the assessment process.

Reporting of temporary impacts

- Number of sensitive receptors that are likely to be affected.
- Any construction operations that may have an impact, including the extent of activities and duration.
- Changes in noise and vibration at sensitive receptors.
- The outcome of any consultations.
- A general indication of the extent of any increases likely on the local road network due to construction activities, if necessary considering those emanating from temporary diversion routes.
- Any limitations in the data used or assumptions made during the assessment process.

Detailed

7.9 The report for a Detailed Assessment should be written in accordance with any instructions from the Overseeing Organisation, and should also report the following:

Reporting of permanent impacts

- A description of the road project objectives, define and display the study area, and the main sources of noise and vibration in the area.
- The results from the assessment (Table A1.1, A1.2 and A1.3) including nighttime noise impacts.
- Provide a list of predicted noise levels at all sensitive receptors used in the assessment, including the associated magnitude of change. Where a large number of sensitive receptors exist it may be suitable to include these in an Annex to the main report.
- The results from the relevant BNL comparisons. A qualitative entry can be given to describe any potential impacts at sensitive receptors further than 50m from any affected link.
- Any possible cumulative impacts.

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- Any possible groundborne vibration impacts or results from surveys.
- The results from the assessment of potential airborne vibration impacts (Table A1.4).
- The results from any noise surveys.
- Noise change contour maps. These should show areas with noise change of 1 dB(A) or greater in the base year and a change of 3 dB(A) or greater between the base year Do-Minimum and future Do-Something assessment year.
- The outcome from any further consultations.
- Any limitations in the data used or assumptions made during the assessment process.

Reporting of temporary impacts

- Number of sensitive receptors that are likely to be affected.
- Any construction operations that may have an impact, including the extent of activities and duration.
- Changes in noise and vibration at sensitive receptors.
- The outcome of any consultations.
- A general indication of the extent of any increases likely on the local road network due to construction activities, if necessary considering those emanating from temporary diversion routes.
- Any limitations in the data used or assumptions made during the assessment process.

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9. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

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ANNEX 1 ASSESSMENT AT SCOPING, SIMPLE AND DETAILED LEVELS

A1.1 This Annex guides the Overseeing Organisation's supply chain through the methods for assessment to be applied at Scoping, Simple and Detailed levels.

A1.2 The flow chart shown in Figure A1.1 has been developed to guide the Overseeing Organisation's supply chain through the assessment process. This indicates the key decision to be taken at each stage. The methods to be applied for each level of assessment are described in greater detail in paragraphs A1.3 onwards.

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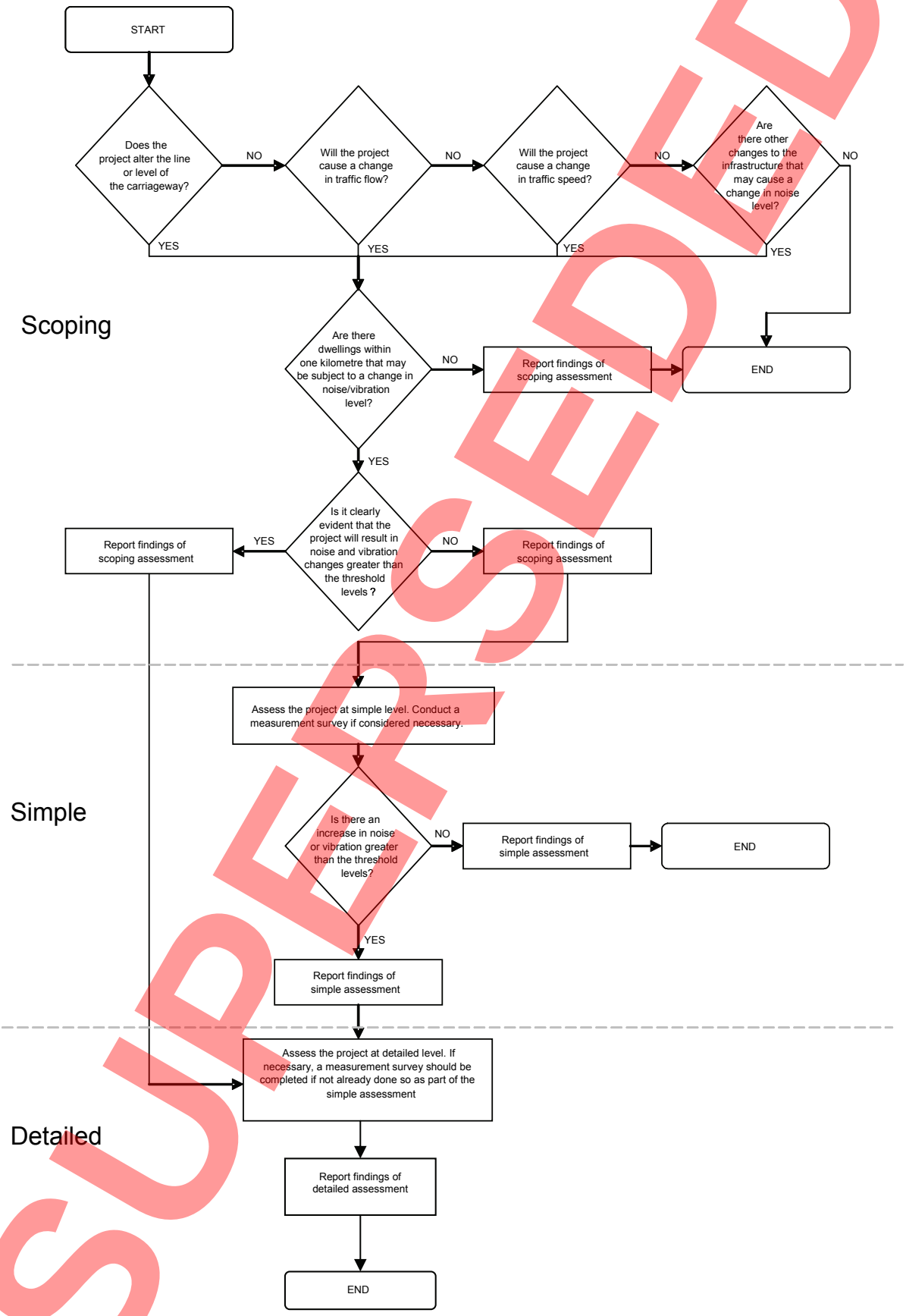


Figure A1.1: Flowchart for Main Stages of Noise and Vibration Assessment

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Scoping Assessment

A1.3 This is predominately a desk-based exercise to determine the need for a noise and vibration impact assessment for any of the project options being considered. This process includes identifying sensitive receptors and considering any other relevant local information.

A1.4 This process also allows stakeholders to register concerns or particular requirements during the period of data collection for this assessment. Those potentially affected will need a full appreciation of the project and the context in which the works are taking place. Depending on the nature of the project, the activities may affect people in their homes or in the vicinity for some or a lot of the time, during day or night, or have impacts on sensitive receptors within a wider area.

A1.5 As a general rule, an assessment will be required where there is a potential for new road construction, improvements, operation or maintenance to affect the quality of life or the local environment as the result of noise and/or vibration.

A1.6 The objective of assessment at this level is to gather sufficient data to provide an appreciation of the likely noise and vibration consequences associated with the project identified by the Overseeing Organisation's supply chain and agreed with the Overseeing Organisation. Any option that could involve significant disruption due to the proximity to population centres, or the possible need for tunnelling, bridgeworks or other intrusive construction processes, should be identified. At this stage of the assessment a site visit is often appropriate.

A1.7 An important part of the overall environmental assessment process is liaison with stakeholders. This could include the local planning authority, Environmental Health Officers and residents associations. Local consultations may serve to acquire existing information and help to identify the appropriate level of assessment. This can ultimately save time and costs in developing the road project and result in better informed solutions.

A1.8 To determine whether the assessment continues to the next stage, the Scoping assessment should identify whether the threshold values (see 3.3) are likely to be met or exceeded. This can be determined by examining if any of the following conditions are likely to be met.

i) the road project alters the alignment of any existing carriageways. This would include new sections of road, additional junctions and slip roads, and hence could result in the introduction of a new noise or vibration source, or a change to noise or vibration levels from an existing road source;

ii) changes in traffic volume on existing roads or new routes may cause either of the threshold values for noise to be exceeded. A change in noise level of 1 dB(A) is equivalent to a 25% increase or a 20% decrease in traffic flow, assuming other factors remain unchanged;

iii) changes in traffic speed or proportion of heavy vehicles on the existing roads or new routes may cause a change in noise level of 1 dB(A) or more, either during construction, including temporary diversion routes, or when the road project is completed. If sufficient traffic flow information is available, then it is acceptable to use this to determine whether there is likely to be a change of 1 dB(A) or more which will result from a combination of traffic flow, speed and composition, instead of using ii) and iii) above in isolation;

iv) changes in traffic volume and composition on existing roads or new routes during the night which may cause either of the threshold values to be exceeded. This applies to both temporary and permanent changes in nighttime traffic;

v) any physical changes to the infrastructure surrounding the road or any change in the way in which the existing road is used that could cause a change in noise level of 1 dB(A) or more. This could include, but not be restricted to, such works as re-surfacing, congestion management schemes, bridge building and barrier installation;

A1.9 The construction or maintenance activities associated with the road project are likely to cause temporary adverse impact for nearby sensitive receptors. This is particularly important for works being undertaken during the night. In determining whether the assessment continues further consideration should be given to the potential for exceeding the criteria provided in BS 5228 for significant change.

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A1.10 Where there is uncertainty if either threshold value will be met at sensitive receptors then the assessment process must proceed to the Simple level. If the above (A1.8) conditions indicate that the threshold values are likely to be met or exceeded at any sensitive receptors or should it be considered likely that temporary impacts will result in significant noise change (A1.9) then the assessment process must proceed to a Detailed Assessment. However, caution should be applied to such an approach as at the Scoping stage sufficient data may not always be available to make this decision. Hence, guidance must always be sought from the Overseeing Organisation before making such a recommendation. For all other situations, further assessment will not normally be required unless stakeholders put forward a reasoned justification for considering particular local impacts. If one or more of the above criteria is met then the assessment must continue.

A1.11 The study area is defined by the following process:

i) Identify the start and end points of the physical works associated with the road project.

ii) Identify the existing routes that are being bypassed or improved, and any proposed new routes, between the start and end points.

iii) Define a boundary one kilometre from the carriageway edge of the routes identified in (ii) above.

iv) Also define a boundary 600m from the carriageway edge around each of the routes identified in (ii) above and also 600m from any other affected routes within the boundary defined in (iii) above. This area is called the 'calculation area'. An affected route is where there is the possibility of a change of 1 dB(A) or more (i.e. conditions (ii) and/or (iii) given in A1.8.

v) Identify any affected routes beyond the boundary defined in (iii) above.

vi) Define a boundary 50m from the carriageway edge of the routes identified in (v) above.

A1.12 If any sensitive receptors are identified within the study area then the assessment must continue to Simple. Examples of sensitive receptors include dwellings, hospitals, schools, community facilities, designated areas (e.g. AONB, National Park, SAC, SPA, SSSI, SAM), and public rights of way. If no sensitive receptors are identified then further assessment would not normally be necessary, and the results of the Scoping exercise reported, clearly stating why no further assessment was considered necessary.

A1.13 For open space sensitive receptors consideration should be given to the assessment location within the open space. In general, this should be identified by a representative position in close proximity to the road project within the open space where the public could potentially be apparent. Justification should be provided for selected this location.

A1.14 At this stage the local Environmental Health Officer(s) should be consulted about the existing noise climate. This consultation should include any known sources of complaint, either from traffic or other environmental sources, any polices relating to temporary or permanent noise sources, and the identification of particularly sensitive receptors. Any noise constraints arising from Local or National Plans should also be identified at this stage.

Simple Assessment

A1.15 The objective of the Simple Assessment is to undertake a sufficient assessment to identify the noise and vibration impacts associated with the road project. These impacts could be temporary or permanent, or both. Should it be apparent that the threshold values (see 3.3) will be exceeded by either temporary or permanent impacts the road project should be considered at the Detailed Assessment level.

A1.16 If it is considered that the only impacts from the road project would be temporary then there is no requirement to assess or report the permanent impacts at the Simple Assessment level. An example of this could be where construction noise or a specific maintenance activity would only cause a temporary impact. If this is the case the Overseeing Organisation's supply chain need only assess and report the temporary impacts at Simple Assessment level.

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A1.17 This stage may be a desk-based exercise to determine the impact at known sensitive receptors and to determine whether the road project needs to be considered at the Detailed Assessment level. It is noted that on some occasions not all the data required to complete this assessment will be available. In these instances the assessment should be undertaken with the data available and commentary be added to any report to indicate the limitations in the data or where assumptions have been made.

Assessment of permanent impacts

A1.18 The steps that should be taken at this stage are:

i) Undertake noise calculations for all sensitive receptors in the study area as defined in A1.11. The level of calculations undertaken will depend upon where the sensitive receptors are located in the study area. For those sensitive receptors within the calculation area (as defined in A1.11 iv), full calculations should be undertaken in accordance with procedures given in CRTN and Annex 4 of this document.

ii) The contribution from all roads within the 600m calculation area should be considered, not just those subject to potential changes of 1 dB(A) or more. For sensitive receptors towards the edge of the 600m calculation area, consideration should be given to the contribution from roads outside the 600m area. The extent of this is left to the professional judgement of the Overseeing Organisation's supply chain.

iii) The noise levels calculated should be façade levels unless the sensitive receptor is an open space. For open spaces, free-field levels should be calculated. All levels should be calculated in $L_{A10,18h}$ at a default height of 1.5m above ground level. For dwellings with a first floor, the noise level should be calculated at 4m above ground level. Further advice should be sought from the Overseeing Organisation where dwellings of over three habitable floors are within the area where noise calculations are to be undertaken. The appropriate height for calculations at non-dwelling sensitive receptors should be determined on an individual basis.

iv) All sensitive receptors where calculations have been undertaken in (i) above should be classified in the categories given in the Table A1.1 (short term) and Table A1.2 (long term). These tables should be completed for the following two comparisons:

  i) Do-Minimum scenario in the baseline year against Do-Something scenario in the baseline year (short term).

  ii) Do-Minimum scenario in the baseline year against Do-Something scenario in the future assessment year (long term).

v) The calculations of BNL should be reported for each of the affected routes identified in A1.11 (v). A count of the number of sensitive receptors within 50m of the centreline of these affected routes should then be undertaken. Comparisons the same as those in A1.18 (iv) should be undertaken, and reported in an appropriate way.

vi) Where a building is predicted to experience different changes on different façades, the least beneficial change in noise level should be reported in the assessment Table. When all facades show a decrease in noise level, then the smallest decrease should be reported. When all facades show an increase in noise level then the largest increase should be reported. If this approach would lead to the reporting of two or more facades (i.e. where the same least beneficial change is shown on two or more facades) then the change on the façades with the highest noise level in the Do-Minimum scenario should be reported. A similar approach of reporting the least beneficial change should be used for the impact at areas within open spaces or sensitive receptors such as footpaths.

vii) It is acknowledged that the results from this assessment may often show the worst case and highlight mainly the adverse impacts of a road project. Where the road project has beneficial impacts that are not clear from the assessment these should be reported by the Overseeing Organisation's supply chain.

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viii) For sensitive receptors that are within one kilometre of a route defined in A1.11 (ii) but not within 600m of an affected route, a qualitative assessment of any possible noise impact should be undertaken.

ix) If any other comparisons are identified that would further demonstrate the noise and vibration impact of the project, these should also be calculated and reported. For example, although the comparison between Do-Minimum and Do-Something in the future assessment year is not required in the decision making process of whether to move from a Simple to Detailed Assessment, this comparison may be useful when comparing options or explaining potential impacts to stakeholders.

x) Prepare a map showing the study area and the sensitive receptors that are included in the assessment. Maps should also be prepared for each of the comparisons identified in (iv) above. This information can be shown as noise difference contour plots, or another appropriate format that clearly indicates the level of noise change at each sensitive receptor. Changes are to be shown in 1 dB intervals with all sensitive receptors clearly identified on the maps. If the 1 dB interval is considered too narrow then a more appropriate interval should be chosen. However, it is essential that the sensitive receptors experiencing a change in noise level of 1 dB(A) in the short term or 3 dB(A) in the long term or more are clearly identified.

xi) Produce a list of predicted noise levels as identified in (iv) above for all sensitive receptors in the study area.

xii) Consider the need for an assessment of nighttime noise. Such an assessment may be necessary when there are changes in nighttime noise that meet the threshold values (see 3.3) and where receptors will be exposed to an $L_{night,outside}$ of 55 dB or greater in any scenario. Nighttime noise changes for sensitive receptors meeting this criteria should be included in Tables A1.1 and A1.2. In the absence of a specific prediction methodology the TRL report 'Converting the UK traffic noise index $L_{A10,18h}$ to EU noise indices for noise mapping' (Ref 3) should be used in the assessment of nighttime noise. This report provides three methods for predicting nighttime noise levels (L_{night}) with the applicable method being dependent on the detail of traffic information available. The method used should be agreed with the Overseeing Organisation.

xiii) Sensitive receptors should be highlighted which meet the following nighttime noise criteria:

- where the introduction of a project results in a sensitive receptor being exposed to nighttime noise levels in excess of 55 dB $L_{night,outside}$ where it is currently below this level; and
- where a receptor is exposed to pre-existing $L_{night,outside}$ in excess of 55 dB and this is predicted to increase

A1.19 The assessment should show predicted noise changes calculated to the nearest 0.1 dB(A) and agreed mitigation should be taken into account (excluding any statutory noise insulation).

A1.20 Although noise calculations are based on future traffic flows, the impact of the changes can only be recorded for people living and using facilities in the affected area in the year the assessment is undertaken. Where planning permission for a residential development or any other sensitive receptor has been granted but for which construction has not started, the potential impacts on these locations should be estimated and reported separately.

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Assessment of permanent traffic induced vibration impacts

A1.21 If ground-borne vibration on existing routes is considered to be a potential problem, calculations or measurements of vibration at the foundations of typical buildings considered to be at high risk may be taken in order to establish whether increasing vibration levels would be likely to exceed the threshold values (see 3.3). Based on these results at a sample of dwellings, an estimate can be made of the number of buildings likely to be exposed to perceptible vibrations along the affected route. This will only apply in rare cases where, for example, traffic is expected to pass very close to buildings. The number of buildings and an estimate of peak vibration levels (PPVs) should be included in the assessment.

Assessment of temporary impacts

A1.22 The steps that should be in the assessment of temporary noise and vibration impacts are given below:

i) Estimate the number of sensitive receptors within the study area. The study area should be as a minimum the same as that used for the assessment of permanent impacts, but may need to be wider in order to include other temporary noise sources, such as any haul routes associated with construction traffic.

ii) Identify any construction operations which could have a significant impact – for example, the scale of earth movements within the construction site, the storage and treatment of surplus material before it can be removed from the works site (such as wet peat which needs to be dried out and which may need to cover a large area of ground), the extent of special operations such as piling, bridgeworks or tunnelling, and the likelihood of nighttime working.

iii) Assess the extent and duration of potential impacts, taking account of proposed mitigation agreed with the Overseeing Organisation, such as the early provision of environmental barriers or noise insulation, restrictions on noise levels or any other special conditions to be written into the contract documents. At this stage the availability of detailed construction information is unlikely and this will determine the level of assessment feasible at this stage.

iv) A separate assessment may be required of the impact from construction traffic using the local road network. In addition, an assessment may be required where temporary diversion routes are in place. This requirement will depend on the period that the diversion route will be in place and further advice should be sought from the overseeing organisation to determine this.

v) For on-line projects, e.g. carriageway widening, where temporary diversion routes are not viable, a restriction on road traffic speed is often implemented for reasons of safety allowing construction works to occur adjacent to a traffic stream. Such decreases in traffic speed can lead to temporary reductions in noise levels for nearby receptors. Where this occurs a qualitative consideration should be made of the potential implications of this short term reduction in noise level.

Assessment of cumulative impacts

A1.23 An assessment of cumulative noise and vibration impacts should be undertaken. This should include identifying where impacts are expected from the combined action of noise and/or vibration with other environmental topic-specific impacts upon sensitive receptors. This should also include identifying where impacts are likely to occur due to the combined action of noise and vibration on receptors. Cumulative impacts expected as a result of the combined action of different road projects should also be described.

Detailed Assessment

A1.24 This level of assessment may be a desk-based exercise, supplemented with site-collected information needed to inform a quantitative assessment. At this level there should be close consultation with stakeholders and it should include a noise measurement survey if not already undertaken, or if noise levels could have changed. Disruption due to construction activities and where applicable temporary diversion routes should also be taken into account at this stage.

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Assessment of permanent traffic noise impacts

A1.25 The assessment and reporting of permanent traffic noise impacts at the Detailed stage is the same as at the Simple stage except that the following three comparisons should undertaken for both day and nighttime periods:

i) Do-Minimum scenario in the baseline year against Do-Minimum scenario in the future assessment year.

ii) Do-Minimum scenario in the baseline year against Do-Something scenario in the baseline year.

iii) Do-Minimum scenario in the baseline year against Do-Something scenario in the future assessment year.

A1.26 The assessment process defined in A1.18 to A1.20 should be followed. A separate Table A1.2 should be produced for the Do-Minimum and Do-Something future year assessments to allow for comparison. The noise contour maps and a list of sensitive receptor noise levels required in A1.18 (x) and (xi) should be provided for the comparisons identified in A1.25 (i) to (iii) above.

Assessment of permanent traffic nuisance impacts

A1.27 The steps to take at this stage are:

i) Calculate the change in nuisance for all dwellings at which full CRTN noise calculations have been undertaken for the assessment of permanent traffic noise impacts. The increases or decreases in the number of people bothered by noise should be tabulated in <10 percentage points, 10<20 percentage points, 20<30 percentage points, 30<40 percentage points, or >40 percentage points. The following assessments should be undertaken:

   1) Do-Minimum scenario in baseline year against Do-Minimum scenario in the future assessment year.

   2) Do-Minimum scenario in the baseline year against Do-Something scenario in the future assessment year.

ii) These comparisons are undertaken in order to compare the Do-Minimum scenario in the baseline year with the two possible scenarios that are available in the future assessment year. All calculations should be based on the highest nuisance levels calculated during the first 15 years after opening. Additional guidance on the calculation of nuisance is given in Annex 6. The results from this assessment of nuisance should be presented in Table A1.3.

A1.28 For the Do-Minimum scenario (e.g. comparison 1 in A1.27(i)), only gradual changes in traffic noise are likely. In this case the 'steady state' curve (Figure A6.1) should be used to estimate baseline and future nuisance levels (i.e. percentage bothered). The 15th year nuisance levels are likely to be the worst, in which case the change in nuisance is the difference between the 15th year value and the value of nuisance in the baseline year.

A1.29 Where there are predicted to be increases in traffic noise in the baseline year as a result of the road project, the nuisance in the Do-Minimum scenario should first be estimated from the steady state curve presented in Figure A6.1. The immediate increase in nuisance as a result of the road project should then be estimated from the short term response curve using the change in dB between the Do-Minimum and Do-Something scenarios in the baseline year in Figure A6.2. The level of nuisance in the baseline year is the sum of the % of people bothered in the Do-Minimum scenario from Figure A6.1 and the change in people bothered in the baseline year from Figure A6.2. The level of nuisance in the future assessment year in the Do-Something scenario should then be estimated from the steady state curve in Figure A6.1. This level should then compared with the level of nuisance in the Do-Something baseline year and the higher of the two levels forms the reported level of nuisance. If the highest level of nuisance is in the baseline year then it is the level of change on opening that should be reported.

A1.30 Where there are predicted to be decreases in traffic noise in the baseline year as a result of the road project, the level of nuisance in the Do-Minimum scenario should first be estimated from the steady state curve. The change in nuisance based on the highest nuisance in the first 15 years after opening as a result of the road project is again required. Generally this will be the 15th year value from the 'steady state' curve, hence the value of nuisance in the future assessment year in the Do-Something scenario should be estimated from the steady state curve. The change in nuisance should

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then be estimated by subtraction, using values from the 'steady state' curve (i.e. Do-Something in 15th year minus Do-Minimum in the baseline year). Where there is doubt whether the highest level of nuisance will occur in the 15th year, it can be checked against that expected soon after the road project opens. The immediate decrease as a result of the road project should be estimated from the short term response curve. The new nuisance level is that in the Do-Minimum scenario minus the decrease. However, if this reports a negative value then a value of zero (per cent of people bothered) should be assumed.

A1.31 Using the highest level of nuisance in the first 15 years after a change means that for most situations where traffic levels will decrease in the baseline year the immediate benefit, as shown in the short term response curve, is ignored.

A1.32 The nuisance calculations should be undertaken on the façade with the least beneficial change in noise (i.e. the one used for the noise assessment, A1.18(vi)).

Assessment of permanent traffic induced vibration impacts

A1.33 Where appropriate, an assessment of traffic-induced vibration should be undertaken. The steps to take at this stage are:

i) Calculate the change in vibration nuisance (See Annex 6) for all dwellings within 40m of roads where noise levels predictions have been undertaken as required in A1.26.

ii) The increases or decreases in the number of people bothered by noise should be tabulated in <10 percentage points, 10<20 percentage points, 20<30 percentage points, 30<40 percentage points, or >40 percentage points. The following assessments should be undertaken:

   1) Do-Minimum scenario in baseline year against Do-Minimum scenario in the future assessment year.

   2) Do-Minimum scenario in the baseline year against Do-Something scenario in the future assessment year.

iii) The results from this assessment of vibration nuisance should be presented in Table A1.4.

A1.34 If ground-borne vibration on existing routes is identified as a potential problem, calculations or measurements of vibration at the foundations of typical buildings considered to be at high risk may be taken in order to establish whether increasing vibration levels would be likely to exceed the threshold values (see 3.3). Based on these results at a sample of dwellings, an estimate can be made of the number of buildings likely to be exposed to perceptible vibrations along the affected route. This will only apply in rare cases where, for example, traffic is expected to pass very close to buildings. The number of buildings and an estimate of peak vibration levels (PPVs) should be included in the assessment.

Assessment of temporary impacts

A1.35 For an assessment of possible disruption at the works site, the steps to take are:

i) Confirm the number of sensitive receptors within the study area for the road project, and highlight any that could be particularly sensitive to any disruption. The study area should be as a minimum the same as that used for the assessment of permanent impacts, but may need to be wider in order to include other temporary noise sources, such as any haul routes associated with construction traffic.

ii) Identify any construction operations which could have a significant impact – for example, the scale of earth movements within the construction site, the storage and treatment of surplus material before it can be removed from the works site (such as wet peat which needs to be dried out and which may need to cover a large area of ground), the extent of special operations such as piling, bridgeworks or tunnelling, and the likelihood of nighttime working.

iii) Assess the extent and duration of potential impacts, taking account of proposed mitigation agreed with the Overseeing Organisation, such as the early provision of environmental barriers or noise insulation, restrictions on noise levels or any other special conditions to be written into the contract documents.

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iv) A separate assessment may be required of the impact from construction traffic using the local road network. In addition, an assessment may be required where temporary diversion routes are in place. This requirement will depend on the period that the diversion route will be in place and further advice should be sought from the overseeing organisation to determine this.

vi) For on-line projects, e.g. carriageway widening, where temporary diversion routes are not viable, a restriction on road traffic speed is often implemented for reasons of safety allowing construction works to occur adjacent to a traffic stream. Such decreases in traffic speed can lead to temporary reductions in noise levels for nearby receptors. Where this occurs a qualitative consideration should be made of the potential implications of this short term reduction in noise level.

Assessment of cumulative impacts

A1.36 An assessment of cumulative noise and vibration impacts should be undertaken. This should include identifying where impacts are expected from the combined action of noise and/or vibration with other environmental topic-specific impacts upon sensitive receptors. This should also include identifying where impacts are likely to occur due to the combined action of noise and vibration on receptors. Cumulative impacts expected as a result of the combined action of different road projects should also be described.

Project/Option:			
Scenario/Comparison:			
		Daytime	
Change in noise level		**Number of dwellings**	**Number of other sensitive receptors**
Increase in noise level, $L_{A10,18h}$	**0.1 - 0.9**		
	1.0 - 2.9		
	3 - 4.9		
	5 +		
No Change	**0**		
Decrease in noise level, $L_{A10,18h}$	**0.1 - 0.9**		
	1 - 2.9		
	3 - 4.9		
	5 +		

Table A1.1 – Short-term Traffic Noise Reporting Table for Simple and Detailed Assessments

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Project/Option:				
Scenario/Comparison:				
		Daytime		Night-time
Change in noise level		Number of dwellings	Number of other sensitive receptors	Number of dwellings
Increase in noise level, $L_{A10,18h}$	0.1 - 2.9			
	3 - 4.9			
	5 - 9.9			
	10 +			
No Change	0			
Decrease in noise level, $L_{A10,18h}$	0.1 - 2.9			
	3 - 4.9			
	5 - 9.9			
	10 +			

Table A1.2 – Long-term Traffic Noise Reporting Table for Simple and Detailed Assessments

Project/Option:			
Scenario/Comparison:			
		Do-Minimum	Do-Something
Change in nuisance level		Number of dwellings	Number of dwellings
Increase in nuisance level	< 10%		
	10 < 20%		
	20 < 30%		
	30 < 40%		
	> 40%		
No Change	0%		
Decrease in nuisance level	< 10%		
	10 < 20%		
	20 < 30%		
	30 < 40%		
	> 40%		

Table A1.3 – Traffic Noise Nuisance Reporting Table for Detailed Assessments

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Project/Option:			
Scenario/Comparison:			
		Do-Minimum	Do-Something
Change in nuisance level		Number of dwellings	Number of dwellings
Increase in nuisance level	< 10%		
	10 < 20%		
	20 < 30%		
	30 < 40%		
	> 40%		
No Change	0%		
Decrease in nuisance level	< 10%		
	10 < 20%		
	20 < 30%		
	30 < 40%		
	> 40%		

Table A1.4 – Traffic Airborne Vibration Nuisance Reporting Table for Detailed Assessments

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ANNEX 2 GLOSSARY OF ACOUSTIC AND OTHER TERMS

A-weighting

In addition to its non-linear amplitude response, the human ear has a non-linear frequency response; it is less sensitive at low and high frequencies and most sensitive in the range 1 kHz to 4 kHz (cycles per second). The A-weighting is applied to measured sound pressure levels so that these levels correspond more closely to the subjective response. A-weighted noise levels are often expressed in dB(A).

AAWT

Annual Average Weekday Traffic.

Ambient Noise

Ambient noise is the total sound in a given situation at a given time usually composed of sound from many sources, near and far.

Baseline year

For an assessment of noise and vibration, the baseline year is taken as the opening year of the road project.

Basic Noise Level (BNL)

The BNL is a measure of source noise at a reference distance of 10m from the nearside carriageway edge. It is determined from obtaining the estimated noise level from the 18 hour flow and then applying corrections for vehicle speed, percentage of heavy vehicles, gradient and road surface.

Calculation of Road Traffic Noise (CRTN)

The technical memorandum issued by the Department of Transport and Welsh Office that describes the procedures for calculating noise from road traffic.

Decibel

This is the unit of measurement used for sound pressure levels and noise levels are usually quoted in decibels (dB). The decibel scale is logarithmic rather than linear. The threshold of hearing is zero decibels while, at the other extreme, the threshold of pain is about 130 decibels. In practice these limits are seldom experienced and typical levels lie within the range of 30 dB(A) (a quiet nighttime level in a bedroom) to 90 dB(A) (at the kerbside of a busy street).

Dwelling

A building used for living purposes. A mobile home used for permanent living should be included in an assessment. If calculations are being conducted for compensation purposes then some mobile homes are dealt with under the Highways Noise Payments and Moveable Homes Regulations.

Facade Sound Level

A facade sound level is that determined 1 metre in front of the most exposed window or door in a facade. Sound is reflected from hard surfaces in a similar manner to light by a mirror and the effect is to produce a slightly higher (about 2.5 dB) sound level than would occur if the building was not there. For façade levels at dwellings required for this assessment process, the level 1 metre from the most exposed façade should be calculated with a reflection correction.

Free-Field Sound Level

The sound level which is measured or calculated, in the open, without any reflections from nearby surfaces. For free-field levels at dwellings required for this assessment process, the level one metre from the most exposed façade should be calculated without a reflection correction.

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Future assessment year — The future assessment year is the year between baseline and the 15th year where the maximum impact from the road project would occur.

L_{A10} index — L_{A10} is the A-weighted sound level in dB that is exceeded 10% of the measurement period. This is the standard index used within the UK to describe traffic noise. From research it has been found that subjective response to road traffic noise is closely linked to higher noise levels experienced and is correlated well with the L_{A10} index.

L_{A90} index — The background noise level is commonly quoted using the L_{A90} index. This is the A-weighted sound level in dB that is exceeded 90% of the measurement period.

$L_{A10,18h}$ index — The $L_{A10,18h}$ noise level is arithmetic mean of all the levels of L_{A10} during the period from 06:00 to 24:00.

L_{Aeq} index — The equivalent continuous sound level L_{Aeq} is the level of a notional steady sound, which at a given position and over a defined period of time, would have the same A-weighted acoustic energy as the fluctuating noise.

L_{Amax} index — The maximum A-weighted level measured during a given time period.

Nuisance — In this document nuisance is intended to generally refer to 'bother' or 'annoyance' and is not necessarily the same as that used in some statutory documents.

Sensitive receptor — Receptors which are potentially sensitive to noise and vibration. Examples include dwellings, hospitals, schools, community facilities, designated areas (e.g. AONB, National Park, SAC, SPA, SSSI, SAM), and public rights of way.

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ANNEX 3 NOISE AND INDICES

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Sound

A3.1 Sound is a disturbance propagated through the air as a pressure wave. The fluctuations in atmospheric pressure are detected by the ear and produce the sensation of hearing. The frequency of the pressure wave is converted to pitch and its amplitude to loudness. The human ear can respond to a very wide range of amplitudes and frequencies of sound, although its sensitivity to high frequencies deteriorates with age. Noise is generally considered to be unwanted sound.

A3.2 The response of the hearing system to the amplitude of sound pressure is non-linear and can be characterised by a logarithmic relationship. The relationship is also frequency dependent and an adjustment or weighting is applied to the response of a microphone to different frequency components of a sound in order to produce a scale that better reflects the hearing system. In addition, in order to characterise sounds that fluctuate in intensity, it is necessary to derive a statistic that applies over a period of time.

A3.3 A variety of statistics are used in different circumstances and an explanation of the different noise scales is presented later. The standard index used to characterise traffic noise in the UK is the noise level exceeded for 10% of the time between 06:00 and 24:00 on an annual average weekday.

A3.4 The human system of hearing is very complex and is capable of analysing specific sound patterns such as speech in the presence of noise. However, background noise can mask the structure of meaningful sounds if it contains a similar range of frequencies as the sound of interest. As background noise levels rise, the effort of concentrating on meaningful sounds becomes greater. Depending on the circumstances, this may lead to a sense of frustration or annoyance, especially if the noise is generated by a source that is outside the individual's control.

A3.5 Very low frequencies of sound may resonate within the chest cavity or with floors, doors and windows and are often perceived as air borne vibration. When experienced within the home, these low frequency effects are sometimes confused with those arising from ground borne vibrations being transmitted through structural foundations.

Units of Measurement

A3.6 Sound pressures are measured in units of Pascals (Pa). The range of sound pressures, from the minimum detectable to the onset of pain, is vast. To cope with such a range in values it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as sound pressure levels (SPL) in decibels (dB) and are defined as:

SPL – 20 log (p/po) dB where p is the sound pressure and po the sound pressure at the threshold of hearing.

A3.7 The audible range of sounds expressed in terms of sound pressure levels (dB) can now be conveniently covered within the range 0 dB (the threshold of hearing) to 130 dB (the threshold of pain). Figure A3.1 below gives a broad indication of typical $L_{A10,18h}$ traffic noise levels likely to be encountered at various distances from the road for two different traffic conditions. The first is representative of a heavily trafficked road (about 150,000 vehicles per day) and the second a lighter trafficked road (about 50,000 vehicles per day).

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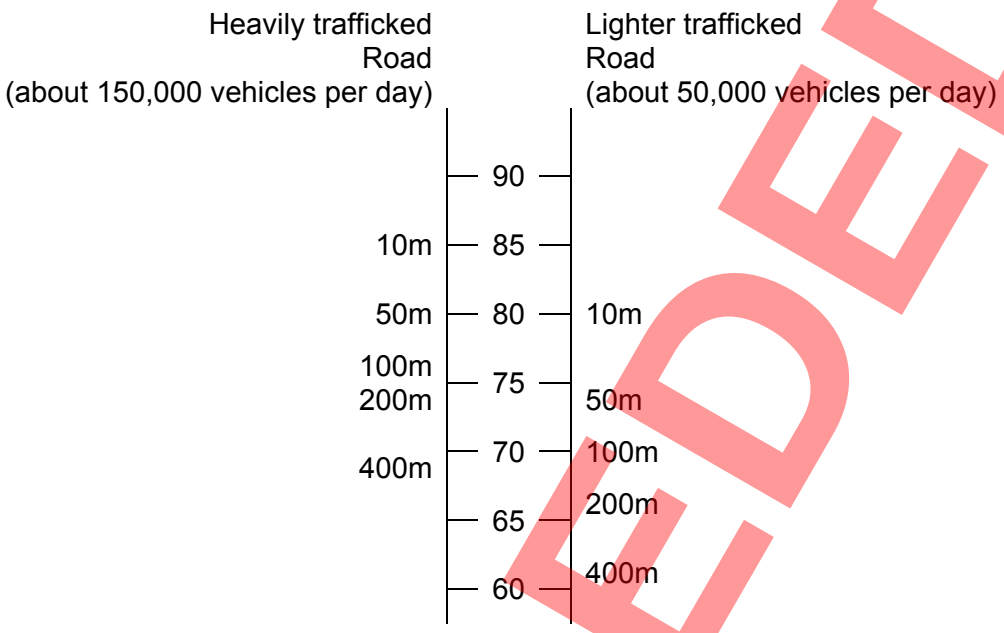


Figure A3.1 – Example of Typical Traffic Noise Levels, $L_{A10,18h}$

A3.8 A further advantage in adopting a logarithmic scale is that the response of the human hearing system to changes in noise level is logarithmic rather than linear in behaviour. Over most of the audible range, a subjective impression of a doubling in loudness corresponds to a 10 fold increase in sound energy which conveniently equates with an increase in sound pressure level of 10 dB. Doubling the energy level (for example the volume of traffic) increases the noise level by 3 dB.

A3.9 The frequency of sound is the rate at which a sound wave oscillates, measured in number of cycles per second, or Hertz (Hz). The human ear is more sensitive to frequencies important for voice communication and hearing sensitivity decreases markedly at frequencies below about 250 Hz. Frequencies below 20 Hz are usually perceived as vibration. The upper frequency limit of audibility is around 20 kHz, but decreases with age.

A3.10 Several different weightings have been proposed to convert measured sound pressure to a measure that correlates with perceived loudness in different circumstances. The 'A' weighting is by far the most commonly used and correlates well with the perceived noisiness of road vehicles. Logically the characteristics of the weighting should be slightly different for higher level sounds.

A3.11 The noise from a traffic stream is not constant but varies from moment to moment and it is necessary to use an index to arrive at a single-figure estimate of the overall noise level for assessment purposes. The index adopted by the Government to assess traffic noise is $L_{A10,18h}$ which is the arithmetic mean of the noise levels exceeded for 10% of the time in each of the 18 one hour periods between 6am and midnight. (Note: 'A' in the subscript denotes that the sound levels have been 'A' weighted). A reasonably good correlation has been demonstrated between this index and residents' expressed dissatisfaction with traffic noise over a wide range of exposures. In addition, the prediction and measurement techniques using this index are well developed in the UK.

A3.12 A commonly used alternative index is the equivalent continuous sound level, L_{Aeq}, which is the level of a notional continuous constant noise that would deliver the same sound energy over the period of measurement as the actual intermittent or time varying noise. Using this measure, a fluctuating noise can be described in terms of a single noise level. This index is easily adapted to describing sources that consist of occasional short periods of noise interspersed with relatively long quiet periods – for example intermittent noise from industry, construction or demolition activity, and from railways and aircraft. However, it does not

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appear to provide a better correlation with people's dissatisfaction with road traffic noise than the L_{A10} index.

A3.13 An index sometimes used to describe background noise levels in the absence of a dominant source is L_{90}, which is the level exceeded for 90% of the time. This index may give a more realistic indication of noise changes in rural areas at a considerable distance from a new road because in such circumstances the main noise effect is likely to be on background noise levels. However, its usefulness as an indicator of noise impact is uncertain and there has been no research to assess how it correlates with people's reactions to noise, nor on how it can be modelled.

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ANNEX 4 ADDITIONAL ADVICE TO CRTN PROCEDURES

A4.1 Since the revision of the technical memorandum Calculation of Road Traffic Noise (CRTN) in 1988 (Ref 10), there have been significant advances in road design, the development of new surface materials and improvements in noise mitigation. In addition, over the intervening years certain procedures have required further clarification. It is, therefore, timely to address some of these issues and provide additional advice for assessment to that already published in CRTN.

A4.2 It is acknowledged that there are other areas where the methodology contained within CRTN may not fully take into account the influences of certain features or conditions. However, these areas have not been addressed in the following text as there is currently insufficient knowledge or research to support any changes.

A4.3 Where calculations are being undertaken for entitlement purposes under the relevant Noise Insulation Regulations, the use of this advice should be discussed with the Overseeing Organisation.

Dual Source Lines

A4.4 In 1989 the Secretary of State for Transport announced additional measures to relieve congestion on major roads in England which included increasing the capacity of existing routes by introducing road widening projects, typically 4-lane dual carriageways.

A4.5 A fundamental assumption in the CRTN method is that the noise from a stream of traffic distributed over the entire width of the highway can be simulated by a single source line positioned 3.5m in from the nearside carriageway and 0.5m above the road surface. A consequence of these new road widening projects was to increase the spread of traffic across each carriageway further than had previously been examined when the method was first developed.

A4.6 Research carried out by TRL in 1994 recommended that the procedures which already exist in CRTN for predicting the noise from separate carriageways (paragraph 13.1) should also apply to dual carriageway roads with four or more lanes per carriageway, irrespective of the horizontal separation or vertical alignment of the carriageways (Ref 1).

A4.7 However, in adopting a dual source line approach for dual carriageways with 4 or more lanes does introduce an inconsistency when up-grading an existing 3-lane dual carriageway to four lanes. The pre-project noise levels would be based on a single source line model compared with post-project predictions assuming a dual source line approach.

A4.8 A further problem can arise where a barrier alongside a dual carriageway only provides partial screening. Prediction of noise levels at a receiver which is sufficiently elevated that traffic on the farside carriageway is not screened by the barrier may be significantly underestimated where a single source line model is adopted compared with a dual source line approach (Ref 28).

A4.9 Furthermore, under certain circumstances, particularly where a receiver is close to a dual carriageway (i.e less than about 50m) and the traffic is not screened, noise levels predicted using the dual source line approach will give lower values than corresponding levels calculated using a single source line approach. However, when predicted noise levels are compared with measurements there is evidence to suggest that the dual source line model performs marginally better than the single source approach under such site conditions (Ref 25).

A4.10 To resolve these problems and provide a method which is internally consistent, it is recommended that the dual source line approach is adopted for all dual carriageways irrespective of the number of lanes per carriageway or the separation of horizontal or vertical alignments.

Median Barriers

A4.11 Median barriers, designed to prevent vehicles from crossing the central reserve, may provide additional benefits in screening noise. Where a concrete barrier is constructed along the central reserve, the screening performance of the barrier relating to the

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farside source line should be taken into account according to the procedures described in paragraph 22 of CRTN.

A4.12 In situations where there is additional screening, for example from a purpose-built noise barrier erected alongside the nearside carriageway, then the combined screening of both barriers should be calculated according to the procedures described in paragraph 35 of CRTN when calculating the noise contribution from traffic on the farside carriageway. Generally, the height of the median concrete barrier above the road surface is less than 1.5m and therefore, reflection and screening effects from the nearside source line are negligible. However, where the height of the median concrete barrier is equal to or greater than 1.5m, a reflection correction is required when calculating the noise contribution from the nearside traffic and calculated according to the procedure described in paragraph 26.2 of CRTN or paragraph 36 where there is additional screening provided by a barrier alongside the road.

Vehicle Classification

A4.13 The vehicle classification system described in CRTN identifies two vehicle groups 'light vehicles' and 'heavy vehicles' which are defined according to the unladen weight of the vehicle i.e. vehicles with unladen weight greater than 1.525 tonnes are classified as 'heavy vehicles'. The classification assumes that vehicles within each group are acoustically similar. However, since this classification system was first introduced in 1975, the proportion of vehicles within the range 1.525 tonnes to 3.5 tonnes has grown significantly and the maximum permissible weight of heavy vehicles has increased from 38 to 44 tonnes. Therefore, the range in vehicle noise emissions within the heavy vehicle category has increased. To address this problem it is recommended that the heavy vehicle category is redefined as vehicles with unladen weight greater than 3.5 tonnes. Those vehicles with an unladen weight between 1.525 and 3.5 tonnes should be treated as light vehicles.

Traffic Forecasts and Speeds

A4.14 The traffic flow used in the calculations should be that expected between 06.00 hours and midnight on an average weekday in the appropriate year. The most likely growth forecast should be assumed in the calculations for determining predicted noise levels in future years. However, where particular local conditions indicate growth forecasts significantly different from these or where unusual traffic patterns exist then the local data are to be applied.

A4.15 For the prediction of nighttime noise levels in accordance with the TRL report 'Converting the UK traffic noise index $L_{A10,18h}$ to EU noise indices for noise mapping' (Ref 3) nighttime traffic data should be used where available. Preferable hourly nighttime traffic flows should be used in predicting noise levels (L_{night}) in line with Method 1 of this TRL report.

A4.16 Traffic noise is sensitive to changes in speed and CRTN includes a table of traffic speed values typical for different road types. These should be used as default values when no other data is available. However, the Overseeing Organisation should be consulted in order to establish whether any alternative speed data is available, such as from TUBA. When TUBA speeds are used, the TUBA inter-peak flow group should be used as a proxy for the day and nighttime periods, providing the speeds are appropriate for the link (Ref 14). Alternatively, in some situations, it may be possible to use observed speeds if the measurements are robust. However, it is recognised that the correction for speed within the CRTN method is only valid within the range 20 to 130 km/hr. A default speed of 20 km/hr and 130 km/hr should be used where the mean speed is shown to fall below or above this CRTN speed range respectively.

A4.17 It should be ensured if TUBA speeds are used, that these allow for carriageway gradients. Where they do not the corrections in CRTN paragraph 14.3 should be applied as necessary.

Surface Correction for Thin Surfacing Systems

A4.18 CRTN provides advice on appropriate road surface corrections to be applied within noise assessments and this advice should continue to be used. However, this advice does not currently extend to the range of proprietary thin bituminous surfacing materials, commonly regarded as a low-noise surfacing, which emerged in the late 1990's. Paragraphs A4.19 to A4.33 set out an example methodology which can be used to determine appropriate road surface corrections for low-noise surfaces.

A4.19 Low-noise surfaces are normally characterised by their 'Road Surface Influence' (RSI) value, which provides a measure by which they can be specified in

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highway works under the Highways Authorities Product Approval Scheme, HAPAS (Ref 7). However, the RSI value alone does not give an indication of the long term performance of the surface. In addition, no long term measurement data is currently available for thin surfacing systems from which any robust correction factors for use in noise assessments can be readily obtained.

A4.20 In the absence of more accurate long term data, it is generally considered that thin surfacing systems will not be able to provide better long term noise reduction performance than other low-noise surfaces such as porous asphalt.

A4.21 On the basis of results from RSI_H (High speed) measurements on a porous asphalt surface and the accepted correction of –3.5 dB(A) implicit in the CRTN method, the following interim relationship has been developed to estimate the benefit of thin surfacing systems for use in noise assessments:

Surface correction for thin surfacing systems = 0.7 * (RSI) dB (A4.1)

where RSI ≥ -5 dB(A) and derived from the HAPAS approval scheme for high or medium speed roads, RSI_H or RSI_M, respectively or by an appropriate similar method agreed with the Overseeing Organisation. For an RSI < -5 dB(A) an RSI of -5 dB(A) should be entered into equation A4.1.

A4.22 Therefore, as a result of applying the equation A4.1, **for any situation a maximum allowable surface correction of -3.5 dB(A) can be claimed from using thin surfacing systems**, compared with hot rolled asphalt surfaces.

Existing Low-Noise Surfaces

A4.23 Where the benefit of an existing thin surfacing system needs to be determined, information regarding RSI_H or RSI_M for the existing surface should be sought from the Overseeing Organisation in order to obtain an appropriate surfacing correction using equation A4.1.

A4.24 Where an RSI value has been determined through measurements then this value should be entered into equation A4.1 to derive a surface correction, taking into account the limitations given in A4.19. This RSI value could have been derived from measurements on the surface in question or on a surface of the same specification from the same manufacturer elsewhere.

A4.25 If there is no information available, a -2.5 dB(A) surface correction should be used for an existing low-noise surface in the baseline year.

A4.26 For the future assessment year, a correction of -3.5 dB(A) should be applied for a low-noise surface which is expected to be in place on an existing road. For existing motorways and major trunk roads clarification from the overseeing organisation should be obtained on any potential future resurfacing proposals.

A4.27 The above advice applies to roads where the mean traffic speed is ≥ 75 km/hr. Where the mean traffic speed is <75 km/hr, a -1 dB(A) surface correction should be applied to a low-noise surface. This is applicable to the baseline and future assessment years. Although it is likely that thin surfacing systems will provide more acoustic benefit at lower speeds, until further research is carried out to provide reliable estimates, it is advised that a qualitative statement highlighting the possible additional acoustic benefits is also included in the assessment.

A4.28 Alternatively, recourse to the measurement method described in CRTN-Section III can be used to estimate the basic noise level which would include the influence of the road surface on traffic noise levels and the façade noise levels determined according to the procedures described in paragraph 37. However, applying this method may not provide a reliable estimate of RSI when comparing measured and predicted noise levels due to other contributing factors. For example, the RSI value will be dependent on the proportion of heavy vehicles in the traffic stream and it is, therefore, advisable that measurements are carried out when traffic conditions are typical for the 18-hour period (06:00 to midnight). However, where the RSI value is required as input to equation A4.1 to determine the surface correction to be used in CRTN, recourse to the measurement method as described in the HAPAS approval scheme should be applied.

New Low-Noise Surfaces

A4.29 Where new carriageways are to be constructed and a thin surfacing system used, or where an existing surface is to be replaced with a thin surfacing system, a -3.5 dB(A) correction should be assumed for the thin surface system (i.e. equivalent to a -5 dB(A) value being entered into equation A4.1), unless any information is available regarding the specific surface to be installed. This advice applies to roads where the mean traffic

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speed is ≥ 75 km/hr. Where the mean traffic speed is <75 km/hr, a -1 dB(A) surface correction should be applied to a new low-noise surface.

Assumptions and Limitations

A4.30 Generally the RSI_H or RSI_M is determined by averaging the results from at least two sites. If the information for each site is known, then, for the purposes of determining the surface correction for thin surfacing systems the least negative value should be used for RSI and the surface correction determined from equation A4.1.

A4.31 For both existing and new road projects, these corrections only apply to situations where the surfacing across the carriageway is predominantly thin surface. For example, in calculating the noise level from a three lane carriageway where two of the lanes have a thin surface applied, the appropriate correction for a thin surface would be applied. If only one lane had a thin surface applied then no correction would be used.

A4.32 For roads not subject to a speed limit of less than 60 mph and the mean traffic speed is ≥ 75 km/hr, the RSI_H value should be used to determine the RSI value and the surface correction determined using equation A4.1.

A4.33 Similarly, for roads subject to a speed limit of 50 mph and the mean traffic speed is ≥ 75 km/hr, the RSI_M value should be used to determine the RSI value and the surface correction determined using equation A4.1.

Extrapolating Beyond 300 Metre Limit

A4.34 Research carried out by TRL has shown that noise levels from field measurements out to 600m from a motorway, where the intervening ground cover was grass, were in good agreement with predicted noise levels using CRTN with the attenuation with distance functions, Chart 7 and 8, extrapolated to 600m (Ref 2). It is, therefore, recommended that this is adopted for predicting noise levels out to 600m from the road. For distances greater than 600m from the road, predicted noise levels become less reliable and the benefits from ground absorption diminish with distance. An approximate indication of noise level can be calculated by applying the attenuation with distance function Chart 7 (extrapolated to distances in excess of 600m) with the correction for ground absorption function Chart 8 (extrapolated to 600m). For this it is assumed that the attenuation rate for distances in excess of 600m is approximately 3dB/doubling of distance.

Sound Absorptive Noise Barriers and Retained Walls

A4.35 Although CRTN recognises that sound absorptive noise barriers will reduce reflection effects when positioned along the opposite side of the road or where a road is flanked on both sides with sound absorptive noise barriers (paragraph 36iii), no allowance is given in the method to take this into account. Similarly, where a retaining wall has been designed with sound absorbing properties, no allowance is given in the method to take into account a reduction in reflection effects. However, to inform the decision process when assessing mitigation, an estimate of the additional potential benefits in noise mitigation provided by the use of sound absorptive materials in the design of noise barriers or retaining walls should be included in the assessment.

A4.36 The potential benefits should be calculated from the reflection correction as described in paragraph 26.2 or 36 of CRTN depending on the type of road project. However, research carried out by TRL (Ref 33) has shown that the predicted benefits from changing a reflective barrier to one which is sound absorptive was over estimated by CRTN when compared with measurements. It is, therefore, recommended that where potential benefits of designing barriers or retaining walls with sound absorbing materials are included in the assessment it is stressed that these benefits are likely to be overestimated and should only be used as a guide to their performance.

Reflection from Opposite Facades

A4.37 Reflection from opposite facades, paragraph 26.2 of CRTN, provides a correction for reflections where there are houses, other substantial buildings or a noise fence or wall beyond the traffic stream along the opposite side of the road. However, there is no advice given concerning the position of the reflecting façade relative to the position of the traffic stream to determine when to apply the correction. Research based on a theoretical model has shown the reflection correction is dependent on the ratio of the distance between the receiver and the source line and the distance between the source line and the opposite façade (Ref 15). From this work the following advice is recommended when

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determining whether the reflection from opposite facades (including barriers) should be applied.

Apply correction for reflection effects from opposite facades:

1. when $d < 12$ m and $D \leq 20$ m

or

2. when $12 \text{ m} < d \leq 300$ m and $D \leq 10^{(0.825 + 0.4 \log_{10}(d + 3.5))}$ m

where

d is the horizontal distance between the receiver and the nearside kerb and D is the horizontal distance between the source line and the opposite façade.

Congestion Management Schemes

A4.38 The assessment of road projects that are designed to manage and reduce congestion are not specifically covered in the CRTN procedures. Advice is given below on methods to adopt when calculating traffic noise from various regimes. Advice from the Overseeing Organisation should be sought where congestion management regimes are not covered by the advice given below.

A4.39 **Variable speeds.** The modelling of roads with a variable speed limit should be undertaken as normal with any predicted changes in average traffic speed together with changes in flow and composition being taken into account by the input parameters to the noise calculations.

A4.40 **High occupancy lanes and Hard shoulder running.** If the road project does not provide additional lanes then the assessment of such a regime should be treated as normal, with the effect of the additional lane being taken into account by any predicted changes in traffic parameters. Where additional lanes are included, the position of the source line may need to be adjusted where this effects the position of the edge of the carriageway. A noise model that predicted on a lane by lane basis is not recommended.

A4.41 The majority of hard shoulder running schemes and potentially high occupancy lane schemes will be implemented for a discrete period during the day, for example at AM and PM peaks. During these periods the road traffic noise source is repositioned. If viable, it is recommended that daily ($L_{A10,18hr}$) and nighttime ($L_{night,outside}$) noise levels for such projects be derived through the prediction of hourly noise levels throughout the day. This will enable the prediction of noise at a sensitive receptor which takes into account periods when the scheme is in operation and when it is not. The prediction methodology for such schemes should be agreed with the overseeing organisation.

A4.42 Ramp metering. Using CRTN to calculate traffic noise levels in the immediate vicinity of a ramp metering project is not recommended. The impact may be better described by a Qualitative entry. If it is considered by the Overseeing Organisation's supply chain that a Quantitative assessment is required then the scope of this should be agreed with the Overseeing Organisation. Where ramp metering is part of a larger road project then this advice should still be used.

Noise Measurements

A4.43 Noise measurements should not be undertaken within the 24 hour period after rainfall where a thin surface system is present on any section of road contributing to the noise climate. This applies to roads either partially or fully surfaced with a thin surface system, on either carriageway.

Shortened Measurement Procedure

A4.44 Although the following paragraphs do not provide any new advice, they contain analysis showing that the shortened measurement procedure is still a valid method for evaluating the $L_{A10,18h}$.

A4.45 The preferred method for calculating noise levels from road traffic is by prediction rather than by measurement (CRTN, paragraph 3). There are several reasons why the prediction method is preferred. In particular noise levels, although generally dominated by traffic noise, can be affected by non-traffic sources. Unless the extraneous noise from other sources is edited the results may lead to an over-estimation of traffic noise levels. However there are occasions when it is necessary to resort to measurements (CRTN, paragraph 38).

A4.46 The shortened measurement procedure deals with estimating the noise index $L_{A10,18h}$ by averaging three consecutively measured $L_{A10,1h}$ values carried out between 10:00 and 17:00 hours and subtracting 1 dB from the result. Since the method was first introduced in 1975 the pattern of traffic flow over the 18-hour period (06:00 to midnight) may have significantly altered

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due to changes in social behaviour (e.g. as society moves towards a 24-hour economy) and therefore, it is important to establish whether the relationship used to estimate the noise index $L_{A10,18h}$ is still valid.

A4.47 To provide an indication of the accuracy of the method, values of the noise index $L_{A10,18h}$ measured outside residential dwellings at 1160 sites from the National Noise Survey carried out by the Building Research Establishment in 2000 were analysed (Ref 36). The survey was designed to represent the noise exposure outside residential dwellings in the UK. Although the measured noise exposure includes noise from all sources, the predominant noise source was from road traffic. The results of this analysis are described below.

A4.48 Figure A4.1 shows the relationship between the measured noise index, $L_{A10,18h}$ and the corresponding estimated values using the equation given in CRTN paragraph 43, as described above.

A4.49 The Figure shows that for all the five possible estimates of the noise index, $L_{A10,18h}$, there is a good correlation between the measured and estimated noise indices. The regression equation shows the best-fit line drawn through the data points which passes through the origin of the graph, indicating that 93% of the variance in the measured value can be accounted for by the regression equation (R2 = 0.93). The slope of the regression equation (0.991) indicates that the relationship between the measured and estimated traffic noise indices that was developed over thirty years ago is still valid for today's traffic conditions.

A4.50 However, it is noted that for measured values below 60 dB $L_{A10,18h}$ there is a noticeable increase in the scatter of the data compared with measured values above 60 dB $L_{A10,18h}$. A possible cause is that at quieter sites the dominant noise source may not be from road traffic alone or that traffic flows at quieter sites are likely to be low and the traffic pattern throughout the 18-hour period may be more variable than compared with the noisier sites where traffic flows are likely to be higher.

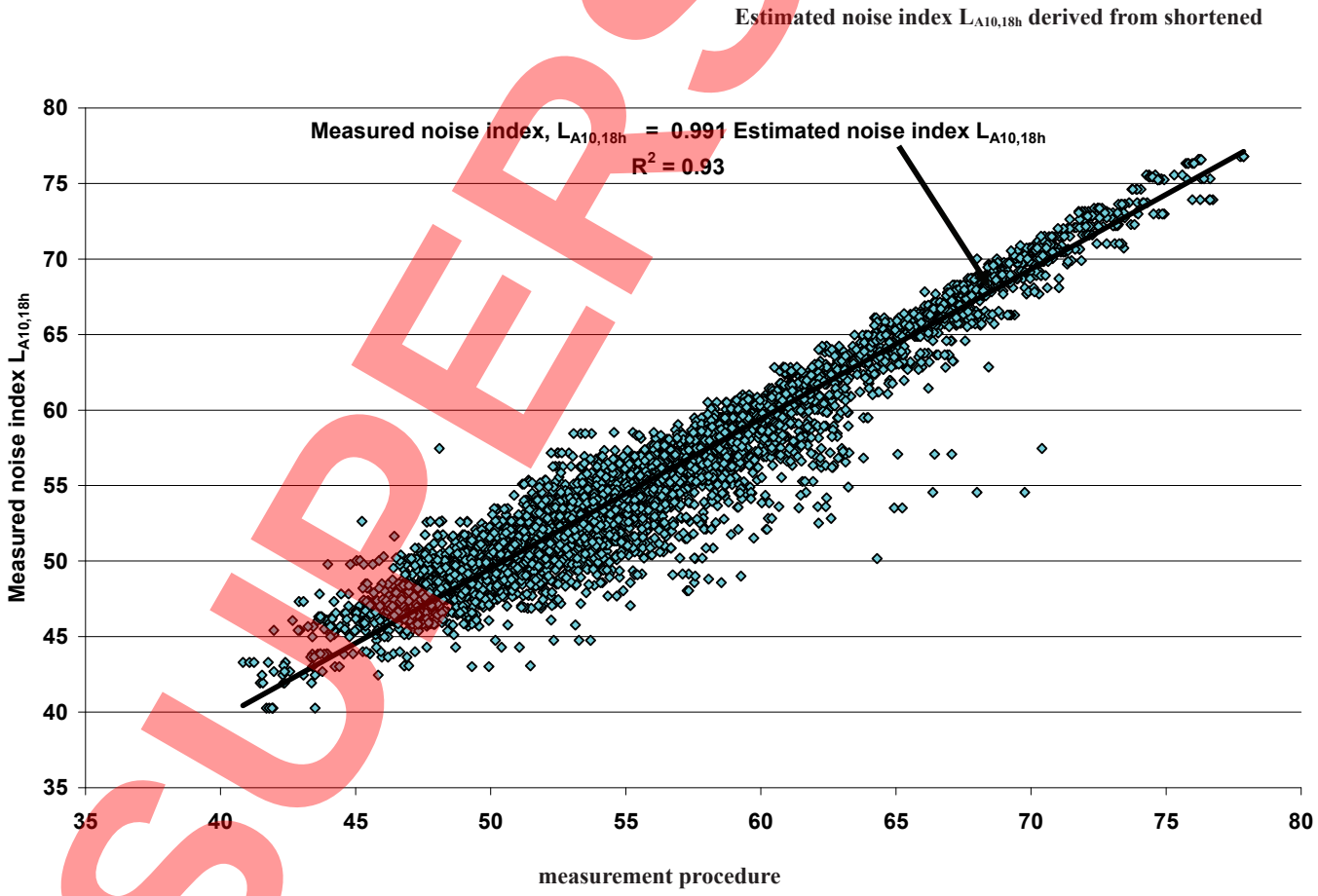


Figure A4.1 – Relationship Between Measured and Estimated Noise Index $L_{A10,18h}$: BRE National Noise Survey 2000

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A4.51 Figure A4.2 shows the same relationship as that shown in Figure A4.1 except that only those sites where the measured noise index was equal to or greater than 60 dB $L_{A10,18h}$ have been selected. As expected, the overall statistical relationship has improved with a significant reduction in the scatter of the data points around the regression equation.

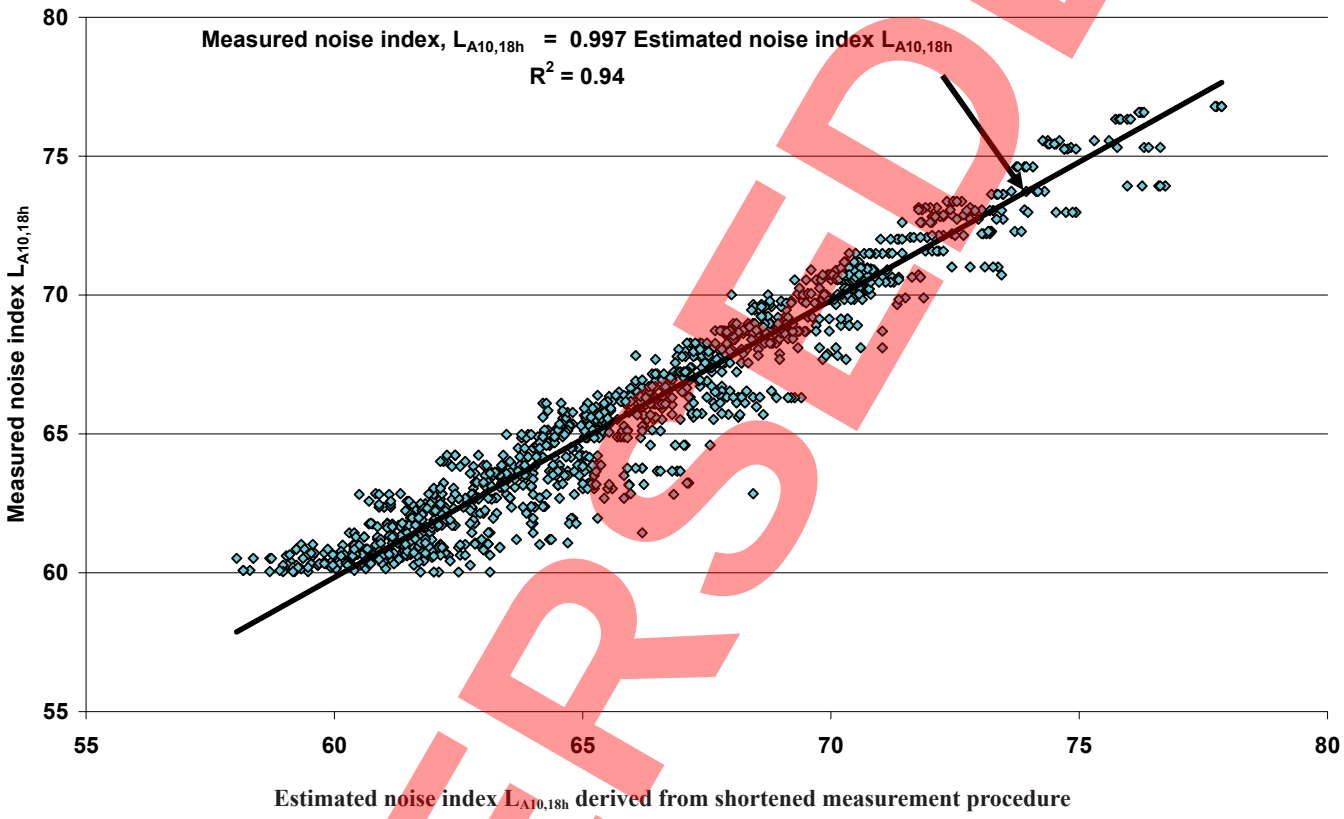


Figure A4.2 – Relationship Between Measured and Estimated Noise Index $L_{A10,18h}$: BRE National Noise Survey 2000 – Measured Noise Levels > 60 $L_{A10,18h}$

A4.52 To illustrate this further, Table A4.1 shows the mean error (measured minus estimated $L_{A10,18h}$ values) and the standard deviation between the measured and estimated noise indices.

Sample	Number of data points	Mean error (measured-estimated) dB(A)	Standard error dB(A)
All	5,800	-0.5	1.9
$L_{A10,18h} \geq 60$	1,290 (30)	-0.2 (-0.4)	1.0 (0.8)
$L_{A10,18h} < 60$	4,510	-0.6	2.0

[1] Values in brackets show corresponding results from similar surveys carried out in the early 1970's.

Table A4.1 – Differences in Measured and Estimated Noise Index, $L_{A10,18h}$: Derived from BRE National Noise Survey 2000[1]

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A4.53 For the whole data set, the mean error is -0.5 dB(A) indicating that on average the method slightly overestimates measured noise levels by 0.5 dB(A). The standard error provides an estimate of the range in the population mean e.g. a standard error of 1.9 dB(A) indicates that the probability of the measured value is within 2 standard errors (± 3.8 dB(A)) of the estimated value is 0.95.

A4.54 Restricting the sample to include only data where the measured index is equal to or greater than 60 dB $L_{A10,18h}$ not only improves the mean error to -0.2 dB(A) but significantly reduces the standard error to 1 dB(A). Comparing this result with the corresponding values derived from a similar but smaller survey carried out in the early 1970's shows no significant difference and provides further evidence that the relationship has not significantly altered over the past 30 years. For completeness the corresponding statistics for sites where the measured index is less than 60 $L_{A10,18h}$ is also shown, indicating a mean error of -0.6 dB(A) and a standard error of 2 dB(A).

Sampling Period

A4.55 There is allowance in the measurement procedure as described in CRTN for hourly noise levels to be estimated by sampling over shorter periods. The minimum length of sample required to obtain a valid estimate of the hourly noise level is dependent on a number of factors as given in paragraph 41.2 of CRTN. An additional consideration in determining the period of sampling is when the traffic flow is not freely flowing, particularly when measuring near to junctions or roundabouts. It is advised that under such traffic conditions, sampling over the whole hour should be adopted when determining hourly noise levels.

Wind Conditions

A4.56 In paragraph 4, CRTN contains the statement '…noise propagation conditions are consistent with moderately adverse wind velocities…'. This statement is often misinterpreted and an explanation of the background is given below. During the development of the algorithms used for CRTN, measurements were undertaken to develop the relationship between traffic flow and noise level. In order to provide a robust relationship these measurements were undertaken during adverse wind conditions (i.e. a wind from the source to the receiver).

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ANNEX 5 RESEARCH INTO TRAFFIC NOISE AND VIBRATION

A5.1 Many surveys have investigated the relationship between traffic noise and its impact on people. 'Nuisance' and 'Annoyance' are often used as general terms to describe this impact, and surveys usually employ ratings on scales such as satisfaction-dissatisfaction or 'bother' as a way of measuring it.

A5.2 The early survey work compared noise and nuisance levels at sites where conditions were generally steady – i.e. no sudden changes in exposure had recently taken place or were in prospect. Such surveys yield 'steady state' relationships between noise exposure and nuisance. Figure A6.1 shows a 'steady-state' relationship between noise exposure and noise nuisance, derived from three surveys (Ref 16, 24 and 31).

A5.3 Nuisance here is measured as the percentage of people bothered by traffic noise (i.e. those who say they are 'very much' or 'quite a lot' bothered by noise on a four point scale, which includes 'not much' and 'not at all' as alternatives). Figure A6.2 shows a relationship between changes in noise nuisance (on the same nuisance scale) and changes in noise exposure.

A5.4 Later surveys of residents before and after changes in noise exposure had occurred as the result of road projects indicated that people are more sensitive to abrupt changes in traffic noise than would have been predicted from the steady state evidence described above. In the period following a change in traffic flow, people may report positive or negative benefits when the actual noise changes are as small as 1 dB(A). As this noise change is equivalent to an increase of 25% or a decrease in traffic flow of 20%, this reaction may be partly attributed to an awareness of the changes in traffic rather than noise.

A5.5 These enhanced reactions last for a number of years and may persist as long as the respondents are those who were interviewed before the change took place. In the longer term, the level of nuisance may tend towards the steady state level associated with the noise exposure as the population interviewed acquires new residents who have no memory of the prior situation.

A5.6 The level of nuisance generated by the opening of a road project has been shown to persist for seven years at least. It seems clear that people living in a previously quiet area will continue to notice the excess noise caused by traffic, but people moving into the area will take account of it in making their choice of house. It is arguable that by the future assessment year changes in population may well cause overall nuisance levels to return to those predicted by the steady-state relationship.

A5.7 The methods of assessing nuisance in the steady state and as the result of changes in noise level are described in Annex 3.

Sleep Disturbance

A5.8 Measurements of noise from roads indicate that on average nighttime traffic noise (i.e. noise between 23:00 and 07:00 on the following day) is approximately 10 dB(A) less than daytime levels. The 18 hour average noise level only takes some account of the nighttime period.

A5.9 There is mounting concern about disturbance from heavy goods vehicle movements during the hours of night and early morning. Noise in the hours before 6am can cause people to awaken earlier than they would otherwise. Similarly, noise from heavy lorries late at night is likely to cause some people difficulty in getting to sleep. Much of the research on sleep disturbance has focussed on aircraft noise, but the noise of isolated heavy vehicles has strong similarities to the effect of aircraft during otherwise quiet periods.

A5.10 A comprehensive synthesis of field and laboratory studies undertaken before 1980 concluded that sleep disturbance could be significant at quite low noise levels (Ref 27). Attempts to find a relationship between sleep disturbances reported in social surveys and noise indices have indicated that there is a rather poor correlation between awakenings and measurements or predictions of noise.

A5.11 Research undertaken in America (Ref 11) on the impact of nighttime road traffic noise in cities has indicated that 25% of people exposed to an external noise level of 54 dB L_{Aeq} between the hours of 10pm

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and 6am were very annoyed; the percentage very annoyed rose to 50% for noise level of 65 dB L_{Aeq}. These rates of annoyance are comparable with the result of applying the annoyance relationship given in Figure A6.1 to a noise level 10 dB(A) higher than that measured at night. Although this time period (i.e. 10pm to 6am) is different to that used for the assessment of nighttime noise in this document, it is considered that a similar relationship for annoyance would exist.

A5.12 A recent meta-analysis of sleep studies undertaken for the EU (Ref 23) has found relationships between the number of noisy events and proportion of people disturbed by aircraft, railways and road traffic at night. The approach recommended to the EU has converted this data into a method of predicting the proportion of people likely to be disturbed from the average nighttime noise exposure for different sources. However, as these relationships have been based on self-reported disturbance, it is not surprising that they diverge from the DfT study, which was based on measuring body movements. The EU relationship for nighttime disturbance from road traffic produces much lower rates of annoyance than found in the German study. There is a clear tendency for road traffic noise to be considered more disturbing than railway noise, which is consistent with the trend found for daytime noise.

Low Ambient Noise

A5.13 While there is an accumulation of evidence about the adverse impacts of noise from new roads through quiet country areas mainly in the form of complaints, objective research has been rather limited.

A5.14 A preliminary study by TRL of a rural bypass (A41 Kings Langley/Berkhamsted) concluded that although people living in quieter surroundings tended to be rather articulate and live in relatively expensive dwellings, there was not enough evidence to show that the impact of noise changes in this case was any different from that predicted from earlier bypass studies where ambient noise levels were higher.

A5.15 The distance over which traffic noise can be detected in rural areas, especially under favourable conditions, is extensive and may give rise to a large number of complaints. As noise is attenuated according to the logarithm of distance, differences in source noise are translated into relatively large changes in the area affected when the threshold of detection is low.

Noise Hotspots

A5.16 Previous studies of the impact of noise changes had been undertaken in cases where there had been significant changes in traffic. The provision of noise mitigation measures at a selection of noise 'hotspots' on England's Strategic Road Network where there had been a history of complaints about high levels of noise gave an opportunity to study reactions to noise changes where the traffic generally remained unchanged.

A5.17 The measures were either noise barriers, or quieter surfaces, or in one case a combination of the two. Surveys similar to those conducted in the bypass studies were undertaken before and after implementation of the measures. Although there were one or two anomalies, the trend of responses was to confirm a reduction in the level of dissatisfaction that broadly corresponded with the change in noise level in accordance with the steady state relationship.

A5.18 However, there was strong evidence of a higher level of dissatisfaction with the noise level before the change than would have been expected from the 'steady state' relationship. This was attributed to a degree of sensitisation as the result of local campaigning and possibly enhanced by anticipation of the change. In at least one case, an increase in dissatisfaction was attributed to disappointment with the reduction in noise actually achieved by the measures compared with expectations.

Effects on Fauna

A5.19 Noise from man-made sources can affect animal behaviour where it masks sounds that are important to their ecology. Examples of impacts are on the breeding behaviour of birds and on prey-predator interactions e.g. owls and small mammals. Most research has been directed at effects of noise on birds.

A5.20 Research in the Netherlands has indicated a wide range of sensitivity, both according to species and depending on whether the noise is continuous or intermittent. It is well-known that colonies of geese for example thrive near airfields where the advantages of relative seclusion overcome the disturbance due to noise. Ducks, on the other hand, appear to be more sensitive to aircraft noise. Dutch research (Ref 26) on the effects of traffic noise showed an increasing impact with increasing noise levels above about 45 dB L_{Aeq} for a range of woodland, marsh and grassland species in

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certain circumstances. The threshold of sensitivity to traffic noise of coot was 60 dB, similar to that shown by black duck to aircraft noise. If considering any impact of noise on birds, care should be exercised in relation to the height of the receptor for which the noise predictions are conducted. The noise levels experienced by birds also depends upon on the habitat and behaviour of the birds because they experience different rates of attenuation in different environments.

Nuisance where Traffic is not Freely Flowing

A5.21 Langdon (Ref 19) found that at sites where traffic does not flow freely, perceived noise nuisance was only weakly related to existing noise indices. The best predictor of noise nuisance at non free-flow sites was found to be the logarithm of the percentage of heavy vehicles (greater than 1,525 kg gross weight) in the traffic flow. However, since Langdon carried out these surveys in the early 1970s, noise emissions from heavy vehicles have been reduced to conform with successive amendments to the vehicle type approval limits.

A5.22 There would be inconsistencies if different methods of predicting nuisance were used in locations where traffic is not free flowing for part of the day. It is, therefore, recommended that Figure A6.1 in Annex 6 is used to estimate noise nuisance even on routes where traffic is not free flowing, taking account of the effect of reduced speeds on noise during periods of congestion if hourly speed/flow data is available.

A5.23 Speed variations at junctions should generally be ignored in assessing noise nuisance as there is a trade-off between the effects of reducing speed and the additional engine noise generated by deceleration and acceleration. An appropriate average speed may be used for predicting the noise from traffic on large gyratory systems.

Vibration Effects

A5.24 There are two impacts of traffic vibration that need to be considered; impacts on buildings and disturbance to occupiers.

i) Impacts on Buildings

A5.25 Ground-borne vibrations are produced by the movement of rolling wheels on the road surface and can be perceptible in nearby buildings if heavy vehicles pass over irregularities in the road. It has long been a popular belief that such vibrations can lead to damage in buildings. Extensive research on a wide range of buildings of various ages and types has been carried out (Ref 30), but no evidence has been found to support the theory that traffic induced vibrations are a source of significant damage to buildings. Minor cracking of plaster may possibly occur at high exposure sites (i.e. existing heavily trafficked roads with poor surfaces and sub grade conditions) but it is very unlikely that this would be distinguishable from cracking due to other causes. There was no evidence that exposure to airborne vibration had caused even minor damage.

A5.26 Significant ground-borne vibrations may be generated by irregularities in the road surface. Such vibrations are unlikely to be important when considering disturbance from new roads and an assessment will only be necessary in exceptional circumstances. Furthermore, as the irregularities causing ground-borne vibration can be rectified during maintenance work, relief of these vibrations should not be presented as a benefit of a new road project.

ii) Disturbance to Occupiers

A5.27 Ground-borne vibration is much less likely to be the cause of disturbance than airborne vibration, but where it does occur the impacts can be more severe. At highest risk are occupants of buildings founded on soft soils close to heavily trafficked older roads where the road surface is uneven or constructed from concrete slabs which can rock under the weight of passing heavy vehicles. Ground-borne vibration levels depend on many factors and are, therefore, difficult to predict with precision, however peak levels and attenuation with distance can be estimated if the size of the road irregularity is known and the speed of traffic and type of sub-grade can be determined (Ref 30).

A5.28 Traffic-induced vibrations from low frequency sound emitted by vehicle engines and exhausts can be a source of annoyance to local people and can occur to some extent along any type of road. Such sound may result in detectable vibrations in building elements (for example, windows, doors and in some cases, floors), as reported in two surveys which investigated the relationship between physical measures of noise, vibration and traffic parameters, and measurements of nuisance obtained by interviews (Ref 5 and 30). It was found that $L_{A10,18h}$ index was among the physical variables most closely associated with average vibration disturbance ratings.

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ANNEX 6 ASSESSING TRAFFIC NOISE AND VIBRATION NUISANCE

A6.1 The nuisance caused by noise mainly affects people in their homes or when they are in the streets. However, areas of open space that are also used for recreational purposes can also suffer from noise pollution.

A6.2 Attempts to measure noise nuisance or annoyance usually make use of questionnaire surveys that attempt to relate the degree of annoyance expressed by the people interviewed with some physical measurement of the source noise level. These surveys have revealed that individuals vary considerably in their sensitivity to noise and this is reflected in their ratings of traffic noise nuisance. In addition it has been found that attitudes to traffic noise are also related to satisfaction with the neighbourhood in general.

A6.3 Given this variability in individual responses, practical research has moved from the ideal of explaining individual attitudes or annoyance with noise and has instead adopted the concept of an average or community annoyance rating for each noise level.

A6.4 Most of the information on the relationship between traffic noise and perceived traffic noise nuisance comes from studies in which the noise exposure has been fairly stable, with changes (mostly increases due to traffic growth) taking place over many years. There have been many such studies, and while the rate of change in nuisance with change in noise has been fairly consistent across all surveys, the absolute level of nuisance at any given noise level tends to vary from survey to survey. Figure A6.1 shows a curve derived from the combined data of three steady-state surveys (Ref 18, 24 and 30).

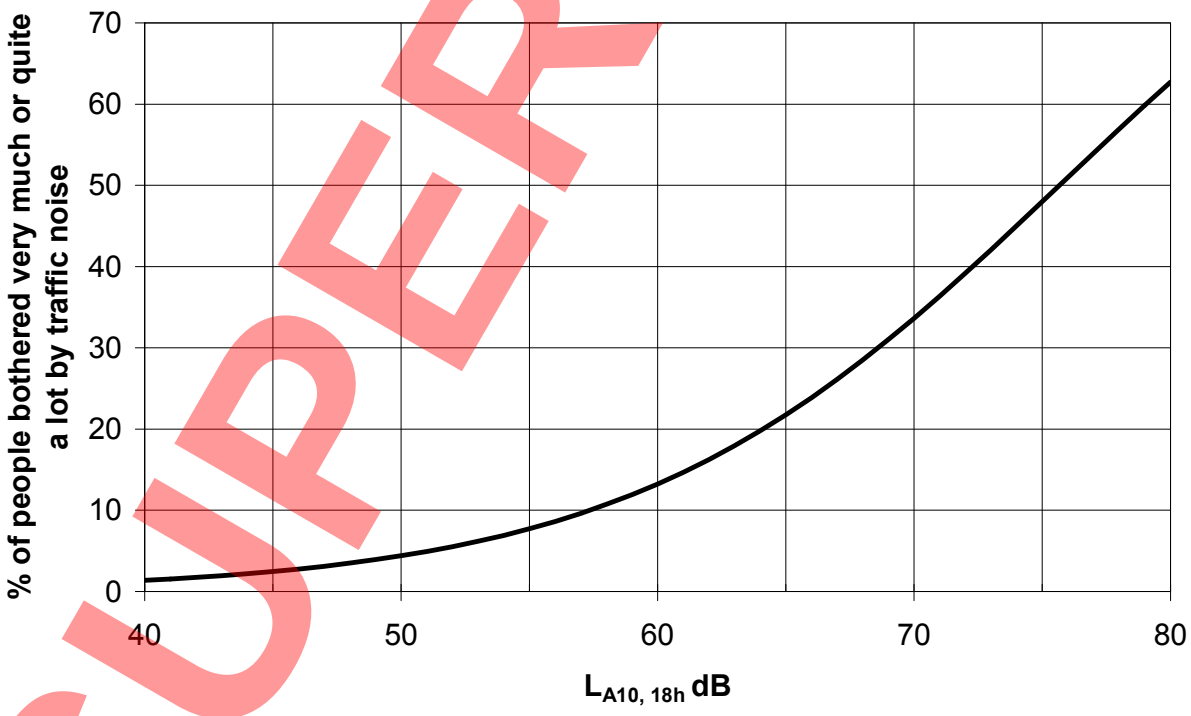


Figure A6.1 – Estimation of Traffic Noise Nuisance – Steady State or Before Noise Change

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A6.5 The curve in Figure A6.1 was derived from the results of these three surveys. For each survey the mean % bothered was calculated for each 2 dB(A) band. The curve was the best fit through the resultant set of points. The curve has been derived from the equation:

$$\% \text{ bothered} = \frac{100}{(1+e^{-\mu})}$$

where $\mu = 0.12(L_{A10,18h}\ \text{dB}) - 9.08$

A6.6 A number of studies have measured changes in perceived noise nuisance associated with changes in traffic exposure (Ref 6, 12, 17 & 20). These studies have found that nuisance ratings change more than would be predicted from the 'steady-state' relationship shown in Figure A6.1. The possible explanations for this excess change in nuisance are complex, and are discussed by Huddart and Baughan (Ref 17). However, the excess annoyance appears to reflect a real change in nuisance that persists for several years.

A6.7 The change in nuisance ratings in these situations can be estimated from Figure A6.2. This curve was based on 'before' and 'after' studies at 14 sites in England (Ref 17), supplemented by data from seven site studies by Griffiths and Raw (Ref 12). The change in nuisance was measured on a seven-point satisfaction/dissatisfaction scale and transformed to percentage very much or quite a lot bothered using a TRL steady-state survey. However, an adjustment was applied to the 'decrease' part of the curve, as described below.

A6.8 Huddart and Baughan (Ref 17) found that ratings of traffic noise nuisance before a decrease in traffic were significantly higher than those measured under 'steady-state' conditions. The question arises of whether environmental assessments should include or exclude this component of the observed change in ratings. Two possible explanations of the before/steady-state difference are given.

A6.9 The first is that steady-state surveys show that at a given level of noise, nuisance varies considerably between sites. If the high nuisance sites tend to be the ones chosen for remedial action, 'before change' nuisance will indeed tend to be higher than steady state nuisance at the same noise level. This explanation would imply that the effect is a real one, and should be taken into account in assessments provided that the project being appraised came forward in the same way as the projects covered by the research surveys.

A6.10 Second, expectations and publicity associated with the forthcoming change may sensitise people to traffic nuisance. This explanation would mean that before surveys would give an inflated estimate of the underlying level of nuisance, and that the assessment should be based on the difference between the steady-state and after levels of nuisance.

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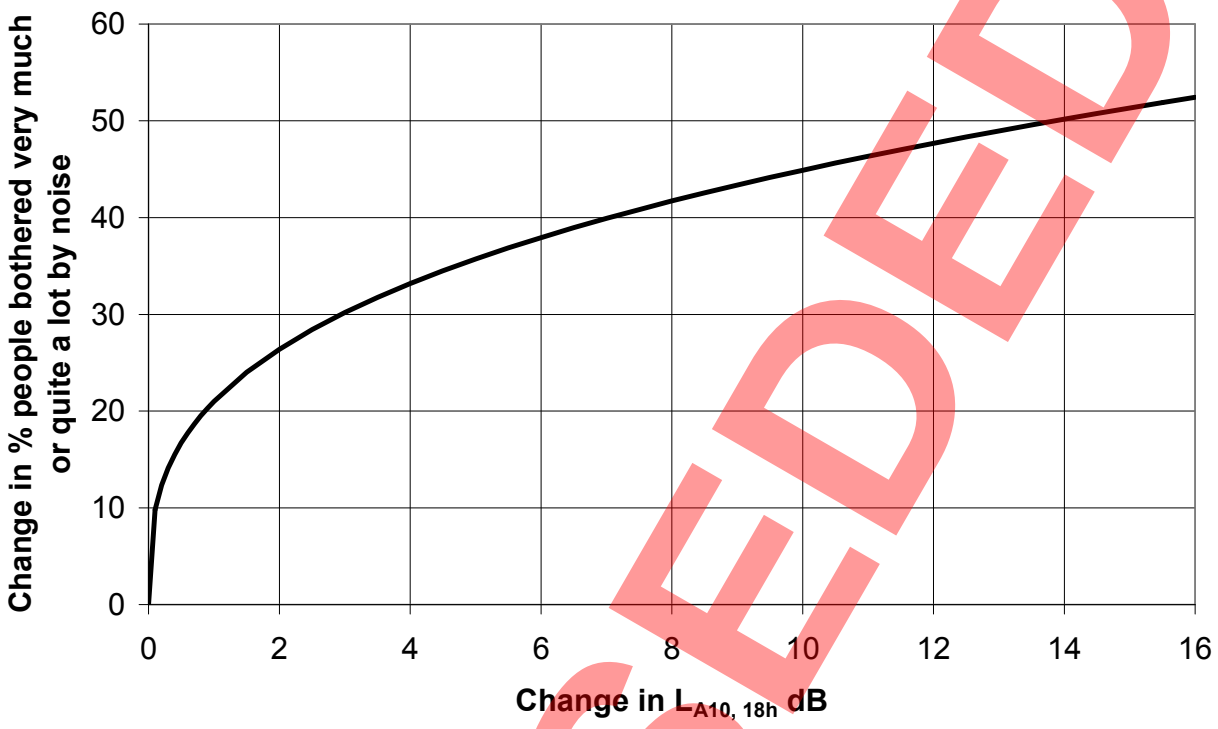


Figure A6.2: Estimation of Traffic Noise Nuisance – Change in % Bothered Very Much or Quite a Lot by Traffic Noise

This curve has been derived from the equation;

$$\text{Change of \% bothered} = 21 \, (\text{Change of } L_{A10,18h} \text{ dB})^{0.33}$$

A6.11 Huddart and Baughan argue that both the above impacts are likely to be operating, but that the first is probably the more powerful. This implies that at least part of the difference between before and steady-state nuisance should be included in assessments. However, problems arise when an attempt is made to build this idea between the two scales into a practical assessment method. For example, it is difficult to specify exactly when the current level of nuisance should be estimated from the steady-state relationship, and when the 'before' relationship should be used instead.

A6.12 It has, therefore, been decided to exclude the before/steady-state difference from the assessment method described here. The effect of this is probably to tend to underestimate the environmental benefits arising from reductions in traffic noise.

A6.13 Nuisance ratings before an increase in noise do not differ significantly from the 'steady-state' ratings. Therefore, no adjustment was required for increase in traffic noise.

A6.14 Once the adjustment for decreases in noise has been made, the relationship between change in noise and change in nuisance was found to be very similar for increase sites and decrease sites. Figure A6.2, therefore, shows a single curve applying to both increases and decreases.

A6.15 Research indicates that the large nuisance changes observed in before and after studies are not simply short term impacts. Griffiths and Raw (Ref 13) found 'after' levels of nuisance to differ from 'steady-state' levels at seven and nine years after the change in traffic noise exposure. What happens to nuisance levels in the longer term is uncertain. They may move slowly back towards those which would have been predicted from the 'steady-state' relation between noise exposure and nuisance.

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A6.16 The assessment method described in this advice assumes that this does happen, and that the nuisance 15 years after a road project is opened can be estimated from the 'steady-state' relationship. One reason for expecting this is that people who move in after the change in noise may react to the noise in a similar manner to people living at 'steady-state' sites. Individuals who experienced the noise change may continue to have a different level of nuisance, but the level of nuisance for the site as a whole may change as more of the original population are replaced by new residents.

A6.17 The method for assessing traffic noise nuisance described in this manual will give estimates for an 'average' site. The level of annoyance caused by changes at any individual site may differ from this 'average' estimate.

A6.18 It should be made clear that the surveys which provided the basis for this method of assessing nuisance were conducted at sites where road traffic was the dominant noise source. Noise exposures ranged from 65 to 78 dB $L_{A10,18h}$, the changes in traffic noise were up to 10 dB $L_{A10,18h}$ and the dwellings were up to 18m from the kerb.

A6.19 When the pre-project noise level is not dominated by traffic noise, it should be measured using the noise index $L_{Aeq,18h}$. It is recommended that this is used as a substitute for $L_{A10,18h}$ to estimate pre-project levels of nuisance in these situations, using Figure A6.1. When estimating the change in nuisance from Figure A6.2, the difference between the 'after' level of noise as $L_{A10,18h}$ and the 'before' noise level as $L_{Aeq,18h}$ should be used.

A6.20 The method is based on surveys of noise changes caused by changes in traffic volume. It will not necessarily give a good prediction if traffic noise changes were brought about by some other means, such as barriers or low-noise road surfaces. A recent study has shown that although a noise reduction by such means reduced nuisance, the limited number of responses showed this decrease not to be as great as where actual traffic volume changes occur. However, further research is required before traffic noise nuisance changes can be estimated for these situations with any certainty.

A6.21 The relationship between the percentage of people bothered by largely airborne vibration and this noise exposure index is similar to that for noise nuisance except that the percentage of people bothered by vibration is lower at all exposure levels. For the purposes of predicting vibration nuisance, the curve in Figure A6.1 should be employed by making a suitable adjustment to the percentage bothered. For a given level of noise exposure the percentage of people bothered very much or quite a lot by vibration is 10% lower than the corresponding figure for noise nuisance. On average traffic induced vibration is expected to affect a very small percentage of people at exposure levels below 58 L_{A10} dB and therefore, zero per cent should be assumed in these cases.

A6.22 The survey of vibration nuisance was restricted to dwellings within 40m of the carriageway where there were no barriers to traffic noise. When using this graph to make predictions of disturbance caused by airborne vibration, professional judgement is needed in cases where the buildings are screened or are not sited within 40m of the road, since this is outside the range of the data on which the empirical method is based.

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Table of Data from Figures A6.1 and A6.2

Figure A6.1

Noise exposure, $L_{A10,18h}$ dB	Approx % bothered by traffic noise
<41	1
41-45	2
45-48	3
48-50	4
50-52	5
52-54	6
54-55	7
55-56	8
56-57	9
57-58	10
58-59	11
59-60	12
60-61	14
61-62	15
62-63	17
63-64	19
64-65	21
65-66	23
66-67	25
67-68	27
68-69	29
69-70	32
70-71	35
71-72	38
72-73	40
73-74	43
74-75	46
75-76	49
76-77	52
77-78	55
78-79	58
79-80	61
80-81	64
82-83	68
83-84	72
84-85	75
>85	79

Figure A6.2

Change in noise exposure, dB	Change in % bothered by traffic noise
<2	23
2-3	28
3-4	31
4-5	34
5-6	37
6-7	39
7-8	41
8-9	42
9-10	44
10-11	45
11-12	47
12-13	48
13-14	49
14-15	51
>15	53

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Noise Nuisance Changes: Worked Examples

Example 1. Do-Minimum

(i) Do-Minimum in the baseline year noise level of 68.2 dB $L_{A10,\ 18h}$, 29 per cent of people are bothered by traffic noise (Figure A6.1).

(ii) In the future assessment year the noise level is predicted to rise to 70.1 dB $L_{A10,\ 18h}$, when 34 per cent will be bothered by traffic noise (Figure A6.1).

(iii) There will, therefore, be an increase of five per cent, in the number of people bothered, and this value should be entered into the assessment table.

Example 2. Increases in Traffic Noise

(i) Do-Minimum in baseline year noise level of 65.9 dB $L_{A10,18h}$, 24 per cent of people are bothered by traffic noise (Figure A6.1).

(ii) An increase of 3.0 dB to 68.9 dB $L_{A10,18h}$ is predicted in the baseline year as a result of the road project, so the immediate increase in the percentage of people bothered will be 30 per cent (Figure A6.2), so 54 per cent will be bothered.

(iii) By the future assessment year the noise is predicted to rise to by a further 1.0 dB $L_{A10,18h}$ to 69.9 dB $L_{A10,18h}$ so 33 per cent of people will be bothered (Figure A6.1).

(iv) The highest level of bother (54 per cent) is, therefore, on opening, and the increase in bother for the assessment table is, therefore, 30 per cent.

Example 3. Decreases in Traffic Noise

(i) Do-Minimum in baseline year of 73.1 dB $L_{A10,18h}$, 42 per cent of people will be bothered (Figure A6.1).

(ii) A noise reduction of 6.0 dB $L_{A10,18h}$ to 67.1 dB $L_{A10,18h}$ is expected in the baseline year as a result of the road project, so the immediate decrease in the percentage of people bothered will be 38 (Figure A6.2), so 4 per cent will be bothered.

(iii) By the future assessment year, the noise is predicted to rise by 1.2 dB $L_{A10,18h}$ to 68.3 dB $L_{A10,18h}$, so the percentage of people bothered is 29 (Figure A6.1).

(iv) The highest level of bother is, therefore, in the future assessment year, and the reduction in bother is 13 per cent, and this value should be entered into the assessment table.

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ANNEX 7 ADDITIONAL GUIDANCE WHEN UNDERTAKING MEASUREMENTS

A7.1 Conducting a noise measurement survey may be an integral part of the assessment process and would usually be undertaken at Detailed Assessment level. A noise survey can assist with the understanding of the existing noise level and in explaining the noise climate of a particular area.

A7.2 Before undertaking measurement work, the Local Authority Environmental Health Officer should be consulted about the availability of existing baseline noise data for the area. However, before using any such data the Overseeing Organisation's supply chain needs to be aware of the circumstances of the measurement (e.g. weather conditions, date and time of measurements, noise weightings used).

A7.3 The measurement methodology contained within CRTN for measurements is strictly for circumstances when predictions are not possible for the assessment of entitlement under the relevant Noise Insulation Regulations.

A7.4 For a noise survey of existing conditions where the noise climate is dominated by road traffic the general guidelines that are contained in CRTN for undertaking measurements should always be followed.

A7.5 Other guidance documents are available to assist with undertaking noise surveys and the Overseeing Organisation's supply chain should choose the most appropriate methodology to be used and agreed with the Overseeing Organisation. This will be dependent on the circumstances of the road project. In all cases, best practice should always be followed.

A7.6 The number and location of measurement sites is left to the Overseeing Organisation's supply chain to determine, and will be very much dependant upon the complexity of the road project. The number of sites should be appropriate to describe the noise climate in the area of the road project. If measurements are conducted at an early stage, sufficient sites should be selected to represent all possible options.

A7.7 When selecting measurement sites, the possible need to conduct post completion noise measurements and potential compensation claims should be considered. For example a road in a rural area may have impacts beyond 600m.

A7.8 To fully understand the noise climate of an area it may be necessary to conduct a full 24 hour measurement at some sites. A nighttime measurement should certainly be considered if traffic flows on nearby roads are too low for prediction or where receptors are located in rural areas where a new road project will be introduced nearby.

A7.9 Traffic noise can vary widely on an hourly, daily and seasonal basis. Care is needed in interpreting any measured data as the effects of varying weather conditions are particularly noticeable when the propagation distance is large. Therefore, in order to estimate the existing noise level within an area, if possible a series of measurements can be taken on several occasions during the assessment period. Where a strong prevailing wind is known to exist between the road and the receiver, the majority of measurements should be taken in those conditions.

A7.10 The weather conditions, especially the wind direction, can have a strong influence on measured noise levels, especially at some distance from the source. Weather conditions should be recorded during all measurement surveys. This could be in the form of a portable measuring device, direct observations on site or information from a reliable calibrated local source.

A7.11 Where the ambient noise level is comprised of a combination of emissions from several non road traffic sources, for example a rural setting with occasional noise from machines, aircraft or animals, the assessment of the noise using L_{A10} would be inappropriate. It would be more appropriate to determine the ambient noise in these situations by also using the L_{Aeq} index. However, it is important to measure over a sufficient time period to ensure the measurement is representative.

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A7.12 Situations may arise where the ambient noise is either partially or completely dominated by noise other than from road traffic. In such situations it is recommended that the baseline noise levels are measured at representative locations during periods when the non-road traffic noise source is both present and not present.

A7.13 During attended measurements it is essential that notes are made of the main noise sources and any other noise producing activities. It should also be noted whether any events were excluded from the measurement, and the reason for the exclusion. A description, sketch and selection of photographs of all sites is considered essential.

A7.14 For unattended measurements, if the logging equipment allows, other parameters may be measured in order to help describe the noise climate. These may include the logging of events above a certain threshold or the use of a shorter measurement period to allow removal of suspect data. However, in this situation care should be taken when calculating, for example, an hourly average from several shorter periods. The comparative measurement procedure in CRTN could also be considered.

A7.15 Noise measurements should not routinely be undertaken in school holiday periods, particularly nearby to main roads as traffic flows can differ during these periods when compared to other periods in the year. Where the noise environment is not dominated by road traffic, measurements within school holidays may be suitable.

A7.16 During the assessment process, measurements should not routinely be compared with calculations for the purpose of predicting changes in noise level. There is currently no methodology available to take account of the potential errors associated with comparing measurements with calculations, especially when the receptor is some distance from the noise source. For situations where it is not possible to undertake calculations in the Do-Minimum scenario but it would be possible in the Do-Something scenario (e.g. at a receptor with existing low noise levels but a noise source is to be introduced with the project), it may be necessary to compare measurements with calculations.

A7.17 As a minimum a noise survey report will include a map showing the location of all measurement positions, a description of each position and a table of results (including meteorological conditions) with appropriate commentary for each attended measurement period. An explanation should be given of all the noise sources that contribute to the noise climate at each measurement position. Commentary should also be made of any changes in the noise climate that are expected to occur between the time of the noise survey and the time when the road project is planned to open. This could include expected changes in traffic composition or new or intensified usage of existing developments. If any measured noise levels are above any statutory exposure limits or guideline levels then these should be noted in the report and highlighted to the Overseeing Organisation.

Vibration survey

A7.18 If a vibration survey is required, this should be undertaken in accordance with available guidance. The decision on whether to undertake a vibration survey should be based on an assessment of likely impacts, which would be determined by such factors as the distance between the road and sensitive receptors, ground type and road condition. However, the Overseeing Organisation's supply chain should seek the approval of the Overseeing Organisation before undertaking any ground-borne vibration survey.

A7.19 When undertaking measurements the Overseeing Organisation's supply chain should also, if possible, include an indication of the expected level of vibration from everyday household activities (e.g. the closing of doors).

A7.20 In reporting the results from any vibration survey, the Overseeing Organisation's supply chain should highlight the number of events likely to be above noticeable levels and also consider the likely cause of the events.

SUPERSEDED

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