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Statement

A303 Stonehenge Scheme, reference TR010025

Review of submitted Environmental Statement in relation to noise and tranquillity

Examination reference number for Stonehenge Alliance: 20019870

Prepared by

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Summary of Representations

I have been asked by the Stonehenge Alliance to review evidence relating to noise and tranquillity provided for the DCO application to construct a tunnel under part of the Stonehenge World Heritage Site. I have recently completed a three and a half year project to develop a new scientific method for the assessment of tranquillity and have written a book (expected to be published later in 2019) on the subject.

Prior to the development of this method, there has been no reliable method available which takes account of the key factors which affect perceptions of tranquillity and which provides information with a high enough resolution to be usable for the purposes of determining a planning decision. I have written a review of other methods which I have attached as Appendix A. I have also provided details of the method which I have developed, known as the Natural Tranquillity Method, in Appendix B.

I have reviewed relevant National Planning Policy and note that this requires that noise assessments for roads which are Nationally Significant Infrastructure Projects should be assessed not only in relation to sleep disturbance and annoyance but also in relation to the use and enjoyment of areas which are important for their quiet character. Policy also requires that tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason should be protected.

There is currently no agreed, reliable, published method for doing this, but the guidance which is available suggests that tranquil spaces are likely to be relatively undisturbed by noise from man-made sources, that lower levels of sound are likely to be important and that natural sounds are likely to be beneficial.

The noise and vibration assessment for the proposed development does not consider noise effects on quiet or tranquil areas within its defined study area. The only noise sensitive receptors considered which are not buildings are the henge at Stonehenge and Parsonage Down SSSI. These sites are considered without the benefit of relevant baseline survey data and the criteria used to assess impact is inadequate for the purpose. Conclusions reached in relation to the impact on tranquillity at these two locations are therefore unreliable, in my opinion.

All assessments submitted by the applicant conclude that noise from road traffic has a detrimental effect at the henge and that the proposed development would result in a significant improvement in noise and tranquillity there. This conclusion is not supported by their evidence. The little evidence which is reported actually demonstrates that there would be a negligible effect, according to their own assessment criteria.

My own tranquillity assessment, carried out only in the immediate vicinity of the henge, reached the conclusion that removing the A303 would have little, if any, beneficial effect on tranquillity at the henge.

In addition to this, the study area is too small in my opinion and fails to address possible impacts on tranquillity which may be found further along the A303 outside the proposed tunnel. It is quite possible that there may be a number of sites in the area which are currently considered to be tranquil and which may be prized for their amenity or recreational value for this reason. These sites could be adversely affected as a result of the proposed development. However, no work has been reported to have been done to find out whether this is the case and therefore I consider the assessment is incomplete.

1.0 Qualifications and Experience

1.1 My name is Clive Frederick Bentley. I am an Associate Acoustic Consultant with the Sharps Redmore Partnership, a specialist acoustic consultancy based in Ipswich.

1.2 I hold two Bachelor of Science (Honours) degrees: one in Combined Studies in Science and one in Environmental Health; and a Diploma in Acoustics and Noise Control. I am a Member of the Institute of Acoustics, a Member of the Chartered Institute of Environmental Health and a Member of the Institute of Environmental Science. I am also a Chartered Environmentalist and a Chartered Scientist.

1.3 I have been employed in my current position since January 2006. Prior to this, I was a Senior Environmental Health Officer for Ipswich Borough Council, where I was responsible for the day to day running of the noise control team in the Environmental Protection Service. I worked in the Environmental Protection service at this Council continuously from 1992, investigating complaints of statutory nuisance and taking enforcement action in relation to them.

1.4 I specialise in the assessment of environmental noise and noise nuisance and have undertaken many assessments in a wide variety of industrial, residential and commercial projects. I have given evidence at many hearings, including Planning Hearings and Inquiries and at Magistrates' and County Courts.

1.5 I am the project lead for the Sharps Redmore team providing ongoing acoustics input for the Sizewell C Power Station and I also lead a team within the company which produces environmental noise and vibration assessments for other projects. Since 2015, I have been researching and developing expertise in the emerging field of tranquillity assessment in relation to developments in both rural and urban locations. I have written a book describing a method for the assessment of tranquillity, which is due to be published in 2019.

1.6 Sharps Redmore Partnership is one of the largest independent acoustic consultancies in the country and has advised many major developers, local authorities and others since 1990.

2.0 Introduction

2.1 I have been asked by the Stonehenge Alliance to review evidence provided by Highways England in relation potential noise effects from the proposal to tunnel at Stonehenge World Heritage Site and provide my professional opinion on this. I had visited the henge in 2017 and carried out an assessment of tranquillity at the site as a case study for a book I was writing (on the subject of tranquillity), so had some understanding of the site prior to this.

2.2 I have focussed my review primarily on the consideration of the effect of noise on quiet areas and on the question of noise impact on tranquillity.

2.3 I have reviewed relevant policy and guidance relating to noise and tranquillity and I provide an analysis of this within Section 3. I have also reviewed the Scheme assessment work carried out by landscape architects, acousticians and cultural heritage experts in relation to noise and tranquillity and provide my analysis of this in Section 4.

2.4 I have provided details of my own assessment of tranquillity and potential changes to tranquillity which would be likely to arise at the henge as a consequence of the proposed changes to the A303 in Section 5. I have also provided a detailed outline of the method which I have developed and used to do this in Appendix B, as this has not been published more widely at the time of writing.

2.5 I have set out my conclusions in Section 6.

3.0 Planning Policy and Guidance

National Policy Statements and other National Policy and Guidance

3.1 Planning policy relating to Nationally Significant Infrastructure Projects is contained within National Policy Statements (NPS). The relevant Statement for this project is the National Policy Statement for National Networks (NPSNN).

3.2 This document states, within the Section Headed "Noise and Vibration", in paragraph 5.186 that:

"*Excessive noise can have wide-ranging impacts on the quality of human life and health (e.g. owing to annoyance or sleep disturbance), use and enjoyment of areas of value (such as quiet places) and areas with high landscape quality."*

3.3 In paragraph 5.188, it explains that one of the factors which will determine the likely noise impact is:

"… the proximity of the proposed development to quiet places and other areas that are particularly valued for their tranquillity, acoustic environment or landscape quality such as National Parks, the Broads or Areas of Outstanding Natural Beauty …"

3.4 It goes on to state that the applicant's noise assessment should include the following:

- *"… identification of noise sensitive premises and noise sensitive areas that may be affected.*
- *the characteristics of the existing noise environment …"*

3.5 In relation to decision making, the document states in paragraph 5.193 that:

"Due regard must have been given to the relevant sections of the Noise Policy Statement for England, National Planning Policy Framework and the Government's associated planning guidance on noise."

3.6 The Government's planning policy is found in the National Planning Policy Framework (NPPF) which states in paragraph 180 that:

"Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:

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

3.7 The associated planning guidance relating to noise and tranquillity is found online at https://www.gov.uk/guidance/noise--2 Paragraph 12: Reference ID: 30-012-20140306, which states, under the heading, "What factors are relevant to identifying areas of tranquillity?":

"There are no precise rules, but for an area to be protected for its tranquillity it is likely to be relatively undisturbed by noise from human caused sources that undermine the intrinsic character of the area. Such areas are likely to be already valued for their tranquillity, including the ability to perceive and enjoy the natural soundscape, and are quite likely to be seen as special for other reasons including their landscape."

3.8 According to the Government's website, ".GOV" (last updated in 2017), when assessing the extent to which this natural beauty may be present (in relation to Areas of Outstanding Natural Beauty and National Parks), a combination of factors should be considered, including:

> *"… relative tranquillity, where natural sounds, such as streams or birdsong are predominant".*

3.9 It is clear from the above guidance that noise is central to the consideration of tranquillity at a location and that a noise assessment should take account of the sensitivity of an area and the characteristics of the noise environment. The noise and vibration assessment should include an assessment of the potential effects of noise on tranquillity and on the character of potentially noise sensitive areas.

Other guidance

3.10 In addition to the national policy and guidance in relation to tranquillity, The Highways Agency has published guidance in an Interim Advice Note titled, "Landscape and Visual Effects Assessment", IAN 135/10. According to its Executive Summary, this note "*sets out the requirements for the Highways Agency and Service Providers for the assessment and reporting of the effects highway projects on landscape character and on views from sensitive visual receptors*". The note does not attempt to deal with noise other than as a secondary feature within the context of an assessment of landscape. It defines tranquillity as:

"… the remoteness and sense of isolation, or lack of it, within the landscape, which is often determined by the presence or absence of built development and traffic."

3.11 IAN 135/10 goes on to suggest that, when assessing landscape impacts, two of the attributes which may be considered (in relation to tranquillity) are:

- *"Less tangible aesthetic and perceptual characteristics concerned with how the landscape is experienced and why, including professional judgment on tranquillity, wildness, intimacy, sense of place, scenic quality and other responses or impressions.*
- *The overall level of background noise, noting any intermittent sources (e.g. aircraft or trains)."*

3.12 However, IAN 135/10 does not contain any guidance on how background noise levels should be considered, what different levels might be taken to indicate, nor how to form a professional judgement on, tranquillity. It wrongly, in my opinion, assigns the consideration of tranquillity to within the landscape impact assessment and, by doing this, it fails to properly address the key policy requirement in relation to tranquillity: which is that it needs to be primarily considered as a noise (or sound character) effect within the noise assessment.

3.13 The Landscape Architects professional body, the Landscape Institute published a Technical Information Note in 2017 titled, "*Tranquillity – An Overview*" which aimed to provide an *"overview of what is understood by the term 'tranquillity' within the landscape profession and to inform any future discussions and actions on the topic".* This note does not provide any method for the assessment of tranquillity, although it does review two methods which had previously been published, often known as the University of Bradford (or TRAPT) method and the CPRE methods.

3.14 The note concludes that:

"… it is clear that there is a definite need for some form of guidance on the subject of tranquillity and further research and methods of measurement to assist with the assessment process."

3.15 It goes on to state:

"Given that tranquillity is well established within the landscape assessment process, having been a consideration under the perceptual factors and 'sense of place' for many years, the landscape profession has a sound base on which to develop appropriate guidance on the subject."

3.16 The note suggests that one possible way to take the assessment of tranquillity forward would be to attempt to refine the University of Bradford method. No further such development work has been undertaken, so far as I am aware.

The Natural Tranquillity Method

3.17 I have developed a method for the assessment of tranquillity and have written a book explaining how this method works. The book is complete but not yet published at the time of writing. The method is called the "Natural Tranquillity Method". Prior to developing this method, I reviewed the University of Bradford and the CPRE methods (and some other "one-off" approaches to the assessment of tranquillity) in detail and also reviewed reports of studies where the CPRE method has been used for tranquillity mapping; I have included a summary of my findings from this review in Appendix A of this statement. I found that none of the methods (prior to the development of the Natural Tranquillity Method) was capable of providing a reliable prediction of how tranquil a location is felt to be and that therefore none could be reliably used to aid planning decision making.

3.18 Planning Policy requires that tranquillity should be considered primarily in relation to noise, although other factors may also need to be considered. I have found that there are a great many factors which have the potential to affect perceptions of tranquillity but that the key considerations are:

- The overall level and types of sound present and
- How natural one's surroundings are.

Both of these can be considered by assessing the level and character of the sounds present in a particular location.

3.19 Since my method is unpublished at the time of writing, a comprehensive explanation of the Natural Tranquillity Method is provided in Appendix B for reference. In essence, the method uses a field survey of four parameters which assess the overall sound level, the amount of sound from road traffic and railway movements, the percentage of time when one can only hear natural sound and the relative amounts of natural and man-made sounds present. These parameters are then input to a formula which provides a prediction of the likely tranquillity score which would be given by a person visiting a site who had no previous connection with the site (so would have no bias due to previous experiences). These scores are then used to produce a tranquillity contour map of an area of interest and this map can be used to determine how tranquil a location is to assist with decision making.

3.20 The tranquillity scores are as shown in Table 3.1 below:

Table 3.1: Tranquillity scoring system used by the Natural Tranquillity Method

Tranquillity score	Modified description
1	Frantic / chaotic / harsh
2	Busy / noisy
3	Unsettled / slightly busy
4	Not quite tranquil
5	Just tranquil
6	Fairly tranquil
7	Good tranquillity
8	Excellent tranquillity
9	Perfect tranquillity

3.21 The method was based on measurements and opinions carried out over three and a half years in around 1,600 locations around England and has been found to correctly predict the tranquillity score for about a third of the time and to be no more than one score out for about 98% of the time.

Summary

3.22 The relevant policy requires that noise assessments for roads which are Nationally Significant Infrastructure Projects take account of the existing noise sensitive areas and that noise impacts should be assessed not only in relation to sleep disturbance and annoyance but also in relation to the use and enjoyment of areas which are important for their quiet character. It also requires that tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason should be protected.

3.23 There is currently no agreed, reliable, published method for doing this, but there is some guidance available which suggests that tranquil spaces are likely to be relatively undisturbed by noise from man-made sources, that lower levels of sound are likely to be important and that natural sounds are likely to be beneficial.

4.0 Review of Assessments found in Environmental Statements for the project

Identification of noise sensitive / quiet / tranquil areas and extent of study area

4.1 The Environmental Statement (ES) chapter 9, on Noise and Vibration, lists the NPS requirements in Table 9.1 and includes the requirements to consider noise sensitive areas and to consider the characteristics of the existing noise environment.

4.2 The assessment identifies paragraph 180 of the NPPF and the Planning Practice Guidance on Noise as relevant policies. As described in Section 3.0 above, the policy and guidance within these documents sets out the requirement to consider the potential impact on tranquil spaces and explain that noise is central to considering this. The ES chapter on noise identifies the requirement to protect tranquil areas in paragraph 9.2.4. However, despite identifying this, the noise assessment does not contain any consideration of tranquil areas. This is an important omission, in my opinion.

4.3 The assessment refers to guidance within DMRB, stating in paragraph 9.5.1:

"DMRB defines residential properties, educational buildings, medical buildings, community facilities (such as places of worship) designated sites (such as the WHS and Parsonage Down SSSI), scheduled monuments and public footpaths as potentially sensitive to noise and/or vibration."

4.4 In relation to the baseline survey work, the following statement is made in paragraph 9.6.5:

"*The purpose of the baseline noise survey was to assist with developing an understanding of the general noise climate along the route of the Scheme. For example, to identify if any other local noise sources (other than road traffic) are present and contribute significantly to the local noise climate*."

4.5 Unfortunately, the assessment contains virtually no information about potential sensitive areas. No public footpaths or other potentially sensitive locations have been considered. Paragraphs 9.6.17 and 9.6.18 provide details the receptors considered: none are areas which may potentially need to be protected because of their tranquil status. The only areas which are considered at all are Parsonage Down SSSI and the henge site at Stonehenge. Very limited baseline data is provided for Stonehenge WHS (a single reading made at the henge) and no baseline data is presented for Parsonage Down.

4.6 The study area is confined to locations within 1km from the route of the scheme and those close to other local roads where a change in noise level is anticipated. It seems very likely that vehicles will currently avoid the A303 to some extent, knowing that it is congested. When people return to using the A303 (and presumably will be able to travel faster on the new road) there may be effects beyond the ends of the scheme, particularly on locations which are currently relatively quiet. Figure 9.5 of the applicant's Environmental Statement (Chapter 9) shows that at the eastern and western end of the study area, noise levels will increase by between 3 and 5 dB. No consideration has been given to impacts on potentially quiet or tranquil locations further afield.

4.7 In my opinion, the failure to identify potentially sensitive areas (other than Parsonage Down and the henge); the failure to carry out proper baseline surveys even at these two identified receptors; and the failure to consider the impacts beyond 1km from the scheme (particularly when it is known that there would be a level increase between 3 and 5 dB in such areas) represents an important omission from the noise assessment meaning that the assessment is incomplete.

Heritage Assets

4.8 Table 9.2 of the ES noise and vibration chapter contains extracts from the scoping opinion along with responses on behalf of the applicant. In this, the scoping opinion suggests that:

"Inter-relationships with other aspects should be considered - for example, noise impacts on the setting of heritage assets."

4.9 The response to this is:

"… the potential for noise impacts on the setting of heritage assets is presented in Chapter 6 (Cultural Heritage)."

4.10 The ES Cultural Heritage Chapter 6 does contain some reference to noise: in Table 6.5 it states that differences in noise or sound quality have the potential to impact on "historic landscape", stating that the greater the difference in noise or sound quality, the greater the magnitude of effect. There is no stated level or technical means put forward in this chapter to suggest how this "difference in noise or sound quality" should be assessed.

4.11 In paragraph 6.11.2 of the Cultural Heritage chapter, the following statement is made:

"The A303 currently has a major negative impact on the setting of Stonehenge, the integrity of the WHS and visitor access to some parts of the wider landscape. The harmful impacts of roads and traffic on the WHS include visual intrusion, noise and air pollution."

4.12 Although the Cultural Heritage chapter states that it "draws on data from" other studies including noise and vibration, no information is provided in this chapter which shows what this data is or how it has been interpreted. However, within the Noise and Vibration chapter some very limited data has been provided, although the data is too limited to be of value and has been interpreted in a way which makes the conclusions of little value, in my opinion. I have considered this in more detail below.

4.13 In my judgement, the impact of noise on Heritage Assets has not been considered in a meaningful way and the conclusions presented in the Cultural Heritage chapter are supported by scant and unreliable evidence.

Noise assessment work for Parsonage Down SSSI and for the henge at Stonehenge

4.14 The noise assessment chapter makes the following statement in paragraph 9.6.3:

"The study area is predominantly rural in nature. Road traffic noise from the existing A303 is a readily appreciable problem that affects the setting of the WHS."

4.15 As discussed above, the study then fails to consider any rural receptors (such as footpaths and byways) and focusses almost entirely on noise impacts for buildings. However, at paragraph 9.9.50, the ES chapter on noise and vibration introduces some commentary on noise impact on the Parsonage Down SSSI. It provides only a small amount of information about the noise levels predicted in Table 9.20, suggesting that the scheme would result in 98 to 99% of the area being exposed to noise levels below 50 dB and the remaining 1 to 2% of the area being subjected to levels between 50 and 63 dB. The assessment interprets that levels below 50 dB would be "below the LOAEL" (LOAEL stands for "lowest observed adverse effect level) and levels between 50 and 63 dB would be above the LOAEL but below SOAEL (and therefore not significant) although no reasoning is given for using these values. SOAEL stands for significant observed adverse effect level). I do not agree with the use of these values and can find no evidence within the chapter (or elsewhere) to suggest that this is a sound basis for the assessment of noise on these locations.

4.16 A similar exercise has been carried out (and results displayed in Figure 9.21 of the ES) for the WHS in general and conclusions have been based on the percentage of the area which would be below 50 dB, between 50 and 63 dB and above 63 dB. For the same reason, this approach is not valid for the consideration of noise effects on potentially tranquil spaces.

4.17 These LOAEL and SOAEL values represent levels which may be relevant for noise exposure for buildings and associated amenity areas such as gardens. They have little or no relevance in the consideration of noise impact on quiet or tranquil spaces. Indeed, there is considerable evidence to show that levels of between 50 and 63 dB from road traffic within a rural location (and in the absence of any other significant noise sources) are likely to result in the majority of people considering a location to be unsettled or noisy.

4.18 Levels below 50 dB from road traffic may also lead to a location being considered to be "not tranquil", although obviously "below 50 dB" contains a wide range of values and some levels of road traffic noise (for example below 30 dB) are quite unlikely to have an effect on tranquillity.

4.19 The way that noise impact has been considered at Parsonage Down SSSI and for the WHS and the conclusions presented are therefore unreliable, in my opinion

Noise baseline and noise modelling of road traffic noise at the henge site

4.20 The only noise sensitive location (other than buildings) at which some baseline information has been presented is the henge site. The results of the survey carried out at this location (which is referred to as M10) are presented, alongside predicted road traffic noise levels for a number of sites in Table 9.9. Paragraph 9.6.11 of the chapter interprets this data as follows:

"At all locations except M10 Stonehenge the predicted noise level (expressed as $L_{A10,18h}$) traffic noise levels align with the average measured ambient levels. At Stonehenge, measured ambient noise levels were higher than the predicted traffic noise levels. At this location non-traffic noise sources were noted as a significant source, notably noise generated by visitors to the site."

4.21 Clearly, road traffic noise is not the most significant noise source at the henge and yet no further consideration of sound in this location has been made.

4.22 Table 9.26 states that the change in noise level at Stonehenge (meaning the henge itself) would result in a significant beneficial effect. This is not supported by the evidence from the baseline survey (set out in Table 9.9) which found that noise at the henge (monitoring location M10) was 62 dB, whereas traffic noise (as predicted) was 56 dB. This means that, according to their own survey evidence, noise from visitors contributed 61 dB of the overall noise level there. Using their numbers, the change in level from complete removal of the road would be from 62 dB to 61 dB. Referring to their assessment criteria (in Table 9.8), this would represent a "negligible" difference and should have been reported as such and not as "significant beneficial effect". This is an error which has led to an incorrect assessment of effect in this important location, in my opinion.

Tranquillity, assessed within the Landscape and Visual chapter

4.23 Noise and tranquillity are not mentioned in the LVIA methodology presented in Appendix 7.2. However, tranquillity is discussed within this Landscape and Visual Assessment Chapter and noise is one of the factors which is identified as having the potential to affect this. However, the only aspect of noise or sound used to assess its potential impact on tranquillity is the extent to which road traffic is audible. In the section on tranquillity, in paragraph 7.6.82, it is stated that the A303 is:

"… evidently highly visible and audible from close range locations including the Stones".

4.24 Paragraphs 7.9.51, 7.9.52 and 7.9.53 all describe adverse or beneficial effects on tranquillity in terms of a visual and audible reduction in vehicles. The assessment of tranquillity (both existing and changes resulting from the proposal) appears to have been based simply on a field surveyor's subjective opinion into relative audibility and visibility of vehicles on the road.

4.25 I cannot comment with any authority on how the visual presence of vehicles might affect tranquillity. However, since there has been no consideration of the presence of natural sounds, man-made sounds or overall sound level and character and no road traffic noise levels have been referred to when assessing tranquillity within this chapter, tranquillity has not been properly assessed in my opinion.

4.26 Table 7.7 set out how changes to "landform, vegetation and tranquillity" would lead to changes to Local Landscape and Townscape Character Areas (LLCA and LTCAs). This suggests that there would be "large beneficial" effects at a number of sites, including Stonehenge and a "large adverse" effect at the Upper Till Floodplains and Meadows.

4.27 Again, I am not qualified to comment in relation to how changes to landform or vegetation might affect Character Areas but since, in my opinion, tranquillity has not been properly assessed I would question whether the conclusions presented in Table 7.7 are reliable.

Summary

4.28 I can find no evidence within the ES to demonstrate that potential impact of noise on use and enjoyment of locations within the study area which are important for their quiet character or tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason has been properly assessed.

4.29 On the contrary, almost no assessment work has been carried out into this and the comments which have been made are:

- Based on an incorrect and incomplete analysis (within the Noise and Vibration Chapter); or
- Based on a subjective assessment of the likely or actual audibility of road traffic noise carried out by a landscape architect (in the Landscape and Visual Assessment Chapter); or
- Simply assertions, not backed by any evidence (as within the Cultural Heritage Chapter).

4.30 No account has been taken in the assessment work of whether a location may be relatively undisturbed by noise from man-made sources, whether lower levels of sound are present or whether natural sounds are significant. These factors are known to be important for the assessment of tranquillity and are referred to in the various guidance.

4.31 The area over which the assessment has been carried out is not wide enough. There are areas outside of the assessment area which would be exposed by the Scheme to increases in road traffic noise of at least 3-5 dB and these areas have not been considered. It is entirely possible that there may be some locations which would be quiet or tranquil and which have not been considered.

4.32 In the only situation where baseline survey data is reported for a receptor which is not a building, at the henge, it shows that the main source of noise is human activity and not noise from vehicles on the A303. Despite this, this has been incorrectly interpreted to mean that:

- Noise from the A303 is a significant problem at the henge; and
- The change in noise level which would result from the proposal would result in a large beneficial effect at the henge.

Both of these conclusions are incorrect, in my opinion.

4.33 In fact, on the basis of the data supplied within the noise and vibration assessment chapter, the change in noise level at the henge as a result of the proposal would result in a negligible effect.

5.0 Tranquillity Assessment using the Natural Tranquillity Method

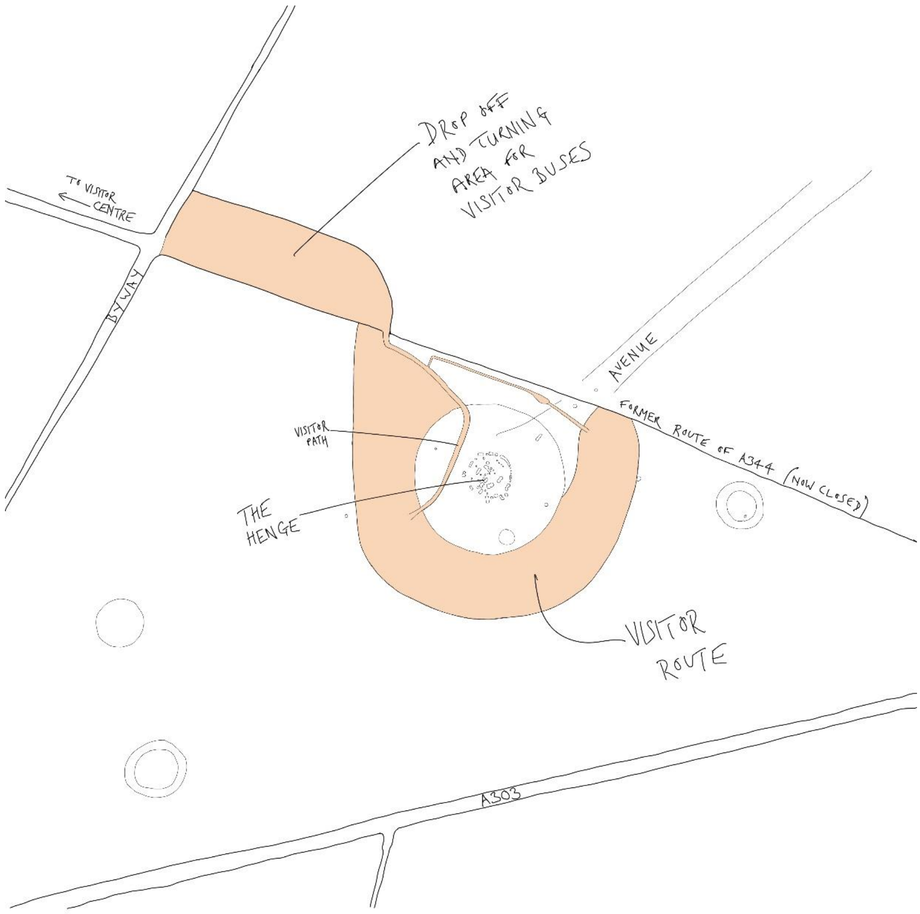
5.1 I visited Stonehenge and its immediate surroundings on two weekdays in August 2017 and carried out a survey. The weather was rather cloudy to begin with on the main survey day but turned sunny later so was considered to be representative of a moderately busy summer day. Whilst on site, informal, unstructured interviews were carried out with a number of members of the public who approached me; English Heritage's Operations Supervisor at Stonehenge (who also approached me to ask what I was doing); and Kate Fielden, Hon Secretary to the Stonehenge Alliance.

5.2 The Operations Supervisor explained that the site was quite busy at the henge area, with around 6,500 visitors on that day but that it would be busier on a sunnier day. Kate Fielden explained her concerns and the reasoning for their campaign. Members of the public mostly asked about the purpose of the survey; however, when asked, "how much do you think road traffic noise affects tranquillity at this site?", the majority of them replied that they had not noticed it.

5.3 Access to the henge is via the visitor centre (where entry tickets must be purchased) followed by a bus ride (or walk) of about 1.5 miles from there to the henge. Once at the site, access is quite restricted, with roped off areas and stewards preventing (or at least discouraging) access outside the designated route.

5.4 Figure 5.1 below shows a plan of the site and immediate surroundings, with the area accessible to the public shown in pink.

Figure 5.1: Plan of Stonehenge and immediate surroundings with visitor access area shown in pink



5.5 There are two areas of the site where visitor density is particularly high, which are the two narrow pathways to the north of the stones and to the west. The path to the west is the closest visitors can get to the stones and the majority of visitors stop here for photographs. These paths get quite congested during the busiest periods and feel busy and noisy because of the people.

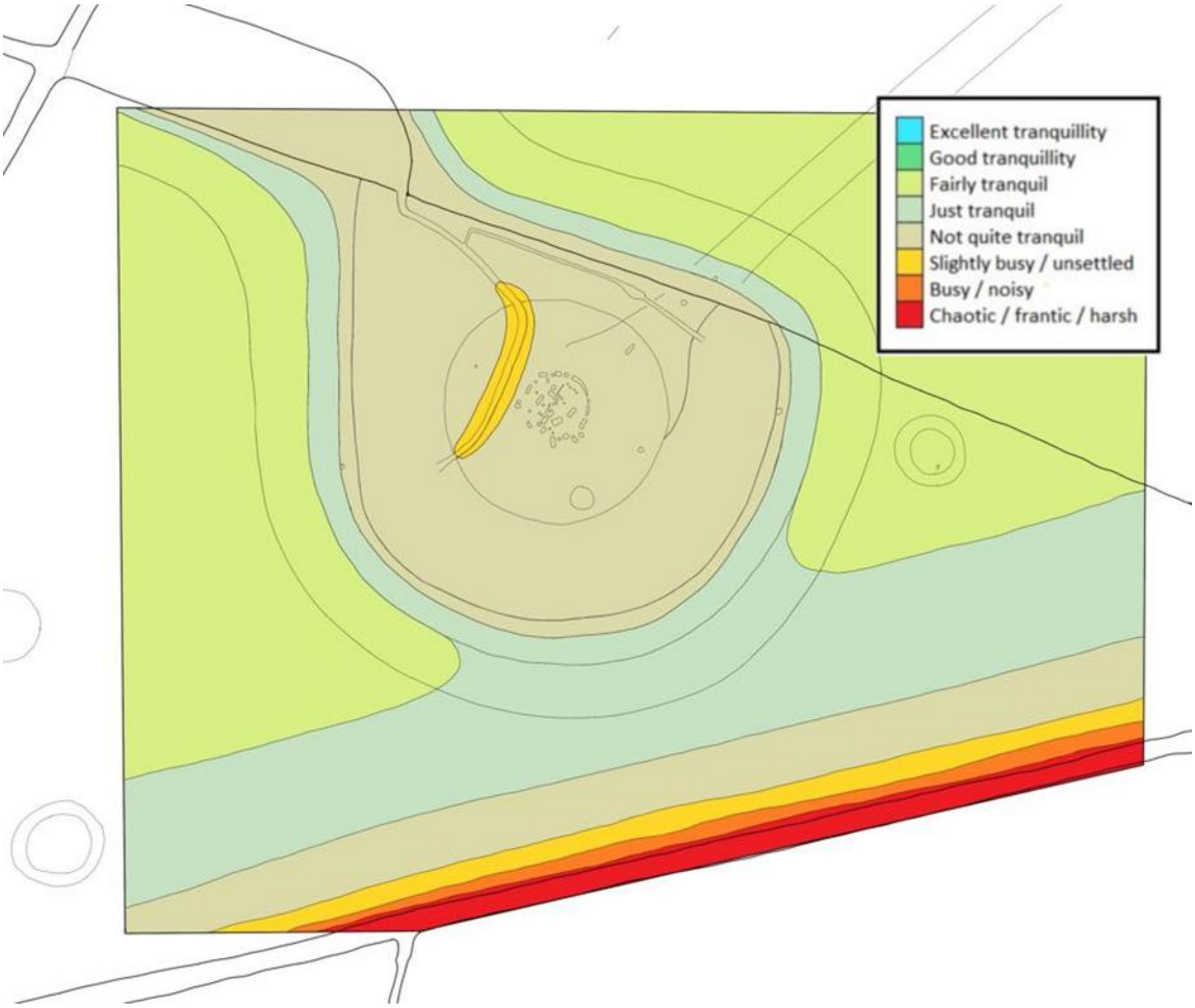
5.6 It was possible to hear road traffic from the A303 constantly all over the site. At the closest publically accessible point to the road, the noise level was around 52 dB and at the furthest (the north western corner) it was around 45 dB. Noise measured around the site was generally between 54 and 59 dB with the noisiest location being along the western path. The area to the far west of the accessible area was the only place where road traffic noise was the dominant source (since there were fewer people here). The noise from road traffic in this location was around 47 dB and the overall level was 48 dB.

5.7 The most significant source of noise on site came from people: their voices and their audio guides. The audio guides were being carried by many visitors and were often set up to play on the speaker so that the visitor and others with and round them could hear the commentary. These guides were constantly present and it was often possible to hear many playing (in a variety of different languages) at the same time.

5.8 The majority of visitors appeared to talk relatively quietly, but on the day of the survey there were many groups of teenage school children visiting who created a lot of noise. There was also some birdsong at times, due to a large flock of birds which settled on the stones for much of the time.

5.9 There was considerably more man made sound than natural sound and very little of the time when man made sound was not present. Road traffic noise (from vehicles on the A303) was surveyed separately and road traffic noise contours were produced to enable a reliable assessment of the L_{RR} parameter. The road was very busy and sometimes congested for most of the day and, according to local news articles, this is normal at this time of year. There were also occasional military aircraft flying close to the site. Survey results were processed to create tranquillity contours for the site and these are shown in Figure 5.2 below.

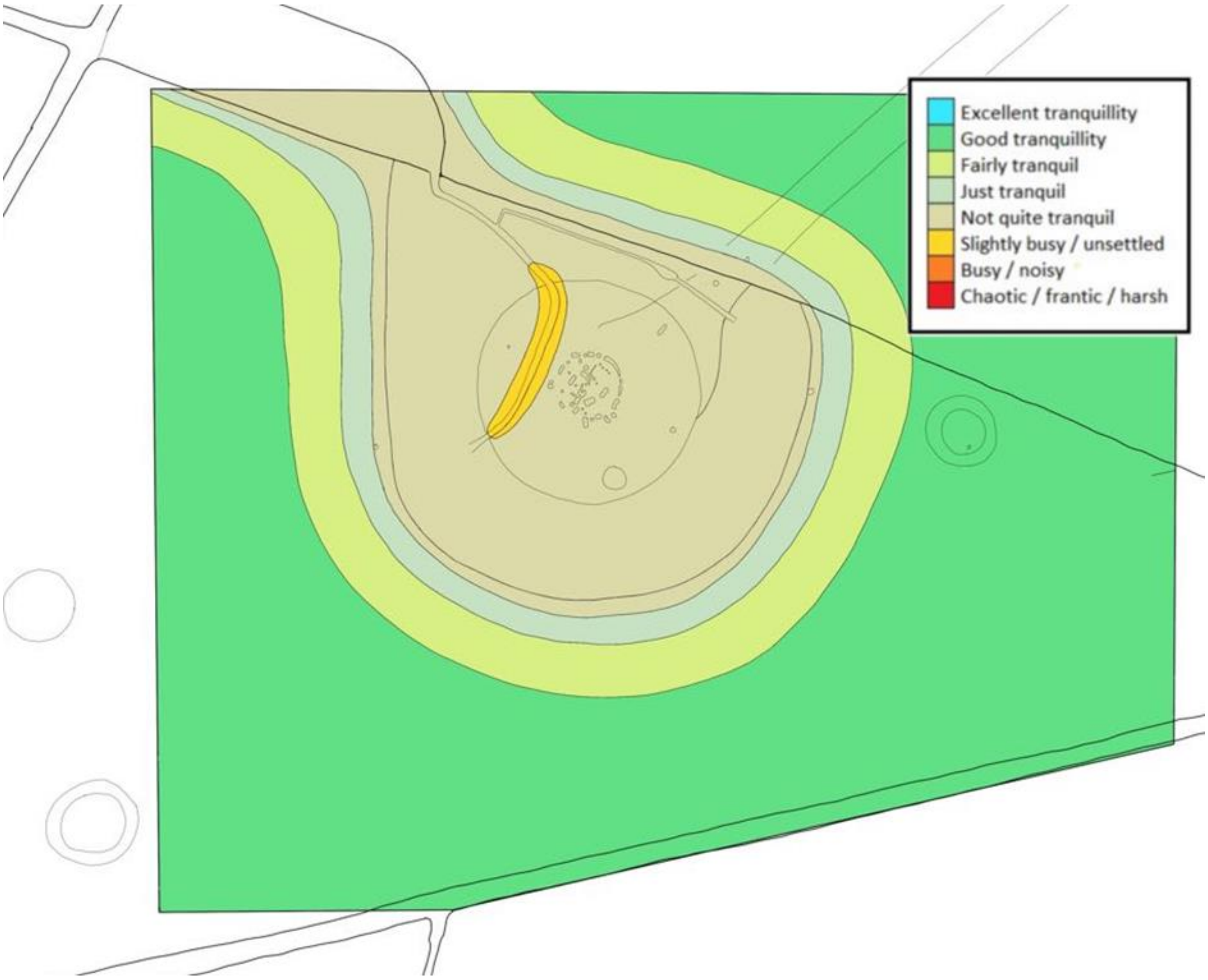
Figure 5.2: Stonehenge tranquillity contours, August 2017



5.10 Virtually all of the accessible site was found to be "not quite tranquil" with the two narrow paths being "unsettled / slightly busy" (occasionally becoming "busy / noisy" when groups of school children were present). This matched my own subjective observations and views expressed by those members of the public who volunteered an opinion.

5.11 The contribution of the road traffic to tranquillity was then removed from the input data and the site remodelled to find out what change in tranquillity would result if the road were removed completely from the environs of the henge. The resulting tranquillity map is shown in Figure 5.3 below.

Figure 5.3: Tranquillity map of Stonehenge with the A303 removed



5.12 This shows that the removal of the road would result in a considerable improvement in tranquillity in the wider area around the henge. However, since the majority of the detriment to tranquillity at the site occurs due to the noise from visitors (and most people seem not to notice the road), removing the road would have very little effect on a visitor's experience of tranquillity at this site. The busy areas would remain busy and the rest of the site would still be "not quite tranquil".

5.13 In summary, the site is not tranquil at present and removing the A303 would result in little, if any, improvement in tranquillity experienced by visitors to the site.

6.0 Conclusions

6.1 Relevant National Planning Policy requires that noise assessments for roads which are Nationally Significant Infrastructure Projects take account of the existing noise sensitive areas and that noise impacts should be assessed not only in relation to sleep disturbance and annoyance but also in relation to the use and enjoyment of areas which are important for their quiet character. Policy also requires that tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason should be protected.

6.2 There is currently no agreed, reliable, published method for doing this, but there is some guidance available which suggests that tranquil spaces are likely to be relatively undisturbed by noise from man-made sources, that lower levels of sound are likely to be important and that natural sounds are likely to be beneficial.

6.3 The noise and vibration assessment for the proposed development does not consider noise effects on quiet or tranquil areas within its defined study area. The only noise sensitive receptors considered which are not buildings are the henge at Stonehenge and Parsonage Down SSSI. These sites are considered without the benefit of relevant baseline survey data and the criteria used to assess impact is wholly inadequate for the purpose. Conclusions reached in relation to the impact on tranquillity at these two locations are therefore unreliable, in my opinion.

6.4 All assessments produced for the developer conclude that noise from road traffic has a detrimental effect at the henge and that the proposed development would result in a significant improvement in noise and tranquillity there. This conclusion is not supported by evidence within the ES. The little evidence which is reported actually demonstrates that there would be a negligible effect, according to their own assessment criteria.

6.5 My own tranquillity assessment, carried out only in the immediate vicinity of the henge, reached the conclusion that the removing the A303 would have little, if any, beneficial effect on tranquillity at the henge.

6.6 The study area is too small and fails to address possible impacts on tranquillity which may be found on the A303 outside of the immediate area of the proposed tunnel. It is quite possible that there may be a number of sites in the area which are currently considered to be tranquil and which may be prized for their amenity or recreational value for this reason. These sites could be adversely affected as a result of the proposed development. However, no work has been reported to have been done to find out whether this is the case and therefore the assessment is incomplete, in my opinion.

Appendix A

Review of Other Assessment Methods for Tranquillity

Review of other published methods for the assessment of tranquillity

Apart from the Natural Tranquillity method, two other approaches have been published: they are referred to here as the "CPRE method" and the "University of Bradford method". There are also some other "one off" methods which have been used for the assessment of tranquillity for a one-off study or at a single site. These are considered in this chapter, with the main focus being on the University of Bradford and CPRE methods.

University of Bradford method

The method developed by the University of Bradford is presented in a number of papers.[1] [2] [3] [4]

The approach considers road traffic noise levels; the presence of landscape features and "moderating factors". It proposes a method for combining these to predict the overall tranquillity of an area, based on an empirical mathematical formula derived from academic research into people's perceptions. As with other research findings, the importance of separating man-made and natural noise is noted, as follows:

> "Tranquillity is often found in natural outdoor environments where man-made noise is at a low level though natural sounds can be at a relatively high level."

The University's research looked at many factors and concluded that a good assessment can be made using just two factors: road traffic noise level and a consideration of the appearance of the surroundings. They state that:

> "Statistically significant factors that have been identified are the noise level (L_{Aeq} or L_{Amax}) and the percentage of natural and contextual features in the landscape."

The researchers used these factors to derive a formula to produce the Tranquillity Rating Prediction Tool or TRAPT. This provides a tranquillity rating number for a given location. The method was developed by scoring people's responses to sounds and landscape appearance in terms of their perceptions of tranquillity and considering the correlation between these and the estimated levels of the factors of interest.

The Tranquillity Rating (TR) for a particular study site can be determined on a Scale of 0–10, where 0 represents "not at all tranquil" and 10 represents the most tranquil. The TR definition was derived following validation exercises and is defined by the equation:

$$TR = 9.68 + 0.041\ NCF - 0.146\ L_{Aeq} + MF$$

where:

NCF = Natural and Contextual Features (this includes natural and man-made features). This is calculated as a percentage of natural and contextual features in a 360^{o} view from the location.

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[1] Watts, G.R, "Towards quantifying the quality of tranquil areas with reference to the national planning policy framework", *Proceedings of the Institute of Acoustics*, Vol. 35, Pt. 1, 2013

[2] Watts, G.R. & R.J. Pheasant, "Identifying tranquil environments and quantifying impacts", *Applied Acoustics* 89 (2015), 122-127

[3] Watts, G. R. and R. J. Pheasant, "Factors affecting tranquillity in the countryside". Applied Acoustics. Vol. 74, No. 9 (2013, pp. 1094-1103

[4] Pheasant, R.J., Horoshenkov & G.R. Watts, "Tranquillity rating prediction tool (TRAPT)", *Acoustics Bulletin* 35(6), November/December 2010

NCF calculations are made over 360°, using continuous photographs taken at a height of 1.5 metres with the lens axis sweeping a horizontal plane. If 'N' is the area with natural features and 'M' is the total area of man-made features, then NCF is given by:

NCF = 100 N/(N+M)

L_{Aeq} = the A weighted equivalent sound level of road traffic noise (although it is understood that this could be adapted to take account of other noise sources) in decibels (and expressed with a time reference period). The reference period has been taken to be daytime, which is defined as the twelve hour period between 07:00 and 19:00 hours.

MF = Moderating Factors: these were added to the formula during development and designed to take into account the presence of litter and graffiti that would depress the rating, or natural water sounds that would improve it. A value of 1 or -1 is assigned due to the presence of enhancing or detracting features, respectively.

Panoramic photos in a wood, ready for an assessment of NCF

Using this formula, the researchers suggested the following scale and descriptors of the calculated TR should apply:

<5	unacceptable
5.0 – 5.9	just acceptable
6.0 – 6.9	fairly good
7.0 – 7.9	good
≥ 8.0	excellent

There are a number of problems when assessing tranquillity using the University of Bradford method, as follows:

1. The method assumes that the presence of other people in a particular location has no effect on people's perception of tranquillity; this means that it is unable to take account of how the tranquillity found at a location might change when there are many or few people present, or due to different types of behaviour those people are exhibiting.

2. The method does not take account of noise sources other than road traffic such as light aircraft, the sound of people shouting and laughing, dogs barking, birdsong, wind in the trees and so on.

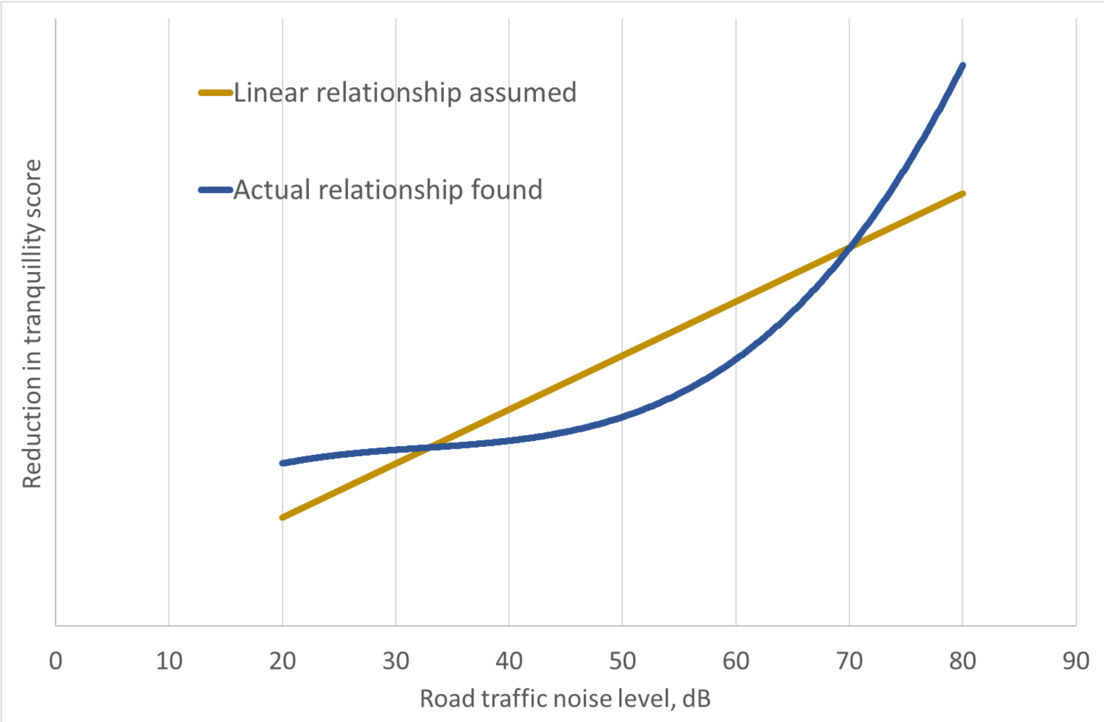
3. The equation used gives roughly equal weight to road traffic noise level and visual appearance. This weighting could not be replicated in field studies undertaken in the development of the Natural Tranquillity Method which found that the visual appearance of a place has a relatively weak correlation with most people's perceptions of tranquillity.

4. The method assumes that the relationship between the independent variables and tranquillity is linear and that tranquillity itself is an ordinal variable. The research carried out in the development of the Natural Tranquillity Method found that this relationship is not linear and that tranquillity scores are better treated as nominal.

5. The method has also been criticised for being easy to "trick". For example, if one were to want to present a site as being more tranquil, one could move the location at which the photographs of the panoramic view were taken by a few metres to take advantage of a natural feature such as a hedge or tree to screen a man-made structure which would otherwise reduce the tranquillity score. Alternatively, if one were to wish to make a location appear less tranquil than it would generally be thought to be, one could drop some litter in front of the panoramic view and assess the location with this adverse moderating factor present.

6. The method assumes that people's response to road traffic noise is linear. Research carried out in the development of the Natural Tranquillity Method has found that this is not the case; people tend to largely "filter out" noise from road traffic so that it has less impact as levels drop below about 50dB and are more conscious of, and feel a greater intrusion from, road traffic noise at higher levels (above about 58 dB). Whilst the CPRE research shows that people in the countryside say that road traffic noise is the single most important factor when considering how tranquil somewhere is, research for the Natural Tranquillity Method has found that, whilst this is true where the area involved is extremely remote and any noticeable human sound would be felt to detract from the otherwise excellent tranquil quality of the place or when road traffic noise is relatively high and dominant, the relationship between road traffic and reduction in tranquillity scores is not linear. The graph in Figure A1 below illustrates the relationship which has been found during research for the Natural Tranquillity Method.

Figure A1: Graph illustrating relationships between road traffic noise impact and reduction tranquillity scores using different methods (the curve is indicative only)



This is not to say that the University of Bradford method is of no use. Although it provides an objectively less reliable assessment method than the Natural Tranquillity Method, it is not affected by seasonal variations or differences in weather conditions. It may also provide a guide for the relative tranquillity which may be found in an area in the absence of people, provided natural sounds are not high enough to mask road traffic and where there are no aircraft or trains. However, given the complexity of most locations and the lack of reproducible findings to support some of the theoretical assumptions of the method, it does not provide a robust assessment of the sort which would be required when producing expert evidence for a legal case or a planning appeal.

The CPRE method

The "CPRE method" is based on research sponsored by the CPRE which led to production of a *Tranquillity Map for England* in 2006. The research was carried out by the Centre for Environmental and Spatial Analysis (CESA) and PEANuT (Participatory Evaluation and Appraisal in Newcastle upon Tyne) project at Northumbria University, in collaboration with Bluespace Environments, Durham and Newcastle Universities. This research built upon earlier research carried out in 2004 which attempted to evaluate tranquillity within the Chilterns Area of Outstanding Natural Beauty (AONB). This study was itself built on an earlier pilot study (also carried out in 2004) which began with a "Participatory Appraisal" seeking the views of people in the Northumberland National Park and West Durham Coalfield in County Durham to find out what factors visitors to these areas believed affected tranquillity.

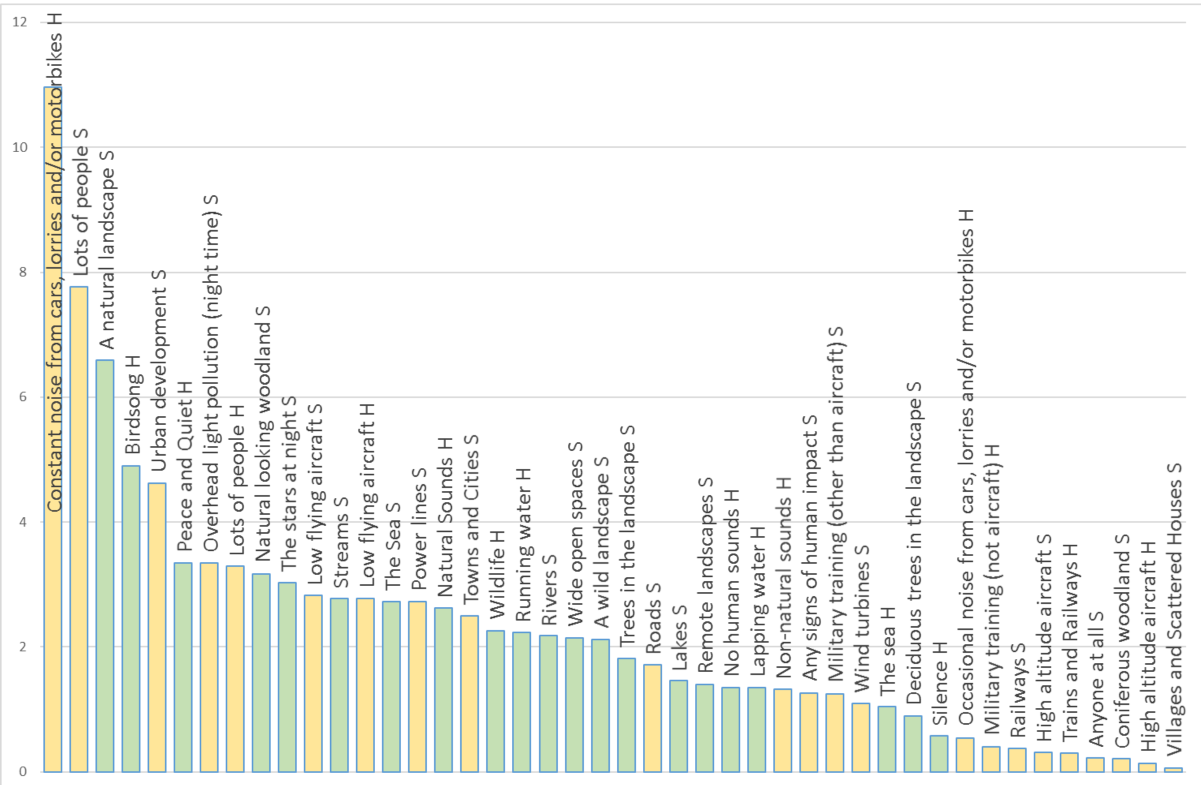
Before 2004, the initial work which pioneered the concept of tranquillity mapping had been carried out by Simon Rendell and others in the 1990s. That work was later criticised for considering the sources of disturbance based solely on expert judgement and for failing to take into account interactions between factors, the influence of local geography and the relative values of the factors considered; in short, it was not sufficiently sophisticated. The research behind the CPRE method in 2004 sought to address these criticisms and to provide a more robust tranquillity map for England.

The work to develop the CPRE method was extensive and provided a valuable database of information about the factors which the people who were consulted described as influencing the tranquillity of a location. The end product, the *Tranquillity Map for England* (published in 2006 and updated in 2011), was an impressive achievement. When the UK Government revised its Planning Policy in 2012, it included a requirement to consider tranquillity in the planning process for the first time: this was largely due to campaigning work by the CPRE whose research and map seem to have formed the backbone of that campaign.

The mapping is produced using a Geographical Information System (GIS); a computer-based system for the integration, analysis, modelling and mapping of geographical data. It uses the Participatory Appraisal (PA) results to identify the significance of different features and then associates these features with nationally available datasets. Predictions are then made of the presence, level or relative presence of each feature based on information within the GIS dataset and these values are then weighted in the analysis (dependent on the PA survey results) to provide a tranquillity score for each 500 x 500 metre square grid.

The features identified and weightings given in the GIS system are shown graphically in Figure A2 below (yellow indicates a negative effect on tranquillity, green indicates a positive effect). The weightings, which indicate the relative importance of each factor are shown on the y axis. The designation “H” refers to factors which affect “Hearing”, and “S” refers to “Seeing”.

Figure A2: Graphical representation of weightings given to features, based on CPRE research



Much useful information can be drawn from the research which led to this method. Without doubt, it was ground breaking and, if it had not been carried out, it is quite likely that there would be no policy requirement to protect tranquillity. Without this research, the Natural Tranquillity Method would not exist and before criticising it, it is important to recognise the extremely useful function which this innovative work has performed.

There are, however, a number of inherent problems and limitations which arise if the CPRE method is used to assess tranquillity on a local scale. Some of the more important of these are discussed below.

1. The method uses a 500 metre grid size, so any area which is less than 500 x 500 metres would be given a single tranquillity value for the whole area. In fact, noise levels will normally vary significantly over such a distance and, since tranquillity is largely a function of noise, such a low resolution renders the method of little practical use for the consideration of most situations for planning or similar purposes.

2. People's response to road traffic noise is assumed by the method to be linear, and this is not a reliable assumption (as discussed above).

3. The only non-natural sounds which are considered are those from transportation sources. A noisy site would not be considered to affect tranquillity if it was screened visually (by a natural tree belt, for example) according to this method. In fact, such a noisy site could potentially have a significant detrimental effect on tranquillity.

4. The method incorrectly assumes that birdsong, wildlife and other natural sounds (excluding the sounds of water and the sea) would only be present where noise from transportation sources is predicted to be low, and it considers low noise areas to be areas which experience a noise level from these sources of less than 25 dB. The method assumes that such low noise areas are places where:

   "… there is an opportunity to hear non-human sounds that would otherwise be drowned out."[5]

   Whilst it is true that one may be able to hear these natural sounds in low noise areas, natural sounds are not only present in areas with very low transportation noise. To consider an example, it is quite possible for a country park to experience noise from birdsong and leaf rustle (due to a light breeze in the trees) at a level of 48 dB and distant road traffic to be producing 36dB. In such circumstances, the CPRE method would predict that natural sound would be "drowned out" and the area would have relatively poor tranquillity. In reality, such a location may feel quite tranquil since the road traffic is probably not audible and the natural sounds around would dominate.

[5] Jackson, S., D. Fuller, H. Dunsford, R. Mowbray, S. Hext, R. MacFarlane & C. Haggett (2008). *Tranquillity Mapping: developing a robust methodology for planning support*, Report to the Campaign to Protect Rural England, Centre for Environmental & Spatial Analysis, Northumbria University, Bluespace environments and the University of Newcastle upon on Tyne.

This may be the single biggest failing of the method since the balance between man-made and natural sounds has been found to be a crucial factor affecting how tranquil a location is likely to be perceived to be.

5. The predictions of noise levels from road traffic are unreliable. Air and ground absorption of sound is considered but no account is taken of local topography or the presence of any structures which might provide screening or reflection of sound. The calculations also assume certain flows and speeds for road traffic and these are likely to overestimate the noise levels from smaller rural roads (in some circumstances quite significantly) as it is assumed that all such roads have 1000 vehicles per day, all travelling at 60 miles per hour. In many rural areas, flows are much lower than this and speeds on smaller country roads will often not reach 60 mph. In such situations, the method will result in a considerable overestimate of the impact of road traffic noise.

6. The methods for assessing the contribution of rail and aircraft noise are unreliable. First, it is assumed that these two sources can be treated in the same way. In fact, it is generally agreed that rail noise is considerably less annoying than road traffic or aircraft noise. Second, the impact assessment for these sources assumes that all aircraft have the same noise level and are audible for two minutes when flying over and that all trains have the same noise level and take 30 seconds to pass a point. In fact, experience shows that the trains having the greatest impact on tranquillity are freight trains, which often take 75 to 90 seconds to pass a point; and that aircraft may have little impact if at high altitude but may have a significant impact at low altitude. Also, using a single value for source noise level is unreliable, since there is considerable variation between noise levels from, for example, a three-carriage suburban passenger train and a fast, inter-city train with 12 carriages. The same is true for aircraft: the differences in impact between a military jet and a propeller driven light aircraft at the same altitude, for example, is very significant.

The CPRE research states the assumption that, when modelling noise from transportation sources,

> "The cut off figure for noise attenuation is 25 (dB), when noise diffusion of a given source has reached ambient noise levels, giving the maximum distance away from which the original noise cannot be heard."[6]

This assumption is incorrect since, in the vast majority of locations around England, ambient noise levels are considerably above 25 dB.

7. The method assumes that the number of people present correlates directly with the intrusiveness of those people. However, the mere presence of people does not necessarily always detract from reported experiences of tranquillity. For example, a group of students quietly studying in an urban park would probably have little negative effect on the tranquillity of the space, whereas the same sized group of students playing football very possibly would.

[6] Jackson, S., Fuller, D., Dunsford, H., Mowbray, R., Hext, S., MacFarlane R. and Haggett, C. (2008). Tranquillity Mapping: developing a robust methodology for planning support, Report to the Campaign to Protect Rural England, Centre for Environmental & Spatial Analysis, Northumbria University, Bluespace environments and the University of Newcastle upon on Tyne.

> Whilst it may be true that wilderness or other countryside areas are generally felt to be more tranquil when others are not present, many people who do not regularly visit or live in the countryside are accustomed to finding tranquil spaces which do have other people in them. Urban parks and gardens are the most obvious example of this. In such spaces, it is not the simple presence of other people which affects tranquillity, but their behaviour.
>
> Surveys carried out in the development of the Natural Tranquillity Method have included observations and measurements at a number of "honey pot" sites within country parks and woodland areas around England and have found a considerable range of behaviours at similar types of site due to the different kinds of visitors who typically frequent them. Urban parks, country parks and woodlands that are full of people, including noisy family groups, are often considered "fairly tranquil" by those who visit them. The work of Liz O'Brien and others[7] has shown that some people need to see and feel the presence of others around them in order to feel secure, before they are able to experience tranquillity.
>
> The CPRE method will over emphasise the importance of the presence of others as a detractor from tranquillity in some situations.

The Participatory Appraisals which were conducted between 2004 and 2006, and established the list of factors, were virtually all carried out in areas that are highly rural. According to the researchers, this approach was,

> "… based around the use of 'participatory appraisal' (PA), an approach to consultation focused on exploring people's perceptions, values and beliefs and designed to allow participants to express these in their own words."[8]

However, since the survey work took place almost exclusively in rural areas, the views expressed by participants may not be representative of the UK population as a whole.

The additional surveys carried out in 2006 took place at a range of rural locations, with sites being selected, as follows:

> "Map based surveys were conducted to locate a range of types of sites at which large numbers of countryside users might be expected. These included visitor attractions, Areas of Outstanding Natural Beauty, Country Parks, Greenways, National Trust properties and privately owned houses and gardens, wildlife reserves and car parks and other sites linked with countryside use (for example those owned by the Forestry Commission)."[9]

CPRE researchers set out to canvass the views of users of the countryside. The answers given and weightings applied may therefore provide a reliable survey of the opinions of people who live in and visit the countryside. They do not necessarily reflect the views of the remainder of the population.

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[7] "Health and Well-being: Trees, Woodlands and Natural Spaces - Outcomes from expert consultations held in England, Scotland and Wales during 2002" (published by the Forestry Commission)
[8] Jackson, S. et al., op. cit
[9] Jackson, S. et al., op. cit

The reason that this may be important and may mean that the results cannot be applied reliably in areas other than the countryside is that many of the most important things people said needed to be present in order for a location to be described to be tranquil are not present in a city where there are few open views and no wild landscape. Also, in cities there is almost always some road traffic noise; there are almost always people present; there is, by definition, "urban development" all around and many other features which detract from tranquillity according to the views of those participating in the study. Nevertheless, you can visit many locations within cities and busier country parks which people say they value for their tranquillity.

Thus, although the CPRE approach provides a useful means of identifying relative tranquillity across England, it is not so helpful for identifying how individuals will experience (or report) particular places.

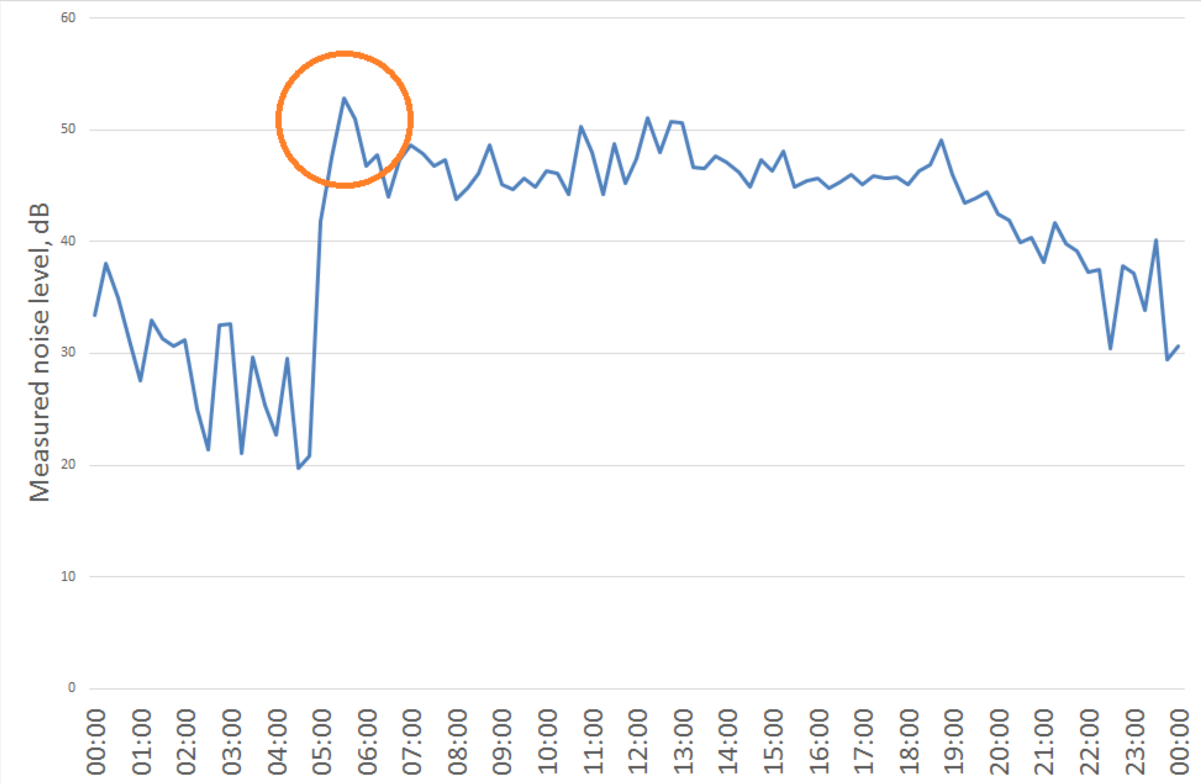
T3 A note on birdsong

The presence of birdsong was identified in the CPRE research work as the second most important sound feature affecting perceptions of tranquillity (after hearing road traffic). Any method which does not account properly for this is unlikely to be reliable.

According to author Julian Treasure, there are three sounds which are beneficial to our well-being: wind, water and birdsong. He points out that the presence of birdsong is an indicator (often at a subliminal level) that we are safe. When danger approaches, birds will fly away, so when we can hear birds singing, we feel secure (without necessarily realising why). No academic research has been identified to support this, but the premise appears sound. Julian Treasure says that recordings of birdsong have been used in airports to provide a calm, relaxing environment; and that installing speakers relaying birdsong along a main street in the city of Lancaster in California has been claimed by the local politicians to have led to a significant, measurable reduction in crime.

Birdsong is often quite "loud". Professional environmental noise consultants must be careful to take account of the dawn chorus, particularly in summer, as it can significantly change the measured night time noise level.

Figure A3: Graph showing measured sound levels (L_{Aeq}) over a day in a quiet village in Essex. Values on the x axis are hours – the dawn chorus appears is circled in orange



The graph above shows a survey of noise levels on the edge of a quiet village in Essex, on a Sunday in April 2015, at a location which was very well screened from road traffic noise. The dawn chorus appears at about 5.30 in the morning, causing a 15-minute average noise level of 52 dB at that time. Birdsong was the dominant sound source throughout the remainder of the day, resulting in levels typically between 45 and 50 dB.

In many locations in the UK, including many urban sites, birdsong will mask (at least partially) other non-natural sounds and for this reason it is very important that it is included in the assessment of tranquillity. A recent study found that birdsong effectively masks road traffic at lower sound levels (which it describes as <52.5 dBA), stating that,

> "Adding birdsong can indeed increase the naturalness and pleasantness of the traffic noise environment at different distances of the receiver from a road." [10]

[10] Yiying Hao, Jian Kang, and H. Wörtche, "Assessment of the masking effects of birdsong on the road traffic noise environment" The Journal of the Acoustical Society of America 140, 978 (2016). https://doi.org/10.1121/1.4960570

Applying the CPRE approach

Mapping of some areas using CPRE methods has been carried out and reported on at Cranborne Chase and West Wiltshire Downs AONB, the New Forest National Park and at the South Downs National Park. It is worth noting some of the comments made within the reports for these studies.

Cranborne Chase and West Wiltshire Downs AONB "ground truthing"[11]

In 2010, the Cranborne Chase and West Wiltshire Downs Area of Outstanding Natural Beauty (AONB) Office released a report[12] which described a study carried out in the preceding years in the AONB, attempting to find out how well the CPRE method worked "on the ground". A number of volunteers were asked to visit locations around the AONB and record what they actually saw and heard. Their response scores were compared with the scores which the CPRE method predicted.

The study found that, although there was some correlation (particularly at the extreme values of high or low tranquillity), there were a number of significant discrepancies where the CPRE method did not match what was found in the survey. It was found, in relation to rivers, streams and lakes, that

> "… unless the water source was particularly large, or you were right next to it, it was difficult to hear."

In relation to low noise areas, the following was reported:

> "This is the factor for which there is by far the greatest differences. For the surveyed data, this factor has the greatest influence on positive tranquillity, whereas for the recorded data it rather strangely scores zero for every square. The definition for this factor is 'Hearing natural sounds - i.e. Hearing birdsong, wildlife, no artificial or human sounds. Distant agricultural noises. Includes hearing silence.' It is therefore reasonable to expect this factor to have a strong influence in an Area of Outstanding Natural Beauty."

And in relation to other non-natural sounds:

> "It is worth noting the occurrence of 'Hearing – low flying aircraft' and 'Hearing – non-natural sounds' for the recorded negative factors. These have a low weighting value and therefore do not score highly overall, but do appear consistently. The non-natural sounds values apply to sounds such as distant artillery, and the low flying aircraft include military helicopters and jets; reflecting the proximity to Salisbury Plain.
>
> Surveyors also noted other non-natural sounds which were prevalent, described by surveyors as being made by automatic detonations of crow-scarers, tractors and farm machinery and lawnmowers in distant villages."

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[11] "Ground truthing". According to Wikipedia, "The collection of ground-truth data enables calibration of remote-sensing data, and aids in the interpretation and analysis of what is being sensed".

[12] *Cranborne Chase & West Wiltshire Downs Area of Outstanding Natural Beauty, Tranquility Mapping Ground Truthing Methodology & Interim Report*, 2010.

Overall, the study concluded that the CPRE method gave the following factors too much weight:

> Seeing the Stars at Night; Seeing a Natural Landscape; Hearing Running Water; Seeing Streams and Rivers; and Seeing and Hearing Lots of People; and gave the following factors insufficient weight:
>
> Hearing Low Noise Areas; Seeing Urban Development; Seeing Overhead Pollution.

The failure to give natural sounds (included in "low noise areas" within the CPRE method) sufficient emphasis is consistent with the points made in point 4 above. Scoring "seeing a natural landscape, hearing and seeing running water, streams and lots of people" too highly is also as predicted by research for the Natural Tranquillity Method.

New Forest National Park Tranquil Area Mapping, 2015

The New Forest National Park commissioned a mapping exercise in 2014, which included ground truthing and did not use the CPRE method published in 2006, preferring instead to use the CPRE's 1996 approach, despite acknowledged criticisms. In relation to the more recent CPRE method the National Park felt that:

> "… these new maps of tranquillity failed to capture some local significant effects on Tranquillity, and in the New Forest the positive effects of the natural land cover 'dilute' the negative effects from significant roads (particularly the A31 which cuts through the National Park) making the resulting map less meaningful on a local scale."[13]

The fact that the CPRE method is unable to capture the positive effect of natural sounds is likely to be the main cause of this.

The South Downs National Park Authority Tranquillity Study, 2017

The 2017 South Downs National Park Authority report[14] sets out the results (to date) of the first phase of their survey work which aimed to map relative tranquillity within the national park using the CPRE method, adjusted to apply to the South Downs (rather than to England). The study has produced a map which the Authority says represents relative tranquillity within the Park's boundaries well, and it believes should provide a good foundation for further work. It is intended to use this and subsequent maps to inform planning decisions in future.

Some interesting points are mentioned in the report. It describes the difficulty of obtaining an idea of the view which may be present at a location where the view is partially obscured. The report says that where its surveyors,

> "… were stopped on a footpath with hedges each side, they might struggle to be able to properly assess the range of factors that influenced the whole survey plot."

Research for the Natural Tranquillity Method suggests that variations in the natural landscape have little, if any, impact on perceptions of tranquillity. It is seems likely that, had the surveyors moved away from these hedgerows, they would not have found a significant change in tranquillity.

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[13] *New Forest National Park Tranquil Area Mapping*, prepared by Land Use Consultants London for New Forest National Park, 2015

[14] South Downs National Park Authority, *Tranquillity Study,* 2017

In relation to the initial outputs, the report states:

> "Results so far indicate that the areas that are most susceptible to change are to a degree more tranquil than the original CPRE desk based study suggests."

Again, since the CPRE method is not able to properly account for the positive effects of natural sounds on perceptions of tranquillity it is to be expected that it will underestimate the tranquillity in many circumstances, particularly in areas where natural sounds are dominant and high levels of tranquillity may be present.

The CPRE method in summary

The CPRE maps for relative tranquillity across England have provided a helpful tool for identifying areas where the most tranquillity might be found. However, the process of turning the vast amount of data they used into these maps necessitated some significant assumptions and generalisations that do not (and, in fairness, do not claim to) give a great deal of reliability for specific locations. A result of this is that all cities and larger towns are uniformly classified as not at all tranquil and all areas which are remote from urban development and roads and which have pleasant views are classified as having relatively good tranquillity. Whilst this is a reasonable generalisation, local sources of noise in rural environments and areas of tranquillity within towns are hidden and this means that the maps cannot be used as more than a rough guide.

Other methods

There are a few other approaches which have been taken to try to assess tranquillity for "one off" projects such as that used by Red Kite Environment when considering tranquillity in Cannock Chase Area of Outstanding Natural Beauty, and that used by consultants at Scott Wilson when considering tranquillity in Westminster Parks in the Westminster Open Spaces Noise Study in 2008. It is interesting to note some of the similarities and differences found in them.

Both of these approaches found that the presence of nature enhanced tranquillity and that man-made sound detracted from it. Lower noise levels were also recognised in both as being beneficial for tranquillity.

However, there were some differences between the factors these two studies rank as most and least important for the assessment of tranquillity. Whereas the AONB study (conducted in a rural area) reports that the presence of people contributed negatively to tranquillity (and that solitude was desirable), the central London study did not identify presence of people as a negative factor unless those people were asking for money or using mobile phones. Also, in the rural location, people ranked "quiet" as the single most important beneficial factor, whereas in central London "hearing complete silence" actually featured as a negative factor.

Conclusion

None of the methods described above is capable of providing reliable, high resolution maps of how tranquil a location is felt to be.

Appendix B

Details of the Natural Tranquillity Method

How to use the Natural Tranquillity Method

In order to use the Natural Tranquillity method, a good understanding of four elements is required: the parameters, the site, the data and the way to report findings. This is therefore presented in the following four parts:

1 The parameters – The surveyor will need to be thoroughly familiar with these and practiced in using them;

2 Understanding the site – Initial research; the more detailed the knowledge about the site, the better. This will include reviewing the opinions of others, as far as is possible;

3 Obtaining the necessary data – This requires field survey work and a prediction of typical road and rail noise around the site. Survey work needs to be carried out in accordance with this guidance in order to produce reliable, repeatable results. Once obtained, the results will need to be processed and moderated taking into account the knowledge gained during the initial research; and

4 Mapping and reporting – The end goal of the assessment is to produce a tranquillity map for the purpose of communicating data efficiently and effectively. Again, this process needs to be carried out in a reliable, repeatable manner.

1. The Parameters

NAMM and PONS

NAMM, the relative levels of natural and man-made sound, is recorded according to Table B1 below:

Table B1: NAMM values

NAMM parameter value	Description
1	All or virtually all sound is from man-made sources
2	Sounds are mainly from man-made sources but natural sounds are also present
3	Natural and man-made noise sources contribute equally to the overall sound level
4	Sounds are mainly from natural sources but man-made sounds are also present
5	All or virtually all sound is from natural sources

Note: “Man-made” sounds include noise from items or animals brought to (or near to) the location by people, so would, for example, include noise from dogs or radios.

PONS is recorded as the percentage of time when you can only hear natural sound. Silence (or absence of man-made and natural sounds, as defined here) is considered a “natural sound” contributing to the PONS value.

When scoring NAMM and PONS, follow the additional rules set out in table B2 below and estimate the value over a 12 hour day (from 07:00 to 19:00 hours). Atypical events (which occur when the circumstances found at or near the site are different to those normally found) should be excluded from results altogether.

Table B2 NAMM and PONS rules

Rule	Topic / situation	Rule
NP1	Road traffic and rail noise	Other than where rules NP2, NP3 or NP4 below apply, when assessing PONS and NAMM values, noise from road traffic and rail must be disregarded.
NP2	Road traffic noise continuous and dominant, defined as: • Where RTN is > 50dB **and** • RTN > (All other sources + 4dB),	Score NAMM = 1 and PONS = 0
NP3	Road traffic is continuous and significant (where RTN is within 3dB of the total measured level)	Record PONS as 0 and if NAMM would be 5, record NAMM as 4 (otherwise record NAMM as normal).
NP4	Rail noise dominant, defined as: • Where rail noise > 56dB **and** • (Rail noise – 6) > (All other sources + 4),	Score NAMM = 1 and PONS = 0
NP5	When recording sound from aircraft, boats, or occasional vehicles passing	For all such events, record using NAMM and PONS.
NP6	Where the overall background noise level is relatively low, distant sounds are more readily audible. In such circumstances, where one can clearly hear a distant man-made sound (such as children playing, dogs barking or aircraft flying over) but where these sounds do not affect the overall L_{AT} by more than 1dB	Record NAMM = 5 and reduce PONS by the amount necessary to account for proportion of time for which the source is present.
NP7	Continuous, low noise level man-made sound (such as a fan or motor in the distance running continuously but which is only noticeable when listening carefully)	Ignore for the purposes of NAMM and PONS and include as part of the L_{RR}.
NP8	Where there is very little man-made or natural sound (such as may be found within a courtyard area).	Record the percentage of time when there is "silence" (i.e. the absence of sounds other than road traffic or rail noise) as a "natural sound" within PONS.
NP9	Where man-made sounds are intermittent, sudden sounds but occur continuously such as hammering or dog barking.	Whenever a non-natural sound of this type occurs in any given minute, then the PONS value for that minute should be 0%.

Road and rail noise – the L_{RR} parameter

The assessment of road traffic noise and rail noise is a subject which is covered in many other texts and so the approach to calculating these levels is not described in detail here.

For road traffic, ideally, levels around a site should be predicted using road traffic flow information (number, type and speed of vehicles) fed into a computer model enabling noise propagation to be calculated taking into consideration local topography, screening, wind conditions, ground and air absorption of sound. This is not always possible in practice, however. When assessing a site it is important to try to assess the contribution of road traffic noise by measurement either to validate the model or because no modelled values are likely to be available. When it is not possible to predict levels by modelling or calculation, the rules in Table B3 below should be followed.

Table B3: L_{RR} rules

Rule	Situation	Rule
RR1	Road traffic noise levels can be heard clearly without interference from other sounds for much of the time.	Measure directly, removing any other sounds from the measurement.
RR2	Road traffic noise levels are fairly steady but can only be heard when other sounds are not present and this may only occur from time to time	Measure directly with care – noting the road traffic noise level when no other sounds are present.
RR3	Where there is a busy road at a distance of more than 100 metres	In this situation, it is particularly important to model RTN if at all possible for typical conditions, bearing in mind the prevailing wind direction. If modelling this is not possible, then measurements must be made with a range of wind conditions and typical levels established with reference to this information.
RR4	Road traffic noise cannot be heard due to masking by other sounds such as may occur, for example, in a busy pedestrianised town centre or a park where there are sounds from other sources	Either a use value which is 10dB below the minimum measured noise or 40dB, whichever is the lower.
RR5	In a rural location, where road traffic noise is inaudible due to being too far away to hear or very well screened and with low flows of vehicles	Use 15dB as value for RTN.
RR6	Where road traffic flows are low, so less than one vehicle per minute.	Road traffic noise level should be recorded as 15dB and the impact of vehicles should be considered in the same way as aircraft or boats (see below)
RR7	If the level of road traffic or railway noise is determined (by calculation) to be below 15 dB.	Record L_{RR} as 15 dB

Rail noise can be predicted by modelling using information about train types and numbers. In practice, however, specific data about train and carriage/wagon types may be difficult to access/utilise. It is therefore often calculated by measuring the level of noise from different train types as the single event level, L_{AE}, at a particular distance, adding up the contribution from each type depending on the number of trains which run in a typical day, then correcting for attenuation with distance and other factors which affect sound propagation, as appropriate to calculate an average level for the period of interest; in this case, generally, a 12 hour day. The approach to doing this is set out in other acoustics texts, so is not reproduced here.

In order to obtain a value for L_{RR} for sites where both road and rail noise is present, the road traffic noise (RTN) should be logarithmically added to (the level of rail noise (RN) - 6dB) over a 12 hour day between 07:00 and 19:00 hours using formula:

$$L_{RR} = 10 \times \log [10^{(RTN/10)} + 10^{((RN-6)/10)}]$$

Using the L_{RR} parameter for other sound sources

The L_{RR} parameter was designed use for assessing the contribution of road and rail noise, but it has been also found to be useful for one additional type of sound source. Occasionally, where there is a continuous, distant man-made sound such as a fan or motor which is only noticeable when listening carefully, this should be logarithmically added to the L_{RR} parameter without the application of any correction.

The L_{AT} – the corrected overall measured level

This is derived from the measured L_{Aeq}, which may be modified according to certain rules in certain conditions. The L_{Aeq} should be measured using a type 1 sound level meter, calibrated, with an appropriate wind shield. All measurements should be taken in a free field location at a height of around 1.5 metres above ground. Meteorological conditions should be suitable for the measurement of environmental sound.

The L_{AT} value used will, in general, be an estimate of the L_{Aeq} value which would be measured over a typical 12 hour day at each location. Reliable spot checks will normally be sufficient for this and the value to use for L_{AT} will simply be the measured L_{Aeq}, with two exceptions:

Exception 1:

When train noise is present, this needs to be removed from the measurement and then added back in. When adding its contribution back into the assessment to obtain the effective "with train" L_{AT} value, the corrected train noise must be used rather than the actual train noise.

L_{AT} = Measured L_{Aeq} (without trains) + (Train level - 6).

The subtraction is arithmetic but the addition of levels is logarithmic.

Exception 2:

If the survey location is within 25 metres of an active playground regularly containing children shouting and screaming, then a 5dB penalty should be added (arithmetically) to the measured L_{Aeq} value to account from the impact of this type of sound. In these circumstances,

L_{AT} = Measured L_{Aeq} + 5dB (arithmetic addition).

If a location has both an active playground and train noise present, then both corrections would need to be applied, with the playground correction being applied first.

2. Understanding the site

Before beginning survey work, it is suggested that three key steps need to be undertaken, which are:

1 Carry out consultation with the local planning authority and other key stakeholders about the relative importance of tranquillity of the site and its surroundings; the key features which contribute to this tranquillity and the location and extent of these features.

2 Review and critically evaluate any existing surveys of site users or other relevant data sources. Consider changes that have occurred since the previous surveys.

3 Visit the site and identify suitable survey locations required to adequately characterise and map the site and surroundings bearing in mind the following:

- How tranquil is the area considered to be and how important is this tranquillity? Is it of national, regional or local significance? Has the location or its surroundings been designated as having a quiet character within a Conservation Area, Area of Outstanding Natural Beauty (AONB), National Park or Local Green Space?
- What are the key features or areas of the site / area which are considered to affect tranquillity or which have been identified as being tranquil or sensitive to change and where are these located on or near the site?
- What is the spatial extent of the area to be considered?
- What are people's expectations when visiting, working or living in the location? (i.e. will they be expecting virtually no man-made sound or will they be expecting some continuous noise, such as that from distant road traffic, to be present?)
- If considering the potential impact on tranquillity from a proposed development, what are the other potential health and wellbeing benefits or detriments which might occur as a result of that development? Would the development have the potential to provide a beneficial impact, for example, by encouraging greater use of an existing tranquil space and thus an overall improvement in well-being for more people? Conversely, would the development result in other detrimental impacts, such as air pollution or odour which may reduce overall well-being locally?
- Which parts of the site are accessible? Which parts of the site do most people use? At many sites there are some areas which are well used and other areas which, whilst open to all, have very few visitors (for example, because they are far from any visitor car park). It is necessary to understand the patterns of use of a site.

Considering these points will help the assessor to understand how significant any changes to the tranquillity score might be and to ensure that survey work is focussed on key areas. It will also provide information to help determine the extent to which a location is considered to be relatively undisturbed by noise and may be prized for its recreational or amenity value for that reason.

A review of local authority policies and statements may reveal many of the answers to these questions. It may also be helpful to carry out a survey (e.g. a questionnaire or focus group) of existing users of the site or area, where this is feasible, whilst bearing in mind that most people will tend to "overrate" places which are special to them.

3. Obtaining the necessary data – the field survey

This involves carrying out a survey to assess and record values of the indicator parameters around the site. When doing this, it is helpful to note details of all noise sources, observations of people's activities and estimates of sound level contributions from natural sounds (wherever this is possible). Levels of any other sounds which can be estimated should be recorded whilst noting the overall measured L_{Aeq}, NAMM and PONS parameters. Whilst carrying out the survey, if aircraft or train noise is present at levels and for a proportion of the time which has the potential to affect the tranquillity score, then these levels will need to be assessed. Road traffic noise will also need to be assessed either by collecting data for modelling, such as traffic counts or by measurement, according to the rules above.

The scope and extent of survey work will depend on resources available but will generally need to involve a review of the site for a minimum of two days to represent different site conditions. These two days should be selected to represent a typical busy day (such as a weekend or a weekday during school summer holidays) and a typical quiet day (such as a week day during school term time). For small sites this may be achievable with a small team of surveyors over just two days, but for larger sites, a larger team and additional days may be required. A site map should be studied to provide an outline of the extent of the area to be surveyed prior to arriving at the site.

Weather conditions and seasonality should also be considered. Survey conditions should be suitable for the measurement of sound levels, as set out in other guidance and standards[15]. Seasonality can also affect the way that a site is used and the presence or absence of certain noise sources. Survey work during winter months will often be difficult, since weather conditions are poor; there will usually be fewer people present than during the rest of the year and there may be less natural noise from wind in the trees, due to the absence of leaves. Also, if there is any water flowing, this will tend to produce more noise than during other seasons so winter conditions may not be typical of the rest of the year. Of course, if the use of the area during winter is a key consideration, then surveying at that time would be appropriate, bearing in mind how the noise may change during other seasons.

Site survey work should generally begin with a familiarisation tour of the site to identify the number and location of survey points needed and to note any relevant features which were not apparent from desk based research. This will normally be informed by consultations and research undertaken prior to the site visit but changes may need to be made once on site due to local conditions. It will be important to note if there are any variations which might exist to noise levels or appearance due to short term events (such as agricultural work or grass mowing) or weather (for example, if there are more distant sounds whose propagation may be dependent on the wind direction).

[15] Such as British Standard BS 7445 "Description and Measurement of Environmental Noise", Parts 1 and 2

The survey team will need to visit each survey location within the site at least once, and ideally twice on each survey day for a minimum of 15 minutes to measure sound levels and make observations. In this fifteen minute period, notes should be made to describe:

The various noise sources present (including an estimate of their contribution to the measured L_{Aeq}, where this is possible);

- the observer's estimate of the NAMM and PONS values (discussed above);
- an estimate of the typical level of sound from natural and man-made sources, where possible;
- the presence of any other unusual, non-acoustic factors which have the potential to affect perceived tranquillity, where such factors are not transient; and
- An estimate of road traffic noise level and the measured L_{Aeq} for the period.

It may also be helpful to note the number of people encountered at the survey location (along with some details of their activities: cycling, walking quietly, playing loudly, dogs barking etc), as this may aid subsequent interpretation of data.

Where noise events take place which may not to be representative of the "typical" environment, the event should be recorded and the survey should be repeated when the untypical event has stopped. An example of this may be an emergency vehicle sounding its siren as it passes, resulting in noise levels which are higher than normal. If there are a number of "atypical" events, it may be worth considering if there is an extraneous factor causing or contributing to them and, if so, whether they need to be incorporated within the survey data. For example, it might transpire that the site is close to the local hospital and therefore emergency sirens are typical of the local noise environment. It may be necessary, in some circumstances, to return to the site on a different day to avoid some atypical sources which last for longer (for example road works).

Dealing with aircraft, trains, boats or roads with very low flows of vehicles

If the site has no audible aircraft, trains or other similar sources (such as occasional vehicles passing) or if these sources are present but make no difference to the overall measured level (for example, as may occur in a city centre) then these events can be ignored. However, when ambient sound levels are low (as is often the case in rural locations) these sources may be more audible and therefore have more of a potential impact on tranquillity. Trains, boats and other occasional vehicles generally run on a predictable route whereas aircraft will frequently cross the area of interest at different heights, going in different directions and at a range of distances from the site. Noise from trains can be simpler to calculate than noise from other events, since it is generally possible to obtain timetables and use these for predicting numbers over a typical day; reliable information of this sort is more difficult to obtain for other types of events.

Events which take place on a predetermined route (such as a boat on a river) will only be likely to influence NAMM values near to that route. Provided that NAMM and PONS scores are determined for a representative period at locations close to these routes, their contribution will be properly included in unprocessed survey data. However, train noise needs to be dealt with using the L_{RR} parameter, so must be assessed separately and aircraft noise also needs separate consideration due to its wider range of potential levels and spatial spread of impact.

There are two practical ways to separate out rail and aircraft noise from other sounds at a site. The first is to use a sound level meter which runs continuously but which has a function which enables each source type to be coded (so that the contribution from each source can be subsequently evaluated); the second is to use two sound level meters and when a train or aircraft passes, pause the first meter and measure the event level on the second meter, restarting the first meter once the event is complete and recording the results from each separately. The first option is much simpler in practice.

Whichever way is chosen some post processing is required to separate out levels from rail or aircraft noise. Once separated, the contributions from aircraft or rail noise can be added back into the assessment. The method for processing data from each of these sound sources is described below.

Adding aircraft noise into the assessment

Aircraft noise tends to affect a much wider area than other event noise. The approach to the assessment of aircraft noise will depend on how frequent, predictable and loud the events are. Unlike with other sources of noise, aircraft will often affect the whole site (or at least a large part of it), and their presence is not readily predictable. This will mean that some locations within a site might happen to experience several aircraft in a 15 minute survey period whereas others might not experience any, by random chance. One cannot, therefore, use the observed NAMM and PONS for each survey location as this would not provide a reliable picture of the impact of aircraft over the site over a day. At larger sites, therefore, it is necessary to record the contribution from aircraft to the NAMM and PONS separately and then, at the end of the survey, to add their impact back in over the site as a whole.

Sometimes, high altitude aircraft will be audible but will not result in a change to the measured level. Where this occurs, the NAMM would remain the same as if there were no aircraft but the PONS must be reduced to account for their presence. This is considered in Example 1 below:

Example 1

At a site where there are high altitude aircraft audible for 40% of the time over the day but their sound does not affect measured levels by any discernible amount, these would not affect the NAMM score and they would reduce the PONS score to 60% of its “without aircraft” value. Table B4 below shows the values which would occur at four imaginary locations with NAMM and PONS scores assumed without aircraft as shown in columns 2 and 3 and the resulting values with aircraft in columns 4 and 5.

Table B4: Estimated values for Example 1

Location	NAMM without aircraft	PONS without aircraft	NAMM with aircraft (no change)	PONS with aircraft
1	5	98%	5	59%
2	4	92%	4	55%
3	3	70%	3	42%
4	4	60%	4	36%

However, wherever the contribution from aircraft produces a change in the overall measured level, NAMM scores will also need to be adjusted to take account of this. Table B5 below shows the recommended approach for assessing NAMM scores from aircraft, using measured values rather than by observation.

In this table, L_{NA} denotes an estimate of the value of $L_{Aeq,\ 12\ hours}$ from natural sound only and L_{MM} denotes an estimate of the value of $L_{Aeq,\ 12\ hours}$ from man-made sound including aircraft noise (but excluding road and rail, as normal).

Table B5: Relationship between natural and man-made sounds to use when considering aircraft contributions to NAMM scores (or when considering new proposals)

NAMM Value	Levels of Man-made and Natural Sound
1	$L_{NA} < (L_{MM} – 10)$
2	$(L_{NA} + 4) < L_{MM} < (L_{NA} + 10)$
3	$L_{NA} = (L_{MM} \pm 4)$
4	$(L_{NA} + 4) > L_{MM} > (L_{NA} + 10)$
5	$L_{NA} > (L_{MM} + 10)$

A more complex example is shown as Example 2 below:

Example 2

In this example, a site has been estimated to have a total of 35 light aircraft flying over it at low altitude in a typical 12 hour day and the average event level for these has been estimated from measurements around the site to be 71dB, L_{AE}. At the same site, over a typical day there are estimated to be 130 high altitude passenger aircraft passing over with a typical event level of 60dB, L_{AE}. In total, light aircraft are estimated (from observations) to be audible at the site for 6% of the time and high altitude aircraft are audible for 23% of the time. For the purpose of this example, road traffic and rail noise are assumed to be inaudible, so L_{RR} would be 15dB, according to rule RR5 above.

To consider how the aircraft would alter the NAMM and PONS scores at five locations around the site, it is necessary to estimate the sound level from natural and man-made sounds. This can be achieved using four sources of information for each location:

- The overall measured L_{Aeq};
- The NAMM value recorded;
- PONS value recorded; and
- Notes on observations made.

In this example, the relevant data is as shown in Table B6 below:

Table B6: Values assumed in Example 2 (without aircraft)

Location	L_{Aeq},dB	NAMM	PONS	Notes (excluding notes on aircraft, and ignoring road and rail)
1	48	5	97%	Birdsong dominates (typically around 48dB). Some sound from leaves rustling in light breeze. People pass in distance occasionally, talking quietly, just audible.
2	46	2	40%	People noise (café with outdoor area nearby). Some birdsong present, but people dominate.
3	44	3	80%	Relatively quiet location. Birdsong and water in nearby stream is main sound (around 42dB) but occasional people passing nearby also contribute noticeably.
4	48	4	30%	Car park in distance. Trees rustling plus birdsong nearby is main sound source (around 47dB).
5	35	5	99%	Very quiet rural location adjacent to river estuary. No man-made sound apparent. Dominant noise is from reeds in wind. Birdsong also present.

Using the above information, an estimate can be made of the natural and man-made sound levels at each location (for the purpose of comparing with aircraft noise), as shown in Table B7 below:

Table B7: Estimated levels of natural and man-made sounds used in Example 2 (without aircraft)

Location	L_{AT},dB	Estimated L_{NA},dB	Estimated L_{MM},dB
1	48	48	25
2	46	38	45
3	44	42	39
4	48	47	42
5	35	35	25

The total noise from all aircraft, over a 12 hour day, using the assumptions above would be 41dB, $L_{Aeq,\ 12\ hours}$ and these would be audible for about 29% of the time. The PONS value, if influenced by aircraft alone, would therefore be 71%.

In this situation, the change to PONS as a result of aircraft noise would simply be the values assessed without aircraft in each location multiplied by 71%.

The NAMM values including aircraft can be estimated by adding the L_{MM} from the estimated values in Table B7 above to the noise level contribution from aircraft. This can then be compared to the L_{NA} using Table 5.5 to arrive at the NAMM value with the aircraft noise included. Using the same example locations, this would result in new NAMM and PONS values as shown in Table B8 below.

Table B8: Example 2 NAMM and PONS values with and without aircraft contribution

Location	Estimated values (No aircraft)		Total level from aircraft	Man-made level with aircraft included	NAMM		PONS	
	L_{NA},dB	L_{MM},dB	$L_{(aircraft)}$,dB	New L_{MM},dB	Without aircraft	With aircraft	Without aircraft	With aircraft
1	48	25	41	41	5	4	97%	68%
2	38	45		46	2	2	40%	28%
3	42	39		42	3	3	80%	56%
4	47	42		44	4	3	30%	21%
5	35	25		41	5	2	99%	70%

As can be seen, the aircraft do not change the NAMM value in locations where man-made sound is already relatively high. The difference occurs when man-made sound is low, but depends on the level of natural sound (and therefore how quiet the location is overall). If the location is particularly quiet, the impact of aircraft on the NAMM value is greater than if the location is not so quiet.

To complete the example, it is necessary to recalculate the L_{AT} to include the “with aircraft” L_{MM}. Table B9 below shows this and, for the sake of completeness, produces “with aircraft” and “without aircraft” tranquillity scores for these locations under these conditions.

Table B9: Summary of with and without aircraft values and tranquillity scores for Example 2

Location	Condition	NAMM	PONS, %	L_{RR},dB	L_{AT},dB	Tranquillity score
1	Without aircraft	5	97	15	48	Excellent tranquillity
	With aircraft	4	68	15	49	Good tranquillity
2	Without aircraft	2	40	15	46	Just tranquil
	With aircraft	2	28	15	47	Just tranquil
3	Without aircraft	3	80	15	44	Good tranquillity
	With aircraft	3	56	15	46	Fairly tranquil
4	Without aircraft	4	30	15	48	Fairly tranquil
	With aircraft	3	21	15	49	Fairly tranquil
5	Without aircraft	5	99	15	35	Excellent tranquillity
	With aircraft	2	70	15	43	Fairly tranquil

This example also illustrates that where existing natural sounds are relatively high (as at location 1) this masks the impact of aircraft on tranquillity to an extent. Comparing the resultant tranquillity at location 1 to that at location 5, it can be seen that the impact of the same aircraft noise on tranquillity is greater when less natural sound present.

With experience, estimates of the NAMM and PONS values with aircraft can often be made quite reliably at the time of the survey, but it will be important to remember to apply these across the whole site taking account of the levels and frequencies expected, according to observed patterns over the day. If close to an airfield or if the number and type of aircraft (and other sounds) is complex then the above approach will result in the most reliable estimates of NAMM and PONS scores.

Occasionally, aircraft noise will be more prevalent in one area of a site than another. This may occur, for example, if the site is near to an airfield. An example of such a site is Hatfield Forest in Essex. This forest is very close to the end of the runway for Stansted Airport and, since the site is quite large, the aircraft noise at the closest corner to the flightpath is 5dB or higher than parts of the site which were further away. At the closest parts of the site, the level from aircraft was 10dB or more above natural sounds, so the resultant NAMM score was 1 on days when aircraft were taking off past that corner. Without these aircraft present, in the wilder parts of the forest, the NAMM score would have been 5 in the same area.

Rail

The assessment of rail impact is relatively straightforward (compared to aircraft). Whilst it is possible to calculate rail noise by inputting data about the train type, the number and types of carriages, the speed and so on into a recognised calculation model[16], and then to run this model to predict train noise around the site, it is often more practical to follow the method outlined below:

Measurements of trains passing should be undertaken separately from the main survey and the L_{AE} from the different types of train assessed at locations close to the boundary of the site which is nearest to the rail line. These values can then be used along with timetable information showing the number of each train type expected on the line during a typical day to calculate noise levels from rail alone across the site and this can be added to road traffic noise levels in the manner described above to provide a value for the L_{RR} parameter for each survey location.

Health and Safety and lone working in remote locations

Working in wilderness areas brings its own set of health and safety challenges and it is beyond the scope of this book to provide a risk assessment and recommended methodology for a professional survey team. Matters such as first aid, taking precautions against potentially hazardous flora and fauna, keeping hydrated, wearing appropriate footwear and other clothes, ability to read a map, welfare and so on are important but it is assumed that dealing with these matters will be relatively straightforward in most circumstances. However, the issue of lone working in a large, potentially wild area is worth mentioning.

In practice, once survey locations have been identified on a site map, a survey team will split up and each member of the team will travel on foot or, for a larger site, perhaps on a bike and will spend much of the day unaccompanied, moving from one location to another and surveying. If the site has good mobile phone coverage throughout, then communication may be straightforward. However, in more remote locations, mobile phone coverage is often not good. It is therefore recommended that each team member follows a specified route and that there is an agreed rendezvous point and time and rigid adherence of every team member to getting to this on time. It is possible for a team member, working alone, to become lost or potentially injured and having such a point and time (to check in perhaps once or twice per day) means that if someone is not present, the team can stop the survey to deal with the reason for their teammate's absence, following the specified route which they know that that person has taken.

[16] Such as "Calculation of Rail Noise 1995" published by HMSO for the UK Department of Transport

Moderation of results

The potential importance of this step should not be underestimated. If results are collected and used to generate the tranquillity scores without thought, the resulting map may not represent typical conditions at the site. NAMM and PONS scores will need to be based on the surveyed values but only to the extent that the surveyed values are typical. Where conditions at the time of the survey were not typical, the results will need to be moderated taking account of whatever information is available from the background research or which becomes apparent during the survey.

Mapping and reporting

Once all values of NAMM, PONS, L_{RR} and L_{AT} have been finalised, the tranquillity scores for each location must be calculated according to the formulae shown in the Table B10 below. These scores then need to be reported.

Table B10: Tranquillity scores and descriptions

Tranquillity score	Relative probability of this score being chosen
1 Chaotic / frantic / harsh	0.00
2 Busy / noisy	74.17+(NAMMx9.572)+(PONSx5.324)+(L_{RR}x0.086)-(L_{AT}x1.211)
3 Unsettled / slightly busy	114.47+(NAMMx10.930)+(PONSx5.273)+(L_{RR}x0.090)-(L_{AT}x1.853)
4 Not quite tranquil	129.58+(NAMMx11.560)+(PONSx5.334)+(L_{RR}x0.130)-(L_{AT}x2.175)
5 Just tranquil	133.99+(NAMMx12.811)+(PONSx5.355)+(L_{RR}x0.125)-(L_{AT}x2.324)
6 Fairly tranquil	136.05+(NAMMx14.119)+(PONSx5.375)+(L_{RR}x0.118)-(L_{AT}x2.460)
7 Good tranquillity	132.75+(NAMMx16.448)+(PONSx5.387)+(L_{RR}x0.059)-(L_{AT}x2.560)
8 Excellent tranquillity	116.06+(NAMMx19.412)+(PONSx5.459)-(L_{RR}x0.088)-(L_{AT}x2.579)

Any given site will have variations in tranquillity across it. One edge of the site may be near to a road so will feel less tranquil close to that edge; there may be an area of woodland with higher levels of natural sounds which feels more tranquil. Even at more remote sites, roads, picnic areas and car parks can reduce tranquillity in their vicinity. In order to determine whether or not tranquillity should be protected when considering a planning application, it is helpful to understand the how existing tranquillity varies around the site in order to properly understand how a development proposal might affect this. For example, if a children's play area were proposed in a woodland location which has a reputation for tranquillity, this may appear at first to be a bad idea. However, if the play area was to be sited immediately adjacent to an existing picnic area, car park and road, it may be that this location is only "just tranquil" and therefore the impact of the play area on tranquillity may be acceptable.

Also, since tranquillity is perceived relative to the area around it, understanding the tranquillity in the surrounding area will also be important.

For these reasons, it is helpful to report tranquillity using a map of the area of interest and its surroundings and the primary output from the Natural Tranquillity Method is a tranquillity map.

In order to create a tranquillity map using a tablet or computer drawing tool an existing map or plan of the area must first be loaded into the drawing programme or application as a background image and this can then be traced over to provide an image of the site and surroundings plus the main features of a site (which relate to tranquillity) labelled as appropriate to the study undertaken. Figure B1 below shows an example of a base layer of a map (of a park on the edge of a town) with main features marked. Figure B2 shows the same map with the monitoring locations added.

Figure B1: Map of example site and surroundings with main park features marked (paths are represented by stippled lines)

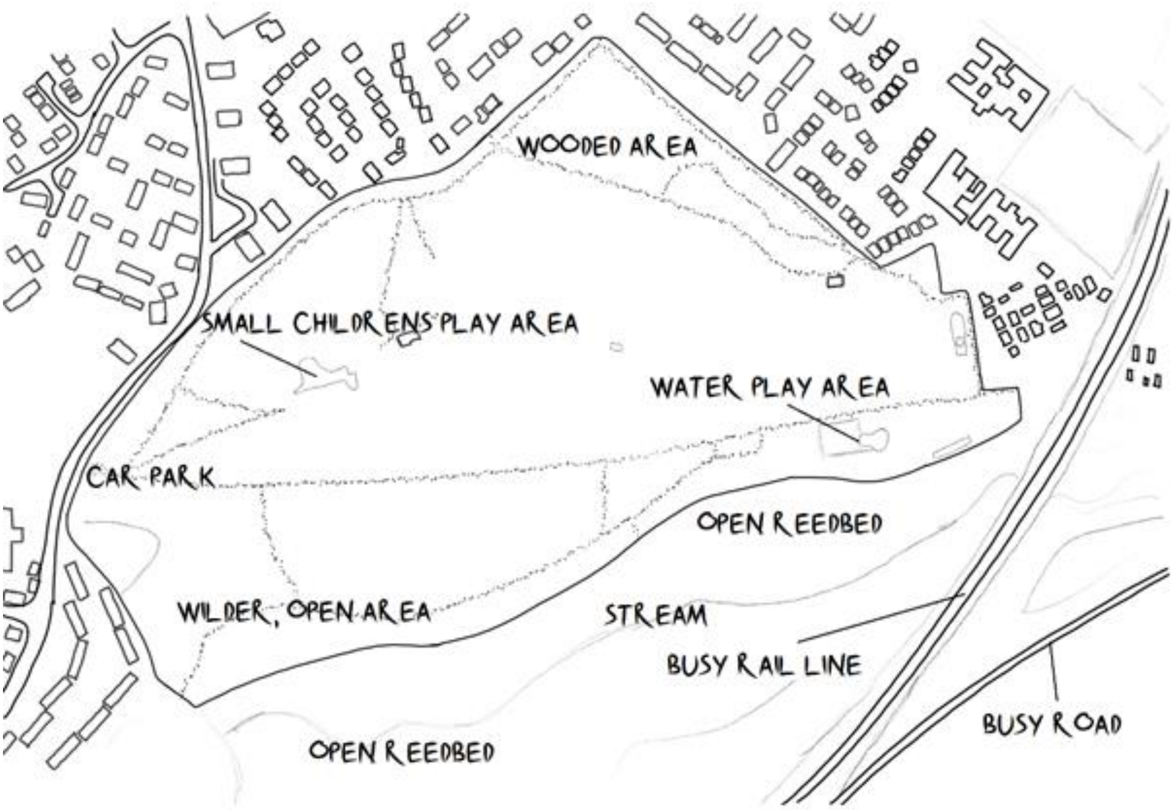
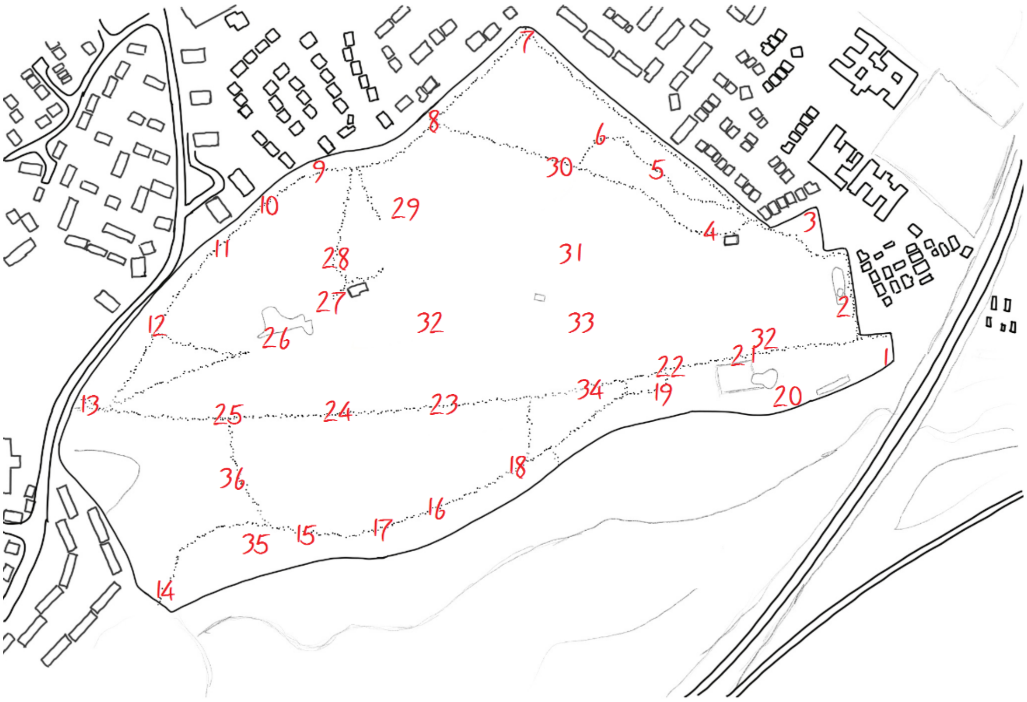
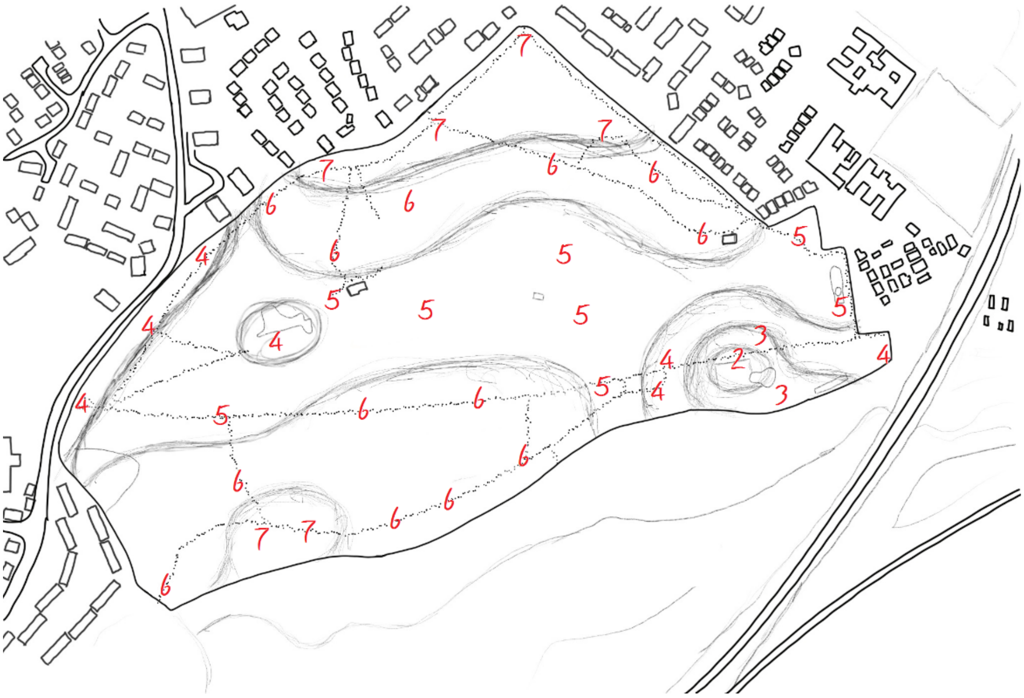


Figure B2: Map with monitoring locations added



A new layer can then be created over the top of the base layers with the tranquillity scores marked for each measurement location. These scores can then be used, along with knowledge of the park's features, to create rough tranquillity contours around these. Figure B3 below shows an example of this.

Figure B3: Map with tranquillity scores marked and rough contours drawn



Finally, clean contour lines can be traced over the rough contours and colour coding can be added. These steps are shown in Figures B4 and B5, respectively.

Figure B4: Map with clean contour lines traced over the rough contours

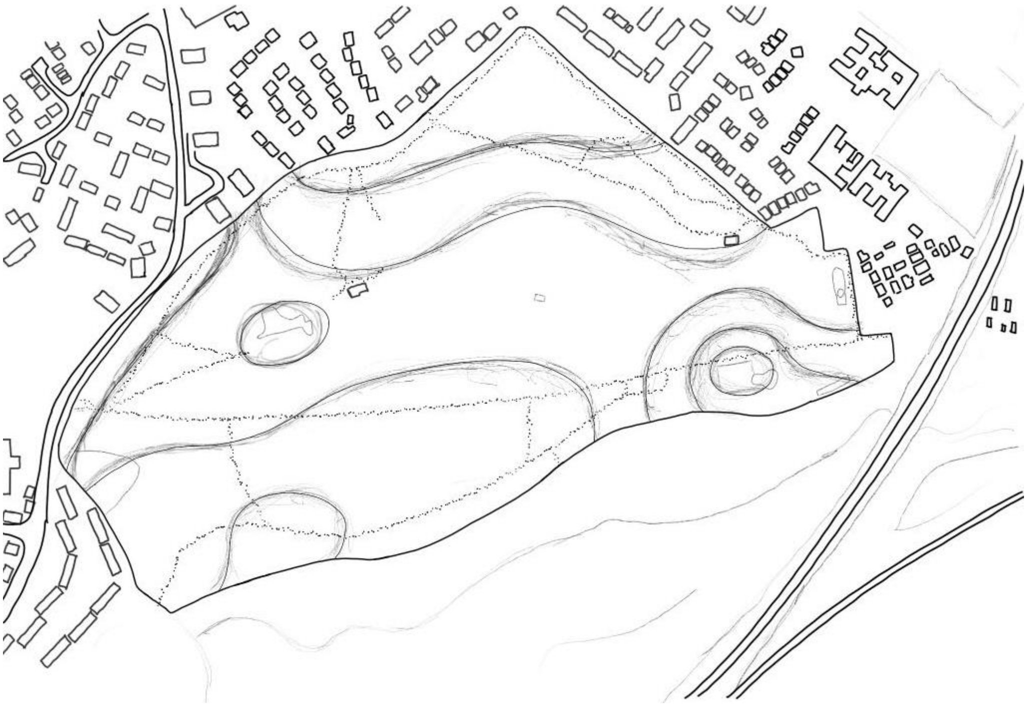


Figure B5: Final map with coloured contours

Once the tranquillity map has been produced, this can be published for the benefit of those who are wanting to consider the importance of tranquillity at a site. Areas with "excellent tranquillity" will almost certainly be in need of protection, but it may also be important to protect areas with "good tranquillity". In cities spaces with a score of "fairly tranquil" may be important and even "just tranquil" scores may be worthy of protection too, dependent on local circumstances and policy.

In urban areas, it is not just the site itself but the tranquillity scores in the area around the site which will determine its importance and therefore a wider area will often need to be mapped in order to help evaluate the degree to which protection may be required.

Sometimes the goal may be to improve the tranquillity found at a site. Where this is the aim, predictions of the effects of proposed mitigation and improvement schemes will need to be prepared as rigorously as the reports of a site's current tranquillity and presented accordingly.

The potential detrimental or beneficial impact of a scheme on tranquillity can be evaluated by predicting the changes to NAMM, PONS, L_{RR} and L_{AT} values which would result from the proposals and then by mapping the existing tranquillity and the predicted tranquillity with the development in place. For example, it may be that at the site shown in Figure B5 above, it was proposed to introduce an additional play area near to the south-western corner of the site. From the map, it can clearly be seen that the south-western corner currently has "good tranquillity" and that this would be adversely affected by such a play area. However, the south-eastern corner is "not quite tranquil" at best so may provide a more suitable site. Modelling the two possibilities would provide an objective comparison of the relative impacts. The Natural Tranquillity Method would not, in itself, present a recommendation but it would empower users to make decisions based on an objective, reliable prediction of the tranquillity that might be experienced.

When reporting on the output from this method, the following information will normally need to be included:

- Background to the study: why it is being carried out, what are the aims?
- Details of all relevant information from initial research carried out to understand the site. This should include a summary of the views of those stakeholders and relevant local policy and an overview of the site and its main features. Details of the extent of the area of interest to be surveyed and an explanation of the reasoning for choosing this area;
- Details of the survey including dates, times, plan of the site showing survey locations, weather, equipment used and raw survey data;
- Details of moderation and corrections applied and a table of finalised parameter values and calculated tranquillity scores for each survey location; and
- An objective commentary on how tranquil the site is, along with its relative importance in context of its surroundings and stakeholder views. Statement on the degree to which the site may need to be protected because of its tranquillity (with reference to relevant policy).

The assessment of proposals for changes which may affect tranquillity

If a development is being considered, calculations will need to be undertaken using the same approach as in Example 2 above, but substituting predicted "with development / enhancement" levels for the "with aircraft" levels. If the proposal would result in an increase in natural sounds, the L_{NA} parameter would also need to be adjusted in the same way.

Details of the proposal and an explanation of how this would change the values of NAMM, PONS, L_{RR} and L_{AT} found in each location would need to be reported. A comparison of values using Table B5 and the same approach as used in Example 2 above can be used to create a "with development" tranquillity prediction. In these circumstances, the following would need to be reported:

- Details of the proposed scheme;
- Description of measures designed to reduce adverse impact on tranquillity or to enhance tranquillity;
- Details of predicted "with development" levels of natural sound, man-made sound and overall sound level plus, where appropriate, predicted new road or rail noise levels;
- Details of the calculations to show how development would affect the NAMM, PONS, L_{RR} and L_{AT} values and thus the tranquillity scores. A table showing "with mitigation / enhancement" values for all parameters and the predicted tranquillity scores for each location;
- Tranquillity maps for both the existing situation and the proposed situation (with development or enhancement in place); and
- Commentary on the extent to which the proposals considered would change tranquillity at the site and statement on whether tranquillity would be adequately protected or whether the changes would achieve the enhancement desired.

Any change to the degree of tranquillity which would result from the introduction of a proposed development must be considered in the context in which it would be found. If the area currently has excellent tranquillity, any change in tranquillity score is quite likely to be significant. If the area currently has good tranquillity but would become not quite tranquil as a result of a change, then this is also likely to be significant. However, if the existing area is only “just tranquil” and changes to “not quite tranquil”, this is unlikely to be significant in most situations. It is worth noting that some areas within a busy city are predicted to be “not quite tranquil” using this method but are viewed by visitors as “an oasis of tranquillity”. Hence, the context, as well as the tranquillity score, is extremely important.

People’s expectations about a location are an important consideration. A study carried out at Hatfield Forest in Essex, which is close to Stansted Airport showed that, if the airport were to be removed from the tranquillity assessment (and assuming that all other noise sources remained the same), there would be a considerable reduction in tranquillity experienced by visitors to the site. However, since the majority of visitors to Hatfield Forest know that it is close to Stansted, they are generally quite tolerant of the planes flying close to the site, even though the plane noise is often considerably above sound levels from other sources. A tranquillity assessment which looked at the likely impact on Hatfield Forest from a proposal to operate Stansted Airport (imagining that this would be a new development) would conclude there would be a significant adverse impact on tranquillity and yet, many people who now regularly visit the site find the place to be fairly tranquil or even to have good tranquillity since they expect the planes to be taking off and flying overhead. The fact that, once excellent tranquillity is lost, people may get used to a new status quo does not, of course, provide justification for a proposed noisy development.

Other relevant factors which may affect the interpretation of results are:

- the proportion of people using the location who might be affected;
- the overall area affected compared to the size of the surrounding tranquil area;
- the proximity of other tranquil spaces (particularly in urban areas); and
- the existing temporal variability in tranquillity at the site due to changes in local circumstances or weather conditions.

When reviewing the overall impact, it is worth considering whether any other health and well-being benefits would offset any loss of tranquillity to a degree. For example, a development which would reduce the tranquillity of a relatively small area of an otherwise tranquil location but which helped to encourage greater and more sustainable use of the wider area, such as a nature trail, would generally be likely to have less impact (since it would result in a greater number of people being exposed to a site which has some degree of tranquillity) than a development which brought no direct health and well-being benefits, such as a proposed industrial use.