Bat Conservation Trust

Bat Surveys

Good Practice Guidelines

2nd Edition

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Bat Conservation Trust

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The Institute of Ecology and Environmental Management represents and supports professional ecologists and environmental managers and seeks to raise standards within the profession. We welcome these much needed guidelines as an important contribution to our aims. They will be of benefit to all who have to plan, specify and assess bat surveys.

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Bat Surveys

Good Practice Guidelines – 2nd Edition

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Foreword

It has now been four years since the first edition of *Bat Surveys - Good Practice Guidelines* was produced. During the last few years the practical implementation of bat conservation has evolved and expanded, with a greater number of individuals undertaking professional bat work. This is good news for bat conservation, but means that it is even more important to ensure survey work is carried out is to a consistently high standard.

A major change in this edition is the strengthening in focus on professional bat work, both for those undertaking the work, and to include more details for planners assessing surveys. This edition also takes account of changes in technology, and the importance of selecting the right equipment to meet the survey aims and being clear about the limitations of different techniques.

In other respects very little has changed. Development or land management proposals that have the potential to impact on bats, still need to be informed by robust surveys, of a sufficient standard to inform decisions on both planning and mitigation.

These guidelines were developed with input from experts in the field and they provide the best current thinking on surveys for bats. My thanks go to all who were involved with the production of this document. I hope that by bringing together their expertise, bats and the habitats they require will be better conserved now and in the future.

Julia Hanmer, Chief Executive, Bat Conservation Trust

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BCT would like to thank all those who responded to the consultation held in 2011. All comments and suggestions were considered by the Editorial Board and many were incorporated into this version. Space precludes us from listing everyone here but their input was invaluable.

Several members of BCT staff have contributed a great deal to this document in a variety of ways: Carol Williams, Lisa Worledge and Phillip Briggs in providing a sounding board and taking time to debate sections of the text and the use of terminology.

Many thanks to Applied Ecology, Echoes Ecology, Greenwillows Ltd., Just Mammals Consultancy Lip and The Ecology Consultancy for providing funding towards the printing costs, thereby enabling proceeds from the sale of this document to go towards bat conservation.

Many others have helped with the production of this document and it has not been possible to list everyone by name. We would like to thank you all for your time and expertise.

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Chapter 1
Introduction

1.1 Aim of this document

To conserve bats effectively, and to meet national and international statutory obligations and agreements, bat surveys by qualified ecologists are sometimes necessary, and there is a clear need for standardisation. Until the first edition of 'Bat Surveys: Good Practice Guidelines' was published in 2007, there was uncertainty around the type of survey and level of survey effort needed, when to survey, and what consideration should be given to the habitat, time of year, geographical location and the species present or likely to be present in the prospective survey area. Since 2007, new developments in equipment, methods, and legislation have meant that revision of the bat survey guidelines is needed.

This updated document provides good practice guidance for those commissioning, undertaking or reviewing bat surveys throughout the UK. It is intended to enhance the standard and consistency of bat surveys and survey reports and ultimately lead to greater understanding of bats and improvements in their protection and conservation.

> The guidance should be interpreted and adapted on a case-by-case basis, according to the expert judgement of those involved. There is no substitute for knowledge and experience in survey planning, methodology and interpretation of findings, and these guidelines are intended to support these. Where examples are given they are descriptive rather than prescriptive.

1.2 Who should use this document

These guidelines are intended for:

- ecologists (such as professional consultant ecologists) undertaking bat surveys (see Box 1.1);
- developers commissioning bat surveys from professional consultants in order to provide information in support of valid planning applications; and
- planners, ecologists and policy-makers, working for local authorities, SNCOs and non-governmental organisations, who are responsible for reviewing and assessing the implications of bat survey results.

The guidelines may also be useful for:

- nature conservationists with an interest in, and responsibility for, the conservation of bats (for example bat workers undertaking voluntary roost visits); and
- ecologists conducting scientific research into the behaviour, occurrence and distribution of bats.

Box 1.1 Statutory Nature Conservation Organisations (SNCOs) and these bat survey guidelines

> Natural England, Scottish Natural Heritage and the Countryside Council for Wales have had input into these guidelines and support their use. However, these bodies expect consultant ecologists to use their professional judgement, knowledge and experience of mitigation and compensation, in order to tailor surveys to specific development schemes or other situations. Occasionally, it is considered acceptable for surveyors to undertake less than the minimum survey effort recommended, and in some cases, more than the recommended survey effort is needed. Deviations from published guidance in mitigation and survey strategies will be considered where they are supported by thorough ecologically relevant justification in applications, and SNCOs judge each submission individually. If an agreement cannot be reached, a summary of the assessment will be provided and areas which need to be addressed will be highlighted.

1.3 Content

These bat survey guidelines are primarily aimed at providing standards for surveys carried out to inform planning applications, although they also apply to other surveys. In Chapter 2, the purpose of, and need for, bat surveys is assessed, and legislative and planning policy information pertaining to bats is summarised. There follow chapters on pre-survey considerations, preparation and planning for surveys, writing and reviewing survey reports, and equipment and techniques. A chapter on each type of survey and a chapter on interpreting and assessing survey results follow, and additional information can be found in the Appendices.

The document is available to purchase as a hard copy, or can be downloaded from: **www.bats.org.uk**.

1.4 Background

The first edition of this document was drafted following input from UK and European bat experts via a series of workshops.

The second edition was produced following public consultation and input from bat experts. This information was used to highlight particular areas in need of clarification and aspects that were previously absent. The Editorial Board then sub-edited individual chapters and comments were incorporated from consultant ecologists, volunteer bat workers, local authority ecologists, developers, SNCOs and government departments. Following this consultation process, the Editorial Board produced the updated document presented here.

1.4.1 Other major guidance

Natural England's *Bat Mitigation Guidelines* focuses on mitigation for bat roosts in buildings, but also addresses a wide variety of topics including legislation and licensing, and includes a short section on survey objectives, methods and standards.

The third edition of the *Bat Workers' Manual* (Mitchell-Jones and McLeish, 2007), the Bat Conservation Trust's (BCT's) Professional Training Standards, and the webpages of the relevant SNCOs, cover all aspects of bat work and are essential references for anyone working on bats in the UK.

For guidance on impact assessment see *Guidelines for Ecological Impact Assessment in the United Kingdom* (Institute of Ecology and Environmental Management, 2012).

Various guidance has been produced by the Scientific Working Groups to *The Agreement on the Conservation of Populations of European Bats* (EUROBATS). Further information about the Agreement, along with adopted resolutions and guidance can be found on the EUROBATS website **www.eurobats.org**.

Chapter 2 - Assessing the need for a survey and complying with the law

2.1 Introduction

In these guidelines, a survey is defined as a sampling activity in which a wide range of variables are used to describe a site or an area. Surveying is distinct from monitoring, which involves repeated sampling, either year-on-year or periodically, usually to quantify changes over time or to assess whether a particular objective or standard has been attained. This chapter includes an outline of the decision-making process that should be followed for determining whether or not a bat survey is needed.

Details of the different survey types and their appropriate use can be found in Chapter 4.

2.1.1 Reasons for surveying and monitoring

Surveys for bats may be undertaken for a variety of reasons; most fall into one or more of the following categories:

- **Species conservation** - surveys are used to record species occurrence, distribution and population size indices;
- **Scientific research** - survey data can enhance our understanding of bat behaviour and/or be used to test scientific hypotheses;
- **Planning for development** - surveys are required to provide adequate information to enable:
  a. a planning authority to assess the likely effects of a development on bat species and to identify and stipulate any further information required on necessary mitigation, compensation or enhancement measures in order to maintain the Favourable Conservation Status (FCS) of the species; and/or
  b. an informed decision to be taken as to whether an EPS mitigation licence should be applied for; and/or
  c. the relevant Statutory Nature Conservation Organisations (SNCO), as licensing body on behalf of the government[1], to determine an application for an EPS licence to allow the lawful disturbance of bats or the damage/destruction of their roosts.

The survey guidelines are primarily aimed at providing standards for surveys carried out to inform planning applications. The rest of this chapter will therefore focus on guidance relating to planning for development. Further information can be found on the relevant SNCO websites.

2.2 Assessing the need for surveys

Every survey has a cost in time or money or both, so it is important from the outset to establish:

- that it is reasonable to request a survey;
- that the method (or suite of methods) is appropriate to meet the objectives of the survey; and
- that the survey effort is proportionate to the context and appropriate for the purpose of the survey.

Once it has been agreed that a survey is necessary, the appropriate methods and level of survey effort to employ must be decided before the survey starts, and during the preparation and planning process (see Chapters 3 and 4).

2.2.1 Is a bat survey necessary?

A bat survey may be necessary, even if there is no record of bats at a location. In practice, the locations of only a small minority of bat roosts have been formally recorded and even householders with large roosts of bats occupying their property may be unaware of their presence. Ephemeral (transitory) roosts are particularly difficult to detect.

A decision to undertake a bat survey should be taken if bats are reasonably likely to be present in the structure, tree, feature, site or area under consideration and may be affected by the proposed activity (whether this is development or conservation management etc.).

In the trigger list in Box 2.1, common development situations are presented where bats are likely to be encountered, and therefore where it is most likely that a bat survey and assessment will need to be undertaken. The trigger list is a guide, but it is by no means exhaustive. Habitats with few visible features suitable for bats might provide good habitat at particular times of year; for example, farmland supports bat feeding activity during the heather flowering season.

Box 2.1 has been prepared to provide local planning authorities an indication of when surveys for protected bat species should be undertaken by developers, to ensure that sufficient information is provided with planning applications.

1 In England – Natural England, in Northern Ireland – Northern Ireland Environment Agency, in Scotland – Scottish Natural Heritage, in Wales – the Countryside Council for Wales.

During the scoping exercise that follows the early stages of a bat survey (pre-survey data search and preliminary ecological appraisal – see Chapter 4), an assessment will be made of the types and levels of further survey, if any, that are appropriate and proportionate.

Box 2.1 Planning and development trigger list for bat surveys
A bat survey should be requested for the types of development and proposals listed. These proposals are likely to affect bats, particularly in sensitive locations and where bats are likely to be present.

(1) Conversion, modification, demolition or removal of buildings (including hotels, schools, hospitals, churches, commercial premises and derelict buildings) which are: ❍ agricultural buildings (*e.g.* farmhouses, barns and outbuildings) of traditional brick or stone construction and/or with exposed wooden beams; ❍ buildings with weather boarding and/or hanging tiles that are within 200m of woodland and/or water; ❍ pre-1960 detached buildings and structures within 200m of woodland and/or water; ❍ pre-1914 buildings within 400m of woodland and/or water; ❍ pre-1914 buildings with gable ends or slate roofs, regardless of location; ❍ located within, or immediately adjacent to woodland and/or immediately adjacent to water; ❍ Dutch barns or livestock buildings with a single skin roof and board-and-gap or Yorkshire boarding if, following a preliminary roost assessment (see Chapter 8 for details) the site appears to be particularly suited to bats.
(2) Development affecting built structures: ❍ tunnels, mines, kilns, ice-houses, adits, military fortifications, air raid shelters, cellars and similar underground ducts and structures; unused industrial chimneys that are unlined and brick/stone construction; ❍ bridge structures, aqueducts and viaducts (especially over water and wet ground).
(3) Floodlighting of: ❍ churches and listed buildings, green space (*e.g.* sports pitches) within 50m of woodland, water, field hedgerows or lines of trees with connectivity to woodland or water; ❍ any building meeting the criteria listed in (1) above.
(4) Felling, removal or lopping of: ❍ woodland; ❍ field hedgerows and/or lines of trees with connectivity to woodland or water bodies; ❍ old and veteran trees that are more than 100 years old; ❍ mature trees with obvious holes, cracks or cavities, or which are covered with mature ivy (including large dead trees).
(5) Proposals affecting water bodies: ❍ in or within 200m of rivers, streams, canals, lakes, reedbeds or other aquatic habitats.
(6) Proposals located in or immediately adjacent to: ❍ quarries or gravel pits; ❍ natural cliff faces and rock outcrops with crevices or caves and swallets.
(7) Proposals for wind farm developments of multiple wind turbines and single wind turbines (depending on the size and location) (NE TIN 051)
(8) All proposals in sites where bats are known to be present [1] This may include proposed development affecting any type of buildings, structures, feature or location.
Notes: 1. Where bat roosts are of international importance, they may be designated as SACs. Developers of large sites 5-10 km away from such roosts may be required to undertake bat surveys and impact assessments in order to account for foraging and commuting habitats as well as the extensive areas around the roost.

2.3 Legislative context

General, rather than comprehensive, guidance on the legislation relating to bats, bat surveys, and mitigation is provided here. When dealing with individual cases, readers should consult the full texts of the relevant legislation, and obtain legal advice if necessary. They should also check regularly for changes to legislation and guidance. A summary of the relevant nature conservation legislation (correct at time of press) is given in Table 2.1.

2.3.1 The Habitats Directive and respective domestic legislation

Annex II of the Council Directive 92/43/EEC 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora (EC Habitats Directive) lists animal and plant species of Community interest, the conservation of which requires the designation of Special Areas of Conservation (SACs); Annex IV lists animal and plant species of Community interest in need of strict protection. All bat species are listed in Annex IV; some are listed in Annex II.

In the UK[2], the EC Habitats Directive has been transposed into national laws by means of the Conservation of Habitats and Species Regulations 2010 (England and Wales), the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (Scotland)[3] and the Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 (as amended). These are commonly and collectively known as the 'Habitats Regulations'; this term will be used in this document.

2.3.2 The Wildlife and Countryside Act 1981 (as amended)

The Wildlife and Countryside Act 1981 (as amended) was enacted to transpose into UK law the Convention on the Conservation of European Wildlife and Natural Habitats (commonly referred to as the 'Bern Convention'). The Act has been amended several times and only a small number of offences now apply to bats, which are listed in Schedule 5. This makes it an offence to:

- Intentionally or recklessly disturb a bat while it is occupying a structure or place of shelter or protection.
- Intentionally or recklessly obstruct access to a structure or place used by a bat for protection or shelter.
- Sell, offer or expose for sale, have in possession, or transport for the purpose of sale, any live or dead bat, or any part of, or anything derived from, such an animal

Table 2.1 Summary of the main legislation pertaining to the protection of bats in the UK

	Habitat Regulations (transposing the EC Habitats Directive)	Other nature conservation legislation
England and Wales	Conservation of Habitats and Species Regulations 2010	Wildlife and Countryside Act 1981 as amended Countryside and Rights of Way Act 2000 Natural Environment and Rural Communities Act 2006
Northern Ireland	The Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 as amended	Wildlife (Northern Ireland) Order 1985 as amended Nature Conservation and Amenity Lands (Northern Ireland) Order 1985 as amended Environment Order 2002
Scotland	Conservation (Natural Habitat &c) Regulations 1994 as amended.	Wildlife and Countryside Act 1981 as amended The Nature Conservation (Scotland) Act 2004

2.3.3 What the legislation means

As a result of the legislation summarised in Table 2.1, it is an offence to:

- Deliberately capture, injure or kill a bat
- Deliberately disturb a bat, including in particular any disturbance which is likely:
  - to impair bats' ability to survive, to breed or reproduce, or to rear or nurture their young, or
  - in the case of hibernating or migratory species, to impair their ability to hibernate or migrate, or
  - to affect significantly the local distribution or abundance of the species to which they belong
- Damage or destroy a breeding site or resting place of a bat
- Possess, control, transport, exchange or sell a bat or parts of a bat, alive or dead.

2 The Habitats Directive does not apply to the Isle of Man and the Channel Islands, which are part of the British Isles but not part of the UK.
3 The Scottish Regulations now include some significant differences from those in England and Wales. For practical purposes in Scotland, the Wildlife & Countryside Act 1981 is no longer relevant to bat conservation, as all European Protected Species were removed from Schedule 5 of the Act in 2007 and from Schedule 6 in 2011.

Activities that may result in the above offences taking place can in some instances be permitted. However, a strict process of licensing must be observed and followed for this to be lawful.

Some species of bat found in the UK (greater and lesser horseshoe bats, barbastelle and Bechstein's bat) are listed on Annex II of the Habitats Directive, which means that their conservation requires the designation of SACs. Even where these species of bat occur outside SACs, their inclusion on Annex II serves to underline their conservation significance.

2.4 European Protested Species (EPS) licensing

Two main types of licence, both issued by the relevant SNCO, are of relevance to this document:

- 'Survey licences' are needed by trained bat surveyors or researchers to allow them to undertake certain activities or projects that would otherwise contravene the Habitats Regulations or the Wildlife and Countryside Act (as amended); for example, entry into a bat roost or capture and radio-tracking of bats. They are normally issued for scientific or education purposes or for the purpose of conserving wild animals.
- 'Mitigation licences' are issued to permit illegal activities relating to bats and their roost sites for specific purposes. They are sometimes also called 'development licences' or 'EPS licences', and are issued under the Habitats Regulations.

2.4.1 Survey Licences

This section provides a brief overview of the system for licensing bat surveyors. SNCOs issue survey licences, so for detailed information, the relevant licensing body and its guidance should be consulted.

A surveyor may need to undertake activities during survey work that would violate the strict protection afforded to bats by the Habitats Regulations. A licence is required to permit such activities, for example, entry into a bat roost and temporary disturbance of bats during the survey, handling or capture and marking of bats with radio-transmitters. Methods for capturing and handling bats, and for radio tracking, are not covered in these guidelines.

The relevant licences are referred to as science and education licences, survey licences or conservation licences. The titles are reflective of the purposes for which they are granted under the Habitats Regulations. These are personal licences allowing a surveyor to disturb, handle or mark bats, or to improve their roost site where the main purpose of the work is for conservation of the species at a specific site. They do not cover the destruction of a roost site for development.

It is best practice for surveys of potential roost sites to be undertaken by bat workers holding a survey licence. If a roost is newly discovered having been entered, an unlicensed surveyor would need to withdraw (or, if a roost is identified from external signs, would need to refrain from entering to complete the survey if bats are present to avoid unlicensed disturbance). However, not all surveys require a licence. For example, a licence is not needed for undertaking activity surveys using bat detectors in the field, or emergence surveys outside roosts, as these do not cause disturbance to bats when undertaken correctly.

Licences for more invasive surveys, such as mist netting, marking and radio-tracking, are usually issued for specific projects, for a set period of time, at a particular location and for a given number of bats. The applicant needs to demonstrate that the level of disturbance is justified and that he or she has the necessary experience and training to undertake the work.

Conservation licences may be issued to allow improvements to a bat roost site where the main purpose of the work is for conservation of the species at a specific site. These licences would normally only issued for a specific proposal at a specific site and only for the duration of the work.

Chapter 3 provides further details on the BCT Professional Training Standards that outline the knowledge and experience required to undertake professional bat work.

2.4.2 Mitigation licences

Mitigation licences are normally issued for 'imperative reasons of overriding public interest', although they may also be issued by the same authority for the purpose of health and safety. When deciding whether to grant an EPS licence application, the licensing authority must apply three tests to the proposed action:

- The main reason for undertaking the action must be one for which a licence can be issued, for example for the purpose of preserving public health or public safety, or other imperative reasons of overriding public interest, including those of a social or economic nature and beneficial consequences of primary importance for the environment.
- There must be no satisfactory alternative.

- The proposed action must not be detrimental to the maintenance of the species concerned at an FCS in its natural range.

In order for these tests to be correctly applied it is essential that survey information of a sufficient quality and standard is supplied. Without this survey information a licence and/or planning application cannot and should not be assessed or issued.

Information on when a licence is required, maintaining the FCS of a species and how to assess planning applications can be found both on the relevant SNCO websites and on the Online Bat Planning Protocol (http://www.biodiversityplanningtoolkit.com/bats/bio_bats.html).

2.5 Planning policy context

Government policy guidance for biodiversity and nature conservation throughout the UK is provided in the following planning documents:

- England: National Planning Policy Framework (NPPF)
- Northern Ireland: Planning Policy Statement 2
- Wales: Technical Advice Note (TAN) 5
- Scotland: National Planning Policy Guidance (NPPG) 14 and Planning Advice Note (PAN) 60 PPS 2).

Government planning policy guidance throughout the UK requires local planning authorities to take account of the conservation of protected species when determining planning applications. This makes the presence of a protected species a material consideration when assessing a development proposal that, if carried out, would be likely to result in harm to the species or its habitat. This requirement has important implications for bat surveys as it means that, where there is a reasonable likelihood of bats being present and being affected by the development, surveys must be carried out before planning permission is considered.

Adequate surveys are therefore required to establish the presence of bats, to enable a prediction of the likely impact of the proposed development on them and their breeding sites or resting places, and, if necessary, to design mitigation and compensation. Natural England's *Bat Mitigation Guidelines* focuses on mitigation for bat roosts in buildings. Similarly, adequate survey information must accompany an application for a mitigation licence, if one is required to ensure that a proposed development is able to proceed lawfully. The term 'development' used in these guidelines includes all activities requiring consent under relevant planning legislation and all demolition operations requiring building control approval under the Building Act 1984. Further details on the standard of information required to assess a planning application is detailed in the British Standard for Biodiversity; A code of practice for planning and development (British Standard for Biodiversity - in development at the time of press).

Chapter 3
Considerations for consultant ecologists working on bats

3.1 Introduction

It is important for those bidding for or commissioning bat survey work to ensure that consultant ecologists have sufficient resources and skills to undertake the survey. Sufficient experienced, trained staff will be required to assess the scope of site surveys, analyse the recordings, complete the impact assessment and provide detailed advice on impact avoidance, suitable mitigation, enhancement and compensation as appropriate.

3.2 Resources and skills required

It is important for those bidding for or commissioning bat survey work to ensure that consultant ecologists have sufficient resources and skills to undertake the survey. Ecologists may need specialised survey equipment such as bat detectors and recording devices for activity surveys and equipment for monitoring bats at height. Enough experienced, trained staff will be required to assess the scope of site surveys, analyse the recordings, complete the impact assessment and provide detailed advice on impact avoidance, suitable mitigation, enhancement and compensation as appropriate.

It is reasonable for those hiring bat consultants to ask for evidence of previous work, in order to demonstrate surveyors' competence in the type of work they are being requested to undertake. By the same token, surveyors and those reporting on surveys, especially unlicensed bat workers, should include evidence of their competence in the documents they produce.

Surveying for bats is a highly skilled task, which requires training and should only be carried out by those with relevant experience. Anyone commissioning surveys or reviewing them should be sure that the surveyor has the necessary expertise. It is the duty of all surveyors to ensure that they are experienced in, and trained for, the work that they are undertaking. Surveyors should be aware of their own limitations in terms of knowledge and experience.

Basic skills needed for bat surveying can be gained by joining a local bat group, attending training courses on bat biology and behaviour, or by working with experienced and licensed bat workers as mentors. However it should be noted that local bat group training is usually aimed at those wishing to obtain a volunteer roost visitor licence and is not designed to provide professional training for consultants."

The SNCOs license bat workers for conservation, science or education. Potential surveyors must undergo training and peer review before being licensed as a bat worker. The possession of a licence to disturb bats is an indication that the surveyor has reached a minimum standard of training, although this may not relate to survey work, impact assessment or the design and implementation of mitigation schemes.

While membership of a professional body such as the Institute of Ecology and Environmental Management (IEEM) or a Chartered Environmentalist (CEnv) qualification does not provide evidence for a skill level with respect to bats or other species, members and qualified consultants are required to undertake surveys in a professional manner, and to make clear any limitations to their work. The British Standard for Biodiversity should also be followed.

Information on the level of experience expected of an ecologist applying for a survey or mitigation licence can be found on the relevant SNCO websites, and is available from BCT (as detailed in Box 3.1).

Box 3.1 Summary of BCT Professional Training Standards

Bat survey reports should be drafted and/or reviewed by licensed bat workers, who should be involved in aspects of the work requiring detailed knowledge, such as the interpretation of survey results and the assessment of findings. A licensed bat worker should carry out internal inspections of potential roost buildings and any other surveys that require a licence.

To undertake professional surveys of bats competently and independently, an individual is normally expected to possess:

A sound knowledge and understanding of:

- The legislation and the protection (and limits to protection) afforded to bats, and how they are administered.
- The implications of bats' protected status for surveys in the UK.
- Species' status, range, conservation and threats at the local, regional and national level.
- The life cycle of a bat including breeding and social behaviour.
- Feeding strategies used by different bat species.
- The physiology of UK bats including adaptations for flight, echolocation, torpor, hibernation and energetics.
- Species-specific and seasonal requirements of roosting bats and the various natural features and manmade structures used for roosting.
- The range of surveys that can be used to identify and study bats, and their limitations.
- The current relevant guidance for surveying bats.
- Seasonality and conditions, and how these might affect surveys.
- How bats are considered in the planning process, and the level of information required for this.
- Health and safety issues commonly associated with bat surveys (e.g. unsafe structures, working at night in urban areas).
- The different techniques (and licence conditions) that may be required for different species (e.g. horseshoe bats).

The skills and experience to be able to:
- Locate signs left by bats and use these to locate roosting positions. Identify the likely genus of bat and type of roost.
- Identify safe techniques to survey different types of roosts for bats.
- Use a range of bat detectors to identify species or groups of species, and record behaviour.
- Choose and use the correct equipment for a survey, and recognise equipment limitations.
- Employ automated detectors to complement activity survey techniques. Identify species or groups of species, quantify relative abundance of taxa, and timing and type of use of a site by bats.
- Record and understand survey effort and data required when surveying roost structures, underground sites, single roost trees in a wood, and flight lines.
- Assess the likely impacts of a proposed development at the scoping stage, and design surveys using appropriate techniques and level of effort.
- Objectively assess the potential value of a building, tree or other structure or feature for use as a bat roost, according to standard guidelines.

If the individual's licence allows handling of bats to survey or supervise minor development works, in order to do so independently and competently, he or she must also be able to:
- Handle and transport a bat with due regard for a) its welfare and b) the handler's own safety.
- Recognise when handling is necessary and have an understanding of sensitive periods when handling could cause great stress.
- Identify a live bat in the hand to the species level (with the exception of whiskered bat/Brandt's bat/Alcathoe bat), and confidently assess its age, sex and reproductive status.

In addition to the above, in order to lead survey teams or design surveys and mitigation independently and competently, an individual is normally expected to possess:

A sound knowledge and understanding of:
- The importance of monitoring bat populations.
- How to avoid or minimise negative impacts on bat roosts during development works.
- The conflicts of managing roosts within manmade structures.
- The issues associated with the management of roosts.
- The principles underlying habitat management for bats and how to apply this knowledge to specific management recommendations and actions on the ground.

The skills and experience to be able to:
- Analyse and interpret data to meet the objectives of the survey, and identify habitats and roosts of key importance within a landscape.
- Quantify the potential impacts of a development.
- Identify the practical constraints in a survey, be able to recognise and articulate how these constraints affect the conclusions in the impact assessment.
- Design site-specific and species-specific schemes to mitigate fully any negative impacts.
- Design, and understand the importance of, appropriate post-development monitoring.

Some of the knowledge and skills set out in this guidance can be gained through personal study, vocational training and structured education. To apply for a survey licence or undertake professional surveys of bats competently and independently, an individual is normally expected to have gained practical experience, preferably under the direct supervision of a suitably experienced licensed bat trainer. Further information on levels of competencies can be found in BCT's full Professional Training Standards.

Additional information can also be found on the relevant SNCO websites and on the BCT website (www.bats.org.uk).

3.3 Health and safety

All jobs carry risks. Bat surveying and fieldwork have some very specific risks from particular hazards. It is important that these risks are adequately considered and accounted for before surveys are undertaken.

It is the legal duty of an employer to have a health and safety policy. Guidance on safety and risk management can be found on the Health and Safety Executive's website (www.hse.gov.uk) or by calling their info line (0845 345 0055).

3.3.1 Hazards, risks and risk management

A hazard has the potential to cause harm; it is associated with a degree of danger and is quantifiable. Risk is the likelihood of harm from a particular hazard, and includes a consideration of its severity and likelihood. If a risk is considered too high, the action should not be undertaken.

The simplest way to ensure protection from harm is to remove the hazard or the risk that the hazard poses. No survey activity should be attempted without undertaking measures to bring the likelihood of risk within acceptable limits. Many of the risks associated with bat survey and fieldwork can be avoided, removed or reduced by employing measures put in place as a result of thorough risk assessment. Appendix 1 lists risks associated with bat field work and measures that can be taken or equipment that can be used to manage them.

A risk assessment should be prepared and completed for every job undertaken. Targeted risk assessments will be required for every site, to ensure that any site-specific risks are considered. On arrival on site, the risk assessment should be reviewed to establish that all possible risks have been taken into account.

Guidance on risk assessments for bat and other survey work is available from various sources including the *Bat Workers' Manual* (Mitchell-Jones, 2004), the IEEM, and from sample risk assessments, for example those designed for volunteer schemes such as the BCT's National Bat Monitoring Programme. In some complex situations, such as where a building is unsafe and asbestos may be present, a Method Statement may also be needed.

As most bat survey work involves at least one risk, or a combination of several risk factors, it will seldom be appropriate for one person to undertake a survey unaccompanied.

All equipment used should be regularly checked and maintained, in line with appropriate legislation.

3.3.2 Health and safety training

Training courses are available for those likely to visit high-risk sites, or to undertake high-risk activities during surveys. High-risk sites include:

- construction sites;
- railways;
- caves, quarries and mines;
- buildings and structures which contain asbestos;
- treatment works;
- remote locations; and
- roads;
- enclosed spaces;
- derelict buildings;
- water bodies;
- industrial plants;
- sites where criminal activities take place and/or with hostile local residents.

The following types of work require advanced knowledge and the use of specialist equipment; information can be gained on the specialist training courses indicated:

- work in confined spaces (tunnels, culverts etc.) – confined spaces training course;
- working at height – working at height training courses provide training on the safe use of ladders and assessment of which equipment is appropriate to the task;
- work in trees – arboricultural climbing course provides training in the use of specialist equipment, ladders, and mobile elevating working platforms;
- work underground (mines, caves etc.) – confined spaces training course, mine safety course. Basic caver training and advice on safety issues in specific local caves and mines can also be obtained from the British Caving Association, Regional Caving Councils or local caving clubs.
- work on active construction sites – course from the Construction Industries Training Board leads to the provision of the Health and Safety Executive's Construction Site Certification Scheme card, which may be needed in order to enter active sites.
- work in buildings which may contain asbestos – asbestos awareness training course.

3.3.3 Working hours and driving

Whether employers provide vehicles or expect employees to drive their own for work purposes, they should have a policy to address working hours and time spent driving. The Health and Safety Executive estimates that up to a third of all road traffic accidents involve a driver who is at work at the time. Road accidents are a particular risk for ecologists carrying out nocturnal bat surveys, as the functionality of a driver decreases with increasing sleep deprivation or fatigue. Companies therefore have a duty to develop policies to ensure safe working practices, and it is recommended that driving is included in working hours in these policies. Example guidance on working hours policy is available from organisations including Network Rail.

3.4 Professional insurance

Before undertaking any work for a client, consultant ecologists should have appropriate insurance, including professional indemnity insurance and public liability insurance.

Professional indemnity insurance can help protect a consultant if claims are brought against him or her by a client, due to a perceived problem with the work undertaken. Professional indemnity insurance is needed if a consultant provides advice to a client, handles data belonging to a client, is responsible for a client's intellectual property, or provides professional services, and if a consultant's work could be challenged or questioned. Consultants may be vulnerable to claims of negligence if professional advice or services fail to meet a client's expectations or are perceived to cause financial loss.

Public liability insurance covers the compensation a consultant may have to pay a client, contractor or member of the public, due to accidental injury or property damage caused by the consultant either on the consultant's premises, during field surveys or at a client's premises.

Chapter 4
Preparing for and planning bat surveys

4.1 Introduction

Once it has been decided that a survey is required (see Chapter 2), preparation and planning will be needed. This chapter provides guidance on this process, which includes defining the purpose of the survey and its aims and objectives, conducting a pre-survey data-search to identify which bat species are likely to be present, consideration of the ecology of those species, preliminary ecological appraisal, preparation of the preliminary ecological appraisal, selection of appropriate methods and effort for bat surveys, and deciding when surveys should be carried out (Fig. 4.1). Methods and results of the elements of preparing and planning a bat survey, as well as those of the survey itself, should eventually be included in the survey report (see Chapter 5).

These guidelines are intended to be adapted on a case-by-case basis according to the risk of impacts at each site. However, if consultant ecologists use methods which deviate greatly from the guidance, justification should be provided, preferably in the form of published scientific evidence, as to why the recommended survey methods or levels of survey effort were not adopted.

4.2 Defining and meeting the aims and objectives of a bat survey

The very first stage of the preparation and planning process is to determine what the purpose of the bat survey is, and what information is required in order to meet the survey's overall aims and specific objectives. In many cases the purpose of the bat survey is to support a planning application or to inform a method statement for an EPS mitigation licence application. The size and complexity of the proposed development will influence the information needed.

The overall aim of surveying at a proposed development site is to collect robust data to allow an assessment of the potential impacts the proposed development will have on the bat populations present on and around the site. The licensing guidance outlines the basic information required from surveys. The data allow the developer to decide whether to proceed with the proposal as it stands, or whether to modify it. Proposals for appropriate mitigation, compensation and enhancement should be made based on the survey data and impacts; Natural England's *Bat Mitigation Guidelines* also provides information on mitigation for bat roosts in buildings and addresses legislation and licensing.

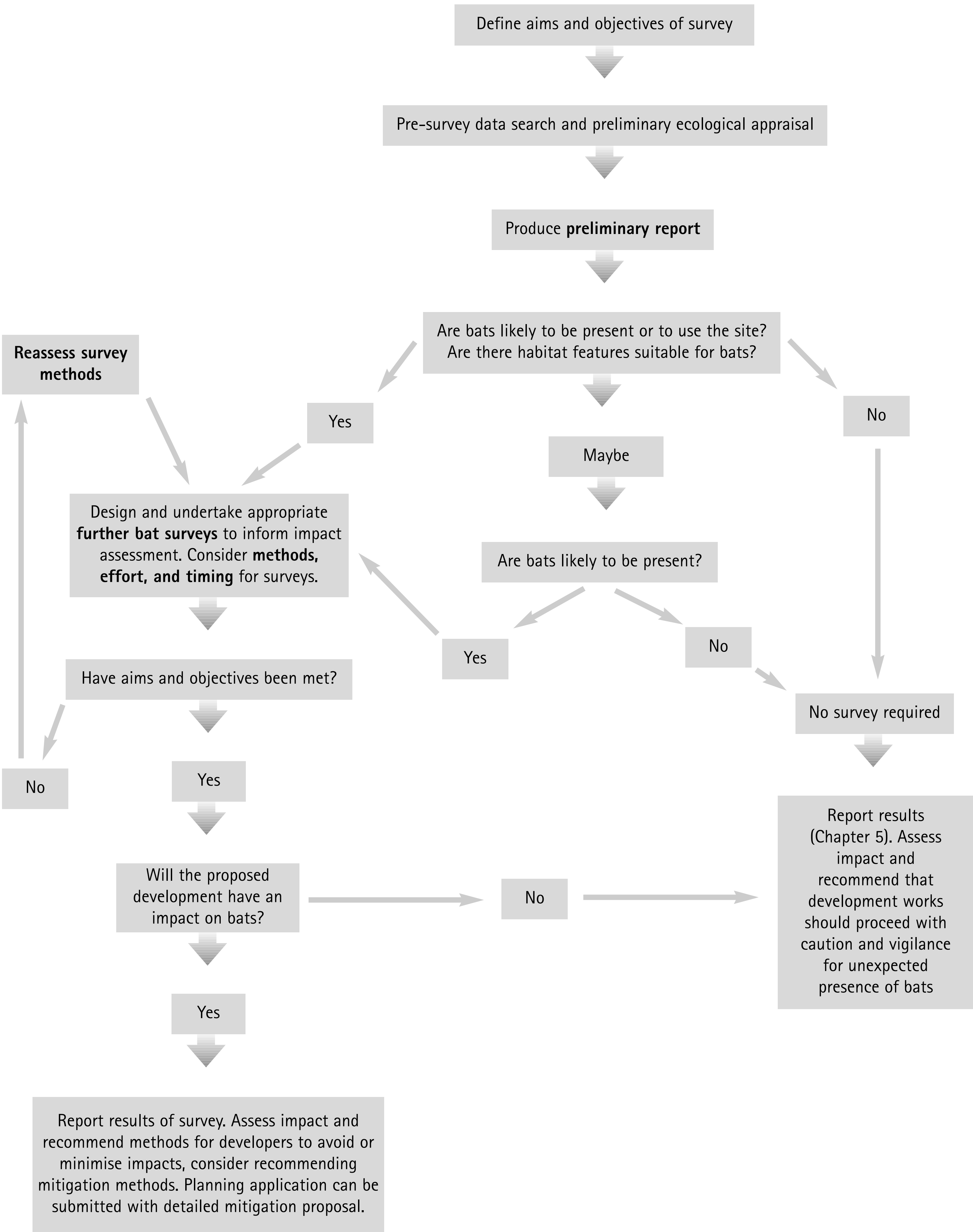
Surveys also provide baseline information with which the results of post-construction monitoring can be compared.

Bat surveys should be commissioned as early as possible in project planning, to avoid later delays. If a development is itself delayed, surveys may need to be revisited or repeated, particularly if the information, proposed plans have changed.

Surveys must be designed to meet their stated aims and objectives, and to provide all the relevant information needed for appropriate identification and subsequent assessment of impacts on bats. Survey design will be dependent on the habitats present on and around a proposed site, and may also need adjustment throughout the survey period to continue to meet the aims. Clear objectives should guide the selection of appropriate survey methods and the amount of effort required. For instance, objectives for surveying buildings might be to determine:

- whether bats are, or have been, present, and if so which species;
- the type of roost (e.g. maternity roost, day roost, feeding perch, night roost, mating roost, satellite roost, transitional roost, winter hibernaculum);
- how bats use the building (e.g. behaviour, and the location of roosting bats, flight paths, exit and entrance points);
- the intensity of use by bats (e.g. number of bats, sex of bats and time and duration of use).

Figure 4.1 The elements of preparing and planning a bat survey for consultant ecologists, and simple consequences of survey results



Once these objectives have been met, the results should be used to identify which activities and taxa are likely to be affected by the proposed development. The objectives might be to determine:

- the assemblage of bat species using the site, and which species or taxa are at high, medium and low risk from the proposed development;
- relative frequency of use of the site by the different species (including seasonal changes in use);
- spatial and temporal distribution of activity of the different species;
- the nature of activity for the different bat species (e.g. foraging, commuting and roosting), and if roosting, the type of roost (e.g. maternity roost, day roost, feeding perch, night roost, mating roost, satellite roost, transitional roost, hibernaculum);
- Surveys should be designed to determine which species or taxa are of medium or high mortality risk, and which are at risk of high impact at the population level, as outlined in SNCO guidance and in relevant scientific findings.

Once the survey information has been collated, assessed and presented (see Chapter 5), the impacts of the proposed work will need to be assessed and any modifications to the proposal and necessary mitigation identified and agreed with the developer. The report should provide details of these so that there is sufficient information on the proposed development for an application to be submitted and determined by the appropriate planning authority and/or licensing authority.

4.3 Pre-survey data search

Once the aims and objectives of the survey have been defined, a pre-survey data search (also called a desk study or scoping study) should always be conducted. The impacts of a development depend on the species and habitats present on the site. The known presence of important habitats, rare species, known roosts, or species that have already been identified as at risk from impacts should be considered from the outset, and surveys should be designed to determine the extent of potential impacts. The aim of the pre-survey data search is therefore to collate existing information from and around the proposed development site on bat activity, roosts and landscape features that may be used by bats.

4.3.1 Conducting a pre-survey data search

The pre-survey data search should include (whenever possible) the collation and review of all information potentially relevant to the assessment, including:
- relevant literature, maps and aerial photographs, and habitat data (if available, to identify any high-quality habitats).
- known bat records or sightings and roost locations. Any available information on the local or regional status and distribution of bat species should also be sought.
- Any previous survey information.
- information on any site designated for bats as a Site of Special Scientific Interest (SSSI) or SAC within 10km of the proposed development site.

Although pre-survey data searches provide useful information, it is unlikely that all potential species present at the site and roosts will be known. Consequently, surveys should be designed with this in mind, both to ensure coverage of the appropriate survey area and with the scope to investigate any rare or unexpected records thoroughly as they come to light.

4.3.2 Information sources

The first step in any pre-survey data search is to obtain maps of the area. These can be supplemented with aerial images, which may be obtained from sources such as Google Earth (**www.earth.google.com**) and Bing (**www.bing.com**). From such maps and images, an experienced surveyor can gain an impression of the habitats and features likely to be important for bats, judge which species are likely to be present, and determine where best to look for them.

It is important to obtain known information about bat roost sites or any sites of nature conservation importance designated for their bat interest near to, or at, the proposed development site. When requesting information, it is usually necessary to provide a 6-figure Ordnance Survey grid reference for the site, and to state the radius within which searches are requested, the time period for which records are requested, the species of interest, and the type of record required. Most information sources are incomplete, and do not cover all parts of the UK, so the data coverage may be patchy. Some organisations may hold records derived from the same source, so data may be duplicated. The absence of records of a species in an area does not necessarily mean that the species is not there.

Information sources for bat roost records and sightings include:
- The Joint Nature Conservancy Council (**JNCC; www.jncc.defra.gov.uk**) has compiled Article 17 reporting maps (2008) to provide, for each bat species, information on its current UK distribution and the estimated size of the total UK geographical range and population. Data were compiled partly by extrapolation from existing distribution maps

and geographical range and population figures, so that some apparent gaps in distribution are likely to be results of under-recording, rather than absence.

- Local Biological Record Centres are found in most counties and will undertake a data trawl of their records for a fee. A list of active centres with contact details can be found on the National Federation for Biological Recording's website (**www.nfbr.org.uk**).
- Local bat groups usually hold databases of bat records. The secretary should be able to provide the name and contact details of the member who maintains the database. Contact details for local bat groups can be obtained from the BCT website (**www.bats.org.uk**) or by calling the BCT National Bat Helpline (0845 1300 228).
- A county Biodiversity or Nature Conservation Officer (also known as the county ecologist) may have access to records, and is employed by some local, county or district councils.
- Local Wildlife Trusts (**www.wildlifetrusts.org**) may hold databases of records.
- County mammal recorders are volunteers who collate records sent to them about mammal sightings in their county. Contact details are available from the Mammal Society's website (**www.mammal.org.uk/**).
- Local or national mining history or caving groups and clubs, and caving councils may have useful information on hibernation roosts. See the British Caving Association's website (**british-caving.org.uk**) for details. Some cave systems have biological recorders, and records are often published in club or regional journals.
- On-site personnel such as site security guards, caretakers or gardeners may provide anecdotal evidence that gives useful pointers, though data may not be robust or reliable enough to be used in a preliminary ecological appraisal.
- Planning applications for the area surrounding the proposed development site can provide a useful insight into bat activity levels, and may include records not in other data sets.

The proposed development site may straddle the boundaries of two or more record-keeping organisations, in which case both organisations should be contacted. When using or referring to materials obtained from external sources, rules of copyright should be noted and adhered to. There may also be restrictions on the commercial use of Internet resources.

4.3.3 Geographical extent of pre-survey data search

The pre-survey data search should cover the site itself and the footprint of any proposed access roads, temporary construction areas, and other associated developments. In addition, information should be requested from up to at least 1 km from the proposed development site. Depending on the nature and scale of the proposed project, and the species likely to be affected, a larger radius search area may be required (see also Chapters 9 and 10). For larger developments, such as a new highway or a planned residential development, the search should cover an area that takes into account the wider landscape. If there are designated sites such as SACs or SSSIs within 10 km of the proposed development site, or if the extent or potential impact of the proposed works is especially high, all information should be requested from up to 10 km away from the site. In exceptional circumstances, such as where rare species that travel further than 10 km may be present, data may need to be requested over even larger areas. Where the proposed development may affect a SAC, a Habitats Regulations Assessment will be required.

4.4 Understanding bats' use of the landscape

Once survey aims and objectives have been defined, and a pre-survey data search has been carried out to assess which species are likely to be found at the site, some knowledge of how and when those species use the landscape is needed so that appropriate survey methods can be chosen. Table 4.1 provides a very broad description of the behaviour and ecology of each of the species of bat found in the UK. Bats are cryptic, use large geographical areas in three-dimensional space, and have the potential to disperse over large areas, so that they are difficult to survey without an understanding of their ecology.

Table 4.1 Bat ecology: foraging and commuting habitat; emergence time; flying range; and distribution of the 17 resident breeding bat species in the UK
(key references Altringham, (2003) , Boye & Dietz (2005) Dietz et al (2007) Harris & Yalden (2008), Hutterer, et al (2005) Russ, J. (1999) Schofield, H. W. and Mitchell-Jones A. J. (2003) are detailed within Chapter 12).

Species	Ecology
Common pipistrelle *(Pipistrellus pipistrellus)*	**Foraging and commuting habitat:** exploits a wide range of foraging habitats including those associated with watercourses, woodland, grassland and built-up areas; also feeds around lights. **Emergence:** from approximately 30 minutes after sunset. **Flying range:** feeding areas up to 3-4 km from roosts. **Distribution:** common throughout the UK; the most common species in England and Wales.
Soprano pipistrelle *(Pipistrellus pygmaeus)*	**Foraging and commuting habitat:** forages mostly over habitat associated with water, often follows watercourses when commuting. **Emergence:** from approximately 30 minutes after sunset. **Flying range:** feeding areas up to 3-4 km from roosts. **Distribution:** common throughout the UK; the second most common species; more abundant in the north and west than elsewhere.
Nathusius' pipistrelle *(Pipistrellus nathusii)*	**Foraging and commuting habitat:** forages over water and also along woodland edges and rides. **Emergence:** from approximately 30 minutes after sunset. **Flying range:** nightly flying range to feeding areas is poorly known. A long-distance migrant (> 1900 km recorded); may cross from continental Europe to the UK seasonally. **Distribution:** unclear. Present in southern England, Scotland, and Northern Ireland and probably Wales.
Brown long-eared bat *(Plecotus auritus)*	**Foraging and commuting habitat:** lives and forages in woodland and parkland with old trees. **Emergence:** when completely dark, from approximately 1 hour after sunset. **Flying range:** generally feeds within 1-2 km of roosts; some bats travel further. **Distribution:** common throughout UK wherever there is suitable woodland. Rarely heard on bat detectors, as echolocation calls very low-intensity.
Grey long-eared bat *(Plecotus austriacus)*	**Foraging and commuting habitat:** forages in more open areas than the brown long-eared bat, over grassland and along woodland edges. **Emergence:** when completely dark, from approximately 1 hour after sunset. **Flying range:** feeds up to 6 km from roosts. **Distribution:** a rare species found in a few areas of southern England and on the Isle of Wight. Rarely heard on bat detectors, as echolocation calls very low-intensity.
Natterer's bat *(Myotis nattereri)*	**Foraging and commuting habitat:** hunts in tree canopies or close to foliage and by the edge of water, higher above the water surface than Daubenton's bat. **Emergence:** from approximately 40 - 70 minutes after sunset. **Flying range:** generally feeds up to 3 km from the roost. Recorded to travel around 60 km between summer and autumn or winter sites. Distribution: throughout UK with the exception of the far north of Scotland; wherever there is suitable woodland.

Whiskered bat / Brandt's bat / alcathoe bat *(Myotis mystacinus /Myotis brandtii /Myotis alcathoe)*	**Foraging and commuting habitat:** whiskered bats forage in a wide range of habitats including parkland, woodlands, flowing water and suburban gardens. Brandt's bats forage in woodlands and close to water bodies. Alcathoe bats forage high in the canopy, near water. **Emergence:** from approximately 30 minutes after sunset in Brandt's and whiskered bats. **Flying range:** unknown. The distance between summer and winter roosts is usually less than 50 km **Distribution:** little is known about their individual distribution. Brandt's and whiskered bats are found throughout England, Wales and southern Scotland and in parts of Northern Ireland. Alcathoe bats have been recorded in England only from sites in Sussex and Yorkshire, since 2003.
Daubenton's bat *(Myotis daubentonii)*	**Foraging and commuting habitat:** hunts mainly close to the surface of slow-moving or calm water. Also forages in trees or along woodland rides, especially if these are associated with water. **Emergence:** from approximately 40-60 minutes after sunset. **Flying range:** mostly feeds up to 6-10 km from the roost. Has been recorded to travel much further (? 100 km) between summer and winter roosts. **Distribution:** found throughout the UK, with the exception of some offshore islands.
Bechstein's bat *(Myotis bechsteinii)*	**Foraging and commuting habitat:** forages in areas of closed-canopy woodland close to water, along overgrown hedgerows and near tree-lines. **Emergence:** early evening, from around sunset to one hour after sunset. **Flying range:** typically feeds within 1 km of the roost. Probably travels further between summer and winter roosts. **Distribution:** southern England from Sussex to Gloucestershire; has been recorded in Shropshire and occasionally in Wales. Not recorded in Scotland or Ireland.
Noctule *(Nyctalus noctula)*	**Foraging and commuting habitat:** flies high and straight to feeding sites over parkland, pasture, water and deciduous woodland. Also feeds around lights. **Emergence:** early evening in daylight, approximately from sunset. **Flying range:** migratory (> 1000 km recorded) in continental Europe. **Distribution:** found throughout England and Wales and into southern Scotland. Not recorded in Ireland.
Leisler's bat *(Nyctalus leisleri)*	**Foraging and commuting habitat:** flies high and straight. Forages mostly in areas of open habitat often over water or pasture. **Emergence:** early evening, from approximately 15 minutes after sunset. **Flying range:** feeds up to 14 km from its roost. **Distribution:** common and widespread in Ireland, rare and widespread in England and southern Scotland with a few records in Wales.
Serotine *(Eptesicus serotinus)*	**Foraging and commuting habitat:** forages mainly over pasture, parkland and along woodland edges. Also feeds in suburban gardens and around street lamps. **Emergence:** early evening from approximately 15 minutes after sunset. **Flying range:** typically forages within 2–6 km of roosts. **Distribution:** widespread, but scarce in southern Britain, restricted to the south and south-west of England with occasional records in Wales. Not recorded in Scotland or Ireland.

Barbastelle *(Barbastella barbastellus)*	**Foraging and commuting habitat**: forages along woodland edge and rides. Uses hedgerows, streams and rivers for commuting. **Emergence:** from 20-60 minutes after sunset. **Flying range:** typically forages 5-6 km from roosts; has been recorded travelling up to 18 km. **Distribution:** widespread. Recorded south of a line from North Wales to the Wash. Not recorded in Scotland or Ireland.
Greater horseshoe bat *(Rhinolophus ferrumequinum)*	**Foraging and commuting habitat:** in spring, feeds mainly over cattle-grazed pasture and in ancient or semi-natural woodland. During summer, forages mainly over hay meadows and silage fields. **Emergence:** from approximately 25-50 minutes after sunset. **Flying range:** typically feeds within 4 km of roosts, but, when habitat is restricted, travels in excess of 12 km. Occasionally moves more than 100 km. **Distribution:** found in south-west England, the Welsh borders and south and west Wales; an increasing number of occasional records in mid- and north Wales. Not recorded in Scotland or Ireland.
Lesser horseshoe bat *(Rhinolophus hipposideros)*	**Foraging and commuting habitat:** flies to feed over areas of deciduous woodland, especially closed canopy. **Emergence:** from approximately 30-50 minutes after sunset. **Flying range:** typically feeds within 2 km of roosts. May travel 20 km between winter and summer roosts. **Distribution:** south-west England,Wales and western Ireland and some records indicate range expansion into NW England. Not recorded in Scotland.
Note: the time of emergence varies through the year and is affected by the weather and by the amount of cover around the roost exit.	

4.5 Preliminary ecological appraisal

The purpose of the preliminary ecological appraisal is to identify the potential value of the habitat for bats. Information gained from being on site is a prerequisite to deciding the appropriate type and intensity of further survey, should it be required. It is an advantage to undertake the preliminary ecological appraisal with knowledge from the pre-survey data search.

The preliminary ecological appraisal survey can be done at the same time as other investigations; for example, as part of an extended Phase 1 survey which also covers protected species. If bat boxes or bird nest-boxes are present, they should be checked for evidence of use by bats either at this stage or during a subsequent survey (survey licences are required for bat box checking).

All site visits require a health and safety risk assessment and appropriate permission for site access. The preliminary ecological appraisal should also be used to look for and take note of additional potential health and safety hazards (see Chapter 3 and Appendix 1). The preliminary ecological appraisal should be undertaken in daylight, and sufficient time should be allowed for the surveyor to walk the whole area. The preliminary ecological appraisal area may need to extend beyond the development footprint (if impacts, for example from lighting, could extend beyond the site boundary). Sufficient manpower should be allocated to cover the whole site in the time available (or vice versa)

During the preliminary ecological appraisal, surveyors should identify and record areas and structures of potential value for bats. Features most likely to be of value for bats should be marked on a map or plan. The surveyor should record the value of each feature on site or in the landscape according to its potential for use by bats for roosting, foraging or commuting, taking into account its quality.

Further information can be found in the IEEM Guidelines for Preliminary Ecological Appraisal (2012) and the Biodiverstity Toolkit. Guidance on assessing the value for bats of sites, based on the occurrence of habitat features within the landscape, is given in Table 4.2.

Table 4.2 Guidance for assessing the value of potential development sites for bats, based on the occurrence of habitat features within the landscape and the likelihood of bats being

Low Increasing site value for bats ↓ **High**	❍ No features likely to be used by bats (for roosting, foraging or commuting). ❍ Small number of potential (opportunistic) roost sites (*i.e.* probably not maternity roosts or hibernacula). ❍ Isolated habitat that could be used by foraging bats *e.g.* a lone tree or patch of scrub (not parkland). ❍ Isolated site not connected by prominent linear features to suitable adjacent/other foraging habitat. ❍ Several potential roost sites in buildings, trees or other structures. ❍ Habitat could be used by foraging bats *e.g.* trees, shrub, grassland or water. ❍ Site is connected with the wider landscape by linear features that could be used by commuting bats *e.g.* lines of trees and scrub or linked back gardens ❍ Buildings, trees or other structures (such as mines, caves, tunnels, ice houses and cellars) of particular significance for roosting bats. ❍ Site includes habitat of high quality for foraging bats *e.g.* broadleaved woodland, tree-lined watercourses and grazed parkland. ❍ Site is connected with the wider landscape by strong linear features that could be used by commuting bats *e.g.* river valleys, streams or hedgerows. ❍ Site is close to known roosts. ❍ Bats recorded or observed using an area for foraging or commuting close to a potential roost.
Confirmed presence	❍ Evidence indicates that a building, tree or other structure is used by bats *e.g.*: o bats seen roosting or observed flying from a roost or freely in the habitat; o droppings, carcasses, feeding remains etc. found; and/or o bats heard 'chattering' inside a roost on a warm day or at dusk.

A continuum is presented between low and high potential value. By referring to this continuum and using their expert judgement, surveyors may wish to classify potential development sites, habitats, or features as low, medium or high value for bats. For example, in a river valley the following features would be identified as having high value to bats, and therefore as indicative of high likelihood of bat presence:

- older trees or woodlands, for foraging and roosting;
- linear landscape elements *e.g.* hedgerows and watercourses, for commuting and foraging; and,
- built structures *e.g.* buildings and bridges, for summer roosting and hibernating.

Alternatively, features could be assigned a level of potential value for bats when they are examined in more detail (by climbing, internal inspection, or observing emergence of roosting bats.

4.6 The preliminary ecological appraisal and bat survey

The aims and objectives of the survey, information from the pre-survey data search, species data and data from the preliminary ecological appraisal should be combined to compile a preliminary ecological appraisal (see Chapter 5) detailing the potential impacts of the development, and informing and identifying the type and extent of further bat survey work needed (if any). If no further survey is needed, the preliminary ecological appraisal should include justification for this. If needed, survey methods and timing should be detailed in the preliminary ecological appraisal and should be appropriate for the proposed development. The level of survey effort and area coverage should be proportional to the site, the development and its likely impacts.

4.6.1 Appropriate survey methods

If further bat surveys are found to be necessary, the survey methods and the amount of survey effort required should be selected to allow sufficient information to be collected to achieve the stated aims and objectives of the survey, taking into account the size, nature and complexity of the proposed development site.

Non-invasive bat surveys fall into two main categories: activity surveys and roost surveys. An overview of techniques used within and in addition to these categories can be found in Box 4.1. Each method provides information on a different aspect of the site and its use by bats. Not all methods are required in every case, but a combination of methods is often required. For more information see Chapters 7 and 8. Invasive methods (e.g. radio tracking and catching) are rarely needed at potential development sites, and fall outside the scope of these guidelines. If they are needed, their use should be justified and informed by information from non-invasive surveys, and agreed with the relevant SNCO.

Box 4.1 Overview of main non-invasive survey methods for bats

Activity surveys
Bat activity surveys in which hand-held bat detectors are used to locate and identify flying bats, such as transect surveys and commuting route surveys, are used to discover which bat species are using the site and which features they are using. Surveyors can respond to bats by moving around the site. The disadvantage of this method is that each surveyor can only operate one or two bat detectors for a number of hours each night.

Automated activity surveys at ground level
Automated bat detector systems, left unattended to record bat calls, may be used to assess bat activity over long periods (eg all night for many nights) and in many locations. Automated detector surveys provide large volumes of data on the bats present at fixed locations at the site. Data can be used to quantify the relative importance of features and locations, and how bat activity changes over time. However, one advantage is that additional information may be gained by visual observations of the bats.

Automated activity surveys at height
Bat detectors can be installed at height, in order to quantify the amount of bat activity in specific locations. This method is normally only employed in specific circumstances such as at high risk wind turbine sites (see Chapter 10).

Preliminary roost assessments - identifying potential roost sites
External and internal inspection survey, conducted to assess the likelihood of bats being present in potential roost sites (e.g. in trees, buildings, bridges)and the need for further survey and/or mitigation.

Presence/ absence survey – identifying potential roost sites
Surveys to establish where and whether bats are roosting at the site and the type of roost, by dusk emergence survey, pre-dawn re-entry survey, backtracking, and/or automated activity survey.

Roost characterisation surveys - surveys at known roosts
Surveys to establish how bats use the roost (e.g. the location of roosting bats, flight paths and flight behaviour, exit and entrance points to the roost); the intensity of use (e.g. number of bats, sex of bats, time and duration of use); and what features and characteristics of the roost and the surrounding area are of importance. Internal climatic assessment (temperature, humidity light etc.) may be necessary, along with activity surveys on flight lines and linear features connecting to surrounding habitat, and, in very rare instances, capture survey to determine the species, sex and/or breeding status of the roosting bats.

Vantage point surveys
If early-flying bats (e.g. noctules) are observed at the site when light levels are high enough to see them, vantage point surveys from several locations overlooking the site can be used to assess the number of bats, the direction or location of the roost, the commuting routes used, and the type of activity. Vantage points should be selected to maximise the view of the site.

Back-tracking surveys
Back-tracking surveys to find roost locations are conducted by observing and following bats which have just left their roost soon after sunset, or are returning to their roost at dawn. Visual observations and bat detectors are used. A back-tracking survey may be required as a follow-up to a vantage point survey or activity survey, to determine the location of a roost.

Observations with infrared cameras, low-light video and radar
Infra-red and low light video can be useful in observing and/or recording roost emergence and observations with low-light video and infrared cameras can be used to help find roost sites. However, infrared cameras may not give the range and field of view needed to provide robust information in open habitats. There is some evidence to suggest that radar can be used to track the movements of bats (Larkin and Szafoni 2008).

These observational methods are not recommended as standard practice, but they may be appropriate at sites where particular potential impacts have been identified and where detailed, targeted surveying is required.

4.6.2 Proportionality of survey

The type of survey undertaken and the amount of effort expended should be proportional to:
- the type and scale of the proposed development and its predicted impacts on bats,
- the size, nature and complexity of the development site,
- the likelihood of bats being present or affected,
- the species and numbers of individuals concerned, and
- the type of roost and/or habitat affected.

Greater survey effort should be expended at sites where high numbers of bats are likely to be present and where they are likely to be adversely affected. For example, the development of a large housing scheme is likely to have a range of effects, and therefore detailed surveys at a landscape scale are likely to be appropriate. The appropriate amount of survey effort also depends on the geographical region, the species identified as likely to be present in the pre-survey data search, and the types of roosting and foraging habitats in the locality. If an Annex II Habitats Directive species is likely to be present (for which a SAC may be designated), then a greater level of survey effort is likely to be required.

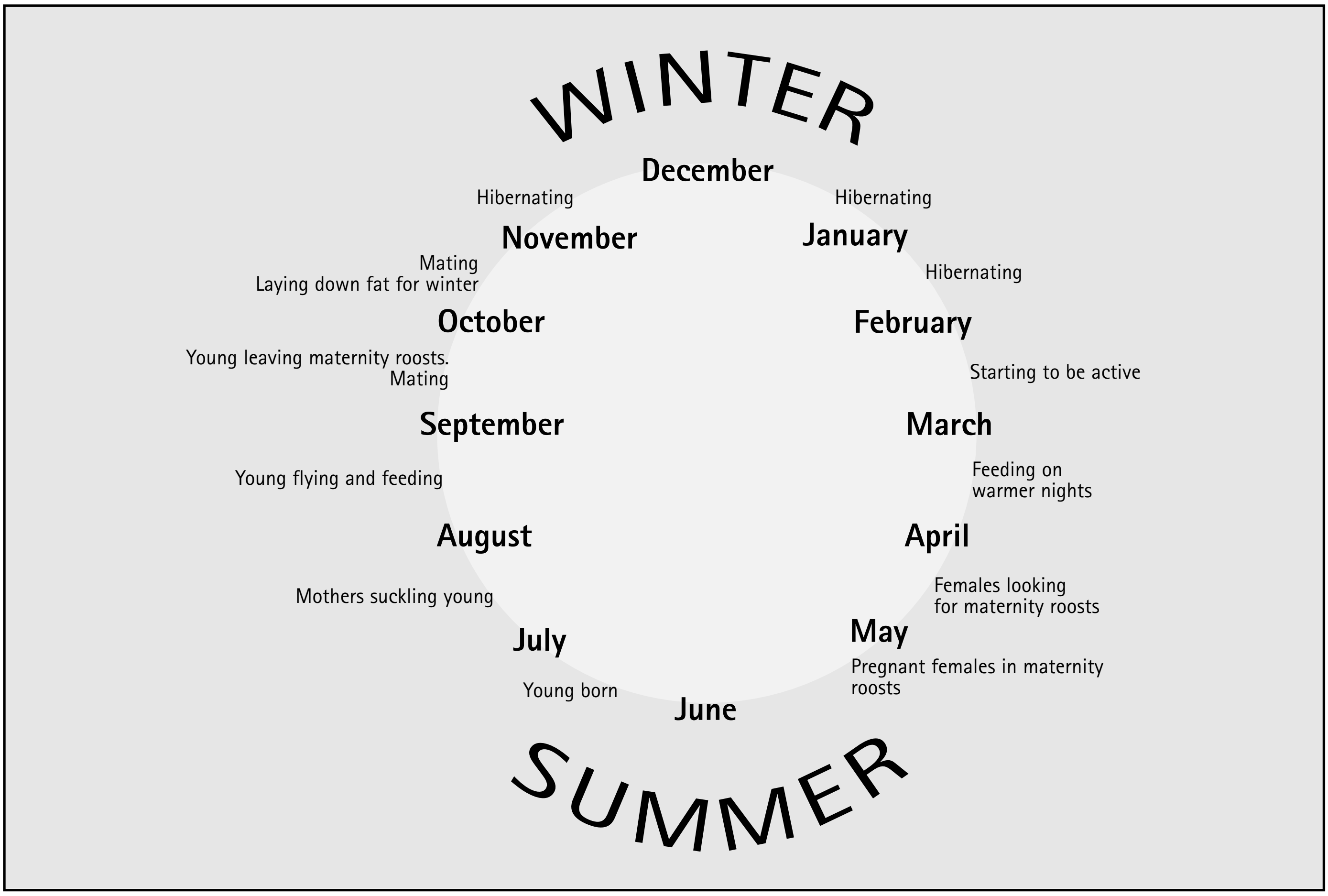
It is much easier to prove that bats are present at a site than it is to prove their absence. It requires a great deal of survey effort to demonstrate beyond reasonable doubt that bats are not present and are not likely to be present at a site. Therefore, the objectives of the survey should also determine survey effort.

In summary, the overall quality of the habitat at the proposed development site, the number of habitat features likely to affect bats if altered by development, the potential impact of the proposed development, the species likely to use the site, and the importance of roosts of species likely to use site should all be considered when deciding the level of survey effort required. The level of survey effort should be proportional to the likely impact of the proposed development (see Chapter 7).

4.6.3 Timing of surveys

The optimum time of year to conduct bat surveys depends on the type of survey and on the ecology and behaviour of bats, which changes markedly throughout the year and influences where and when they may be found in different habitats (Figure 4.2).

Figure 4.2 Overview of a year in the life of a bat



A large part of the year (October to May) may be spent hibernating, although on warmer nights bats awaken to go out and forage. Bats may change roosts depending on changes in weather conditions. As spring approaches, bats increasingly feed at night, and the period from April to early June is a time of intense feeding activity to recover weight lost during the winter. During this time, females gather together at maternity roosts, sometimes moving from one roost to another to find one with the right conditions. Some males may be present, but most roost elsewhere, either singly or in small groups. Most births occur in the middle two weeks of June, but depending on the weather, latitude and species, birth can be as early as late May, or as late as August. Once the babies are weaned, at three to five weeks old, the females leave the maternity roost and disperse, both to gain weight before winter and to find mates. During autumn, many Myotis bats swarm at caves and mines to mate and/or find a hibernation site. Males of other species of bat establish mating territories where they may fly or call specifically to attract females. As the weather turns colder, bat activity declines and foraging becomes restricted to warmer nights. Bats spend progressively more time in torpor, and slowly return to hibernacula.

Table 4.5 provides recommended optimal and sub-optimal timings for all types of survey methods discussed in these guidelines. Although the survey timings are applicable for most of the UK, they vary according to the geographic location of the survey. For example, bat activity in Scotland commences later in the spring than in most of England. Optimal timing may also vary from year to year depending on the timing of the onset of spring. Outdoor surveys are weather-dependent, and should be undertaken only in suitable weather conditions.

Even when undertaken at optimal times, activity surveys provide snapshots of activity when they are undertaken. Additional surveys may be needed if information on temporal or seasonal changes in activity is needed, if a significant period of time has elapsed since the previous survey, or if surveys have been constrained by timing, weather, access or other factors. Consultant ecologists experienced in bat work should be able to judge when further surveys are required. However, in many cases the use of a site by bats during seasons in which no survey has taken place can be predicted from the survey results.

Table 4.5 Recommended survey times (adapted from Limpens 2005) for various survey types. Optimal periods are shown in dark grey, sub-optimal periods in light grey

Survey type	J	F	M	A	M	J	J	A	S	O	N	D
Activity surveys (Chapter 7)												
Inspection of buildings and structures for roosts (see Chapter 8)												
Mating roost/autumn swarming surveys (see Chapter 8)												
Winter hibernation surveys including surveys of underground sites (see Chapter 8)												
Tree surveys for features used by roosting bats (by observation from the ground; Chapter 8)												
Tree surveys for active bats (bat emergence or re-entry surveys; Chapter 8)												
Bat detector surveys for dusk/dawn emergence/re-entry[1] (Chapter 8)												

1 The months shown are optimal for maternity roosts. For other roosts, other months may be optimal.

Chapter 5
Writing and reviewing survey reports

5.1 Introduction

Following consultation, local planning authorities in the UK requested that consultant ecologists' bat survey reports, especially those supporting planning applications, should be standardised for ease of reading and in order to facilitate the planning process. In this chapter we provide a standardised survey report template, meeting planning authorities' requirements that can be used by consultants for ecological reports in support of planning applications, and for other survey reports. We also provide information about reading and assessing survey reports from consultant ecologists as part of the planning process, and about how the planning process works. This information can also be used to inform report writing.

5.2 Writing survey reports

The results of bat surveys must be reported in a thorough and clear manner, and it is recommended that a standard format is used. A general reporting template is given in Box 5.1. Not all parts of the template are relevant in every case, so it should be modified and used accordingly, but the overall structure of the report should be retained. Further details of the different types of survey techniques are given in Chapters 7-10.

5.2.1 Limitations of equipment and methodology used

Any limitations of the survey methodologies and equipment used should be stated in the survey report. It is also important to assess and explain the impact of these acknowledged limitations on the conclusions that can be drawn from the survey data. If equipment fails or if survey effort has to be reduced, the results of the survey need to be interpreted accordingly. If survey effort is deliberately reduced or increased, the reason for this should be explained and the decision should be justified.

5.2.2 Submission of survey records

It is good practice for bat records resulting from clients' surveys to be submitted to Local Records Centres, local bat groups and/or the National Biodiversity Network (www.searchnbn.net). Many consultant ecologists state in their terms and conditions that records from surveys are submitted to records centres. Clients can opt out of this if they wish, and if the development is sensitive.

5.2.3 Report writing in general

Authors of survey reports should:
- write concisely and clearly, leaving no room for misinterpretation;
- use clear and simple sentence structures;
- use a standard consistent format for references;
- cite appropriate references;
- list scientific names of species in taxonomic sequence order where appropriate, and also give common names
- check English, including spelling, grammar and punctuation;
- be honest about limitations of the survey;
- use appendices where appropriate (if large amounts of data or supporting information need to be included).

Once the first draft of a report has been written it should be reviewed, preferably by a colleague, to check for any errors, discrepancies, mistakes in spelling or grammar, and inconsistencies. Non-specialists will read the report, so it must be easy to read and understand.

Box 5.1 General template for bat survey reports (see also the British Standard for Biodiversity)

TITLE
Authors
Main author and the senior member of staff supervising the work, with survey licence details.

EXECUTIVE SUMMARY
A brief non-technical summary of site, methods, results, assessment, recommendations and mitigation.

1 INTRODUCTION
1.1 Site description
Six figure Ordnance Survey grid reference or other locational information, description of location, brief

habitat descriptions (including buildings or other features of potential value to bats), size of site and photo or plan of site showing the boundary.

1.2 Proposed works

Summary of the proposed development, including details of demolition, habitat destruction, renovation, buildings, and timing. If the details of the proposed development are not known, state this.

1.3 Aims of survey

Overall aims and specific objectives of the survey.

2 METHODS

2.1 Summary of survey methods

Why the methods used are appropriate to achieve the aims and objectives (see 1.3), with reference to these guidelines. Explanation and justification of any deviations from best practice. How the pre-survey data search informed the survey design. Limitations of survey techniques and equipment, and assessment of the impact of any constraints.

2.2 Pre-survey data search

List of organisations and sources from which bat records and information on sites of nature conservation importance were requested and obtained. Pre-survey data search data may be placed in an Appendix. If no data were sought or secured, state this.

2.3 Surveyor information

Names of surveyors and their survey licence details or evidence of competency (e.g. training courses attended, number of years of experience).

2.4 Field surveys

2.4.1 Habitat survey

Methods used (e.g. Phase 1 habitat survey) and date of survey.

2.4.2 Roost surveys

Date and time of survey, weather conditions (temperature, humidity, wind speed and direction, cloud cover, precipitation, light level). Which parts of the site were surveyed, and equipment used by surveyors. Locations of bat detectors in the field and/or within buildings (marked on a plan), and reasons for their positions.

2.4.3 Activity surveys

Date and time of survey, weather conditions (temperature, humidity, wind speed and direction, cloud cover, precipitation, light level). Which parts of the site were surveyed and equipment used by each surveyor. Locations of transects or bat detectors (marked on a plan), and reasons for their positions.

3 RESULTS

3.1 Pre-survey data search

Results of pre-survey data search.

3.1.1 Designated sites

Location of sites designated for their bat interest.

3.1.2 Protected species

Location and date of bat records.

3.2 Field surveys

3.2.1 Habitat description

Description of habitats of potential value to commuting, foraging and roosting bats.

3.2.2 Roost survey

Locations of potential access points and roost sites; locations of actual access points and roost sites; descriptions of bat signs and bats found. Descriptions of potential and actual roost sites (including height above the ground and aspect). Results of emergence/re-entry surveys and backtracking surveys.
<u>Buildings/structures</u> - Type of building/structure, dimensions, age, construction, current use.
<u>Underground sites</u> – Type of site (e.g. cave/mine), dimensions.
<u>Trees</u> – Tree species, dimensions, age.
Reference to roost report forms (Appendix 2) and photographs (Appendix 3).

3.2.3 Activity survey

Quantitative and qualitative results of transect surveys, including analysis of bat detector recordings and sightings, results of automated bat activity surveys.

4 ASSESSMENT

4.1 Constraints on survey information

Any constraints (due to weather, access, health and safety, etc.) on the survey, and a full assessment of the impacts of those constraints.

4.2 Constraints on equipment used
Constraints of the bat detectors, endoscopes and any other equipment used, and an assessment of the impact of these constraints.
4.3 Potential impacts of development
Potential impacts of the proposed development, during construction and operation.
4.3.1 Designated sites
4.3.2 Roosts
4.3.3 Foraging and commuting habitat
4.4 Legislation and policy guidance
Details of UK and European legislation relating to bats, relevant national and local planning policy, national and local bat species biodiversity action plans. Place the findings of the survey and the impact assessment into a legal and policy context.

5 RECOMMENDATIONS and MITIGATION
5.1 Further survey
5.2 Mitigation measures
5.2.1 Proposed mitigation for roost sites (subject to agreement from the relevant licensing body).
5.2.2 Proposed mitigation for foraging and commuting habitat.
5.3 Mitigation licences
If bats or their places of shelter or protection are likely to be affected by the proposed development, explain why a mitigation licence may be needed.

6 SUMMARY
A brief summary of the main findings (assessment, recommendations and mitigation).

7. REFERENCES
8. GLOSSARY or DEFINITION OF TERMS

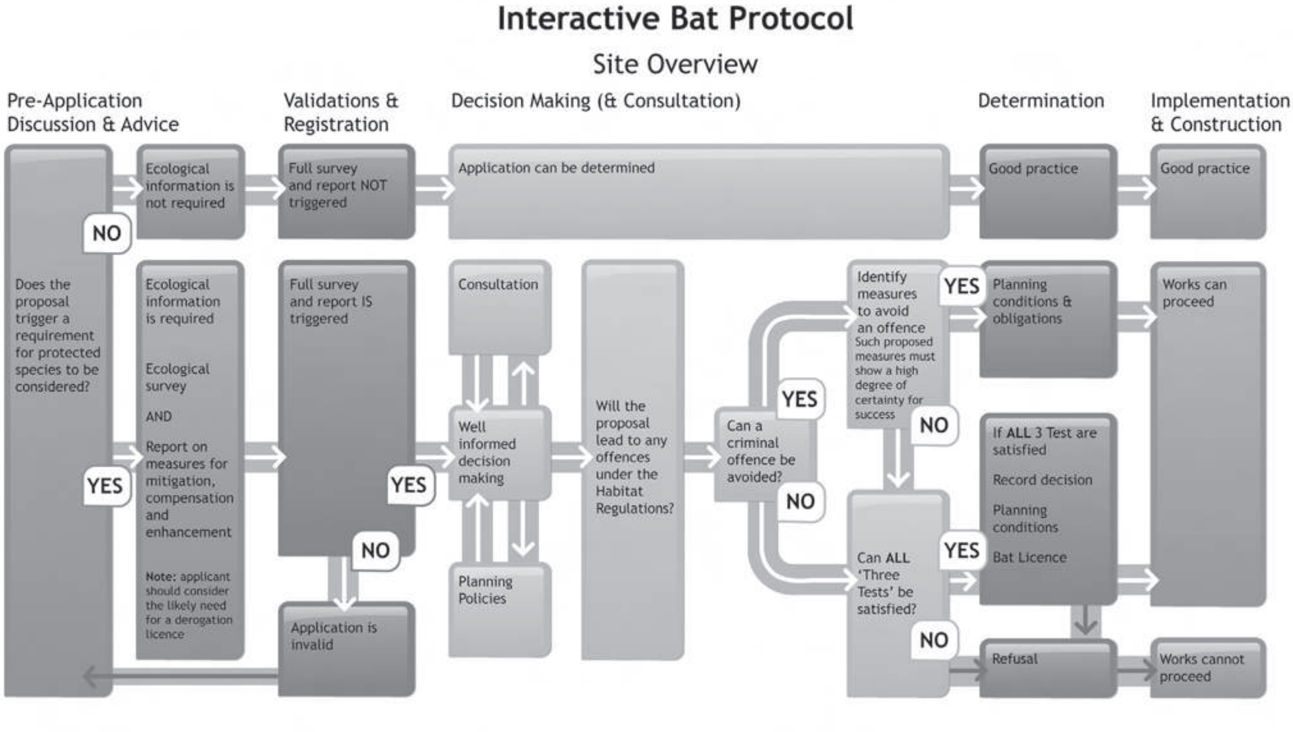
APPENDIX 1. Pre-survey data search results
APPENDIX 2. Bat roost report forms
APPENDIX 3. Photographs

5.3 Reviewing survey reports

5.3.1 Statutory obligations

Figure 5.1 provides an overview of the various steps and considerations involved in the planning process. As outlined in Chapter 2, planning authorities have a duty to consider the conservation and enhancement of biodiversity when determining a planning application. Biodiversity includes species protected under the Wildlife and Countryside Act 1981 (as amended) and the Habitats Regulations. Protected species are also a ‘material consideration’ in the determination of a development proposal that, if carried out, would result in harm to the species or their habitats. Therefore, to meet statutory obligations, before planning permission may be granted, the planning authority must have sufficient information on whether any protected species are using a site and whether they will be affected by the proposed development. A planning authority should reject information that is inadequate, meaning that an application could be judged as invalid and not registered, or planning permission could be refused, if insufficient information is submitted. However, government guidance states that developers should only be required to undertake surveys for protected species where there is a reasonable likelihood of them being present.

Figure 5.1 Consideration of bats in the UK planning system – an overview
Adapted from the Online Bat planning Protocol - http://www.biodiversityplanningtoolkit.com/bats/bio_bats.html



Whether there is a reasonable likelihood of bats being found within or adjacent to a development site can be determined by using the trigger list produced by the relevant planning authority as part of their planning validation requirements. If the planning authority does not have a trigger list, the planning and development trigger list for bat surveys (Box 2.1) should be used.

> It is good practice for a planning authority to bring to the attention of the applicant the legal protection afforded to bats, through an advisory note or informative. This may be especially useful at sites which have a reasonable likelihood of supporting bats, but where none were found. Here, developers must remain watchful for bats prior to and during the implementation of works.

5.3.2 The preliminary ecological appraisal

A preliminary ecological appraisal should be produced as part of the process of preparing and planning for a bat survey (see Chapter 4) at sites which have a reasonable likelihood of supporting bats (see Box 2.1). The preliminary ecological appraisal should outline any evidence that bats are using (or have used) the site, and/or assess the likelihood that bats are using (or have used) the site. If there is a reasonable likelihood that bats are using the site, the preliminary ecological appraisal should inform future survey objectives, and the type, intensity, seasons and area to be covered by further surveys.

If a site has very little or no potential for bats, this should be explained in the preliminary ecological appraisal and no further surveys should be proposed. In this case, the preliminary ecological appraisal alone will be submitted with the planning application. However, it can be difficult to be certain that a feature has low value for bats, and if there is any doubt, further surveys (e.g. roost and activity surveys) should be recommended in the preliminary ecological appraisal. Chapter 4 provides details of the types of information and methods expected from these types of survey.

5.3.3 Information needed for decision-making

Before any planning application can be considered, sufficient information needs to have been received, including a preliminary ecological appraisal and bat survey report. The level of survey effort and methods needed should be assessed on a case-by-case basis using the guidance within this document. Deviation from these guidelines may be acceptable depending on the characteristics of the site, species present and the size and associated risk of the proposed development, but should be acknowledged clearly in the report, and should be accompanied by a rationale that is informed by scientific knowledge, evidence and expertise. Box 5.2 provides an overview of factors to consider when assessing the quality of a survey report and these are explained further in sections 5.3.4 to 5.3.7.

Box 5.2 Assessing report quality – factors to consider

1. Survey objectives
2. Experience of surveyors
3. Licensing for the survey
4. Justification for any deviations from best practice guidance
5. Rationale of survey techniques
6. Limitations of surveys
7. Assessment and interpretation of results including validity of conclusions and recommendations (based on the information provided and any restrictions)

5.3.4 Survey objectives

As explained in Chapter 4, a clear set of objectives should guide the selection of appropriate survey methods and the amount of effort required. A survey report must therefore provide all the relevant information needed for appropriate identification and subsequent assessment of impacts. Box 5.3 details the essential information required from a survey.

Box 5.3 Essential information required from survey

- Assemblage of bat species using the site; identification of species groups in relation to the potential impacts of the development;
- Relative frequency of use of the site by the different species;
- The spatial and temporal distribution of activity for different species;
- The nature of activity for different bat species, for example foraging, commuting and roosting (where possible);
- Details on how the surveys have been designed to determine presence of species of higher risk of impact from the development, or cryptic species that are more difficult to detect.

5.3.5 Assessment of and interpretation of results

Survey data should be collected, recorded and analysed to provide information that can be applied to the proposals for the site and used to assess the likely impacts. The level of analysis depends on the bat species found at the site and the impacts of proposed development, as well as any limitations imposed by the data. Factors to consider are the vulnerability of the species to impacts and their local, regional and national population status. Chapter 11 provides information on how to interpret and evaluate survey results.

5.3.6 Is the survey adequate?

Assessing whether a survey has been carried out and interpreted to an adequate level is reliant on an understanding of the underlying questions (the objectives) driving the work. The survey report should therefore provide an overview and rationale that takes the reader through the process of determination clearly and concisely. In effect, the report should provide an overview of the bat activity on the site and the potential impacts of the development, setting it all within the context of what was found on site (see the example provided in Box 5.4). This can only be achieved if the surveys have been both designed and interpreted correctly.

Box 5.4 Example of information to include in a bat survey report

A survey has been commissioned to inform planning permission for a two story home extension. The owners want to build in October and landscape the surrounding garden at the same time. A known roost of brown long-eared bats is present in the building. The bat survey report should detail:

- Records that indicate that brown long-eared bats are present.
- That therefore adaptations were made to the surveys methods to take account of this information: emergence surveys were conducted late because the species emerges late.
- The potential impacts of removal of vegetation, which could expose the roost and/or make it isolated.

The survey should confirm:

- The species of bats using the building.
- Where they are roosting.
- The type of roost.
- Roost features: access points, temperature, dimensions etc.
- Habitat features: flight lines, unlit areas.
- The importance of the roost in a local and national context.
- Limitations of the survey and whether any precautionary measures need to be taken.

The survey report should detail, in relation to the proposed development:

- What will be impacted.
- How can this impact be avoided or minimised both during and after works by means of mitigation.
- Whether a mitigation licence will be required.
- Whether the site will need to be monitored.

Further, more in-depth guidance on the process of determining planning applications in relation to bats can be found in the online Bat Planning Protocol - **http://www.biodiversityplanningtoolkit.com/bats/bio_bats.html.**

Chapter 6 Equipment and techniques

6.1 Introduction

Before selecting the equipment required for a bat survey, it is essential that the aims of the survey have been defined (see Chapter 4), and that competent surveyors are available to design and implement the survey, interpret the data and findings and report these in a concise and thorough manner (Chapter 5). The aims and objectives of the survey will inform the selection of appropriate equipment and techniques.

Aside from the standard equipment used to undertake bat surveys, such as bat detectors and torches, there are an increasing number of sophisticated devices available. Whilst the use of these technologies may improve our knowledge of bat ecology, they also present new challenges for those expected to select and operate them, and to interpret results gained from their use. In this chapter we focus on the most commonly used equipment and techniques available to survey bats. It is not an exhaustive review, and we do not make comparisons between different commercially available brands.

6.2 Basic equipment for roost surveys

It is possible to undertake a basic survey for bats using minimal equipment. However, any equipment which makes a survey more comprehensive and reliable is to be encouraged, providing its use does not result in prolonged disturbance to bats, especially during sensitive life stages. The following equipment is recommended for roost surveys:

- Elevation and baseline drawings of the building or structure.
- Reporting form.
- Compass.
- Tape measure or equivalent equipment to measure or estimate the dimensions of the roof void or other structures.
- Clinometer to measure height of building or structure and roost emergence points.
- Binoculars.
- Powerful torch to illuminate dark corners from the ground, preferably with a red filter to minimise disturbance to bats.
- Endoscope and mirrors for inspection behind boarding and in cavities.
- Ladders.
- Small torches for close inspection of cavities and cracks.
- Spare batteries and other consumables (e.g. bulbs, data storage cards) for all equipment.
- Collection pots and labels for corpses and droppings.
- Camera to record evidence and potential roosting sites.
- Personal protective equipment (e.g. gloves, helmet), and mobile phone.
- Bat detector.
- Thermometer.

6.3 Specific equipment

The main specific types of equipment used for bat surveys are listed in Table 6.1, along with their uses, limitations and other considerations. These items should be viewed as tools to make the survey process easier, more efficient, or more comprehensive. Electronic equipment only works optimally if the user sets it up and operates it correctly; operators should therefore be adequately trained in the use of the different equipment they are required to use. This chapter cannot replace manufacturers' instructions or training.

Table 6.1 Equipment commonly used for bat surveys

Equipment type	Uses	Considerations	
High-powered lamps	Illumination of dark roosting features and also active bats at night to observe behaviour and aid identification of species.	Numerous brands are available. Various battery types with differing lifespans and brightness. Users of very bright lamps should illuminate bats only for short periods.	Spotlamps and floodlights are available, but the use of a lamp to watch bats can cause disturbance, particularly to certain species such as lesser horseshoes (Stone et al 2009) and should be avoided wherever possible.
Bat detectors (see below)	Principally for acoustic identification of bats, measuring temporal and spatial variation in bat activity and describing echolocation behaviour.	Each of the many different detector types available has specific strengths and weaknesses. Some are reviewed below.	Consider the data required when selecting a detector. Consider the total cost of the equipment including peripheral hardware (e.g. sound cards), analysis software and training.
Binoculars	Inspections of structures and trees, viewing bats and signs in roosts, including in hibernacula. Can also be used for watching early emerging species (e.g. vantage point surveys).	Important factors to consider when buying binoculars are cost (you generally get what you pay for), depth of field, focussing distance, weight, brightness (especially in low light conditions), waterproofing and comfort.	Light-gathering and close focussing are particularly important considerations when selecting binoculars for bat surveys.
Night vision scopes and infrared cameras (see below)	Viewing and recording bat activity in low light conditions.	Resolution is much lower than with daytime use and is also limited by the quality of onboard infrared illumination; a separate infra-red lamp will often be needed for illumination.	'Zero lux' capability is needed to capture images in total darkness. Options include standard video cameras with low-light functionality, security cameras, and specialist night vision equipment.
Endoscopes / fiberscopes	Inspection of cavities and crevices that may be occupied by bats.	Limited by the size and manoeuvrability of the equipment and the size of the cavity. Experience is required to achieve good results.	Newer devices have small video cameras; older ones have fibre-optic transmitters.
Thermometers / humidity meters / lux meters	For recording environmental parameters within roosts and in the open.	Wait for the equipment to reach equilibrium before recording environmental parameters.	A wide range of devices and prices. Use of long term data logging equipment in conjunction with environmental recording devices should be encouraged to enable scientific investigation and comparisons (e.g. pre- and post- mitigation monitoring).
Digital cameras	For recording findings and providing evidence of identification, signs, sites, and habitats.	Ensure you are appropriately licensed to use a camera with or without a flash if bats are present in a roost.	Even low-cost digital cameras can take superb quality pictures. Low light modes can also be used to minimise disturbance.

6.4 Using bat detectors

Bat detectors are the principal survey tool of most bat ecologists and are used both to make ultrasonic bat vocalisations audible to humans and to enable recording and analysis of them. Many different hardware and software options are now available; we aim to highlight some of the more common pitfalls and misconceptions, and provide solutions to challenging survey scenarios.

There has been a significant increase in the number of models and brands of bat detectors available in recent years with new units continually under development in an increasingly competitive market. In some ways the considerable choice makes selecting the right detector more difficult, especially for commercial surveys the results of which may be subject to scrutiny at a public inquiry or used as evidence in a criminal court case. Nonetheless, competition is driving improvements in detector and software design that will improve the quality of our data collection, analysis and assessment.

Selecting the most appropriate detector for a survey, or selecting what equipment to purchase, is complex. No one bat detector is the best in all situations – they have different microphones, different sound/data storage methods, different additional capabilities or accessories (e.g. for monitoring temperature, light, location etc.), and there are a number of different software packages and methods of analysis available. The following factors should be considered before making a purchase:

- method of ultrasound transformation for listening/playback (heterodyne, time expansion, frequency division) and for recording (frequency division, full spectrum). Several detectors incorporate more than one method (see Box 6.1);
- microphone sensitivity, directionality and frequency response[4];
- range of frequencies sampled by the detector;
- cost of device and accessories (batteries and power leads, data storage cards etc);
- portability (for activity surveys);
- suitability for automated monitoring (including availability of weather proofing);
- quality of captured data;
- download times and required data storage capacity;
- battery life and whether rechargeable batteries can be used;
- ease, speed and accuracy of analysis of calls;
- cost of analysis software licence;
- additional features such as GPS connectivity, real-time spectrogram displays, automatic and/or preset tuning for heterodyne, external power connections, voice recording capability,

Heterodyne bat detectors are useful for voluntary work such as guided bat walks, but are no longer considered acceptable for commercial surveys unless used in conjunction with other detectors. The use of a detector that can record bat calls for later analysis should be considered standard for bat surveys by professional ecologists, for the purposes of planning applications and impact assessment. Bat call identification is difficult, both in the field and from sonogram analysis and conclusive identification of bat calls is often not possible. Recordings should be kept as evidence, which is valuable, and in some situations essential e.g. where data may have to be provided to inform a public inquiry or in court.

Box 6.1 Types of detector (adapted from Russ 2012)

The three main systems for converting ultrasound produced by bats into sound that we can hear are heterodyne, frequency division, and time expansion. In addition full spectrum sampling enables the recording of ultrasound at a high sampling rate without converting frequencies to the audible range. The last three are all ‘broadband’ systems that simultaneously sample all frequencies in the bat calls which means that all bat calls can be sampled if the sampling rate of the detector is at least double the frequency that needs to be sampled, and that recordings from these systems are suitable for sonogram analysis and bat call identification. This enables measurement of call parameters, to varying degrees of precision depending on the bat detector system used, which can help to confirm species identity.

Heterodyne

In a simple heterodyne system, ultrasound is picked up by the microphone and mixed with a signal from a tuneable oscillator in the detector which the user can adjust, normally by turning a dial on the detector. The bandwidth varies between detectors and can affect how accurately the peak frequency of bat calls can be determined, since a narrow bandwidth makes it easier to discern differences in tonal quality (linked to peak frequency) when tuning. Conversely, a wider bandwidth may result in more bats being detected.

4 All microphones are more sensitive at particular frequencies and may be biased towards detecting bats calling within a particular frequency range.

Frequency Division
This is normally the cheapest of the 'broadband' systems that simultaneously monitor the full range of frequencies contained within all bat calls. A frequency division of eight, for example, refers to counting the average time spent for eight oscillations of the electrical signal (that matches the acoustic signal). The time is measured when the voltage of the transformed sound wave equals zero[5]. This measurement of time allows a calculation of the average frequency of those eight oscillations. A single (dominant) frequency is plotted for each measurement point in time, with many more frequency points recorded in full spectrum sampling. As a result, low amplitude bat calls will not be recorded (unlike full spectrum recordings) if another sound source of higher amplitude is received (e.g. background noise or interference) and harmonic frequencies cannot be recorded at the same time as a higher amplitude dominant frequency. Sufficient frequency information is preserved using this system to enable basic sonogram analysis: recordings can be recorded and analysed using software that processes the recordings to give us a visual image of the sound to represent frequency against time, but not multiple frequency content and amplitude. As zero-crossing analysis only preserves a small proportion of the detail of recordable sound it is likely that a reasonable proportion of the bat passes received by the microphone will not be recorded when data is transformed through zero-crossing analysis. This is something to assess on a site by site basis and revisit depending on developments in equipment.

Time Expansion
Along with full spectrum sampling (see below) this method gives the most accurate reproduction of the bat calls. In summary the detector digitally stores the ultrasound signal, and replays it at a slower speed (usually x10, but sometimes slower) so it can be recorded. The signal retains the original signal in high resolution (Figure 3.4) and the entire call can be played back at a lower frequency 10 times lower in frequency and, as a result, it sounds 10 times slower to our ears. Recently developed time expansion units do not have recording limitations (except the size of the card) and it is now possible to listen back to time expansion recordings whilst recording full spectrum data rather than having to stop recording to listen back to previously recorded bat calls.

Full Spectrum Sampling
In addition to time expansion and frequency division systems, detectors are available that record ultrasound in 'real time' using a high-speed data acquisition card (A/D card). A microphone is connected to the A/D card which records sound at very high sample rates, thus enabling high frequency sounds to be recorded directly. These enable the production of high resolution sonograms as with time expansion, but also real-time continuous monitoring as with frequency division, so you get the best features of both systems. One disadvantage is that the sounds outputted by the detector are not in the audible range so it is not usually possible to hear what you are recording in the field, although new technology means that it is possible to record in real-time while listening in heterodyne, frequency division or listening back in time expansion. Some models are designed mainly for long-term unattended monitoring while others can also be used hand-held in the field and may display 'live' real-time sonograms

6.4.1 Sampling limitations of bat detector surveys
Bat detector surveys are limited by the likelihood of detecting bats acoustically. This will depend on the propagation of sound through the air, the characteristics of bat calls, and the way sound is received and processed by the bat detector. There is substantial variation in the overall detectability of different UK bat species due to variation in the frequency and amplitude of their calls. There is also variation in the sensitivity of different bat detectors to different bat calls and this variation should ideally be taken into account when using particular bat detectors. In summary, bats with calls that can be detected over greater distances use calls that are both high amplitude (loud) and low frequency such as the noctule and the most difficult to detect are those which use low amplitude (quiet) calls, such as the brown long-eared bat and barbastelle, or high frequencies, such as horseshoe bats (Hobbs et al, 2011). As a result each bat detector has its own effective survey area[6] in any given scenario which will vary between different species of bats and will be dependent upon the amplitude and frequency of bat calls as well as the temperature and humidity (which affect sound attenuation) at the time of the recording. It is important to consider this when assessing data from bat detectors.

It is not possible to use bat detector data to obtain a count of individual bats passing through a detector's effective survey area unless more than one bat is recorded simultaneously on a sound file, in which case that minimum count would only apply to that sound file and not a sequence of sound files. An automated detector can provide an index of bat activity, quantified as a number of bat passes (strings of recorded echolocation calls) per unit time, i.e. per hour or per night. Each bat pass recorded may refer to a different individual bat or it may refer to one or more bats passing a bat detector repeatedly. Although abundance cannot be estimated without visual (or automated video) verification (see use of night vision equipment below), it can be used, with cautious interpretation, to assess the likely type of activity

5 Most frequency division bat detectors do not measure zero-crossing points as the signal at zero is not quiet but includes background noise as well as internal electronic and microphone noise. A sensitivity threshold is set above this to avoid dominant background noise masking bat calls
6 This is best appreciated as a three-dimensional volume around a microphone in which an echolocating bat will be detected.

in certain survey scenarios. For example, a number of bat passes of the same species during the commuting period (either close to dusk or dawn) may indicate that the detector may be located on a commuting route; or a sequence of terminal feeding buzzes with more than one bat clearly present on a number of sound files may indicate that the location is of importance for a number of foraging bats. These assessments, particularly the former, would benefit from field observations to ground-truth their veracity.

6.4.2 Calibration

If a surveyor wishes to make comparisons between echolocation calls or bat passes recorded by different detectors (e.g. to compare bat activity on two sides of a hedgerow, or activity levels at numerous different automated sampling locations at a large site), it is important for the sensitivity of detectors to be standardised. Using the same sensitivity settings on bat detectors may be sufficient if a precise threshold, based on the minimum input level (in dB pe SPL) at which the unit will start to record, can be set, and settings should be recorded on survey forms. Ideally, detectors used for comparisons should be subject to a standardised calibration regime which is recorded and repeated at set intervals (e.g. annually / prior to each deployment).

A commonly used approach for calibration is to set up an ultrasonic sound source a set distance away from the detectors being calibrated. They can then be adjusted according to the manufacturer's instructions to achieve a uniform level of receptivity. It is important that detectors are calibrated in exactly the same location (i.e. with uniform proximity to objects) and that temperature and humidity is as constant as possible. This is best achieved by calibrating all detectors to be used for comparison (e.g. all detectors to be used on one wind farm site) together (Larson & Hayes 2000).

6.4.3 Bat call identification and subsequent analysis

Bat call identification is difficult, even in the UK where there is a limited range of species. Some species, such as a UK *Rhinolophus* species (e.g. lesser horseshoe bat) can be identified with certainty from a spectrogram, but a *Myotis* bat (e.g. whiskered bat) can be identified with a low degree of confidence to the species level and with a higher degree of confidence to the genus level. It should be made clear in survey reports that a reasonably large proportion of bat species cannot be identified with 100% certainty from their echolocation calls and it is important to include considerations as to how bats are identified, either as single species or to genus or group (such as *Myotis*, '*Nyctalus/Eptesicus* sp.' or '*Myotis/Plecotus* sp.') and what level of confidence can be applied to identification.

The complexity involved in identifying bat calls is compounded by variability within the calls used by different species of bats. All species of bat vary the characteristics of their calls within a given range (for e.g. frequency, call duration, inter pulse interval) that is typical of the species and there is often a substantial degree of overlap for some or all characteristics between species. This adaptive call design depends on mode of behaviour (e.g. commuting, searching or approaching prey) and surrounding habitat and bats will adjust their calls depending on their distance from objects, either prey items or obstacles they want to avoid (e.g. Holderied et al 2006; Murray et al 2001). The quality of recorded calls will also depend on the location of the bat detector and the orientation of the bat to the microphone. If a detector is deployed on a hedge and a bat is flying over the hedge or behind the hedge the quality of the recorded call is likely to be lower than if the bat is echolocating directly at the microphone with no obstacles between the two to impede the passage of sound. All detectors will record bat calls at optimum quality (and at greater distances) if the call is received by the microphone on axis[7] although this is less important for omni-directional microphones.

Accurate analysis of echolocation calls for species identification is dependant, not only on an understanding of call parameters (Russ 2012), but also on a thorough knowledge of the analysis programme utilised. Numerous different software packages are available for analysing echolocation call data. Some are generic and can be used with recordings from a wide range of equipment; others are brand-specific and are only suited to the data from specific bat detectors. Many of these programmes have complex analysis functions which take training and experience to learn to use competently. When selecting equipment, users should consider the software they will use for call analysis, the cost of the software, the cost of training, and the time needed to become familiar and efficient with new software.

6.4.4 Positioning, security and weather-proofing

Attempts to record echolocation calls can fail or result in poor quality data due to poor positioning of the detector or microphone. To avoid problems and optimise recording quality the following points should be considered:

- it is advisable to locate detectors and microphones, particularly omni-directional microphones, away from solid objects that may impede the passage of sound and create echoes. This is best achieved by locating microphones away from the ground, in open space (1-2 m from solid objects should be sufficient) and, if possible, detached from the detector on a cable[8] and mounted on a pole or similar;
- if a detector microphone is pointed along a feature then it may bias the data towards bats flying towards the detector and not record bats flying in the opposite direction, particularly with more directional microphones;

7 On-axis, for most microphones, is a line in the same direction as the long dimension of the microphone
8 Long cables may impede sound transmission, affecting sensitivity, and manufacturers should be approached to advise on likely effects.

- most species of bats prefer to fly out of the wind when commuting and/or foraging and insects often collect in the lee of habitat features, e.g. hedgerows. The weather forecast for the recording period may be useful to determine likely wind direction and therefore the optimal deployment location;
- recording sensitivity can be reduced if inappropriate attachments are used to secure the detector against theft and vandalism or to protect it from wind and precipitation;
- damage to microphones can reduce sensitivity very significantly and microphones should be handled with care and kept dry if not waterproof. If damage occurs then microphones should be replaced;
- some bat detectors are expensive and there are known instances where have been stolen, vandalised, and destroyed. It is important for landowners to be made aware of their presence and for detectors left in the field to be:
  - secured from theft and vandalism;
  - safe from risks such as falling from height;
  - well-camouflaged if hidden (e.g. with a locked box hidden on the ground and a cable and microphone up a tree), or to appear 'official' if on display to dissuade tampering;
  - suitably labelled with their purpose and owners' contact details.

Potential locations should be selected with respect to the objectives of the survey and some potentially suitable locations for automated detector systems are suggested in Table 6.2.

Table 6.2 Suggested locations of bat detectors, according to survey purpose

Location of detector	Purpose of survey
Attached to a wall or beam above head height in a roof space or barn. The detector should be located either close to potential roosting features or in a central location.	To determine if a barn is used by bats.
Inside the entrance of a grilled underground site.	To determine if an underground site is used by autumn swarming bats.
Next to a hedgerow at the position of severance, pointing along or across a potential flight-line.	To identify commuting activity along a hedge line to be severed by a proposed road.
On a tree facing across or along a woodland ride.	To determine if a woodland ride is used for commuting or foraging.
Detector microphone at height, fixed to a wind monitoring mast or balloon.	To determine bat activity in the area of a proposed wind farm, by surveying a proportion of the proposed rotor blade swept area.

6.4.5 Retention of sound files

For all projects where data may be required in future (notably for evidential and public inquiry) the raw digital or sound file data should be retained long-term, in a suitable format. It is good scientific practice to retain raw data, because future developments may enable new techniques to be used for species identification or other analysis.

6.4.6 Other considerations

Care should be taken if electronic equipment is used in potentially explosive atmospheres. Precautions may also need to be taken to help prevent the spread of disease (e.g. white nose syndrome), if bat detectors and other pieces of equipment are moved between sites.

6.4.7 Detector surveys for species with low intensity calls

A few bat species (Table 6.3) are difficult to detect with bat detectors because they produce quiet echolocation calls (low amplitude), have very directional echolocation calls, or use their eyes or ears and do not echolocate all of the time (especially in or close to roosts or when gleaning prey). Where the pre-survey data search shows that these species are likely to be present, additional effort may be required for acoustic surveys as longer sampling periods will increase the likelihood of detecting these species. Advanced techniques may also be useful and could include mist netting or harp trapping, the use of acoustic lures, and/or radio tracking. Use of these techniques should be proportionate to the significance of any likely predicted impacts.

Species	Echolocation characteristic/s which create low detection likelihood	Approach for addressing the problem
Brown or grey long eared bat	Low amplitude and frequency modulated (FM: where energy is spread across multiple frequencies) calls are often used. It is likely that foraging bats often make no sound and use eyes or ears to hunt by gleaning (Swift & Racey 2002).	Attempt to intersect bats with detectors on commuting routes, when calls are potentially of higher intensity. Infrared night vision equipment can be used to identify *Plecotus* species bats by their distinctive appearance. Inside buildings, placing a detector high up usually increases the number of passes recorded.
Bechstein's bat	Calls of *Myotis* species for which call intensity has been measured are of fairly low amplitude (Faure et al 1990) and are generally FM. When in woodland this species is likely to spend a proportion of its time high in the tree canopy, making it potentially *difficult to detect.*	Even if its calls can be recorded, separating Bechstein's bat from other *Myotis* species is difficult (or impossible) by acoustic analysis. Catching surveys are likely to be required where there is a reasonable potential for this species to be present (i.e. habitat is suitable and a site is within the known geographic range) if this species may be at risk from a potential development.
Lesser horseshoe bat (similar issues for greater horseshoe bat but are reduced due to lower frequency calls)	Calls are directional at high frequency and are subject to a marked degree of attenuation that reduces potential detection distance and the likelihood of a bat being detected if echolocation calls are received by the microphone significantly off-axis. Call intensity has yet to be measured in the field for both UK horseshoe bats.	Where possible utilise a bat detector with good high frequency sensitivity. Full spectrum recording is recommended as there is some evidence that zero-crossing analysis 'loses' a high proportion of passes for this species. Deploying an automated detector within constrained flight corridors such as tunnels and natural corridors through vegetation that are often used by this species and where flights are concentrated will increase the likelihood of recording bats.
Barbastelle	Very low intensity echolocation calls (Goerlitz et al 2010). Flight is relatively fast, so recordings tend to be of short duration.	Use of broadband recordable detectors has helped to demonstrate that this species is present more frequently and across a wider range of habitats than previously believed. Calls are often missed by surveyors listening in the field as they are often indistinct, not repeated and masked by calls of other species. It is essential to use recordable detectors with this species.

6.5 Using night-vision equipment

Night-vision equipment can increase precision in emergence counts by ensuring that bats are less likely to be missed, and can allow poorly-observed behaviour close to the roost entrance to be interpreted. If footage can be recorded, detailed post-survey analysis is especially useful if highly accurate counts are required. The use of night-vision equipment has an important role to play, especially for the later emerging bat species such as Daubenton's and brown long eared bats.

6.6 Disturbance of bats during surveys

Resolution 4.6 of the EUROBATS Agreement 17 gives guidance on invasive survey techniques such as catching bats. It states that "the research being proposed should not adversely affect the conservation status of the population and should take account of the welfare of individual bats". It also states that radio-tracking "should only be used for well-organised and authorised projects where essential data cannot be acquired with less intrusive methods". Therefore, when surveys are undertaken for development, non-invasive survey methodologies should be exhausted first before invasive techniques are employed; where they are used, constant re-appraisal of the value of the information in relation to the potential risks to the bats is essential. Disturbance caused by a survey should be the minimum required to obtain the necessary information, and the least intrusive methods possible should always be employed.

Chapter 7
Bat activity surveys

7.1 Introduction

In this chapter, bat activity surveys are defined as: surveys undertaken with hand-held bat detectors by surveyors observing and recording bats in the field, and automated surveys, in which bat detectors are deployed to operate unattended. Activity surveys as defined in this document are surveys of active bats carried out by using non-invasive measures. In this chapter the focus is on acoustic surveys using bat detectors; visual surveys using night vision equipment can also be used (see Chapter 6).

The first step in developing a survey is to establish overall aims and specific objectives (see Chapter 4). Activity survey programmes for bat populations often have objectives such as determining the spatial distribution or abundance of bats, the use of an area by bats, and perhaps the extent to which activity changes over time. The objectives should inform the survey design. A poorly conceived survey design is likely to result in a waste of resources; information collected may be of little value for the ultimate aim of the project.

7.2 Aims and objectives of activity surveys, and types of data collected

The aim of a bat survey at a proposed development site is usually to assess the likely effects of the development on bat populations. The specific objectives of activity surveys vary depending on the specifics of the site and the proposed development. For example, objectives may be to identify:

- The assemblage of bat species using the site.
- The relative frequency with which the site is used by the different species.
- The spatial and temporal distribution of activity for different species.
- The nature of activity for different bat species, for example foraging, commuting and roosting.

Other incidental information may be obtained during activity surveys; for example, the emergence of bats from a building or structure may indicate a roost. However, the survey of building and structures is best undertaken with a survey design dedicated for such a purpose (see Chapter 8).

To achieve the aims of an activity survey it is not normally necessary or possible to quantify abundance (the number of individuals) or density (the number of individuals per unit area) of bats. Estimating abundance and calculating density requires the complete enumeration of bats within the sampling area, which is not normally achieved, but can be robustly inferred through the use of mark-recapture techniques (Kunz 2009). These require the use of invasive techniques not advocated for general survey work associated with development and are outside the scope of these guidelines.

In acoustic bat activity surveys, bat activity (expressed as an index, such as numbers of bat passes) is often quantified. Bat activity is, however, not a population index. An index is a statistic correlated to the true parameter of interest, but in fact there is little evidence that higher levels of bat echolocation activity reflect higher bat abundance (Hayes 2000). Bat activity indices can be more accurately described as indices of the amount of use bats make of an area, and should be used to quantify bat activity, not abundance (see Chapter 11).

Presence-absence data can be used to provide an estimate of the spatial distribution of a taxon, or of the proportion of an area occupied by a taxon. Echolocation techniques are applicable to this approach: a taxon is noted as having been detected or not detected at a number of sampling areas using a standardised procedure, such as a transect. The site can then be revisited, and the change in occupancy among sampling areas can be noted. Although this technique does not provide direct information on abundance, changes in spatial distribution can act as a surrogate for changes in abundance.

Recording and subsequently analysing echolocation calls in activity surveys can be costly in terms of both time and money. An alternative is evaluating the presence or quality of habitat features known to be closely linked to the presence, abundance, or demographics of species of interest which could reveal information about the status of that species. For example, woodpecker holes could be counted in woodland, or the area of unimproved grassland could be calculated. However, the relationship between bats and their habitats are complex, multi-faceted and poorly understood. Habitat characteristics often interact with other factors such as availability of food, level of predation, prevalence of disease, anthropogenic disturbance. As a consequence, structure or habitat surveys are unlikely to provide adequate information to judge the abundance or distribution of bats in an area (Hayes 2009). Nevertheless, surveys of structures or habitats are often undertaken prior to activity surveys, with or without quantitative assessment, and can be useful in suggesting the presence of bats, or as part of a preliminary ecological appraisal (see Chapter 4).

7.3 Identification of bats from their echolocation calls

Acoustic surveys are used to determine levels of bat activity in different habitat types, and to a lesser extent, to describe behaviour (e.g. foraging or mating). Acoustic techniques can also be used to investigate resource use, habitat partitioning by cryptic species and biodiversity; in these cases identification of individual species or taxa is at least desirable if not essential. Identification of bats from their echolocation calls is a non-invasive method that can be applied efficiently over a wide geographical area and can provide detailed species-specific ecological data (Russ 2012).

Bat activity levels are expressed as indices of bat activity (relative presence or counts of bat passes – see Chapter 11). However, call intensity varies among species, so interspecific comparisons in activity levels from echolocation monitoring data may be biased.

Recent advances in echolocation analysis allow repeatable identification of taxa. A probability of correct identification is associated with each identification, and the methods can be used by non-specialists (Parsons et al 2009). This makes the comparison of bat activity at a site across space or time more robust, because it removes variation in the skill of the observer to identify species. Quantitative techniques in echolocation analysis that allow repeatable identification will be increasingly adopted over time; however, activity surveys undertaken using subjective identification remain valid. Further discussion can be found in Chapter 11.

Echolocation call structure can vary between habitat types both within and between species. Subjective identification may be undertaken in combination with observations of morphology, flight behaviour and the environment the bat was recorded in (e.g. open landscape, clutter, or edge habitat). Identification of bats in the field is aided by careful and consistent recording (either as sound commentary or on paper) of observations. Key factors to observe are:

- bat species (or if the species is unknown, its echolocation call, morphology, pattern of flight and apparent size);
- location and habitat;
- type of activity – feeding, commuting, social calling;
- time of activity; and
- weather conditions.

The subjective identification of bats relies upon the individual skill and experience of the surveyor. When comparisons across space or time are being made, variations in the skill of the observers can become problematic: it is difficult to replicate studies (e.g. repeated transects) if the individual skill of the surveyor cannot be replicated. Training and the use of standard identification keys or methods can be used to minimise the impact of surveyor variability.

7.4 Survey design

The design of activity surveys should only be decided following a pre-survey data search and preliminary ecological appraisal (see Chapter 4) and must be developed in line with the survey's aims and objectives. Activity surveys often include various transect surveys and automated surveys at ground level, particularly at large development sites (see Chapter 9).

Transect surveys involve surveyors on foot carrying bat detectors along linear routes through the site (section 7.6). Transect surveys are seldom conducted in isolation; even a programme of four or five transect surveys each lasting a few hours gives only a snap-shot of bat activity. For example, five transect surveys conducted between April and September inclusive would take place on five of the total 183 nights (less than 3%). Automated surveys, in which detectors are left in the field, can be used to increase sampling time. The detectors can be moved around periodically, or the number of detectors can be increased to intensify the survey effort. However, automated systems cannot entirely replace transect surveys, because surveyors can make observations at the time of sampling and move around in response to bats. Surveyors on foot can also undertake spot counts (sampling at point transects, moving between them periodically) and timed searches (searching for bats for a given amount of time in each location, before moving to the next location; see section 7.6).

The location and combination of transects and automated surveys should be decided before the activity survey begins, through the use of aerial photographs and maps, and after a daytime preliminary ecological appraisal. Activity survey locations should be chosen so that they incorporate habitat features with potential for use by foraging and commuting bats. These may include, if present on the site, woodland, woodland edge, hedgerows, lines of trees, stream corridors, lake or pond edges, scrub margins and grassland, especially semi- or un-improved pasture. If the site has a uniform distribution of habitat features and/or is difficult terrain to traverse, such as wetland or dense woodland; then a random selection of accessible locations could be made. Surveyors should become familiar in daylight with all planned locations of transects, spot counts and timed searches, prior to the activity survey taking place. Survey sites must be safe for surveyors, and sites for automated bat detectors should be chosen with their security in mind.

7.4.1 Timing

Bat activity surveys should take place at the time of year, and at the time of the night, when bats are most likely to be recorded or observed. Weather conditions are also important, as few bats will be recorded if surveys are conducted on wet or windy nights. Starting times vary throughout the year as they are always referenced to sunset or sunrise.

Transect surveys can be undertaken as:
- dusk surveys only;
- dusk and pre-dawn surveys with a break between the two;
- dusk to pre-dawn surveys; or
- pre-dawn surveys only.

Activity surveys and automated surveys can be carried out at any time of year to gain an overview of seasonal activity, but at any given site, surveys should be carried out during the optimal survey months (April to September inclusive in most cases) to maximise the chance of revealing the importance of the site to bats.

Table 7.1 gives guidance on timing for individual activity surveys for two common survey objectives. Table 7.2 gives guidance on timing for automated surveys, and on frequencies and time of year for transect surveys.

Table 7.1 Recommended timing for individual activity surveys. See Table 7.2 for automated surveys and for the recommended frequency of individual activity surveys (survey effort)

Survey objective	Dusk survey	Pre-dawn survey (if undertaken)
Bat activity away from roost (e.g. transects; all species)	START: 1/4 hour before sunset[1] LENGTH: 2-3 hours[2]	LENGTH: 2 -1 1/2 hours FINISH: sunrise[3]
Mating activity & swarming sites (all species)	START: approximately sunset LENGTH: 4+ hours after sunset	–

Notes
1 Some bat species emerge earlier; starting 1/2 an hour before sunset may be more appropriate (Dietz and Yalden 2009).
2 When the site is larger than 1ha, or at sites within 4 km of a greater horseshoe bat roost, 3 hours may be required.
3 Some bat species return to their roost whilst it is light and may require longer survey periods (Dietz and Yalden 2009).

7.4.2 Survey area

As a minimum the survey should cover the area affected by the proposed development. The survey may need to extend beyond the site boundary or footprint; for example, if proposed new lights may disturb a flight corridor outside the development.

The area to survey must be known and defined, so the activity surveys can be planned. The area may also be used to calculate a transect effort index (see Box 7.2).

7.5 Survey effort

When undertaking surveys at sites proposed for development, the survey effort should be proportionate to the likely use of the site by bats and the potential effects of the proposed development on the species present. The survey effort should be related to the habitats present; for example, more effort is required at a site which is predominately deciduous woodland with a river corridor than at a site which is mostly a paved car park. The regional location of the site also needs to be taken into consideration; bat species richness increases to the south and west of the UK.

Factors to consider when determining the correct level of survey effort are:
- the results of the pre-survey data search;
- the species likely to be found and the risk the proposed development is likely to pose for them;
- the size of the site;
- the type of development proposed; and
- the complexity of the site (e.g. does it have multiple and various features suitable for bats, or only one habitat type).

An activity survey should provide a representative sample of the bat activity at the proposed development site. Sampling should be appropriate to provide a sufficient amount of data to assess the potential implications of the whole development.

For activity surveys, the appropriate number of surveyors (and/or the number of visits) depends not only on the area of development but also on the value of the site for bats: the species expected to be present, the number of potential roost sites and the availability of suitable habitat. Additional survey effort may be needed if species with low-intensity echolocation calls are suspected of being present (see section 6.4.7). Ease of access and navigation around the site may also be a factor in determining the number of surveyors (and/or the number of visits). Transects should be designed to cover representative habitats within the majority of the site.

It is recommended that a quantitative approach is applied to activity surveys, in which they are designed so that as many factors are controlled as possible. Box 7.2 outlines a method to calculate an index of the survey effort for a site, so that survey effort can be quantitatively reported.

Box 7.2 Calculating the transect effort index (number of transect hours per ha)

A method of comparing and categorising the activity survey effort, for the wide range of circumstances encountered in surveying, is to use an index; such as:

transect hours : site area (hectares)

The ratio **transect hours: site area (hectares)** provides a measure of two important parameters related to survey effort: the time surveyors spent walking transects, and the site area in total. The index can be used to compare survey effort at sites of the same or dissimilar areas, and allows comparison between sites with different development types and survey objectives.

Transect hours is calculated as the number of transects undertaken through the survey season multiplied by the number of hours spent on each transect (including time spent on spot counts).

The index offers a consistent and transparent method of calculating survey effort; its adoption by consultant ecologists would enable guidelines to be created for survey effort relative to development type, survey objective and site area. An effort index for automated surveys can also be calculated.

Example:

A 2.1 hectare brownfield medium sized, low risk site is to be developed for housing. A survey objective is to quantify bat activity on the site (as bat passes per hour). A dusk transect was carried out by one surveyor on three occasions, evenly spaced between May and August. Each transect took 2½ hours. The number of transect hours = the number of transects per survey multiplied by number of hours and the number of surveys = 1 x 2.5 x 3 = 7.5 transect hours.

Transect effort index (number of transect hours per ha) = 7.5 transect hours : 2.1 ha = 3.6 hours/ha

Table 7.2 gives guidance on the minimum number of bat activity surveys that should be conducted to achieve a reasonable survey effort. Activity surveys should be spread through the optimal survey months, and more than one transect may be required to cover all areas as well as all habitats of the site in each survey session (one dusk or pre-dawn time period). Transects at one site should be of similar lengths, and should not normally exceed 5km. Pre-dawn surveys are particularly useful for locating roosts, and can be used in combination with dusk transect surveys. In Table 7.2, sites are categorised into having low, medium and high quality habitat for bats, and minimum survey effort guidance is provided for each.

Table 7.2 provides an overview of factors to consider when designing survey for projects and combining different survey approaches.

Further details on designing for large scale infrastructure projects can be found in Chapter 9.

Table 7.2 Minimum recommended visit frequency and timing for activity surveys

	Bat habitat quality		
	Low habitat quality	**Medium habitat quality**	**High habitat quality**
Small sites • **Site area < 1 ha (where deemed necessary)**	**Transect surveys**		
	One transect on 2 visits[1] Mar[2] – Sept[3] Optimum period Jun - Aug	One transect on 3 visits[1] Mar[2] – Sept[3] Optimum period Jun - Aug At least one of the three surveys should comprise dusk and pre-dawn surveys (or a dusk-to-dawn survey) within one 24-hour period.	One transect on 4 visits[1] Mar[2] – Sept[3] Optimum period Jun - Aug At least one of the four surveys should comprise dusk and pre-dawn surveys (or a dusk-to-dawn survey) within one 24-hour period.
	Automated surveys		
	1 location for 3 consecutive nights on 2 occasions Mar[2] – Sept[3]	1 location for 3 consecutive nights on 3 occasions Mar[2] – Sept[3]	1 location for 3 consecutive nights on 4 occasions Mar[2] – Sept[3]
Medium-sized sites • **Site area[4] 1-15 ha** • **Project value £1M - £20M**	**Transect surveys**		
	One visit per transect each season (spring, summer and autumn)	One visit per transect each month (Apr-Sep or Apr-Oct) At least one of the surveys should comprise dusk and pre-dawn surveys (or a dusk-to-dawn survey) within one 24-hour period.	Up to two visits per transect each month may be requested (Apr-Sep or Apr-Oct) At least one of the surveys should comprise dusk and pre-dawn surveys (or a dusk-to-dawn survey) within one 24-hour period.
	Automated surveys		
	1 location per transect. Data to be collected on 3 consecutive nights each season (spring, summer and autumn)	1 location per transect. Data to be collected on 3 consecutive nights each month (Apr-Sep or Apr to Oct)	2 locations per transect. Data to be collected on 4 consecutive nights each month (Apr-Sep or Apr to Oct)
Large sites, proposed for major infrastructure developments • **Site area[4] >15ha (or 5ha for brownfield sites)** • **Project value >£20M**	**Transect surveys**		
	One visit per transect each season (spring, summer and autumn)	One visit per transect each month (Apr-Sep or Apr to Oct) At least one of the surveys should comprise dusk and pre-dawn (or dusk to dawn) within one 24-hour period.	Up to two visits per transect each month may be requested (Apr-Sep or Apr to Oct) At least one of the surveys should comprise dusk and pre-dawn (or dusk to dawn) within one 24-hour period.
	Automated surveys		
	1 location per transect. Data to be collected on 4 consecutive nights each season (spring, summer and autumn)	2 locations per transect. Data to be collected on 5 consecutive nights each month (Apr-Sep or Apr to Oct)	Up to 3 locations per transect. Data to be collected on 5 consecutive nights each month (Apr-Sep or Apr to Oct)

Notes:
1 Surveys should be approximately spaced through the period of sampling.
2 Surveys should not start before April in the north of the UK, and should start later in years when the weather is inclement.
3 Season can be extended to October - November if working in southern England, or if surveys for mating activity are required, unless the weather is particularly cold.

7.6 Activity survey methods

7.6.1 Transects

Line transects are carried out by a surveyor carrying a bat detector, who walks at a constant speed along a planned route and records sound for subsequent analysis, and/or bat passes or species. The data collected can be used to provide an index of bat activity (e.g. bat passes per 100 metre section or bat passes per night) along the transect. Line transects are best suited to open habitats such as farmland and moorland, rather than enclosed habitats, such as woodland and scrub, but can be used on woodland rides or walks.
Transect surveys, when repeated, should be undertaken in opposite directions and, if possible, started from different points along the route. This is to allow for the differing emergence times of bat species and to provide a more complete overview of bat activity across the site throughout the survey period. Transect routes should be kept as close to the original routes as possible as the season progresses.

The number of transects required to cover the main habitat features of the proposed development site depends on its size and complexity. Sufficient transects should be planned to ensure that all features identified that may be used by bats are sampled within 2-3 hours after sunset. More than one transect is likely to be required to cover all areas and all habitats of the site in one survey session. Pre-dawn surveys may also be useful, particularly for locating roosting bats, and can be carried out in combination with dusk transects over the course of a season.

Listening points can be identified along transects to divide the route into comparable sections of distance and / or habitat. Points should be evenly distributed in distance and amongst the habitats at the site, including habitats considered to be of low value to bats, such as arable fields. Bat activity should be recorded for a set amount of time (at least 3 minutes) at each listening point, and may be recorded continually between the points. The number of passes should be recorded at each listening point and between listening points, so that bat activity can be compared throughout the site and within different habitats.

Data collected on transects should be retained. This can be done in a number of ways. The species (seen or heard), the time and the location can be noted on paper or by using the comment facility available on some bat detectors. Sound recordings should be made for later analysis. The recorded data provides an auditable record from the transect and should be archived for future reference. The recordings can also be analysed to identify the species or genus of bats. Table 7.3 provides an example of how transect data can be recorded/represented in the first instance. More detailed records are needed once call analysis is completed.

Line transect methods are efficient as they enable surveyors to cover large areas in a relatively short time. They can be adapted for point counts (section 7.6.2), vehicles (section 7.6.5) or boats (section 7.6.6).

7.6.2 Point counts

Point counts are counts or recordings made at a series of points; the surveyor moves between the points with or without sampling for bats. Point counts may be better suited to dense habitats such as woodland and built-up areas than line transects, and safer than line transects in steep or difficult terrain.

Listening points can be evenly spaced along the route, or spaced to include all habitats, including those considered to be of low value to bats, such as arable fields. Bat activity or sounds for subsequent analysis should be recorded for a set amount of time (at least 3 minutes) at each point. Activity can then be quantified and used to represent and compare bat activity throughout the site and within different habitats.

Table 7.3 Example of point count data sheet. Similar notation can be used for transects without points

Project name	Proposed housing S of Keynsham	**Start Time**	2050h	**Finish Time**	2350h	**Direction of travel**	N-S
Transect	1, near pond, red line on map	**Date**	24/07/12	**Sunset**	2105h	**Weather**	70% cloud, Beaufort 3
Surveyors	Joe Bloggs			**Bat passes heard**			
Station number	**Time (start–end)**	**Common pipistrelle**	**Soprano pipistrelle**	***Myotis* or long-eared bat**	**Large bats (noctule, serotine, Leisler's bat)**	**Other**	**Comments**
Point 1	2050-2055h	15 passes	1 pass	0	5 passes high overhead, from E, check woodland for roost	-	Time-expansion recordings made of whole transect
Walk	2055-2103h	7 passes, 1 social call?	4 passes	0	0	-	-
Point 2	2103-2108h	40+ passes	3 passes	0	0	-	-
Walk	2108-2118h	0	1 pass	1 pass?	1 pass	-	Large bat not recorded?

7.6.3 Driven transects

Driven transects can be useful to supplement walked transects and provide additional survey data when surveying for proposed road widening schemes, or on large sites. One long transect or a series of short ones can be carried out, and driven transects can also incorporate listening points.

Vehicles used for driven transects should travel slowly. If public highways are used, it is recommended that an orange rotating beacon is mounted on the vehicle's roof as a warning to other road users, and that a sign is placed on the vehicle saying "SURVEYING". It is also recommended that the authorities (for example police and local councils), as well as local residents if appropriate, are informed of the survey.

The transect should be driven along a predefined route, at a steady speed of 15 mph (24 km/h), preferably with dipped headlights. Echolocation calls are continually recorded by a detector mounted to point out of the window or sunroof on the hedgerow side of the vehicle, at a 45 degree angle to the direction of travel. A time expansion or frequency division detector is normally used for the recording, and the data are subsequently analysed so that bat taxa can be identified. The location at which bat passes were recorded can be estimated if a simultaneous Global Positioning System or Satellite Navigation record of the transect route is made. During the survey, the ambient air temperature, humidity, cloud cover, wind speed and direction, and any precipitation are recorded. On a plan of the transect route, the locations of street lighting (including bulb type e.g. sodium or metal halide) can be recorded. Lux levels may also be recorded.

Recordings made at a speed of 15 mph can be analysed, but sounds may be distorted and may be harder to identify than recordings made on walked transects or point counts. At higher speeds, interpretation of the recordings is difficult and bat identification may be unreliable; however, such surveys can be used to detect the presence of bats. If it is possible (e.g. when off the public highway), a steady speed of approximately 5mph should be maintained.

Driven transects can be used to cover a large area with relatively few surveyors, and do not require highly trained individuals. Analysis of the recordings requires considerable expertise and time needs to be allocated for this task. Bat passes recorded on driven transects are less likely to be made by the same individual bat than those recorded on walked transects, but passes should still be interpreted as quantifying bat activity, rather than counts of individuals.

7.6.4 Boat transects

Transects to record bat echolocation calls can be undertaken by boat, allowing access to areas that are otherwise difficult to survey. As with driven transects, boat transects can be used to provide additional survey data, but should not normally be used to replace walked transects entirely.

The craft used must be suitable for the waterway to be surveyed, the water must be deep enough, and there must be adequate headroom for the surveyor to pass safely beneath bridges or overhanging vegetation.

Boat transects are conducted along the waterway, close to the bank (the distance depends on the type of waterway). The speed of the boat should be below 5mph (8km/h) to allow recordings to be identified to species level to reduce distortion. The same detectors can be used as in walked or driven transects. The detector should be held or fixed angled at 45 degrees to the direction of travel at the side of the boat (i.e. pointing towards the river bank). Alternatively, the detector can be switched between pointing horizontally and downwards, in order to detect bats flying near to or within bankside vegetation as well as those flying close to the water's surface; or more than one detector can be used.

As with driven transects, the locations of bat sightings, ambient temperature, humidity, cloud cover, wind speed and direction, and precipitation should be recorded, as should the presence and position of any ambient lighting.

7.6.5 Timed searches

In timed searches (or time counts), surveyors move freely around the site for a set amount of time, recording bats and responding to any visual or acoustic evidence of bats they obtain at the time of the survey by moving towards it. Timed searches can be used to standardise survey methods for bat species that are difficult to detect, or if bats are spread over a wide area which cannot easily be sampled by using transects or point counts. Timed counts provide a simple and effective means of obtaining estimates of relative abundance in difficult terrain, such as:

- mountains or wetland bogs,
- landscapes with few features (moor, open farmland, large expanses of water),
- areas where it is difficult to walk around (e.g. in dense woodland, built up areas, buildings and structures elevated from the ground, railway marshalling yards, and road junctions).

Large sites can be subdivided into smaller areas; a random sample of these can be selected for sampling or each can be sampled on a different night. Searching for a set amount of time introduces an element of standardisation, which can be repeated in subsequent surveys. Timed search methods can be used when surveying for the presence of a species, and for estimating relative bat activity, or can form part of an activity survey programme that also involves other survey methods.

7.7 Automated surveys

The simplest automated bat detector systems consist of a broadband detector (frequency division, continuous full spectrum, or time expansion) attached to a recording device and left to collect data unattended in automated surveys. Automated systems are employed to achieve a greater level of survey efficiency than is possible with walked transects. They can allow several sample points to be surveyed at the same time, providing more comparable results, or be used to provide a more flexible timetable for surveying.

Automated surveys can be conducted at any time of year, but negative results obtained when the weather is less favourable for bat activity need careful interpretation. During the summer, the system can be used to record bats as they pass. During autumn, it can be used to quantify the level of activity at a swarming site. During winter, bats arouse periodically from hibernation, but as activity levels are low, such activity is unlikely to be captured by non-automated surveys. Automated surveys can be carried out to supplement transect survey data. An automated system can function throughout the night, while surveyors are carrying out other work nearby, and between transect surveys.

The numbers of bat passes recorded by automated systems vary appreciably from night to night, but the overall pattern of activity through the night, and the proportions of different species, are likely to be similar on successive nights. It is recommended that automated systems are used in each location for several nights in succession, in order to give representative figures for that time of year.

Programmable automated detectors can be left where appropriate year round. The optimum sample season is from mid-May to mid- September, switching on and off at pre-set times. The detector should be set to activate 30 minutes before sunset and to switch off either 3 hours after sunset or at dawn, depending on the survey design. Constraints are security, the weather and the need to change batteries or link the battery to a self-charging system such as a solar panel. The equipment could be left to run for months, with only infrequent visits to change batteries and download data, if the location being surveyed is secure and protected from rain, such as inside a barn or a grilled mine. In order to correlate results to weather conditions, the use of temperature and humidity data loggers in conjunction with automated bat detector systems should be considered.

Before automated detectors are positioned, the purpose of the survey must be considered so that the automated survey positions can be chosen to fit into the overall survey design. Automated detectors placed in the open can supplement transect surveys and indicate whether the results are representative of activity at other parts of a large site. The flight characteristics of the species under study also need to be considered. A survey of high-flying bats in an open area requires different placement of detectors than a survey of a bat species associated with cluttered habitats. A discussion of the likelihood of detecting different groups of bats with the type of automated equipment used can be included in the survey report.

Automated detectors have been used where bats are constrained into a narrow flight path, such as under bridges, or at roost entrances to identify direction of travel. Detectors along flight paths or close to roost entrances can indicate the level of activity of bats commuting to or from the roost, if the time of the observations is recorded. If several time-linked detectors are used, the direction of flight can also be deduced. However, because the position and recording direction of automated detectors is fixed, bats may be missed. Automated detector surveys therefore cannot replace observational surveys of buildings to identify roost sites (see Chapter 8); nor, alone, to determine the behaviour of bats crossing over/under roads (though useful, in combination with human observers).

The recorded data from automated surveys provide an auditable record of the survey and should be archived for future reference. The recordings may be subject to analysis to identify the bat species (or genera) present, and to quantify indices of activity (e.g. bat passes per hour).

Chapter 8
Roost surveys

8.1 Introduction

All bat species resident in the UK have been recorded using buildings and built structures as roosts (see Box 8.1 for definitions) at some time during the year. Many bats also use underground sites or trees as roosts. This chapter provides guidance on how to survey potential roost sites for use by bats.

The appropriate methods for roost surveys depend on the aims and objectives of the survey and the information needed to assess and mitigate for any potential impact of the proposed development. Roost surveys often include the following stages:

- Preliminary roost assessment
- Presence/absence survey
- Roost characterisation survey

In simple situations, all three stages could be completed in one or two visits, but in more complex situations or when preliminary roost assessments are undertaken at sub-optimal times of year, each stage may require a number of visits, and various methods may need to be applied, to provide the information needed to assess bats' use of a roost.

In this chapter we provide guidance on how to approach these stages and undertake roost surveys of different types in order to obtain the information required. The guidance cannot cover all the possible circumstances that bat surveyors will encounter, but is designed to be adapted to unique or unusual survey situations.

Box 8.1 Definitions used in these guidelines

Building
A structure with walls and a roof, for example a residential property, block of flats, office block, warehouse, garden house, folly, barn, stable, lime kiln, tower, church, former military pill box, school, hospital or village hall. Some buildings have cellars (underground sites) beneath them.

Built structure
A structure that was made by humans but cannot be described as a building or as an underground site, for example a bridge, wall, monument, statue, free-standing chimney, or derelict building consisting only of walls.

Underground site
A human-made or natural structure that is entirely or partially underground, for example a cave, cellar, souterrain, mine, duct, tunnel, military bunker, well, or ice house.

Roost (breeding site / resting place)
The guidance document on the implementation of the EU Habitats Directive provides general definitions for breeding sites and resting places. For bats the two often overlap, which is why in many cases they are both referred to as roosts. Any interpretation of the terms 'breeding sites', 'resting places' and 'roosts' must take into account the prevailing conditions. The following are general definitions:

Breeding site
Breeding is defined here as mating and giving birth to young. A breeding site is the area needed to mate and to give birth in, and includes the vicinity of the roost or parturition site, where offspring are dependent on such sites. For some species, breeding sites include structures needed for territorial definition and defence. Breeding sites that are used regularly, either within or between years, must be protected even when not occupied.
Breeding sites include areas required for:
1. courtship,
2. mating, and
3. parturition, including areas around the parturition site when it is occupied by young dependent on that site.

Resting place
Resting places are defined here as the areas essential to sustain bats when they are not active. Resting places that are used regularly, either within or between years, must be protected even when not occupied. Resting places essential for survival include structures and habitat features required for:
1. thermoregulatory behaviour,
2. resting, sleeping or recuperation,
3. hiding, protection or refuge, and
4. hibernation.

8.1.1 Understanding the roosting behaviour of bats

When carrying out any type of roost survey it is essential to understand the different types of roost used by bats (Table 8.1), the reasons they are selected, and the roosting preferences (Box 8.2) of the 17 species of bat which are resident and breeding in the UK. It is only through the application of this knowledge that a thorough survey can be carried out.

A basic understanding of the different types of roosts used by bats throughout the year is essential for bat surveyors, as it informs the initial assessment of the likelihood of bats being present and how a roost survey might be undertaken. Chapter 4 provides information about the annual cycle of bats.

Box 8.2 Broad categories of bat species according to roosting preferences (preferences for Alcathoe are currently assumed until further evidence arises)

- Crevice-dwelling bat species (which tend to be hidden from view): *common pipistrelle, soprano pipistrelle, Nathusius' pipistrelle, Brandt's bat, whiskered bat, Alcathoe bat, Bechstein's bat.*
- Roof-void dwelling bat species (that may or may not be visible on roof timbers): *noctule, serotine, Leisler's bat, Daubenton's bat* and *barbastelle.*
- Bat species that need flight space in certain types of roost: (that may or may not be visible on roof timbers) *Natterer's bat,* and *brown* and *grey long-eared bats.*
- Bat species that need flight space and flying access: (and roost hanging freely in the open) g*reater and lesser horseshoe bats.*

Table 8.1 Places often used by bat species for shelter and protection in summer and winter

Species	Summer	Winter
Common and soprano pipistrelles	Often found in relatively modern houses (post-1940s), in confined spaces on external parts of buildings e.g. under lead flashing, in box eaves and cavity walls. Often in buildings with flat roofs. Also found in older buildings and structures such as walls and bridges.	Small crevices in buildings, trees, stone walls, bridges, barns and also in bat boxes. Often in fairly exposed locations, to take advantage of warmer winter days for feeding. Rarely in caves and tunnels.
Nathusius' pipistrelle	Trees, buildings and bat boxes.	Trees, buildings and bat boxes.
Brown and grey long-eared bats	Older buildings with large uncluttered roof spaces. Roost along the ridge beam, in mortice joints, gable ends and around chimney breasts.	Buildings, caves, mines, tunnels and ice houses. Roosts in crevices as well as in the open.
Natterer's bat	Old, often stone, buildings with large main roof beams, timber-framed buildings and trees. In buildings they like small crevices such as those between beams or in mortice joints.	Cool entrances of caves, mines buildings and other underground structures - even exposed rock face crevices. Often in crevices.
Whiskered, Brandt's and Alcathoe bats	Found in a range of buildings, old and new, but do have a preference for older buildings with stone walls and slate roofs. Crevice dwellers found under ridge tiles, under slates, behind rafters, hanging tiles and roof boarding.	Caves and tunnels, but also some sites barely underground such as follies and lime kilns. In caves they tend to occupy areas close to the entrance.
Daubenton's bat	Bridges, especially over water, tree cavities, mill-races, tunnels, mines and cellars. Occasionally in buildings, usually old stone ones. More frequently found within houses in Scotland than in other parts of the UK.	Caves, mines and other underground sites. Often found in the warmer more stable environments. They can be found closer to the entrance towards the end of winter.
Bechstein's bat	Woodland species. Roosts in trees and bat boxes. Very rarely, roosts in buildings.	Trees.

Noctule	Primarily a tree dweller. Very rarely in buildings and structures such as walls. Uses bat boxes.	Trees, rock fissures, hollows and bat boxes.
Leisler's bat	Tree holes, bat boxes and buildings, both old and new. Found around gable ends, under felt or ridge tiles, and under loft insulation. Highly mobile species; roosts can be occupied for only a few days at a time.	Tree holes, crevices in buildings and occasionally in caves and other underground sites.
Serotine	Typically in 1930s buildings with high gable ends and cavity walls. Also occur in much older buildings and often in churches. Less frequent in modern buildings. Rarely obvious in the building. Found in cavity walls, crevices, around chimneys, under ridge tiles, between felt and roof tiles or boarding and roof tiles.	Thought that most hibernate in buildings.
Barbastelle	Trees and occasionally buildings such as timber-framed barns. Rarely found using buildings for breeding.	Buildings, rarely in caves and tunnels.
Greater horseshoe bat	Buildings, particularly older ones with a large fly-in access point to an open roof. Sites include older manor houses, churches and barns.	Caves, disused mines and tunnels, some of which can be 50 km or more from the breeding roost.
Lesser horseshoe bat	Larger rural houses, barns and stable blocks offering a range of roof spaces and a nearby cellar, cave, tunnel or ice house where they can become torpid in poor weather. Prefer access with uninterrupted flight, but can use more inconspicuous gaps if necessary (e.g. under door gaps).	Caves, disused mines and tunnels, some of which can be 50 km or more from the breeding roost.

N.B. Preferences for Alcathoe are currently assumed in the absence of further evidence

The use of a building or built structure by bats can sometimes be complex and the bat surveyor should always consider how the building or built structure could be used throughout the year. Box 8.3 provides a brief overview of the different roost types to consider when surveying any potential site.

Box 8.3 Roost types used by bats at different times of year (adapted from the Natural England Bat Mitigation Guidelines 2012)

Transitional roost (April-September/October)
On waking from hibernation or in the period prior to hibernation, bats search for roosts in which they stay for only a few days or on some occasions several weeks. These transitional roosts can be occupied by a few individuals or occasionally small groups. The transitional roosts used prior to hibernation are generally cool and thus may allow bats to reduce their energy requirements before going into hibernation.

Maternity roost (May-August)
Breeding females gather together around the beginning of May to form nursery colonies. During this period gestation begins with births typically occurring between June and July. The females and their young remain within the maternity roost until the young are weaned and independent (late July-August). These roosts tend to break up between August and September. Adult males are rarely found within these colonies. However, the adult males of long-eared bats, Daubenton's, Natterer's, greater and lesser horseshoe bats can be found roosting within maternity colonies with their numbers increasing throughout the active season.

Satellite roost (May-August)
Breeding females may have alternative roost sites in close proximity to the main nursery colony. These are referred to as 'satellite roosts'. The numbers of bats using these roosts can vary greatly, from a few individuals, to small groups.

Mating roost (September-November)
All British bats are polygynous i.e. males mate with several females. Mating generally takes place from late summer and can continue through the winter. A number of different mating strategies are used by bats, though males of some species establish mating roosts, whereby they defend territory and display/call to females to mate.

Hibernation roost (October-March)
Depending on the weather and food availability, bats tend to move to hibernation sites from October. Hibernation roosts can vary greatly in terms of the number of individuals and the diversity of species that occupy them. However, they tend to have a constant cool temperature and high humidity, which allows the bats to use less energy regulating their temperature. Bats will wake occasionally during hibernation to drink and feed.

Night roost (March-November)
Bats may use roosts other than traditional day roosting sites to rest in during the night. These roosts vary in their conservation significance. Night roosts may be used by a single individual on occasion or they could be used regularly by the whole colony. Studies have shown that night roosts may be of particular importance to some species i.e. the lesser horseshoe (Knight 2006), providing key resting places within core foraging areas.

Day roost (March-November)
These roosts are used during the day to rest in. Males of most British species spend the summer roosting alone or in small groups with other males in such roosts. Bats may regularly use a number of day roosts, switching between them on a daily basis, though conversely they may occupy the same roosting site for several weeks.

Feeding roost (May-November)
These roosts can be occupied by a single animal or a few individuals throughout the active season. They vary in their significance as they may be used by the whole colony or just a few individuals to feed, to shelter from the weather or to rest temporarily. Feeding roosts are often used by *Plecotus* and *Rhinolophus* species.

Other considerations
Swarming sites
Swarming takes place between August and November, whereby large numbers of bats from several species gather, generally around caves and mines. They are often dominated by the *Myotis* species and appear to be important mating sites with some bats travelling several kilometres to reach these areas. A proportion of the bats that travel to these sites will remain to hibernate.

As with most ecological survey work, in roost survey work there is no substitute for practical experience. With greater experience comes an ability to judge whether a building or structure is likely to be used as a bat roost. However, experience can also lead to over-confidence, which can result in some potential roosting locations being dismissed before appropriate and thorough survey methods are applied.

Table 8.2 lists some of the features of buildings and built structures that surveyors should be aware of when assessing the need for, or undertaking, a survey. Further guidance on assessing the need for a survey is provided in Chapter 2.

Table 8.2 Features of buildings and built structures that are correlated with their use by bats in summer[1]

Likelihood of bats being present	Feature of the building or built structure and its location
Higher	Pre-20th century or early 20th century construction[2]. Agricultural buildings of traditional brick, stone or timber construction. Large and complicated roof void with unobstructed flying spaces. Large (>20 cm) roof timbers with mortice joints, cracks and holes. Entrances for bats to fly through. Poorly maintained fabric providing ready access points for bats into roofs, walls, bridges, but at the same time not too draughty and cool. Roof warmed by the sun, in particular south facing roofs. Weatherboarding and/or hanging tiles with gaps. Low level of disturbance by humans. Bridge structures, follies, aqueducts and viaducts over water and/or wet ground.

	For rarer species, buildings or built structures in the core area of their distribution. Buildings and built structures in proximity to each other providing a variety of roosting opportunities throughout the year. Buildings or built structures close to good foraging habitat, in particular mature trees, parkland, woodland or wetland, especially in a rural setting
Lower	Modern, well-maintained buildings[3] or built structures that provide few opportunities for access by bats. Small, cluttered roof space. Buildings and built structures comprised primarily of prefabricated steel and sheet materials. Cool, shaded, light or draughty roof voids. Roof voids with a dense cover of cobwebs and no sections of clean ridge board. High level of regular disturbance. Highly urbanised location with few or no mature trees, parkland, woodland or wetland. High levels of external lighting.

Notes
1 The features listed here may not be indicative of use of the site by bats during winter or spring. This table should be read in conjunction with Box 2.1 - Chapter 2, which provides triggers for bat surveys.
2 Pre-1914 buildings may present the greatest likelihood of providing roost space for bats due to their design, materials used and age. Pre-1990 buildings, especially when close to good foraging habitat, and with favoured features such as cavity walls and soffits, also have a high likelihood of providing roost sites for some bat species.
3 Post-1990 buildings are generally less likely than older buildings to house roosts; however, some modern designs provide access to suitable roosting spaces for bats. Pipistrelles in particular occupy modern buildings and built structures providing that there are suitable access gaps (> 8mm) and provided the structure has appropriate characteristics for roosting.

8.1.2 Aims of roost surveys

The appropriate methods for a survey of a potential roost site depend on the purpose of the building or structure and the nature of the proposed development project or circumstances being assessed. In general, the **preliminary roost assessment** is an external and internal inspection survey, conducted to assess the likelihood of bats being present and the need for further survey and/or mitigation. The **presence/absence survey** should establish where and whether bats are roosting at the site, and the type of roost (Box 8.3), by dusk emergence survey, pre-dawn re-entry survey, backtracking, and/or automated activity survey. If roosts are found, and in particular if a mitigation licence will be applied for, a detailed **roost characterisation survey** should be conducted to establish how bats use the roost (e.g. the location of roosting bats, flight paths and flight behaviour, exit and entrance points to the roost); the intensity of use (e.g. number of bats, sex of bats, time and duration of use); and what features and characteristics of the roost and the surrounding area are of importance. Internal climatic assessment (temperature, humidity light etc.) may be necessary, along with activity surveys on flight lines and linear features connecting to surrounding habitat, and, in very rare instances, capture survey to determine the species, sex and/or breeding status of the roosting bats.

8.2 Preliminary roost assessment

A preliminary roost assessment is used to determine the actual or likely presence of bats and how they use a roost site. It involves compiling information on the location of all known or likely roost sites and looking for evidence of whether they are used by bats, by means of internal and external inspection. For many built structures, such as bridges or walls, internal inspections are not possible and different methods may be required; however, where possible, internal inspection of a structure should be carried out. To enter any known roost site, surveyors should be in possession of a survey licence or be accompanied by a licensed person (see Chapter 2).

A systematic search should be made of the ground, especially below potential access points, windows sills, window panes, walls, hanging tiles, weather boarding, lead flashing, eaves, behind peeling paintwork or surfacing materials and under tiles. For buildings constructed from stone rather than brick, particular attention should be paid to cracks and crevices that provide protection from the elements. Such features are known to be used by small numbers of bats throughout the summer period, and occasionally maternity roosts have been recorded where access to rubble-filled walls has been available. The external survey should also consider the state of any structures and assess whether they are safe to enter.

Once the external inspection has been completed, an internal inspection should be undertaken. The building should then be entered and an internal inspection conducted in daylight, aided with a torch. In derelict or abandoned residential, institutional or office buildings, bats may be using rooms and other spaces within what would have been the living or working space of the building, and each room should be surveyed for bat presence. Surveyors should work quietly and check the buildings in a systematic manner working upwards from the entrance (checking any cellar space last). On entering an individual level (or room) the places bats are most likely to be should be checked first; for example, if there are droppings under the ridge beam, the area above should be viewed. In open warehouses, the darker areas should be surveyed first.

Within rooms in the buildings, surveyors should pay particular attention to:
- the floor and surfaces of furniture;
- behind pictures, posters, furniture, peeling paintwork, wallpaper, plaster and boarded up windows;
- window shutters and curtains;
- wooden panelling;
- lintels above doors and windows; and
- clean swept floors (which may indicate evidence has been removed).

Even where the building is still occupied, an internal inspection of the upper floors is necessary. Close inspection of window sills and window glass can provide information not available from an external survey from the ground.

Frequently-used roost locations within roofs include:
- the top of gable end walls;
- the top of ridge and hip beam and other roof beams;
- mortice joints;
- the junction of roof timbers, especially where ridge and hip beams meet;
- the top of chimney breasts;
- behind purlins; and
- between tiles and the roof lining.

A search of the roof void should be made, with particular attention to:
- all beams (for free hanging bats);
- clean swept floors (which may indicate evidence has been removed);
- droppings beneath the ridge and hip beams of the roof and junctions between the two;
- droppings and urine staining on and at the base of dividing walls, gable end walls and around chimney breasts;
- droppings, urine staining and corpses on, under or in materials or boxes stored in the roof;
- droppings beneath purlins;
- droppings and corpses beneath roof insulation;
- corpses at the base of walls and near wall plates at the base of rafters;
- corpses in uncovered water (header) tanks or other containers in the roof;
- bat-fly (Nycteribiid) pupal cases (Hutson 1984);
- scratch marks and characteristic staining from fur oil on timber and walls;
- mortice joints and junctions between roof timbers and between timbers and walls;
- clean gaps and sections of ridge beam and other timber and walls within the roof;
- gaps between lintels above windows or doors;
- light gaps in the roof indicating access points to the outside;
- access to cavity or rubble-filled walls; and
- cool areas suitable for torpor or hibernation;

In addition to searching the roof and other parts of the building the surveyor should listen for bats squeaking and chattering during the day, as this can often give away a roost location that is not visible.

A list of equipment needed for surveying roosts is provided in Chapter 6. It is important that surveys are undertaken using the most appropriate equipment in order to provide the necessary health and safety protection and minimise the risk of missing bats.

The time needed for internal and external inspection surveys depends on the number of surveyors and the complexity of the structure being surveyed. Surveys of relatively simple buildings may be straightforward and quick to complete, but it takes time to view and understand the roof structure of complex buildings or groups of buildings. Finding and accessing multiple entrance points adds time to the survey process. Buildings and other structures may be used by more than one species of bats, in more than one roost location, and at different times of year; discovering and understanding complex use patterns also takes time.

As a guide, an internal inspection of the roof area of an unexceptional four-bedroom domestic property is likely to take one surveyor one to two hours; an internal inspection of a traditional timber-framed farm building may take one surveyor between four hours and one day; an internal inspection of a large complex building such as a former hospital or stately home, with numerous roof voids and buildings, may take one surveyor more than one day.
When assessing a site's potential as a hibernaculum, surveyors should be aware that bats may hibernate in places that

cannot be seen or accessed; this may lower the confidence in a negative survey result. It also means that inspections of winter roosts can be time-consuming, as endoscopes and mirrors are often required in order to search for individual bats or small groups of bats hidden in crevices.

Time taken for daytime external inspection surveys also varies depending on the complexity of the structure. Evidence of bats may not remain after rain or wind, so weather and time of year will have a bearing on the level of confidence that an external inspection will give.

An inspection survey, whether internal or external, should be carried out as follows.

- Permissions should be obtained and an appropriate risk assessment should be completed (see Chapter 3).
- Sufficient time should be allowed during daylight hours to enable a thorough survey to be completed of all external and internal parts of the potential roost site.
- A systematic search pattern should be used. The inspection should be thorough, and a consistent search effort should be applied to all parts of the structure (see Appendix 4).
- The results of the survey should be recorded in a standard manner. Box 8.4 provides details of evidence to record and features to note for buildings and built structures. Further details of information required for survey reports can be found in Chapter 5.

Box 8.4 Standard information to be recorded in preliminary roost assessments of buildings and built structures

Evidence of use by bats:

Location and number of any live bats.

Location and number of any corpses or skeletons.

Location and number of droppings.

Notes on relative freshness, shape and size of droppings.

Location and quantity of feeding remains.

Location of clean, cobweb-free timbers, crevices and holes.

Location of characteristic staining from urine and/or grease marks.

Location of known and potential access points to the roost.

Location of the characteristic smell of bats if no other evidence is recorded.

Features of the building or built structure:

Type.
Age.
Aspect.
Wall construction, in particular the type of brick or stone used to build the walls and whether it has cavity walls or rubble-filled walls.
Form of the roof, in particular the presence of gable ends, hipped roofs, etc. and the nature and condition of the roof covering.
Presence of hanging tiles, weather-boarding or other forms of cladding.
Nature of the eaves, in particular if they are sealed by a soffit or boxed eave and the tightness of the fit to the exterior walls.
Presence and condition of lead flashing.
Gaps under eaves, around windows, under tiles, lead flashing etc.
Presence and type of roof lining.
Presence of roof insulation.
Presence of water tanks in loft (note if covered or uncovered).
Structure of the roof including the truss type, age and nature of timber work.
Information or evidence of work having been undertaken that could affect use of the structure by bats.

More detailed instructions on searching buildings for bats can be found in Appendix 4

If a maternity roost is known to be present, accessing the roost during June and July should be avoided in order to prevent disturbance to lactating females. At this time an indication of the size of the roost and the species can be obtained using indirect survey methods such as counting and recording bats as they emerge from the roost.

8.2.1 Churches

Churches, because of their age, structure and location, often support bats. They are often complex structures without roof voids, but with bell towers or spires. Bats may share the main spaces of a church with worshippers. Where there are roof voids, these should be surveyed in the same manner as roof voids in domestic and other buildings. Where there is no roof void, the main space of the church itself requires survey.

Most churches are regularly cleaned, so bat droppings may be removed. Surveyors should find out when cleaning takes place, and take account of the cleaning schedule in their preliminary roost assessment of the use of the church by bats and speak to the cleaners. Bat droppings attached to walls, other structural features or furniture, out of reach of cleaners, should be searched for and inspected, with binoculars and powerful torches if necessary. Whilst droppings may be removed, urine splashes often leave a characteristic stain that is not removed by regular cleaning. Urine staining is particularly obvious on polished wooden, stone and metal surfaces. However, stains can persist for many years and so do not always indicate recent use of the church by bats.

Churches exist in a wide variety of shapes, but all have common architectural features; surveyors of churches should familiarise themselves with basic church structures (*Bat Workers' Manual* Mitchell-Jones and McLeish, 2004).). Churches may have crypts and other underground structures, and surveyors should check with the appropriate church authorities for the presence of such structures (see also Appendix 4).

8.2.2 Timber-framed and stone barns

Timber-framed and stone barns may be used by bats throughout the year, and can support a range of roost types for a variety of different species. Barns are often very open and tall, making preliminary assessment and detailed surveying of potential roost sites difficult. They may also contain farm machinery and other materials that can impede bat surveys.

When surveying barns, the features that should be given particular attention during an inspection survey include:

- tenon and mortice joints between truss beams and braces and the principal support columns;
- spaces between external weather-boarding/cladding and the timber frame or walls;
- gaps behind window frames, lintels and doorways including the main doors;
- cracks and crevices in timbers;
- gaps between ridge tiles and ridge and roof tiles, usually where the mortar has fallen out;
- gaps between stones or bricks (especially where purlins etc. enter the wall and by the wall plate)
- broken or lifted roof tiles;
- the ridge area of the roof (particularly between the ridge beam and roofing material)
- lifted lead flashing associated with roof valleys, ridges and hips, or where lead flashing replaces tiles;
- surfaces such as the ground, ledges, windows, sills or walls, machinery or stored material within the barns (which should be searched for bat droppings).

Close inspection of cavities and behind timbers should be undertaken using endoscopes and/or mirrors. This often requires the use of ladders. Inspection of the roof timbers and ridge beam often requires binoculars and powerful torches to illuminate the roof from the ground.

8.2.3 Bridges

Bats regularly use a wide range of bridges, especially those that cross slow-flowing watercourses or that are close to good foraging habitat (Billington and Norman, 1997). Bridges are often used as night roosts and for mating and social behaviour, thus bats may use bridges at almost any time of the year, and several bat species may use the same bridge; the preliminary roost assessment should be designed to take this into account. Species most often recorded from bridges include:

- Daubenton's bats;
- Natterer's bats;
- pipistrelles;
- brown long-eared bats;
- whiskered/Brandt's bats; and
- occasionally lesser horseshoe bats (in box girder bridges).

Bats roost in many different locations within old and new bridges. Features offering potential include holes, cracks and crevices leading to voids, particularly where there is clear access. Roosting locations in which bats have been recorded in bridges include:

- widening joints;
- expansion joints;
- gaps at the corner of buttresses;
- widening gaps (where the width of the bridge has been increased, forming a gap between the original and new structure);
- cracks and crevices (usually over 100mm deep) between stonework and brickwork, where mortar has fallen out (locations include the underside of the bridge span and spandrel, parapet and abutment walls);
- drainage pipes and ducts; and
- internal voids within box girder bridges.

Access is one of the most difficult issues to address when undertaking preliminary roost assessments of bridges. There are significant hazards to the bat surveyor because bridges are usually associated with roads, watercourses or railway lines. Where the bridge is over water, a boat may be required in order to inspect the underside of the bridge. If the bridge is tall, lifting equipment or scaffolding may be required in order to undertake a detailed inspection of potential roost sites. If the bridge is over a working railway line, road or canal, consideration needs to be given to the specific requirements and associated risks of working in these environments, and work needs to be agreed with the appropriate operating authority.

Once safe and appropriate access has been secured, searches should be made of the ground (especially below potential access points) and an inspection should be made of key features and locations within the bridge structure that are likely to support bats. Where close access can be arranged, it is recommended that potential or likely roost sites are inspected using an endoscope, torch or mirrors. Bridges and walls do not usually have accessible internal areas, but where there are internal voids that can be accessed; they should also be surveyed, following the guidance provided for buildings (see Appendix 4).

8.2.4 Underground sites

Bats use underground sites mainly as hibernacula. It is advisable to consult mining history organisations, the British Caving Association (BCA, **http://british-caving.org.uk/**) or local caving groups before undertaking visits to natural caves and abandoned mines. Such organizations frequently have important information about safety precautions needed for the site, its layout, history and details of any access agreements. The BCA also has a *Cave Conservation Code* (downloadable from their website). Caving groups may be available to provide training or practical assistance for survey work, and may even have records of bats at the site that could mean further disturbance could be avoided or reduced.

Each underground site has a particular set of hazards, and appropriate training, including Confined Spaces Training, may be required, along with specialist equipment. Entrances to underground sites may be above ground level, for example in quarries or cliff faces, requiring surveyors to have climbing experience and further specialist equipment. No underground site should be entered without conducting a thorough risk assessment, if necessary developing a method statement and ensuring that appropriate training has been undertaken and suitable equipment is available. Underground sites beneath buildings, such as cellars, may be more readily accessible to surveyors than caves and mines. They are often used as part of the building, for example for storage, and may not require the same survey approach as other underground sites

In preliminary roost assessments, underground sites should be searched systematically from the entrance in winter, and the locations of any bats seen should be marked on a map or plan of the site. A good torch is essential to light the way and to illuminate cracks, crevices and ceilings. With the exception of horseshoe bats, which usually hang from the walls and ceilings of hibernacula, hibernating bat species are often under-recorded because of their crevice-dwelling habits.

Careful inspection for droppings or oil staining around cracks and crevices, including in rock piles, may also yield evidence of use by bats. Automated bat detectors or loggers, which record bats' echolocation calls over periods of days or weeks, may also be used to provide a greater level of survey intensity (see Chapters 6 and 7). The presence of any significant accumulations of droppings, *Nycteribiid* pupal cases (Hutson 1984), stained or marked areas should be recorded, as these may indicate the presence of large numbers of bats at other times of the year. Further visits during different seasons may be required in such situations to assess use of the site. Handling hibernating bats has been shown to have a detrimental effect (Speakman *et al.*, 1991) and this must be avoided unless there is specific need to do so; for most purposes it is not necessary. Whilst it may not be possible to identify individual bats to species (particularly some of the *Myotis* bats), for many surveys it is sufficient to be able to state that bats use the site, and to identify them to genus. Surveyors entering hibernacula should familiarise themselves with the latest information on white nose syndrome (see Box 8.5).

Box 8.5 White nose disease and in bats in the UK

White nose syndrome is a detrimental condition affecting hibernating bats which has caused the death of millions of bats in eastern North America since 2006. Since 2009, the fungus associated with the syndrome has been identified in bats from eight European countries. Symptoms of white nose disease are:

- visible white fungus (*Geomyces destructans*), particularly around the nose of bats, but also on the wings, ears and/or tail;

The disease has been recorded in bats in Europe, but the other factors associated with the syndrome have not. These include:

- bats clustered near the entrances of hibernacula, or in areas not normally identified as winter roost sites;
- bats flying outside during the day in temperatures at or below freezing; and
- dead or dying bats in or near hibernation sites.

Currently (early 2012), up to no cases of white nose disease, or the syndrome have been confirmed for the UK, but surveyors are asked to report any suspected cases to BCT without touching any hibernating bats believed to have white nose disease, and to observe decontamination procedures after visiting hibernacula if any suspected cases of the disease or syndrome are being investigated locally. See http://www.bats.org.uk/ for more information.

The period during which bats hibernate in any given winter depends on factors such as ambient temperature and humidity. Bats can use hibernacula anytime between October and March, depending on the prevailing weather conditions. The highest numbers of bats in underground hibernacula are usually found in January. During the winter, individual bats move around to sites that present the optimum environmental conditions for their age, sex and body weight. Many species are only found in underground sites when the weather is particularly cold. Bats periodically arouse to drink, as well as to feed if it is warm enough for insects to be active. Arousal may also be triggered by disturbance through increased levels of noise, light or heat, which may result from the presence of surveyors. The disturbance is not always obvious to the observer at the time, as bats do not necessarily arouse immediately. There is evidence that the longer the bats have been in a torpid state, the more sensitive they are to arousal stimuli (Thomas, 1995).

Because winter surveys may disturb hibernating bats, visits should be limited to the minimum necessary to gain the required information. If it is necessary to assess the numbers of bats using a site, two visits are recommended, one in mid-January and one in mid-February. BCT's National Bat Monitoring Programme hibernation surveys are carried out once in January and once in February. However, if the temperature during March is very low, a third visit at this time may also be considered, especially following a warm winter when temperatures rarely fell below freezing. Visits should be carried out by a small number of people, in order to keep disturbance to a minimum and to prevent increases in temperature.

For sites used by more than ten bats, a single survey during cold weather in January or February is likely to reveal the presence of at least one bat and thereby confirming the existence of a hibernaculum. Absence is more difficult to demonstrate and, in some cases, it may be prudent to assume that a suitable site underground in good habitat and close to other known roost sites is used by bats and employ the use of static detectors.

8.2.5 Trees

All trees near to proposed developments that are likely to have an impact on bats should be subject to a preliminary roost assessment. This can be carried out at any time of year, but winter surveys when there are no leaves on the trees reveal more potential, while summer surveys are more likely to reveal signs of activity. In some instances both summer and winters surveys are required.

Preliminary roost assessment should be undertaken as follows:

- Use close-focussing binoculars to inspect the tree from the ground to the canopy.
- Inspect all aspects of the tree.
- Look for features indicative of bat roosts (see Table 8.3). Use a high power torch, even in daylight, to inspect cavities and shaded areas of the branch structure. This is useful at any time but especially so on a dull day. On bright days, it may be necessary to time the surveys to avoid being dazzled by sunlight.
- For surveys undertaken in summer, listen for bats making audible social calls from roosts in trees. An example is available on the CD-ROM that accompanies *Woodland Management for Bats* (Forestry Commission *et al.*, 2005).
- Ask appropriate people (landowners, managers, wardens, workers, dog walkers) if there is a history of bats using the site; be aware this may not be accurate.
- Record findings on a map. It may also be useful to mark the tree with tape, paint or a tag.

Table 8.3 Features of trees commonly used by bats for roosting and shelter, and field signs that may indicate use of trees by bats

Features of trees used as bat roosts	Signs indicating possible use by bats
Natural holes. Woodpecker holes. Cracks/splits in major limbs. Loose bark. Hollows/cavities. Dense epicormic growth (bats may roost within it). Bird and bat boxes.	Tiny scratches around entry point. Staining around entry point. Bat droppings in, around or below entrance. Audible squeaking at dusk or in warm weather. Flies around entry point. Distinctive smell of bats. Smoothing of surfaces around cavity.

Trees scheduled for arboricultural work should also be assessed, and may be categorised (Table 8.4) to relate the value of their features to recommended actions. This approach allows trees to be graded according to their potential to support bat roosts. Trees may be assessed as having the potential to support bats (from an individual to a larger roost); even if no bats have been found. This approach should be considered by arborists as the basic standard for assessing trees prior to pruning or felling. For arboricultural operations, an inspection should be made at the earliest opportunity, for example when an arborist is quoting for a job or undertaking a tree risk assessment. Failure to identify features with potential as roosts or signs of a bat roost could cause considerable delays, if these are detected later. When signs of bat use are found, or where the potential for use is high, the assistance of a consultant ecologist with appropriate experience should be sought.

This assessment method can be used to assess any tree for its value to bats, but is not considered appropriate for trees affected by proposed development. Here, more intensive survey work is likely to be required in order to assess the value of the trees along with other structures at the site, and to determine the impact of the development on flight lines and the impact of general disturbance over a longer period of time. Survey effort should be proportionate to the likely impact of any given operation.

Table 8.4 Protocol for visual inspection of trees due to be affected by arboricultural work, to assess the value of the trees to bats. **(Adapted from a protocol provided by Corylus Ecology Ltd.)**

Tree category and description	Stage 1 Initial survey requirements	Stage 2 Further measures to inform proposed mitigation	Stage 3 Likely mitigation
Known or confirmed roost	Follow SNCO guidance and these guidelines wherever possible, to establish the extent to which bats use the site. This is particularly important for roosts of high risk species and/or roosts of district or higher importance and above		The tree can be felled only under EPS licence following the installation of equivalent habitats as a replacement.
Category 1* Trees with multiple, highly suitable features capable of supporting larger roosts	Tree identified on a map and on the ground. Further assessment to provide a best expert judgement on the likely use of the roost, numbers and species of bat, by analysis of droppings or other field evidence. ***A consultant ecologist is required***	Avoid disturbance to trees, where possible. Further dusk and pre-dawn survey to establish more accurately the presence, species, numbers of bats present and the type of roost, and to inform the requirements for mitigation if felling is required.	Felling would be undertaken taking reasonable avoidance measures[3] such as 'soft felling' to minimise the risk of harm to individual bats.
Category 1 Trees with definite bat potential, supporting fewer suitable features that category 1* trees or with potential for use by single bats	Tree identified on a map and on the ground. Further assessed to provide a best expert judgement on the potential use of suitable cavities, based on the habitat preferences of bats. ***A consultant ecologist required***	Avoid disturbance to trees, where possible. More detailed, off the ground visual assessment. Further dusk and pre-dawn survey to establish the presence of bats, and if present, the species and numbers of bats and type of roost, to inform the requirements for mitigation if felling is required.	Trees with confirmed roosts following further survey are upgraded to Category 1* and felled under licence as above. Trees with no confirmed roosts may be downgraded to Category 2 dependent on survey findings
Category 2 Trees with no obvious potential, although the tree is of a size and age that elevated surveys may result in cracks or crevices being found; or the tree supports some features which may have limited potential to support bats.	None. ***A consultant ecologist is unlikely to be required***	Avoid disturbance to trees, where possible. No further surveys.	Trees may be felled taking reasonable avoidance measures. Stop works and seek advice in the event bats are found, in order to comply with relevant legislation.
Category 3 Trees with no potential to support bats	None. ***A consultant ecologist is not required unless new evidence is found***	None.	No mitigation for bats required.

8.3 Presence / absence surveys

Following preliminary roost assessment by external and internal inspection of a roost site, further survey work in the form of a dusk emergence, pre-dawn re-entry, backtracking, or automated survey may be undertaken to provide additional information on an identified roost or to provide a reasonable level of confidence that bats are not present. All three survey approaches can be used to provide additional information during the summer period, but automated surveys are likely to be most effective to determine bats' use of hibernacula.

Presence/absence surveys may be required when:

- a roost has been identified, but more information is needed in order to assess its importance and the potential significance of any impacts on it. Information may be needed on the number of bats within the colony, the access points, the species, and flight paths to and from the roost;
- a comprehensive internal inspection survey is not possible because of restricted access, but the structure or tree has features with a reasonable likelihood of supporting bats;
- a comprehensive preliminary roost assessment is not possible because it is a sub-optimal time of year, or there is a risk that evidence of bat use may have been removed by weather, human activities or the presence of livestock; or
- preliminary roost assessment has not ruled out the reasonable likelihood of a roost being present, but no definitive evidence of the presence of bats has been recorded.

Activity surveys, although strictly not presence/absence surveys, can be useful in identifying roosts before bats leave to forage.

8.3.1 Dusk emergence and pre-dawn re-entry surveys

Dusk emergence and pre-dawn re-entry surveys, in which bats are observed leaving and entering night roosts, are the primary methods for locating bat roosts in trees, buildings or built structures, as bats are not always found by internal and external inspection surveys. An emergence survey can also be used to estimate of the number of bats present in a roost.

During the preliminary roost assessment, the tree, building or structure should have been inspected in daylight before an emergence survey is undertaken, using binoculars where necessary, in order to assess all potential exit locations and the number of surveyors required. Surveyors should be informed of the areas on the tree, building or structure they are to pay particular attention to, and should not stand more than 50m away from the potential roost. Sufficient surveyors should be used so that all aspects of the tree, building or structure can be viewed at one time; for a tree or regular four-sided building, two surveyors may be adequate, but it is better to have some surveillance overlap. Each surveyor should count bats in a defined area, to avoid double counting. In public places, the surveyors should be able to see each other; additional surveyors may be required and fluorescent jackets are a useful aid to visibility.

Some bat species do not emerge until an hour or more after sunset (see Chapter 4), so the use of night-vision equipment and bat detectors should be considered to aid observation and identification of species. Observation of the potential roost may need to continue for two hours (see section 8.3.3); this requires vigilance and concentration.

Pre-dawn roost re-entry surveys are particularly revealing, as bats generally spend more time near the roost when returning to it than when emerging from it, giving surveyors more time to see the bats and entrance location; the dawn light can also be more favourable. August is an especially good month to observe maternity roost re-entry, as young bats are inexperienced flyers at that time and are often highly visible when returning to the roost. Different species vary in the time that they return to the roost. For example, pipistrelles and noctules return when light levels are relatively high compared to other species.

To obtain a reasonable estimate of the number of bats present, all bat exits and re-entries should be counted. There is often more than one roost exit, so the number of bats present in a tree, building or built structure cannot be calculated until all the surveyors report their numbers at the end of the survey.

8.3.2 Backtracking surveys

Backtracking surveys, used to find roosts by observing bats and tracking them to their roosts, were first developed in the Netherlands. The technique is based on four principles:

(i) The earlier a bat is seen after sunset or the later it is seen before sunrise, the closer it is likely to be to its roost (the exact time depends on the species).
(ii) Bats fly away from their roost at sunset, so surveyors should move in the opposite direction as the bats at this time to locate the roost.
(iii) Bats fly towards their roost at sunrise, so surveyors should move in the same direction as the bats at this time to locate the roost.

(iv) At sunrise, some bats species swarm (interact socially while in flight) at roost entrances for between 10 and 90 minutes before entering.

In the evening, backtracking surveyors search for bats from half an hour before sunset, noting the time each bat is encountered and its direction of flight by means of an arrow (with time and species) marked on a detailed plan. Surveyors move freely around the site and in the opposite direction to any bats. At 2 to 2 1/2 hours before dawn, surveyors search again, this time for returning bats, starting on the potential flight routes identified the previous evening. Surveyors move in the same direction as any bats, and look out for concentrations of flight activity around roosts (swarms).

The information is later pooled from all surveyors to identify potential commuting routes and roost sites, and surveying continued if necessary for several nights. Backtracking surveys work best for early emerging species with loud echolocation calls which form large roosts, but can be used to locate the roosts of any bat species.

8.3.3 Timing

Presence/absence surveys, except in hibernacula, should be undertaken when bats are most active (April to the end of September), to optimise the likelihood of recording bats. May to August is the optimum time to survey for maternity colonies. Surveys may also need to be undertaken in spring and in autumn to ensure that spring transitional roosts and mating roosts are not missed. Multiple surveys at a single site should be spaced out to sample during as much of the time of year when bats are active as possible. In spring and autumn, bat activity may be low due to cooler temperatures or inclement weather, such as high winds and strong rain. Survey days should be chosen carefully in order to maximise the likelihood of detecting bat activity. Summer visits cannot confirm the use or otherwise of a roost in winter, although an assessment of its likely use in the winter may be possible. Automated surveys in buildings or structures during the winter period should be undertaken between November and February.

Dusk emergence surveys should begin at the latest 15 minutes before sunset, and should continue for up to two hours after sunset in order to take account of all species. For example, Natterer's, Daubenton's and brown long-eared bats often emerge well after dark. Some species, for example serotines and pipistrelles, emerge earlier, so an earlier start time (30 minutes before sunset) may be required. Pre-dawn re-entry surveys should be started 1.5 – 2 hours before sunrise, and should continue at least until sunrise.

8.3.4 Survey effort and frequency

Determining an appropriate level of presence/absence survey effort, in particular to allow surveyors to have confidence in negative survey results, is difficult. The effort is determined by a combination of the number of survey visits, the number of surveyors and automated surveys carried out, the season in which the survey is undertaken, and the weather at the time of survey. The likelihood of determining the presence of bats is increased if a variety of survey methods are used, so the survey methods used are also important in determining effort. Appropriate effort depends on the results of the preliminary roost assessment, the site, and the variety of buildings, built structures and trees present, and can only be determined by expert judgement; such judgement is difficult when the survey requirements and circumstances are complicated. The guidance given below and in Table 8.5 shows the minimum acceptable level of effort required in most circumstances. If, in the expert judgement of the surveyor, less survey effort is considered appropriate, a clear explanation should be presented in the survey report.

> A single daytime preliminary roost assessment visit to a site, in which no bats were found, is not normally considered sufficient, especially if the daytime visit was conducted outside the optimum time of year.
>
> However, if bats and bat signs were not found to be present and the building or built structure provides no suitable locations for roosting bats, then no further visits are normally required. In this case sufficient information should be provided to give confidence in the assessment.

If a building or built structure is considered to have a low likelihood of use by bats, one dusk emergence survey at an appropriate time of year, together with a pre-dawn re-entry survey or automated survey, is recommended to provide confidence in a negative survey result.

If a building or built structure is considered to have a moderate or high likelihood of use by bats, the preliminary roost assessment, even if negative for bats, should be followed by several presence/absence surveys. It is recommended that at least three dusk emergence surveys, pre-dawn re-entry surveys per roost should be undertaken during the summer period in order to give confidence in a negative survey result. At least one of these surveys should be a pre-dawn re-entry survey. At least two of the surveys should be completed between mid-May and August.

The presence/absence survey effort may need to be significantly increased if it has not been possible to undertake an internal or adequate external inspection of a potential roost as part of the preliminary roost assessment, for example because access into a roof void was prevented by the presence of asbestos. Under these circumstances, increased dusk emergence and pre-dawn re-entry survey effort should be made, and backtracking should be considered.

Table 8.5 Minimum number of presence/absence survey visits required to provide confidence in negative preliminary roost assessment results from buildings, built structures and trees in summer

High roost potential	Low to moderate roost potential	Low roost potential
3 dusk emergence and/or pre-dawn re-entry surveys during May to September Optimum period May – August	2 dusk emergence and/or pre-dawn re-entry surveys during May to September Optimum period May – August.	1 dusk emergence and/or pre-dawn re-entry survey during May to September Optimum period May – August.
If bats are discovered emerging from any of the buildings during surveys, the survey schedule should be appropriately adjusted to increase the survey effort so that sufficient information can be collected. **Note: two surveys carried out within the same 24 hour period constitute 1 survey**		

For large buildings or complexes with a moderate to high likelihood of supporting roosting bats, many presence/absence survey visits may be necessary, and survey data may need to be gathered by using automated techniques. Automated surveys for winter activity within buildings or built structures with a moderate to high likelihood of bats being present should be undertaken over a minimum of two weeks per survey. To provide confidence in a negative result, a minimum of two two-week survey sessions should be undertaken during the winter period. One session should be between December and February.

8.4 Roost characterisation surveys

If preliminary roost assessment and presence/absence surveys reveal a bat roost at a proposed development site and a mitigation licence is likely to be required for a roost characterisation survey is needed. Appropriate, well-designed mitigation is reliant on well-informed decisions based on good roost characterisation survey information. Whether the survey is for the disturbance, damage or destruction of the roost, information on the following should be collected if possible:

- Numbers of bats in the colony
- Access points used
- Temperature and humidity regime within the roost
- Aspect and orientation of the roost
- Size and perching points
- Lighting
- Surrounding habitat

This information is needed, because if it is necessary, as part of mitigation, to create a post-development roost to replace a roost lost through development, the conditions of the original roost need to be reproduced as closely as possible.

8.4.1 Colony counts and access points

The size of the bat colony and the way in which the bats access the roost are essential information used to determine what type of roost is present and what features are of importance. It can be difficult to ascertain this information during a single dusk emergence or pre-dawn re-entry survey, particularly if bats are roosting in complex buildings. In this case it is recommended that a dusk emergence survey is followed by a pre-dawn re-entry survey within one 24-hour period. It is particularly important to locate access points close to vegetation and flight lines, as these are used by bats to emerge earlier and forage for longer. Details such as the distance between bat access points and sheltering vegetation are important to record, so that appropriate conditions can be reproduced in the final mitigation provision.

8.4.2 Temperature and humidity regime within the roost

The ability for roost sites to achieve and maintain optimum species-specific roost temperatures is crucial for successful mitigation. Details on optimum temperature can be found in the Natural England mitigation Guidelines and on the BCT website.

The ambient temperature in the roost at significant maternity and hibernation sites should be monitored continuously for a period of time (e.g. by using a data logger), during at least one season before development. External temperature collection should also be obtained for comparison, as it can be the damping temperature variation. These baseline data can then be used to guide the mitigation plan in order to achieve or maintain an appropriate temperature in the post-development roost (though roosts may be improved by providing a warmer or cooler roost environment than the original structure, or an environment offering more diverse temperatures to accommodate bats over a prolonged part of the year).

8.4.3 Aspect and orientation of the roost

The precise aspect and orientation of the existing roosts, particularly significant ones, should be carefully documented, so that the solar properties can be fully understood and incorporated into future mitigation designs and planting regimes. Notes should also be taken of the presence of alternative heat sources, for example, if the roost is north-facing but adjacent to a hot water tank.

8.4.4 Size and perching points

The internal dimensions of the roost should be carefully documented, including the presence and locations of timber joists or beams, so that it can be recreated or retained as necessary. The availability of perching points is documented to be a limiting factor for bat species (Williams 2010). The availability of sufficient roosting substrates is a key measure of the ecological functionality of a site, and should be given full consideration by consultant ecologists in survey reports.

8.4.5 External lighting and internal light levels

If significant changes in light levels are planned as part of the proposed development, light levels should be measured both within roosts and externally as part of subsequent presence/absence and/or roost characterisation surveys. In order to carry out these measurements a suitable light meter should be held perpendicular to the most obvious source of light at different sample points on the site. Light readings should be taken at the main roost access points and along flight lines, to note the extent to which they are lit. This information should be noted on a site plan and factored into impact assessments and the design of mitigation.

8.4.6 Habitat assessment

Bats often use features such as hedgerows, tree lines, and waterways as commuting pathways between roosts and foraging areas. Sheltering vegetation, such as that in tree lines, not only acts as cover from potential predators and the weather, but also provides structure for acoustic orientation and navigation. Sheltered areas also allow insects to gather and therefore support bat foraging. Activities which affect these bat flyways are likely to have consequences for the bats using the roost.

It is important to record landscape and habitat features that may be important for bats using the roost. Where possible, important habitat features around the roost should be identified and included in the survey report, in particular linear features such as hedges, treelines and waterways, and features that could be used for:

- Shelter
- Foraging
- Connectivity between the roost and foraging habitats

Chapter 9
Surveying major infrastructure projects

9.1 Introduction

Major infrastructure projects usually take several years to conceive, commission, design and implement. Depending on their location and nature they may have a considerable impact on bat species and populations. Consequently, a proportionate survey is required to inform impact assessment and mitigation.

The types of development scheme which constitute major infrastructure projects include:

- Housing schemes of above 500 units or 15 ha in area.
- Business park and industrial plant developments greater than 15 ha in area.
- New port developments.
- New hospitals and other public projects.
- Power station and energy generation projects (excluding onshore wind farms).
- New or modified sewage treatment facilities.
- Open cast extractions.
- Landfill schemes.
- Pipeline schemes greater than 1 km in length.
- New railways and major station infrastructure projects.
- Road schemes including widening and major junction works of 1 km or longer.

This list is not exhaustive. Any development scheme with an anticipated construction value of £20,000,000 or greater may be classed as a major infrastructure project requiring an appropriate level of survey effort given its likely impact. Major infrastructure sites are also defined as, in general, those of over 15ha in area (or 5ha for brownfield sites).

9.2 Footprint and duration of impacts

Survey design and effort should reflect whether projects are 'footprint developments' or linear and the nature of the impacts. For example, a housing scheme has a permanent impact (loss of habitat), while the installation of a new water main has impacts only while it is being installed (construction impacts), and not once the landscape is restored. However, an extraction site could, for example, have a long-term operational impact.

Table 9.1 Development footprint (area or linear) and types of impact of various major infrastructure projects

Scheme	Area	Linear	Operational Impact	Implementation Impact
Housing	Yes	No	Yes	Yes
Business / industry	Yes	No	Yes	Yes
Brownfield	Yes	No	Yes	Yes
Ports	Yes	Yes	Yes	Yes
Hospitals	Yes	No	Yes	Yes
Power stations	Yes	No	Yes	Yes
WW treatment	Yes	No	Yes	Yes
Extraction	Yes	No	Yes	Yes
Pipelines	No	Yes	Yes	Yes
Railways	No	Yes	Yes	Yes
Roads	No	Yes	Yes	Yes

9.3 Current published guidance

Previously issued guidance on bat surveys at proposed development sites are provided in the Design Manual for Roads and Bridges Volume 14, in the chapter on bats. Wind farms may have particular consequences for bats and bat populations, which are addressed in Chapter 10. The survey guidance presented in this chapter builds on the methods described elsewhere to allow the surveyor to produce sufficiently robust data for assessment proportionate to the scale of the development.

9.4 Planning and legislation

Major infrastructure projects are subject to the requirements of the various planning acts and regulations, and are often subject to separate enabling legislation such as the Transport and Works Act, Port and Harbours Acts and in some cases permitted development. In most cases the approval for such acts will include the need for an Environmental Impact Assessment, which should usually address the ecological impacts, including those on bats. Habitats Regulation Assessment Effect may also be required if bat populations associated with SACs may be affected.

The principal requirement of legislation based on the European Union Habitats directive is that there should be 'no net loss' in the nature conservation status of the (protected) species. This should be achieved through conditions imposed during planning and through other acts, and through the appropriate licensing and permitting regimes. The 'no net loss' objective can only be achieved in major developments that affect bats through appropriate mitigation, which can only be designed based on sufficient high-quality survey information.

In developing mitigation for major infrastructure projects, there is a particular need to consider constraints on mitigation or compensation and the opportunities for enhancement at the earliest opportunity. Mitigation may need to include management of land outside the development area, or even land purchase.

9.5 Assessing the need for a survey

Guidance on assessing the need for a survey is provided in Chapter 2; existing techniques can be extrapolated to match the scale of major developments.

For major infrastructure projects, the zone of influence should be included when assessing the need for a survey. A strip of at least 500 m wide either side of a proposed linear route, and an area with a radius of 1km around other sites, should be included. The exact distance should depend on the value of the habitat, the species of bats likely to be in the area and the likely impact of the scheme (e.g. short term loss or reduction in quality of foraging habitat vs. severance of flight lines, loss of roosts). An assessment of the need for a survey should include consideration of:

- Existing information on bat species, populations and roosts,
- Protected sites, for example SACs designated for bats.
- The context of the site in its surroundings.
- Extant and quality of habitats within and around the site including water features, hedges, woodland, veteran trees; from maps and aerial photographs.
- Presence of known roosts or suitable buildings and other structures for roosts.
- Types of roost and species present.

In some sites proposed for major infrastructure projects, only relatively limited surveys are required; for example, green field locations currently in arable production and with no trees, buildings or water features present. In such cases the limited requirement should be confirmed using existing data verified by a field visit by an experienced surveyor. In most major projects, the scale of development would dictate presumption that field survey effort is needed.

The geographical location of a proposed site should be considered with respect to the known distribution of bat species in the UK. Surveys should then be conducted in advance of the design process to inform it, and during it to help refine it.

9.6 Preparation and planning

9.6.1 Resources required for survey

Organisations involved in the commissioning and operation of major infrastructure projects should be aware of the need to plan ahead for sufficient surveys effort to inform their design. Ideally one to three years baseline data should be available to design robust mitigation for bats.

Organisations should also be aware of the level of resources and expertise required to survey, assess and inform mitigation, and to provide continuity during the course of the project. A considerable degree of expertise is required to design surveys effectively and a considerable amount of manpower and equipment may be required to implement those designs. Surveys need to be robust enough to stand up to challenges brought by statutory consultees and other parties during the permitting process, which may include environmental impact assessment, public inquiry and parliamentary enactment.

Consultant ecologists proposing to design and undertake surveys for major infrastructure projects should consider whether they have sufficient expertise and resources to design, conduct, assess and interpret the survey. The need for continuity throughout the project should also be considered when assigning personnel.

9.6.2 The importance of meeting survey aims

The aim of surveys is to provide data to assess the potential impacts of a scheme, to inform the design of that scheme. Major infrastructure projects are unlikely to be moved to alternative locations or cancelled altogether, as planning applications are determined by a detailed process based on nature conservation and many other factors, and because the projects are deemed to be of overall public benefit. Consequently the data obtained should be sufficiently robust to inform mitigation ensuring that there is 'no net loss' to the conservation status of bat species present at the proposed development site.

Surveyors should aim to satisfy themselves and statutory consultees that sufficient data are available to minimise impact, inform mitigation, and, where possible, achieve enhancement. In some circumstances it may be possible to mitigate impact only by means of actions beyond the development site itself. This approach is known as mitigation banking; it may involve the manipulation of habitat elsewhere to improve it for the target species and populations. If this is a possibility for a particular project, the survey design should include appropriate survey effort to facilitate it.

All parties must understand that there may be limitations to survey effort, particularly at sites outside of the applicant's control. These limitations should be clearly stated in the methodology section of the survey report.

9.6.3 Pre-survey data searches

Pre-survey data searches are essential for all major infrastructure projects to determine the appropriate level of field survey effort. Given the size of these projects a thorough data collection exercise is required which should include all available information which can be reasonably obtained. Data on any sites designated for bats within 10 km should be obtained. Details requested should include locations of known bat populations, roosts, sightings within 2km of the proposed development and known details of habitats within a site and within 1km of it. Chapter 4 provides further details on specific methods and considerations.

Particular consideration should be given to the use of maps and aerial photography, which provide a useful resource to determine, for example, whether a site is substantially different from or substantially similar to the surrounding landscape and it's connectivity.

The limitations to information from pre-survey data searches should be clearly understood; in many cases, few data on bat presence and use will be available. The age of data, their level of detail and source should be considered. For example, information on a bat colony, collected during the last two years by a named individual that includes species, location of roost, and numbers of individuals should be given greater weight than a ten-year-old record of a 'vesper' bat with a location and no further information.

9.7 Survey techniques and standards

The methods described in Chapters 2-6, and the survey techniques presented in Chapters 7 and 8, may be applied to major infrastructure projects if appropriate. However, survey methods may need to be adapted to reflect the stage of a development as well as its nature. For larger projects, which take two to three years, early surveys to inform, for example, route options for a road scheme taking into account key features of potential importance to bats including roost sites, swarming sites, commuting routes and foraging areas should inform the design and can be followed by more detailed surveys of crossing-points and roosts. At each stage, the results should be communicated, to ensure they feed iteratively into the design of the scheme and any mitigation.

Netting and radio-tracking surveys can cause significant disturbance to bats, and should only be used when there is no other way of determining the necessary information, and where appropriate mitigation measures cannot be determined from survey information gained by other means.

9.8 Survey effort

In assessing impacts, consultant ecologists should consider the scale of the likely impacts and take a proportionate approach. The impacts of developments vary in terms of their likely direct impact on bats, and in terms of the area of habitat affected and the infrastructure required. Even relatively low risk developments may have a large impact if the site is important for bats. In large-scale schemes, because of the area involved, there may be more options for mitigation through sensitive design than in smaller schemes. Large proposed developments also provide potential for onsite or offsite habitat enhancement schemes.

Deviation from these guidelines (by either an increase or a decrease in survey effort) may be reasonable, depending on the characteristics of the site, the species present and the size and associated risks of the development. However, any deviations from the recommended survey effort should be detailed in the survey report, and should be justified by a clear rationale that is informed by scientific knowledge, evidence and expertise.

Surveys of known roosts should follow guidance outlined in Chapter 8. At major infrastructure sites, additional surveys should be carried out to identify the main commuting routes of species which cross the site and that have been identified as potentially at risk of negative impacts. It is also important to understand any seasonal patterns of use. The level of survey effort required for commuting surveys should be assessed in accordance with the activity survey guidelines (Chapter 7).

Bat activity surveys only provide a snapshot of activity, but do enable detailed information to be collected in most areas of the site and allow for additional visual observations to be made of bat activity. Automated detectors, if located correctly, can provide an invaluable volume of data on the bats present at the site, and are essential at major sites in order to gauge the relative importance of features and locations, as well as to quantify nocturnal and seasonal patterns of activity. It therefore recommended that activity surveys and ground-level automated surveys are carried out as a minimum at major infrastructure sites.

Appropriate survey design differs depending on the proposed development. However, consideration should be given to the spatial scale for surveys, which should closely reflect the potential impact and potential use of the site by bats. This is largely influenced by the complexity of the habitats within the site; the site's potential to support bats, and any historical data pertaining to the site and the surrounding area. Table 7.2 in Chapter 7 provides an overview of minimum recommended bat activity survey effort in small, medium and large sites of low, medium and high habitat quality for bats (see also Chapters 4 and 7).

9.9 Timing

Unlike in small development sites, in major infrastructure sites there are normally at least two years of surveys; bat surveys should be planned accordingly. A prerequisite for any good impact assessment is a sufficient year one baseline survey that enables potential impacts to be assessed. Baseline data collected in year one should be collected, recorded and analysed to provide information to direct the proposal, assess the likely impacts throughout the year, and identify and inform further survey effort. It is essential that sufficient information is received as part of the year one survey report.

At sites where sensitive high-risk species have been recorded, such as Bechstein's bat, it is recommended that comprehensive year one baseline surveys are followed by additional specialised surveys by experienced surveyors in year two. Additional survey tools can be used to gain a full understanding of the records from year one, and to understand the impact of the proposed development.

9.10 Interpreting results

Whether the survey programme encompasses one or more years of data and recording, a considerable amount of information will need to be analysed and assessed with respect to any major infrastructure project. Those interpreting the results will need to be suitably qualified and experienced in bat ecology, ecological reporting and appropriate ecological assessment methodology. The interpretation must assess the importance of the site for all bat species and populations present, describe the nature of the development, and propose mitigation and enhancement methods.

When surveys are conducted over more than one year, analysis and interpretation should be conducted each year and interim reports should be submitted, in order to minimise delays to survey interpretation and provide continuity. This approach also ensures that consultant ecologists can continue an effort started by others if necessary.

Chapter 10
Surveying proposed onshore wind turbine developments

10.1 Introduction

There is evidence from North America and continental Europe, though not (currently) from the UK that single large wind turbines and wind farms (multiple large wind turbines) have direct negative impacts on bats and bat populations and these are the primary focus of this guidance. Offshore wind farms and micro-turbines[9] are excluded from this guidance, although brief reference is made to them. The guidance also concentrates on collecting suitable baseline survey data for assessing the potential impacts of wind turbines upon bats, rather than any impacts associated with ancillary infrastructure, such as access tracks, site compounds etc. Impacts associated with the latter are likely to be limited and best assessed using standard methods described in other chapters of this guidance.

Some guidance is already available on survey standards and assessing the impacts of proposed wind turbine developments on bats. The Advisory Committee of the Agreement of the Conservation of Populations of European Bats (known as EUROBATS) has provided generic guidance on assessing the impact of wind turbines on bats (Rodrigues *et al*. 2008). The guidance cites evidence that bats have been killed by interaction with rotor blades in the late summer and autumn, but that resident bats from local populations have also been affected and recommends that pre-construction surveys should therefore be undertaken throughout the active bat season (spring – autumn). The guidance also states that pre-construction assessment should identify bat species and any feature used by bats within the landscape. Further details can be found on the EUROBATS website (www.eurobats.org).

All parties to the EUROBATS Agreement were urged to develop their own national guidelines for surveys of proposed wind turbine development sites. As so little evidence is available from the UK, interim guidance was drawn up by Natural England (Natural England, 2009a[10]) and ratified by Countryside Council for Wales and Scottish Natural Heritage. It interprets the EUROBATS guidance in a UK context, with additional guidance published for proposed single large turbines (Natural England 2009b). These guidelines are subject to review and a more recent summary of the SNCOs position has recently been published and should be sought from the relevant SNCOs.

In this chapter of the Bat Survey Guidelines, we build on the current guidance to provide a greater level of detail for ecologists responsible for carrying out impact assessments for proposed onshore wind turbines. Surveys designed following these guidelines will produce a sufficient level of detail to allow planners and authorities determining planning applications to make a well-informed assessment of impacts. We outline basic standards of good practice, and highlight specific considerations relating to proposed wind turbines.

It is important that any assessment considers the scale of the likely impacts and takes a proportionate approach. The likely impact of a single large wind turbine may differ from that of a large multi-turbine wind farm, not only regarding the likely direct impact on bats, but also because of the area of habitat affected and the infrastructure required. The relatively lower risk of a single, or small number of turbines needs to be balanced against the suitability of the site for bats, for example proposals for a single turbine in an area of high bat activity or preferred foraging habitat could pose a greater risk than several turbines in an area of low or no bat activity. It is often the case that larger schemes of 10 turbines or more are located in upland areas or generally homogeneous landscapes that provide a reduced resource for bats in terms of foraging/commuting and/or roosting habitat.

10.1.1 Offshore wind turbines

The extent to which bats use offshore areas in the UK is unknown. Studies from the UK and continental Europe are beginning to provide evidence of seasonal movement of Nathusius' pipistrelles across large areas of water such as the English Channel and the North Sea (Russ et al 2001), and of possible foraging by Daubenton's bats, pipistrelles, noctules, Leisler's bats and serotines over the sea (Ahlen et al 2009). Local records and observations made during scoping surveys indicate that bats, particularly those at high risk of collision with wind turbines, may be affected by proposed offshore wind turbine developments. As a precaution it is advised that the need for surveys at proposed offshore turbine sites should be considered on a case-by-case basis.

This chapter does not cover survey for offshore wind turbines in detail, as generally accepted survey techniques and standards for such schemes have not been developed yet. Proposed offshore wind turbine sites may be surveyed using

9 Micro and Small wind turbine systems are covered under the Microgeneration Certification Scheme (MCS) and are defines as turbines with a swept path of up to $200m^2$.

10 This was updated and re-issued in February 2012.

similar activity survey methods to those used for onshore sites, but surveys will need to be undertaken in different ways depending on the site. Boats or temporary offshore platforms may be used, or radar from coastal structures. Where deemed necessary, surveys should focus on possible migration routes rather than on foraging areas, and should be undertaken during spring (April/May) and autumn (August/October), unless bats found in offshore areas near to the proposed site, such as oil rigs and islands, indicate that bats are likely to be present at any other time of the year.

10.1.2 Micro-turbines

Micro-turbines are small wind turbines usually installed to service a domestic property or individual appliance (e.g. a road sign or remote monitoring station) and not for commercial energy production. This guidance does not include recommendations for surveying sites proposed for micro-turbines, although concerns exist about their possible impacts on bats. The production of best practice guidance is likely to be required following changes to permitted development regulations, which will vary between the devolved UK countries, and pending the results of research currently underway. Evidence suggests that micro-turbines may impact bats, particularly when they are installed close to roosts (BCT 2007). It is therefore recommended that potential impacts on bats from micro-turbines are assessed on a site-by-site basis.

10.2 Assessing the need for a survey

Building on existing guidance, an assessment should be made of the quality of the habitat at the site and in the wider landscape, and the potential for these areas to support bats, taking into account:

- the extent and quality of foraging and commuting habitat surrounding and on the site, e.g. woodland, well connected and structured hedgerows, waterways and water bodies;
- the proximity of the proposed site to areas designated for bats (SSSI or SAC); and
- the presence of buildings or other features or structures that may support, or are known to support bat roosts.

The factors outlined above provide indications of some of the features to consider when assessing the need for a survey for both wind farms and single wind turbines. More detailed information is outlined in Table 10.1 which provides an overview of factors to consider when assessing the level of risk that a proposed turbine development may present to bats (both to individuals and populations), i.e. low, medium or high risk. Any proposed site that has the potential to regularly support bats may have an impact on bats, although the potential impact is likely to increase in relation to the number and quality of habitat features (listed as examples in Table 10.1). It is recommended that any site with the potential to have an impact on bats should be surveyed prior to development.

10.3 Potential impacts

Research in the US and continental Europe has shown that impacts of wind turbines on bats vary depending on site, species and season. The most commonly documented impacts include:

- direct collision with blades, and
- barotrauma (mortality due to damage to bats' lungs caused by sudden change in air pressure close to the turbine blade (Baerwald et al 2008).

Other possible impacts include:

- loss of foraging habitat (due to wind farm construction or because bats avoid the wind farm area); and
- fragmentation of habitat (because wind farms form barriers to commuting or seasonal movements, and due to severance of foraging habitat).

Little is known about the impacts of wind turbines on bats in the UK, as there have been no systematic studies to date. Only a small number of fatalities have been documented and these have been found either during surveys for bird fatalities or ad-hoc (University of Bristol / BCT. 2009). Recent research from north-western Europe (principally Germany) shows that peak mortality (90%) has occurred at low wind speeds from late July to early October (Rydell et al 2010a) with a secondary peak (10%) during April-June and that bat mortality at operational turbines is, on average, 3.6 to 5.4 times greater than mortality associated with non-operating turbines (Arnett et al 2010).

10.3.1 Species-specific risk and impacts on local populations

The 'Bats and single large wind turbines: joint agencies interim guidance' includes a collision risk assessment for British bat species. This is divided into two parts: first an assessment of the category level of risk of each species based on its ecology (including foraging range and flight height); second an assessment of the populations likely to be most threatened, incorporating information on population estimates. Three species are identified as at high risk at the population level: Nathusius' pipistrelle, noctule and Leisler's bat. In research published since the interim guidance, noctules, common pipistrelles and Nathusius' pipistrelles were found most likely to be killed by wind turbines. Further studies (Rydell et al 2010a) have supported these findings; recorded bat mortality is predominantly (98%) among taxa adapted to open-air foraging, represented in the UK by *Nyctalus*, *Pipistrellus* and *Eptesicus*. Mortality was found to increase with turbine tower height and rotor diameter, but is independent of the distance from the ground to the lowest rotor point. A second publication by the same authors suggests that mortality of bats at turbines may be linked to high-altitude feeding on migratory insects that may accumulate at turbine towers (Rydell *et al* 2010b).

The level of risk ascribed to bat species or species-groups should be taken into account when designing surveys for wind farms so that survey work is devised in proportion to the likely value of a site for bats, whether the species present are at high risk from wind turbines and the likely scale of the proposed wind farm development (as in Table 10.1). As such it is important to be clear which UK species are of higher priority. The conclusions presented by Natural England (2009b) and Rydell *et al*. (2010a) are compatible in most respects as all species identified as being at high or medium risk by Natural England are included in Rydell's list of 'high-risk' species[11], with the exception of barbastelle. Rydell et al. identified that 'high-risk' species were those most likely to be killed by turbines (the 98%) and that 'low-risk' species are the group for which low mortality had been recorded. A single barbastelle fatality had been recorded at the time of publication of the paper and this put barbastelle in the low-risk category. Barbastelle is a fast-flying and aerial-hawking species that is thought to feed principally on moths (Sierro & Arlettaz 1997). It has very short range echolocation (Goerlitz *et al*. 2010) and there is no evidence that it is a species that may feed at altitude in contrast to the high-risk species identified by Rydell *et al.* 2010. Nonetheless, barbastelle is a rare species and a precautionary approach is advised until further evidence is available to clarify the level of risk to this species. We recommend that the approach advocated by Natural England is followed with respect to identifying the level of risk to all bat species and assessing potential impacts upon their populations until UK-based evidence is provided that may necessitate a re-assessment of this approach.

In the absence of a robust evidence base to show if and why impacts on UK bats occur from the operation of wind turbines, assessments for UK turbine development sites should take into account findings from elsewhere, such as those cited above from north-western Europe. It is advisable to adopt a precautionary approach until evidence does exist and assume that impacts may potentially occur (as at some sites in Europe).

10.4 Preparing and planning field surveys

10.4.1 Meeting survey aims and specific resources required

The overall aim of surveying at proposed wind turbine development sites is to collect robust data to allow an assessment of the potential impacts of the proposed development on the bat species present on and around the site. Guidance from the SNCOs (Natural England 2009a 2009b) outlines the basic information required from surveys. Chapter 4 of this document provides general information on the factors to consider when designing a bat survey, and Box 5.3 shows the information needed from surveys to enable an impact assessment to be made. In addition to this, surveys of proposed wind turbine development sites must identify species of medium and high mortality risk, and species whose populations are considered to be significantly threatened, as outlined by Natural England (2009a 2009b) and the relevant scientific literature. Surveys should also provide baseline information with which data from post-construction surveys (see below) can be compared. Appropriate survey design depends on a number of factors (see Section 10.5 and Table 10.1) and may need adjustment throughout the survey period to continue to meet the aims identified above.

As well as the resources, skills and specialist equipment needed in general by consultant ecologists surveying for bats (see Chapter 3), automated detector systems for use at height are often needed for surveys of proposed wind turbine developments (see section 10.5.6).

10.4.2 Pre-survey data searches

As for other proposed development sites, data from pre-survey data searches is used to inform survey design at proposed wind turbine sites (see Chapter 4), and searches should include the footprint of the site and any proposed access roads and temporary construction areas or other associated development. The data search for known bat records and roost locations should extend to 10km from the site boundary for high risk species (as identified by Natural England, 2009a and 2009b) and to 5km for all other bat species. The search for any site designated for bats as a SSSI or SAC should also extend to 10km of the proposed wind turbine development site boundary.

> In order to ensure that these aspects are sufficiently covered, a scoping survey should **always** be undertaken for a proposed wind farm site.

11 Rydell's list does not include medium-risk species or categories that define whether a species' population is thought likely to be threatened due to impacts from wind turbines as Natural England's guidance specifies.

10.4.3 Information on future land use

Consideration should be given to future changes in land use on the site that may occur as a result of the wind turbine development or during the proposed lifespan of the turbine. For example, a change from arable habitat before construction to cattle pasture following construction could provide higher quality foraging habitat for bats and lead to greater risk of mortality; or mitigation and habitat enhancement for other ecological receptors may attract bats into the area following implementation. Surveys should be designed to allow the assessment of any future impacts on bats as a result of a change in habitat management.

10.4.4 Re-powering

Many early wind turbines in the UK pre-dated the requirement to undertake pre-construction and post-construction bat activity surveys. At some of these sites, proposals may exist for re-powering (i.e. replacement of turbines with new and often larger turbines). It cannot be assumed that re-powering at existing sites presents lower risks to bats than the construction of new turbines, so re-powering proposals should be assessed before permission is given by the relevant body.

If bat surveys or monitoring have been undertaken at sites where re-powering is planned, the results should be used to assess whether the proposed changes are likely to increase the risk of bat mortality, and what, if any, mitigation should be applied. If no surveys or monitoring have been undertaken, the methods proposed here for new developments should be used as the basis for assessing the risk of re-powering.

10.5 Survey methods

Surveys at proposed wind turbine sites should be designed to provide the information required to complete a full impact assessment as set out in Chapter 5. Surveys need to provide information on spatial and temporal variations in bat activity of different species in the developable area (the part of the site where turbines may be located) and nearby. Data should be collected using survey techniques designed to confirm, and provide more information on, any potential impacts identified as part of the pre-survey data search.

The surveys required to obtain these data fit into two broad categories: Activity Surveys and Roost Surveys. Each of these techniques will provide information on different aspects of the site and its use by bats. This section of the document will outline the standards of best practice for each survey technique and highlight specific considerations relating to the surveying of wind energy sites. More detailed information on the general techniques and equipment that can be used for different methods can be found in relevant chapters of this document.

It is important to consider that the recommendations for the survey methods as well as the survey effort employed and frequency of surveys cannot be expected to fit every situation and professional ecological judgement should be used in all cases to guide appropriate survey design. In some situations a pre-survey assessment of site risk may need to be revised with accompanying revisions of survey method, frequency and effort. This may happen when, e.g. high activity levels of a high-risk species are recorded during April and May on a site assessed as low or medium-risk and the level of survey needs to increase from June, or at the end of the first survey season it becomes clear that a site initially identified as high-risk only supports low activity levels of a single high-risk species and that further targeted survey work (during a second season) may not be required. In any scenario where this happens, an ecologist will need to justify why the assessment of site risk has changed and whether the survey work provides an appropriate level of baseline information to assess the level of risk to bats.

> If a site is assessed as having no need for a bat survey, evidence to justify the assessment should be provided or requested to support this assertion.

10.5.1 Measuring environmental parameters

Bat activity surveys should take place in optimum weather conditions in order to maximise the likelihood of recording bats. It is usually advised to avoid very heavy rain, strong winds, mists and dusk temperatures below 10oC. This guidance should be followed for surveys at proposed wind turbine sites. However, where automated detectors are deployed for a number of days at a time, over a period of months, survey nights with ideal weather condition cannot be selected, and data from windy, wet or cold nights may be useful if weather information is also available. Whenever possible, data on wind speed, rainfall and temperature should be gathered during the entire data collection period. This information may indicate what parameters influence bat activity at the site, and could feed into mitigation plans such as plans to feather turbines (change blade angle to slow or stop movement) at certain times. Consideration should be given to installing a weather station or using data from a met-mast at high risk sites to ensure a sufficient level of detailed information is obtained.

10.5.2 Timing and survey season

Bat activity surveys should commence half an hour before sunset (dusk surveys) and finish at sunrise (pre-dawn surveys). Automated detector surveys should commence half an hour before sunset and finish half an hour after sunrise to ensure that bat species that emerge early in the evening and return to roosts late, such as noctules, are recorded.

Automated detectors are normally left in position to collect data all night. If they may be subject to interference due to public access to the site, security measures should be employed, such as placing detectors in locked boxes. Timers determining the start and end times of the survey should be regularly adjusted through the season to take account of the variation in night length.

Rydell *et al*. (2010a) identified that peak mortality (90%) of bats in north-western Europe occurred during late July to early October with a secondary peak (10%) during April-June. The core activity period for bats in the UK is also April-October and this should be taken as the core bat survey period for UK wind farms (weather permitting. In some instances it may be necessary to carry out surveys in March. Decisions to undertake surveys at this time should be influenced by geographic location of the site and the weather conditions at the time; i.e. are there any nights with sufficiently warm night temperatures in March to carry out surveys.

When deploying static detectors for assessing wind farms the core survey period is April to October (weather permitting)

In some instances it may be necessary to carry out survey in March. Decisions to undertake surveys at this time should be influenced by geographic location of the site and the weather conditions for the year.

10.5.3 Roost surveys

At sites offering opportunities for roosting bats, the survey should include a daytime inspection of structures and trees within 200m[12] of the developable area for evidence of roosting bats and to make a general assessment of potential roosting features within the survey area. Although it is not essential (and may be difficult) to locate roosts of individual or low numbers of bats, sites with evidence of roosting by medium and high-risk species and/or roosts of district importance and above (see Tables10.1 and 10.2 for further details) that use the site may require additional surveys as outlined by SNCO and in Chapter 8. In addition, any roosts of medium and high-risk species identified from the data search should also be surveyed if bats from such roosts may cross or use the site.

10.5.4 Activity surveys – ground level transects

Broadband bat detectors (frequency division or full spectrum) should be used for all bat activity surveys, either connected to a recording device or with an in-built recording capability, to ensure that all bat calls are recorded and can subsequently be analysed for identification to species or species group level. Detailed information on designing appropriate transect surveys can be found in Chapter 7.

The recommended frequency of surveys is listed for low, medium and high-risk sites in Table 10.2. For high-risk sites 1-2 surveys per transect per month (April-October) is recommended. If two surveys per month are thought to be required then justification should be provided for increasing sampling frequency, e.g. the presence of high levels of activity of medium or high-risk species (e.g. barbastelle) that have low intensity echolocation (are difficult to detect) and for which the effective survey area of bat detectors will be substantially reduced.

10.5.5 Automated activity surveys at ground-level

Automated detectors should be deployed in sufficient number or rotated to enable collection of representative data on bat activity across the range of habitats within the site as recommended in Table 10.2. The best way to achieve this depends on the size of the site and of the developable area, the habitat features present, and the number of proposed turbines.

Survey effort should concentrate on proposed turbine locations if they are known or fixed, and, for comparison, at additional habitat features close to turbine locations that have been identified as of potentially medium or higher quality for foraging or commuting bats of medium or high risk species, e.g. hedgerows, tree-lines, watercourses or water bodies, woodland and valley bottoms i.e. that should provide abundant resources for bats such as connectivity within the wider landscape, shelter and prey[13]. It is important to emphasise that such features may not be present on low-risk sites and an ecologist should be able to justify selection or non-selection of habitat features (as survey locations) based on which bat species they are likely to support as well as the characteristics mentioned above. Survey at low-risk sites should focus on collecting an appropriate level of baseline survey information that would confirm the

12 200m is a selected distance which acknowledges the importance of assessing potential roost locations in proximity to potential turbine locations.
13 The likely seasonality of foraging resources should be taken into account.

site's status as being of low-risk and effectively scope out the necessity for additional survey and the potential for impacts on bats to occur. If no suitable habitat features are present, this would involve selecting a sample of potential survey locations that are representative of the habitats present and the geographical scale of the site and would include both low quality habitat features (e.g. a sparsely vegetated upland stream or a relict hedge) and potential turbine locations.

To allow valid comparisons to be made between bat activity at both locations, pairs of calibrated automated detectors may be set up to record simultaneously. For example, one detector would be set to record at a proposed turbine location, another at the nearest habitat feature as described above. Levels of bat activity can be compared from both locations. Alternatively, automated detectors can be set up on a grid system that should be based upon deploying detectors in pairs to compare activity in open habitats (potential turbine locations) with that at the nearest habitat feature/s, as described above for more fixed scheme designs. The grid can also be based on the likely predicted spacing between turbines within the site, if the approximate dimensions and indicative layouts of the turbines are known in advance[14]. If more than one suitable habitat feature is located in proximity to a turbine location (e.g. if a turbine is located close to the corner of a field bordered by two hedgerows) then the second detector of the pair can alternate between recording at both features, e.g. for a medium-risk site a detector would record at one location during April, June, August and October and at the other during May, July and September. If more than two suitable habitat features exist then the closest two to the potential turbine location should be selected.

The method of using pairs of detectors simultaneously should allow a quantitative assessment of the reliance of certain species on linear features as opposed to open habitats through a comparison between the two. For species such as common pipistrelle and barbastelle activity levels are likely to be much higher at habitat features rather than in open habitats and this difference may be less pronounced for species such as noctule and Nathusius' pipistrelle that often prefer foraging and commuting at height over open habitats. This will allow the level of risk of particular turbines to be assessed based on activity levels at the turbine and also the level of activity at adjacent habitat features in combination with the distance of the turbine to that feature. As such this approach should validate the recommendation of Natural England (2009b) to ensure that turbines are located at least 50m plus the rotor radius from linear habitat features. Although recording at each pair of locations should be carried out simultaneously it is not essential for recording at all locations (if more than one pair of locations is used) to be carried out simultaneously and detectors can be rotated between pairs of locations.

There is no requirement to survey using pairs of detectors if suitable habitat features are more than 100m beyond the rotor swept radius of potential turbine locations. If potential turbine locations are located in predominantly open landscapes with few habitat features then survey should focus on potential turbine locations close to habitat features as described above. If such features do not exist (i.e. in low-risk sites) and/or there are large areas of homogenous, open land that may incorporate multiple turbine locations then survey should be limited to a representative sample of potential turbine locations. The spacing of these locations should take into account the uniformity of the landscape and make assumptions as to whether bat activity is reasonably likely to be uniform across such a landscape. If turbine locations are not known then a grid can be used which would include a similar perimeter beyond the proposed developable area (100m plus rotor radius) (see Box 10.1 for case study examples of how to apply this).

It is also advisable, although not essential, to carry out automated surveys at some other habitat features within the developable area that are not paired with a turbine location if they are identified as likely to be of high quality for medium or high-risk bats for commuting and/or foraging. Survey at such additional locations may help to explain movements of bats across the site and to make a more realistic assessment of the value of the site for bats if the highest quality habitat for bats within the survey area is located away from features that are closest to turbines (and that will be surveyed simultaneously as a pair of locations). Surveys (five consecutive nights recording) at each additional location should be carried out three times during the survey season (spring, summer, autumn).

As stipulated in Table 10.2, survey periods at each single or pair of locations should comprise five consecutive nights of recording irrespective of the frequency of surveys, i.e. for low, medium or high risk sites. Recording for five nights will allow variation of bat activity to be taken into account as well as enabling the detection of regular patterns of nocturnal activity over a suitably prolonged recording period. Much of the variation in activity can be accounted for by changes in weather but also by the fidelity of bats to particular foraging areas and commuting routes. The recommended frequency of surveys is also provided for low, medium and high-risk sites in Table 10.2. For high-risk sites 1-2 surveys per single or pair of locations per month (April-October) is recommended although there is a reduced likelihood of single locations being surveyed rather than pairs at high-risk sites. If two surveys per month are thought to be required then justification should be provided as for increased levels of walked transects.

14 If turbines are located too close to each other operational efficiency will be affected by wake-induced turbulence from adjacent turbines and this will depend on individual turbine dimensions, e.g. height and rotor sweep.

If directional bat detector microphones are used they should be directed at an angle of 45 degrees towards the target area of the potential rotor swept zone[15]. This may be at the proposed turbine location or the area along a hedgerow if the aim is to record activity along linear features. If recording at turbine locations it is advisable to point the microphone towards the most open part of a recording area and away from any habitat features to avoid recording bats with far-carrying echolocation calls (e.g. noctule) that may be associating with such features.

10.5.6 Automated activity surveys at height

With the exception of in woodland, bat activity and species richness is generally higher at ground level than at height (for example, at the height of proposed turbine blades) (Collins & Jones 2009). However, more aerial-hawking bat species, which are considered high-risk for collisions with turbine blades, may be recorded at height, so automated surveys at height may be important at proposed wind turbine development sites. However, unless existing masts can be used to support detector microphones, automated surveys at height are often expensive and difficult to implement, so their use needs to be justified.

The need for monitoring at height should be assessed on a site by site basis.

In woodland, some bat species may preferentially forage above the canopy and may not be recorded in ground-level surveys. Where so-called key-holing wind turbines are proposed in small clearings in woodland, automated surveys at height are essential in addition to ground-level surveys at woodland edges or along rides. At woodland sites, whether the proposal involves clear-felling areas or key-holing, pre-construction survey data may not represent the situation post-construction, as the habitat available for bats will change following construction. Automated survey locations should therefore also include open areas, to provide an indication of how bats may adapt to and use the new habitat created through turbine construction. Such areas should be as close to the expected characteristics of new habitat created to make space for turbines, e.g. existing clearings in woodland.

Automated detectors should be placed as close as possible to the proposed site of each turbine, within the rotor swept area, if the exact location and specification of turbines is known, or at representative locations if not. However, if detector microphones are fixed to met masts, their locations are limited, as there are usually only one or two met masts in the developable area. Automated detector microphones may also be installed on portable towers or masts specifically erected for the purpose, as is often done in North America (Kunz et al 2007), or on the nacelles of existing turbines where a site extension is proposed, as has been trialled in continental Europe (Sattler & Bontadina 2005) and is being piloted in the UK (University of Bristol / BCT. 2009). The erection of masts over 15m high requires planning consent and so may not be possible until the proposed scheme has been made public. Masts of less than 15m high can only be used to provide valuable data if the rotor swept area is less than 15m high. Helium-filled balloons, kites and kite balloons have been trialled in the UK to elevate bat detector microphones, but are expensive and are therefore not likely to be used over many nights. They can also only be used in good weather conditions and a lower number of nights of (non-consecutive) recording is required if these are considered to be necessary (see Table 10.2). Short-term data collected in this way may be useful for sites where a high level of bat activity has been recorded for high risk species. Permission is required from the Civil Aviation Authority if captive or tethered balloons are to be flown above 60m agl[16].

It is recommended that before embarking on this type of survey, the value of the additional data can be clearly justified.

10.5.7 Other survey methods

At some sites, the first year's baseline survey may indicate the need for specialised survey techniques and experienced surveyors. For example, if there is a roost of high importance of a medium or high-risk species that may be vulnerable to impacts of the proposed development, further surveys of the roosts and/or radio-tracking may be appropriate to provide comprehensive information on the bats' use of the site. Some examples of other survey methods that could be considered are provided below.

Vantage Point Surveys

In some circumstances where bats are appearing on site early in the evening such as noctules, vantage point (VP) observations from several location overlooking the site can be helpful to assess the number of bats, direction to the roost (sometimes actual roost locations), commuting routes and type of activity. These should start at least 30 minutes before sunset using binoculars and bat detectors with a high sensitivity. VP locations should be selected to maximise coverage of site. The need for this type of survey will be determined on a site by site basis.

15 Orientating a microphone at a particular angle to determine the effective survey area of a detector is of less relevance when using an omni-directional microphone.
16 As found in Articles 163 and 164 of the UK Air Navigation Order 2009 (as amended), which is available at http://www.caa.co.uk/docs/33/CAP393.pdf.

Back tracking surveys
In some instances a back tracking survey to find a roost may be required as a follow-up to vantage point surveys or activity transects to determine location of roosts (see Chapter 8 for further details).

Infrared cameras, low light video and radar
Other methods such as low light video, infrared cameras and radar can also provide additional information. Low light video and infrared camera can be used to help identify potential roost sites to determine the need to follow up surveys. There is some evidence to suggest that radar could be used to track the movements of bats (Larkin & Szafoni, 2008) but consideration should be given to the fact that infrared may not always give the range and field of view needed to provide robust information in open habitats. It is not recommended that these form part of a standardised methodology. However, such techniques may be appropriate for sites where particular potential impacts have been identified and more detailed, targeted surveying is required.

10.6 Survey effort

The appropriate level of effort for a bat survey at a proposed wind turbine development depends on the scale of its likely impact, which in turn depends on the size of the site and the quality of the habitat. It follows that some sites, particularly single turbine developments in low quality bat habitat, may require no more than a scoping and ground-truthing exercise, while large scale schemes in good quality habitat may require extensive survey work that is refined over a number of years.

Manual activity surveys **and** static surveys at ground level should be carried out **as a minimum** at multiple turbine sites

Table 10.2 provides recommendations of minimum standards of survey effort in instances where sampling is required. Box 10.1 includes two case studies where the results of desk study, preliminary site appraisals and pre activity survey has been considered to provide an appropriate level of survey effort for sites assessed as medium (Site 1) and low (Site 2) risk.

Table 10.1 Factors to consider when determining survey effort and site risk

Quality of habitat and number of habitat features likely to affect bat mortality rates if altered by development*	Species likely to use the site*	Importance of roosts, of species likely to use site, which may be affected by development*	Potential risk level of development
No potential habitat for roosting, foraging or commuting bats	None	Local	Lowest
Small number of potential roost features, of low quality Low quality foraging habitat that could be used by small numbers of foraging bats Isolated site not connected to the wider landscape by prominent linear features	Low number, single low risk species High number, several low risk species	Parish	Low
Buildings, trees or other structures with moderate-high potential as roost sites on or near the site Habitat could be used extensively by foraging bats Site is connected to the wider landscape by linear features such as scrub, tree lines and streams	Low number, medium risk species High number, medium risk species	District County	Medium
Numerous suitable buildings, trees (particularly mature ancient woodland) or other structures with moderate-high potential as roost sites on or near the site, and/or confirmed roosts present close to or on the site. Extensive and diverse habitat mosaic of high quality for foraging bats Site is connected to the wider landscape by a network of strong linear features such as rivers, blocks of woodland and mature hedgerows.	High number, single high risk species High number, several high risk species High number, all high risk species	National International	High

* As outlined in current scientific research, SNCO guidance and illustrated in (Wray S, Wells D, Long E and Mitchell-Jones T (2010)

Table 10.2 Minimum standards for bat surveys at proposed onshore wind turbine developments (See Section 10.5 for further details)

	Site risk level (taking into account factors detailed in Table10.24)		
	Low risk	**Medium risk**	**High risk**
	Roost Surveys		
Selection of roosts requiring further survey	If evidence of roosting by medium or high-risk species and/or roosts of district importance and above (see Table 10.1) is found, further survey should follow SNCO guidance and guidelines given in Chapter 8 wherever possible.		
	Activity surveys		
Survey period	Surveys should provide data for one season as a minimum.		
Survey area[17]	Up to 200m + rotor radius from turbine locations or potential turbine locations	Up to 200m + rotor radius from turbine locations or potential turbine locations	Up to 200m + rotor radius from turbine locations or potential turbine locations
Ground level transect surveys**	One visit per transect each season (spring, summer and autumn)	One visit per transect each month (April-Oct)	Up to two visits per transect each month may be required (April-Oct)
Automated surveys at ground level	5 consecutive nights for each single[18] or pair of locations within the survey area, per season	5 consecutive nights for each single or pair of locations within the survey area, per month	Up to 2 sets of 5 consecutive nights for each single or pair of locations within the survey area, per month
Automated surveys at height	See Section 10.5.6 for situations where at-height survey may be appropriate. For surveys undertaken from masts (met mast or other) survey effort is as outlined above for surveys at ground level.		

Box 10.1 Examples of how to apply the principles outlined in Table 10.2 and Section 10.6 in practice

Site 1: Lowland site (medium/high risk) in south-west England
A desk-study has identified the presence of noctule, serotine, common and soprano pipistrelle (as well as several low-risk species) within the search area. The site is also within the known UK range of barbastelle and Leisler's bat and there is some potential for Nathusius' pipistrelles to occur. A small maternity roost of common pipistrelle and a large (100+ adult bats) maternity roost of soprano pipistrelle have been identified in a small town 1 km to the west.

The site is 80ha in size and comprises two large arable fields. Both fields are bordered by hedgerows on all sides except the divide between the two fields, which is fenced. There is a broad, reed- lined and well vegetated ditch along the southern border of both fields with cattle-grazed marshy grassland located beyond the southern boundary of the site. A 2ha block of mature, mixed woodland (largely composed of oak and ash but not listed on the ancient woodland inventory) runs along the entire western border of the site, with further arable land to the north. The wider landscape comprises a mosaic of arable and pasture farmland, small blocks of woodland and lower-lying marshy areas.

Six turbines are proposed for the site; four located towards the edges/corners of the two fields and a further two within the middle of the field on opposite sides of the fence.

A Phase 1 habitat survey identified potential roosting features for bats and a detailed survey of potential roosting features within 200m of the developable area was carried out in March. The survey identified the presence of 10

17 This should include potential turbine locations plus the nearest habitat features likely to be used by bats.
18 Single locations will be at potential turbine locations. It may not be necessary to survey potential turbine locations without suitable habitat for bats located within 100m plus the rotor radius. See 10.6.5 for further information.

trees with medium or higher potential to support roosting bats in the woodland block adjacent to the site. Features present include woodpecker holes, vertical splits and hanging bark.

The site is identified as being of medium risk (see Table 4.4) due to the presence of trees with medium-high roosting potential in woodland adjacent to the site, the presence of a suitable diversity of foraging habitats that are connected to the wider landscape, and the presence of a large breeding roost (of district or county importance) of a medium-risk species relatively close to the site (within the potential foraging range of the colony). The following range of survey work would meet with the guidelines provided in this chapter given the level of risk associated with the proposed development:

- One walked survey was carried out per month during April-October over two transect routes, covering the eastern and western halves respectively. The transect routes covered the field boundaries as well as each turbine location to allow sampling of open habitats as well as boundary habitat features;
- A weather station was erected in a central location on the site to record wind speed and direction, temperature, rainfall and relative humidity throughout the survey period;
- Pairs of calibrated automated detectors recorded at ground level simultaneously for five consecutive nights each month (April-October) at each of four turbine locations located close to suitable habitat features (woodland, hedgerow and ditch) and at suitable habitat features located within 100m plus the rotor radius of these locations;
- No suitable habitat features were located within the recommended perimeter of the two central turbine locations and a single detector was rotated between these locations during April-October with one turbine location covered for five nights during April, June, August and October and the other during May, July and September; and
- Emergence/re-entry surveys were carried out of the soprano pipistrelle roost in June and August to confirm numbers of bats using the roost and any potential flightlines to and from the roost.

Site 2: Upland fringe site (low-risk) in the Borders region of southern Scotland

A desk-study has identified the presence of records of common and soprano pipistrelle (as well as two low-risk species – Natterer's bat and brown long-eared bat) within the search area. The site is also within the known UK range of noctule and Leisler's bat and there is some potential for Nathusius' pipistrelles to occur. There are records of two small summer roosts of common pipistrelle, the status of which is unknown, in farm buildings around 1.5km west of the perimeter of the site.

The site is 400ha in size and comprises a range of habitats including open heather moorland (30%), sheep grazed pasture (30%), peat bog (15%), immature coniferous plantation woodland (15%) and a large loch (10%) on the eastern edge of the site with a 10ha block of wet woodland bordering its eastern shore. On the lower lying areas of pasture on the western side of the moorland (which occupies the eastern half of the site) there are some marshy areas with several ponds bordered by mature willows and two well-vegetated and sheltered stream valleys lined with occasional alders and abundant bracken. The wider landscape is similar to the site with extensive areas of open moorland; sheep grazed pasture and occasional blocks of coniferous plantation woodland with limited connectivity provided by inter-locking stream valleys.

Twenty 2MW turbines are proposed for the site. Although the layout has not been determined the likely spacing has been considered and 12 will be located on open moorland with eight within pasture areas. The perimeter of the developable area within open moorland is located (at all points) at least 200m away from any habitat features. Most potential turbine locations within the developable pasture area are located away from habitat features identified as of medium or higher quality habitat features with two within 100m of low quality features (a relict hedgerow and a dry stone wall containing two small trees) with one location within 150m of a vegetated valley bottom and another around 120 m from a pond lined with willows. The latter two locations have been identified as of medium quality for foraging bats.

A Phase 1 habitat survey identified a small number of low potential roosting features for bats in farm out-buildings on the western edge of the site and in some trees within the site. A detailed survey of potential roosting features within 200m of the site boundary was carried out in April and confirmed the results from the Phase 1 survey but also located two hollow cavities within mature willow trees close to ponds that were thought to provide medium-high potential for roosting.

The site is identified as being of low risk (see Table 4.4) due to the presence of largely low quality (and two higher potential roosting features) in the western half of the site, all of which have limited connectivity to the wider landscape; and the presence of largely low quality foraging habitat for bats with some areas of moderate quality foraging habitat (the loch, stream valleys, trees and ponds) which are located in a fairly isolated upland context.

The site also does not appear to offer high quality foraging habitat for any high-risk species based on published preferences for these species in the UK. The following range of survey work would meet with the guidelines provided in this chapter given the level of risk associated with the proposed development:

- Walked surveys were carried out in May, July and early September over eight transect routes, covering largely distinct habitat blocks. Access was restricted to some areas of moorland and peat bog/mire due to health & safety considerations but all habitats were sampled effectively during all surveys. The transect routes covered boundary features as well as strip transects through moorland to ensure representative sampling of open habitats as well as defined habitat features;
- Two weather stations were erected, with one in the lower lying pasture area and one on the exposed moorland to record wind speed and direction, temperature, rainfall and relative humidity throughout the survey period;
- Pairs of calibrated automated detectors recorded at ground level simultaneously for five consecutive nights in May, July and September at two potential turbine locations and at two suitable habitat features within pasture areas; at the edge of a pond and along a valley bottom (as described above);
- No suitable habitat features were located within the recommended perimeter of the other eighteen turbine locations. As a result, a representative sample of the turbine locations was surveyed with half of the turbine locations within pasture habitats (three) and a quarter of the locations within moorland (three) sampled. The lower sample on moorland was selected to reflect the lower potential of recording high bat activity in exposed upland habitats as opposed to the more sheltered and more varied pasture habitat; and
- Two other detectors were deployed for five consecutive nights in May, July and September at two habitats that may provide moderate quality foraging habitat for bats within the site; the wooded edge of the loch and on a ride separating two blocks of plantation woodland. Although these habitats were sampled during transect surveys they had not been covered by automated detector surveys.

The recommendations included above for both sites do not take into account any adjustments that may need to be made to level of survey or additional survey types (e.g. at-height surveys) that may need to be taken into account if preliminary or first season survey results indicate that the site is more likely to be of higher risk than originally identified.

10.7 Results of surveys

Survey data should be collected, recorded and analysed to provide information that can be applied to direct the proposals for the site, and used to assess the likely impacts of the development throughout the year. At wind farm development sites where potentially significant impacts on bats are thought likely to arise, data from year one should be used to assess whether additional surveys or specialised techniques are needed in year two. More work may be needed if species vulnerable to impacts of wind turbines or if bat populations of district importance or above are present. Chapter 11 provides details on the appropriate interpretation of survey data.

Year one baseline survey information should be used to assess whether there is a need for an additional survey effort and/or specialised techniques.

10.8 Post-construction activity surveys

Bat activity at wind turbine sites may change after turbine installation. In 2009, phase one of a study on ecological effects of wind turbines on bats (Determining the potential ecological impact of wind turbines on bat populations in Britain) was published: a literature review and proposal for phase two. Phase two, which will involve field work to quantify the extent to which bats are affected by wind turbines, will be complete in 2013. Updates to the current EUROBATS guidance on onshore wind farms (Rodrigues et al 2008) may also provide further data on effects.

While we await the results of current research, the effort and techniques appropriate for post-construction monitoring of wind turbine sites should be assessed on a site-by-site basis. The aims of post-construction surveys should be to assess changes in activity patterns and to provide information on the efficacy of any mitigation schemes. Surveys should be carried out in the first two years of wind turbine operation, but effects of habitat modification and off-site enhancements on bat activity may require monitoring over a longer period. Where more severe impacts have been identified or predicted, data collection may need to continue for longer to assess the effectiveness of any mitigation proposed, and it may be necessary to quantify fatality rates by searching for dead bats under wind turbines.

Chapter 11
Interpreting and assessing survey results

11.1 Introduction

Data collected during bat surveys requires appropriate interpretation and assessment. The type of data collected depends on the surveys completed and the scale of those surveys, and the overall aim of the survey. Data on bat presence, species and numbers, gathered during roost surveys, needs to be put into the context of local populations, species presence and abundance, as far as is known, at local, regional and, where appropriate, national levels. Data on bat presence, species and activity levels, gathered during activity surveys, needs to be interpreted in relation to species presence, timing and relative level of use of areas and spatial distribution of bats (see Figure 11.1). The most appropriate type and level of data assessment will depend to a certain extent on the aims of the survey and the information required from it. Some examples of the types of questions that may be investigated and the types of interpretation likely to be carried by consultant ecologists out are given in this chapter, which should be read in conjunction with Chapter 5, on writing and reviewing survey reports.

11.2 Roost surveys

Chapter 8 describes methods for surveying for bat roosts. The information collected from these surveys includes:

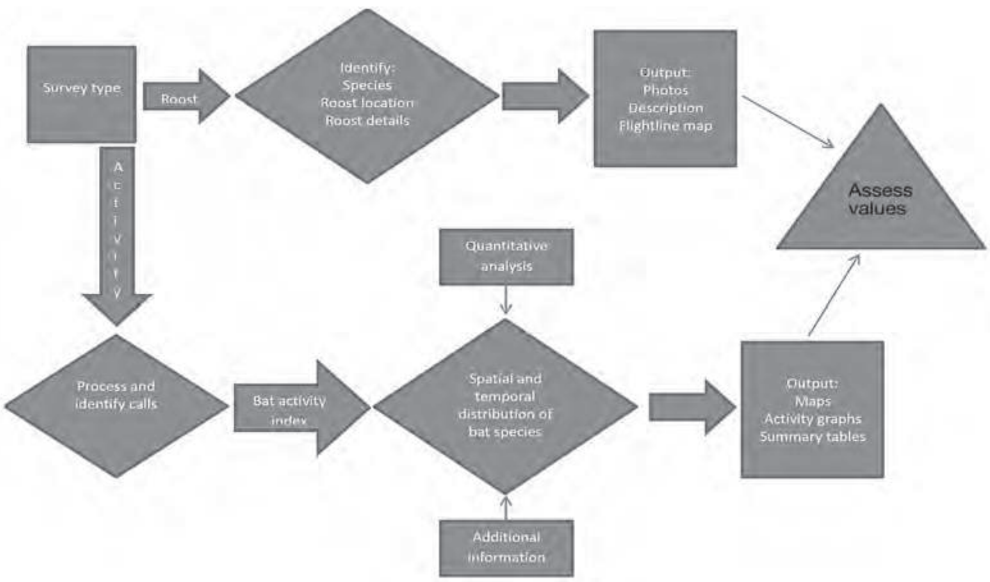
- Type of structure surveyed.
- Details of the structure (including location e.g. grid reference), its features and the likelihood of it being used by roosting bats.
- Details of signs of bat presence found at the roost.
- The type of roost and time of year it is used.
- Details of the surveys completed at each roost, including specific methods (e.g. dusk emergence survey, pre-dawn re-entry survey, backtracking, and/or automated activity survey), timing of surveys and results of these surveys.

This information should all be included in the survey report. It is helpful to include photographs to illustrate the structures surveyed. If bat roosts were identified, roost access points should be shown on the photographs and described in detail.

11.3 Activity surveys

Chapter 7 describes methods for bat activity surveys; Chapter 6 provides information on the equipment used in these surveys. Activity surveys provide recordings of bat echolocation calls that can be processed and analysed to give information on the species assemblage present at a site, the levels of activity of each species, and the spatial and temporal distribution of that activity. Activity survey data can also be used to determine the relative use of a site by bats of a given species, from the amount of activity recorded in different parts of the site.

Figure 11.1 Interpretation of bat activity and roost survey results, leading to the assessment of the value of resources for bats



Activity surveys can produce a large number of data. If, for example, automated bat detectors are used to collect data over several months at a number of different locations on a large site, many thousands of bat echolocation calls may be recorded. In the processing, assessment and interpretation of those data, the important features of the site (e.g. the species present, spatial hotspots of activity, or important temporal peaks in bat activity) must be extracted according to the aims of the survey. The quantitative approach to data analysis proposed (Box 11.1) allows the most common aims to be achieved.

Box 11.1 Quantitative data analysis and the interpretation of bat activity survey results

A bat survey should have a specific objective, e.g. to quantify the relative abundance of bat species in a defined area. The survey program should be planned to collect data in a robust way to achieve the objective, standardising as much as possible so that errors in measurement are reduced.

Data from activity surveys are most useful if the survey design and implementation has been rigorous. For example, in repeated surveys and monitoring, it is important to be able to quantify bat activity with the same detectability in each session. The rate at which bats are recorded in field surveys depends on: 1) bat detector model; 2) survey duration; 3) time of year; and, 4) temperature. Standardisation therefore involves using calibrated bat detectors of the same model, having consistent survey durations at the same time of year each year, or recording the date of each survey, and measuring and recording temperature and other weather parameters accurately.

Statistics are used to organise, summarise and describe quantifiable data, and in methods for drawing inferences and generalizing upon them. They can be applied to both the sparse data collected from transect activity surveys, and the copious amount of data obtained from automated surveys.

Statistical literacy is important in reporting because it allows for the presentation of results in a form that is authoritative. Surveying or monitoring programmes should be planned anticipating the statistical methods that are appropriate for the eventual analysis of the data. Statistical methods also allow the survey aims to be achieved.

Useful references:

1. National Bat Monitoring Programme http://www.bats.org.uk/pages/nbmp.html
2. Fowler J., Cohen L. & Jarvis P. (1998) *Practical Statistics for Field Biology* 2nd Edition. Wiley-Blackwell ISBN 978-0471982968
3. Dytham C. (2011) *Choosing and Using Statistics – A Biologists Guide* 3rd Edition. Wiley-Blackwell. ISBN 978-1-4051-9839-4
4. McCarthy M. A. (2007) *Bayesian Methods for Ecology*. Cambridge University Press. ISBN 978-0-521-61559-4

Comprehensive open source statistical package: The R Project for Statistical Computing http://www.r-project.org/

11.3.1 Interpretation of bat echolocation calls

The first stage of data processing is to complete sound analysis of the bat calls recorded. The methods used to do this will vary depending on the recording equipment used. Appropriate software should be employed to process all bat calls, identify them to species, taxon or as ‘unknown bat calls’ (see Chapter 6.)

It is important to interpret the presence of bat calls on a site as part of the reporting process for activity surveys, to provide an index of bat activity. It should be noted that a bat activity index does not represent the number of bats present at a site but an indication of their abundance and/or activity only. Bat activity levels can be compared between sites, between different parts of a site or between seasons (Hayes et al 2009), to reveal differences in bat activity in areas or at different times. Bat calls can be used in a number of ways:

1. Determining presence
   This is the simplest form of interpretation of the data, which provides a species list for each location, transect or site. Bat calls recorded from each survey location are identified, and the species or species groups recorded are provided as a list, showing presence.

2. Measuring presence to give an activity index
   Bat call data can also be used to give an indication of the relative level of species presence for each location, transect or site. In this method, the data from an activity survey are split into fixed time periods, for example of 15s. Within each time period, the presence of each species for which calls are recorded is noted. The resulting data are presented as the number or proportion of 15s time periods in which each species is present.

3. Counting bat passes to give an activity index
   An alternative method is to count the number of bat passes of each species throughout the recorded survey. A bat pass is defined as two or more bat calls in a continuous sequence; each sequence or pass is separated by 1s or more in which no calls are recorded. The number of bat passes for each species or species group identified is counted for each transect, transect section, or point.

The bat activity index is calculated as the number of bat passes (or other measure of presence) per unit time (e.g. per hour).

11.3.2 Differences in species detection rates

Differences in the likelihood of detection of bat species at any given site must be taken into account in the interpretation of bat activity survey data. Although activity survey data can be used to compare spatial and temporal variation in bat activity, as noted in the previous section, comparisons should not be made between species, as there is variation in how likely the different species are to be detected (Fenton 1970).

It is important to note the limitations of any equipment and survey techniques used during activity surveys (Ganon et al 2003), and all of these factors need to be taken into account when assessing the likelihood that all bat species that may be present on the site have been detected during the surveys carried out. This information should be included in the survey report to assist in the interpretation of the survey findings. Chapter 6 provides further details of the factors to consider when assessing what equipment to select, and how representative calls are.

11.3.3 Types of activity recorded

The type of activity being carried out by bats recorded during activity surveys may vary. It is possible to infer activity from the data collected from activity surveys. For example, a high level of activity at a location early in the evening (within the first hour after sunset), followed by less activity later, suggests that bats are commuting. Sustained activity throughout the night is more likely to suggest an area is being used for foraging. Foraging by each species or species group can be confirmed through the detection of feeding buzzes as well as search phase echolocation calls, although often too few feeding buzzes are recorded to compare levels of foraging in different areas. The activity recorded in different parts of a site may also vary throughout the season, as the suitability for foraging in an area changes.

11.4 Representation of survey data

Data from activity surveys should be represented to show how the activity of different bat species recorded on the site surveyed varies both temporally (over the period of the surveys) and spatially (within the survey site).

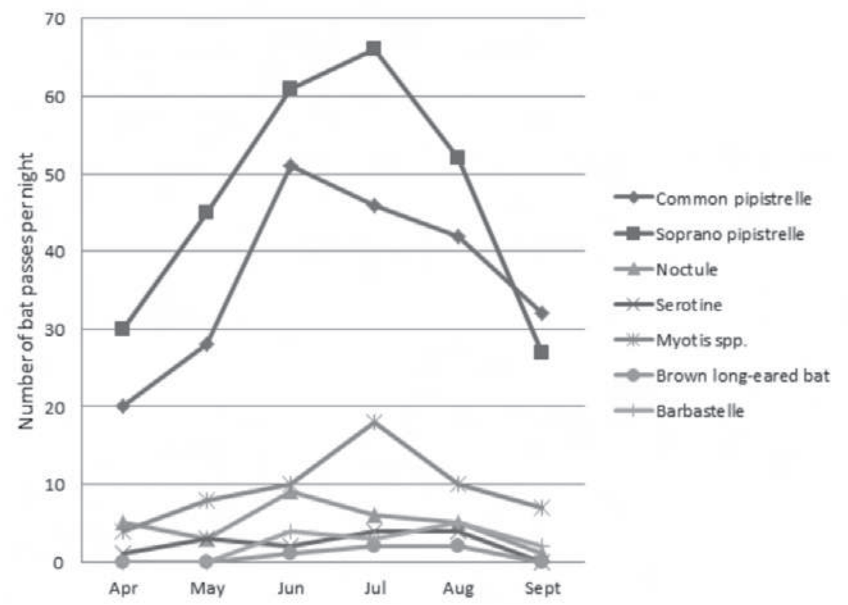
11.4.1 Temporal representation of survey findings

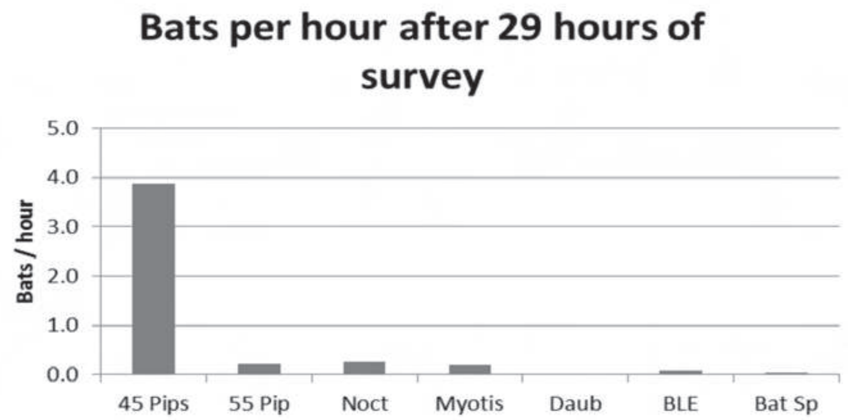
Data collected from transects should be converted into an index of bat activity for the site as suggested in section 11.3.1. The bat activity index may be provided for all bats or for individual species or species groups separately, or both. The night length changes throughout the year, so it may be useful to present bat activity indices per hour. Any summary tables or similar should present both bat passes per hour and passes per night if possible, and sunset and survey times should also be reported.

The bat activity index should be calculated for each species or species group identified at the survey site if sufficient data are collected. This information will provide a relative assessment of the amount of bat activity for each species or species group, and also can be used to identify any important periods within the survey season when bat activity was high.

Temporal representation of bat activity index is best done using graphs as these are easy to interpret. A graphical representation of how bat activity index varies over the survey season for each species can be used, for example to identify peak periods of activity (see Figure 11.2). The appropriate timescale for the breakdown of bat activity depends on the site and aims of the survey – by month, fortnight, week or night may be appropriate under different circumstances.

Figure 11.2 Two examples of temporal representation of bat activity survey data

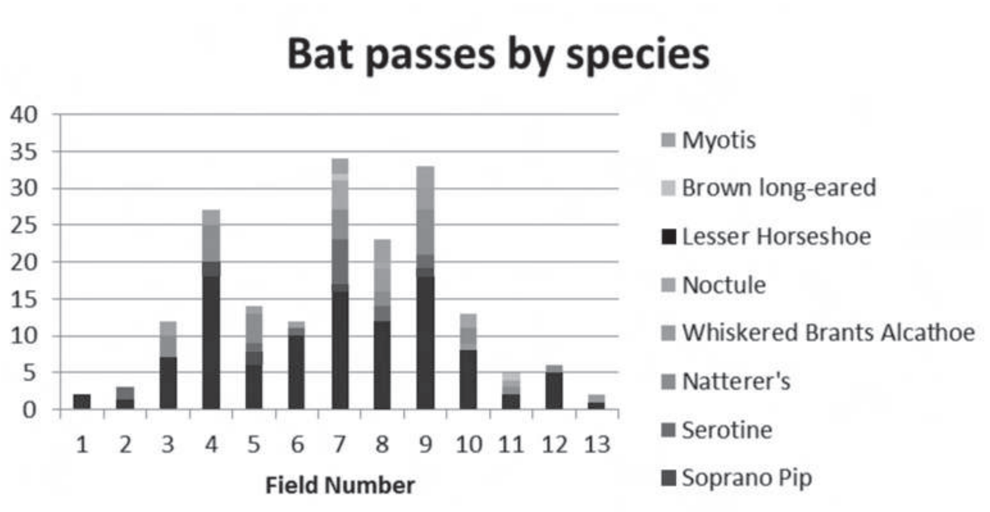




11.4.2 Spatial representation of survey findings

Spatial representation of activity survey results should be used to identify key areas of a proposed development site which support high levels of bat activity. This is best done using maps to illustrate the locations of transect and/or point count surveys within the site, and the locations where bats were encountered. It is also possible to illustrate relative differences in activity levels on maps. Transect routes, point count or automated detector locations should be marked onto a map which also shows the site boundary. The results of the surveys, showing where bats were encountered and/or the relative levels of bat activity can be represented overlaying an aerial photograph; this facilitates identifying important habitat features within the site. It is possible to represent different levels of activity of each species or species group by using different sized symbols, explained in a legend, to represent categorical levels of bat activity. Actual activity levels could also be summarised and represented in a graph as illustrated in Figure 11.3.

Figure 11.3 Example of representation of levels of bat activity per location, in 13 fields at a proposed development site



If present, the locations of high bat activity of species of interest or importance, or where activity is high for several species for example, can then easily be located and identified as the bat hotspots for that site. This helps to target important areas for bats, which need to be taken into account in any assessment of the impacts of the proposed development.

Bats move through the landscape, and therefore a site being surveyed, over time, and are likely to utilise different parts of a site on different nights, so between-night variation in activity will exist. It may therefore be necessary to combine the temporal and spatial variation in bat activity recorded at a site to understand the relative use of different parts of the site by different bat species fully.

11.5 Quantitative analysis of data

11.5.1 Comparing levels of bat activity

It is possible to carry out simple quantitative analysis of bat activity data to compare the distribution of bats, for example in different broad habitat types or in different areas within a site. This can be done using a simple Chi square test to investigate whether or not bat activity is distributed as expected from the relative sizes of the habitats or areas.

The method involves assigning bat activity into the different sections on the transect to be investigated, measuring the relative sizes or lengths of those sections, and comparing the bat activity observed within each section with the activity expected if activity was randomly distributed across all of the transect surveyed.

For example, once a transect has been planned on a site, aerial photographs (e.g. from Google Earth http://www.google.co.uk/intl/en_uk/earth/index.html) can be used to section the transect into broad habitat categories such as woodland, woodland edge, hedgerows and pasture. The length of each section in each habitat is measured. The bat activity within each section is then quantified. The expected values for bat activity are calculated based on the relative length of transect in each habitat type, and compared to the observed values using a Chi square test (Fowler and Cohen 1990). In the example in Table 11.1, the number of bat passes in each of four habitat types is shown along with the length of each habitat within a 6km transect. The expected values for each habitat type are then calculated assuming bats are distributed randomly. The Chi square statistic is calculated as follows:

$$\mathbf{X^2 = \sum \{(observed - expected)^2/expected\}}$$

In this example $X^2 = 13.59$. A Chi square distribution table shows that the distribution of bat activity is not randomly distributed between the habitat types as the result is significant ($P<0.01$, df = 3). Further analysis can be completed to discover which habitats differ in terms of bat activity, or qualitative interpretation can be made from the relative levels of observed and expected activity. Table 11.1 shows that common pipistrelle activity is higher than expected in woodland edge and hedgerow habitats, and lower than expected in woodland and pasture habitats.

Assumptions are made when completing a Chi square test which must be met before any analysis is carried out. In particular, it is assumed that the expected values for the majority of categories are >5, and therefore the test is not suitable for species or species groups where low levels of activity are recorded.

Table 11.1 An example of statistical analysis: using a simple Chi square test to discover whether bat activity is distributed randomly between habitats

	Woodland	Woodland edge	Hedgerow	Pasture	TOTALS
Length of transect in habitat (km)	1	2	1.5	1.5	**6**
Observed no. bat passes (Common pipistrelle)	4	21	15	2	**42**
Expected number of passes (Common pipistrelle)	7	14	10.5	10.5	**42**

Bat survey data particularly data from walked transect can have highly skewed distribution with few passes at some listening point and very high number of passes next to ponds and trees. Where data has a normal distribution simple statistical test such as Chi-square test can be used, but where there is a non-normal distribution an appropriate non parametric test (e.g. Mann- Whitney U Test, or Wilcoxon's matched pairs test) should be used.

11.5.2 Comparing data from paired detectors

If calibrated bat detectors of the same model are deployed in pairs, for example, during automated surveys of a site, data on relative bat activity from their two positions can be compared directly. For example, on a proposed wind farm development site, one automated detector may be deployed at a proposed turbine location and another simultaneously at a nearby feature suitable for bat foraging. Non-parametric statistics to compare the paired samples can be used to avoid making invalid assumptions about the distribution of the data. For example, a Wilcoxon's test for matched pairs will reveal whether bat activity is statistically similar or significantly different in the paired locations.

The method involves quantifying the bat activity index for all bats (or for a species or species group) from calls recorded from each paired detector on each night, and subtracting one from the other to give the difference in bat activity. The differences are then ranked on their actual values, the sign of the difference is assigned to the rank, and the sum of the positive and negative ranks are calculated separately. The smallest sum is used as the test statistic which can then be used to determine whether there is a significant difference between the pair for the sample size (any zero differences must be subtracted from the sample size). This test can be carried out when the sample size is six or more, so it can only be applied if the pairs of bat detectors are used to record bat activity for at least 6 nights in the same locations, and if the bat activity index is calculated for each night.

Chapter 12
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Appendix 1
Hazards and risks associated with field work

Hazards and risks associated with fieldwork	Procedures to remove or reduce risk	Equipment to remove or reduce risk
Lone working	Lone working should be avoided wherever possible, in particular when surveyors are working at height. If lone working is unavoidable, a buddy system and late working procedure should ensure that someone knows where each surveyor is and can raise the alarm if he or she does not return when expected. Surveyors should park so that they can drive away from a site without turning. This is useful in the dark, in case of emergency, and in case of aggression.	In case of separation or accident a mobile phone (satellite phone in remote areas), two-way radio, whistle, map and compass should be carried.
Tiredness *a, b, c, d*	Limits to the number of surveys carried out are recommended (refer to: *Working Time Regulations 1998*): • Staff doing bat surveys only (with no daytime work) – up to four dusk or four dawn surveys, or two of each, or two all night surveys, per week. • Staff doing other work – up to 2 dusk or 2 dawn surveys, or one of each, per week. No all-night surveys.	
Bad weather *a*	Awareness of the weather forecast.	Clothing appropriate to the local situation (surveyors working in the north of Scotland require a greater level of protection than those working in the south of England at the same time of year).
Working in the dark *a, b, d*	Surveyors should familiarise themselves with the site during daylight hours.	Powerful torch (and spare torch, batteries and bulbs).
Working in confined spaces *b, d*	Confined spaces training – see Section 3.3.2	
Working underground where there may be sudden drops, changes in roof height, unstable rock, decaying fixtures *d*	Mine safety training – see Section 3.3.2	Protective warm clothing, strong boots, helmet and helmet-mounted lamp. Ladders and/or ropes if necessary for the site.
Working at height (*e.g.* in attics *b*, trees *c*, on quarry faces) where there is a risk of falling. *d*	(Refer to *Working at Height Regulations 2005*) Arboricultural Climbing Course – see Section 3.3.2 Training in use of ladders and mobile elevating work platforms.	Safe means of access, eg mobile elevating work platforms, ladders or ropes.

Working on busy roads, on railways, or on farmland with working agricultural machinery *a*	If appropriate, ensure local workers know that a survey is underway.	Fluorescent or reflective jacket (appropriate to site).
Working in derelict structures/construction sites *b* /trees *c* where there is risk of falling masonry or branches	If appropriate, ensure local workers know that a survey is underway.	Hard hat, fluorescent or reflective jacket, safety footwear.
Working near water (rivers, streams, ditches, lakes, canals etc.) *a*	Take care when moving around. Employ safe methods of crossing watercourses such as rivers, streams and ditches. Check the flood conditions.	Life jacket (consider self-inflating type to allow for greater mobility).
Working near unfenced slurry or silage pits, ponds, grain silos and stores *a*	Surveyors should take due care and familiarise themselves with the site during daylight hours.	Torch or head torch.
Slips, trips and falls on rough ground *a, b, c, d*	Take care in moving around, ensure visibility is adequate.	Torch or head torch.
Sunburn/sunstroke	Awareness of the weather forecast.	Sun screen, hat, and long-sleeved shirt.
Diseases such as Weil's disease, Lyme disease, ornithosis (an infectious disease that affects birds and can affect humans and other mammals) and tetanus (for example from rusty barbed wire)	Awareness of diseases, e.g. surveyors should carry a Weil's disease awareness medical card and be familiar with tick identification. Tetanus inoculation.	Protective clothing. Bandages or plasters over any open cuts or wounds. Ornithosis – protective dust mask and gloves.
Insect bites and stings (horseflies, ticks etc)		Insect repellent and/ or barrier clothing
Bat bite *b* and rabies (European Bat Lyssavirus)	All those who handle bats should be vaccinated (and regularly boosted) against rabies because of the risk of European Bat Lyssavirus. Care should be taken when handling to avoid bites. Information on vaccinations and what to do if bitten is available on the Health Protection Agency's website (www.hpa.gov.uk), or by calling the HPA Centre for Infections (020 8200 4400). See also the Department of Health's 'Green Book' *Immunisation Against Infectious Disease 2006* from the Department of Health's website (http://www.dh.gov.uk/en/Policyandguidance/Healthandsocialcaretopics/Greenbook/index.htm)	Appropriate gloves should be worn when handling bats (advice is available from the Bat Conservation Trust).
Asbestos, fibreglass and dust *b*	Every non-residential building should have an Asbestos Register. Surveyors should ask to see it, particularly if the building being surveyed was built between 1950 and 1985. Asbestos should be avoided and specialists called.	Asbestos - disposable overalls and respirator. Fibreglass and dust – protective dust masks (conforming to BS EN149), safety glasses and overalls.

Sharp objects, such as broken glass or hypodermic syringes *a*	Take care in moving around, ensure visibility is adequate.	Safety work boots with protective toecaps and reinforced soles, impact grade gloves, overalls, first aid kit.
Land that has been sprayed *a*	Surveyors should ask landowners or agents whether pesticides have recently been used on land being surveyed. Many pesticides have a 'harvest interval' between spraying and harvesting; surveys should not take place until after this interval.	
Aggressive farm animals such as guard dogs, geese, bulls and cows with calves *a*	Surveyors should ask landowners or agents where animals are kept, and avoid those areas if possible.	
Shooting, e.g. for predator control (often takes place at dusk) *a*	Surveyors should ask landowners or agents when any shooting is likely to be taking place, and avoid surveying at those times.	Fluorescent or reflective jacket.
Verbal and physical assault *a*	Avoid lone working, work within sight of an accompanying surveyor, park so as to be able to leave quickly.	Attack alarm.

a Risk particularly associated with transect bat activity surveys in the field
b Risk particularly associated with roost surveys of buildings
c Risk particularly associated with roost surveys of trees
d Risk particularly associated with roost surveys of underground sites

Appendix 2
Glossary of bat terms

Autumnal swarming	Bats gathering in flight at an underground site in autumn
Dawn swarming	Bats gathering in flight outside a roost before and during sunrise
Day roost	Site where one or more bats spend the day
Feeding perch	A place where a bat hangs while detecting prey or consuming it
Hibernaculum	A winter site where the bats enter torpor during hibernation
Maternity roost	A breeding roost where mothers give birth to and care for their young
Night roost	A site where bats rest, groom etc between bouts of foraging
Nursery roost	As maternity roost
Parturition	Giving birth
Pre-lactation	The state of a female before producing milk for suckling
Post-lactation	The state of a female after producing milk for suckling
Pre-parturition	The state of a female before giving birth
Post-parturition	The state of a female after giving birth
Roost	A resting place of a bat
Satellite roost	A smaller roost than a maternity roost but nearby
Swarming	Bats gathering outside a roost at dawn or in autumn
Torpor	Slowing the metabolic rate and entering a state of deep sleep
Transitional roost	An occasional roosting site usually used in spring and autumn before and after using a maternity roost
Volant	Able to fly

Appendix 3
List of abbreviations used

ALGE	Association of Local Government Ecologists
BCT	Bat Conservation Trust
CBD	Convention on Biological Diversity
CCW	Countryside Council for Wales
CEnv	Chartered Environmentalist
CITB	Construction Industries Training Board
DEFRA	Department for the Environment, Food and Rural Affairs
DOENI	Department of the Environment Northern Ireland
EA	Environment Agency
EEC	European Economic Community
EC	European Community
EHS	Environment and Heritage Service (Northern Ireland)
EN	English Nature (now Natural England)
EPS	European Protected Species
FCS	Favourable Conservation Status
HPA	Health Protection Agency
HSE	Health and Safety Executive
IEEM	Institute of Ecology and Environmental Management
JNCC	Joint Nature Conservation Committee
NE	Natural England (formerly English Nature)
NERC	Natural Environment and Rural Communities (Act)
NNR	National Nature Reserve
NPPG	National Planning Policy Guidance (Scotland)
PPE	Personal Protective Equipment
PPS	Planning Policy Statement (England)
SAC	Special Area of Conservation
SE	Scottish Executive
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEPA	Scottish Environment Protection Agency
SI	Statutory Instrument
SNCO	Statutory Nature Conservation Organisation
SNH	Scottish Natural Heritage
SR	Statutory Rule
SSSI	Site of Special Scientific Interest
VTA	Visual Tree Assessment
WAG	Welsh Assembly Government

Appendix 4
Searching structures for bats

Standard methodology

Species most often recorded from buildings include:
- common, soprano and Nathusius' pipistrelles;
- brown and grey long-eared bats;
- serotines;
- greater and lesser horseshoe bats;
- Natterer's bats;
- whiskered/Brandt's bats; and
- Daubenton's bats

Barbastelles, Leisler's bats, noctules and Bechstein's bats are rarely recorded from buildings and built structures.

For residential, commercial and stone agricultural buildings, the features that should be given particular attention during an external inspection include:
- holes in walls, pipes, and gaps behind window frames, lintels and doorways;
- cracks and crevices in stonework and brickwork;
- gaps between ridge tiles and ridge and roof tiles, usually where the mortar has fallen out;
- gaps between lintels above doors, windows and hay holes;
- broken or lifted roof tiles;
- lifted lead flashing around chimneys, dormer windows, roof valleys, ridges and hips, or where lead flashing replaces tiles;
- gaps between the eaves, soffit boards and outside walls;
- gaps behind weatherboarding, hanging tiles and fascia boarding;
- possible entry and exit points around the eaves, soffits, fascia and barge boarding, under tiles;
- cavity walls and rubble-filled walls; and
- areas where bat droppings might accumulate, on the ground, ledges, windows, sills or walls.

A search should be made of the ground, especially below potential access points, windows sills, window panes, walls, hanging tiles, weather boarding, lead flashing, eaves, behind peeling paintwork or surfacing materials and under tiles. For buildings constructed from stone rather than brick, particular attention should be paid to cracks and crevices that provide protection from the elements. Such features are known to be used by small numbers of bats throughout the summer period, and occasionally maternity roosts have been recorded where access to rubble-filled walls has been provided.

Once the external inspection has been completed, an internal inspection should be undertaken. In derelict or abandoned residential, institutional or office buildings, bats may be using rooms and other spaces within what would have been the living or working space of the building, and each room should be surveyed for bat presence. Surveyors should work quietly and check the buildings in a systematic manner working upwards from the entrance (checking any cellar space last). On entering an individual level (or room) the places bats are most likely to be should be checked first; for example, if there are droppings under the ridge beam, the area above should be viewed. In open warehouses, the darker areas should be surveyed first.

Within rooms in the buildings, surveyors should pay particular attention to:
- the floor and surfaces of furniture;
- behind pictures, posters, furniture, peeling paintwork, wallpaper, plaster and boarded up windows;
- window shutters and curtains;
- wooden panelling;
- lintels above doors and windows; and
- clean swept floors.

Even where the building is still occupied, an internal inspection of the upper floors is necessary. Close inspection of window sills and window glass can provide information not available from an external survey from the ground.

Frequently-used roost locations within roofs include:
- the top of gable end walls;
- the top of ridge and hip beam and other roof beams;

- mortice joints;
- the junction of roof timbers, especially where ridge and hip beams meet;
- the top of chimney breasts;
- behind purlins; and
- between tiles and the roof lining.

A search of the roof void should be made, with particular attention to:
- all beams (for free hanging bats);
- clean swept floors;
- droppings beneath the ridge and hip beams of the roof and junctions between the two;
- droppings and urine staining on and at the base of dividing walls, gable end walls and around chimney breasts;
- droppings, urine staining and corpses on, under or in materials or boxes stored in the roof;
- droppings beneath purlins;
- droppings and corpses beneath roof insulation;
- corpses at the base of walls and near wall plates at the base of rafters;
- corpses in uncovered water (header) tanks or other containers in the roof;
- bat-fly (Nycteribiid) pupal cases ;
- scratch marks and characteristic staining from fur oil on timber and walls;
- mortice joints and junctions between roof timbers and between timbers and walls;
- clean gaps and sections of ridge beam and other timber and walls within the roof;
- gaps between lintels above windows or doors;
- light gaps in the roof indicating access points to the outside;
- access to cavity or rubble-filled walls; and
- cool areas suitable for torpor or hibernation;

In addition to searching the roof and other parts of the building the surveyor should listen for bats squeaking and chattering during the day, as this can often give away a roost location that is not visible.

Particular considerations when searching churches

In churches, the features that should be given particular attention during external inspection surveys include:
- holes in walls, pipes, gaps behind window frames, lintels and doorways, including the main doors to the church;
- cracks and crevices in stonework and brickwork;
- gaps between ridge tiles and ridge and roof tiles, usually where the mortar has fallen out;
- broken or lifted roof tiles;
- lifted lead flashing associated with, roof valleys, parapet walls and ridges and hips, or where lead flashing replaces tiles;
- gaps between the eaves, soffit board and outside walls;
- cavity walls and rubble-filled walls; and
- areas where bat droppings might accumulate, on the ground, ledges, windows, sills or walls.

Whilst many churches are open to the public, internal surveys of churches should be undertaken only with the permission of the appropriate church authority. This is particularly important as churches are places of worship and are often held in special regard by members of the public and members of the local church community. In addition, parts of churches are not open to the public, and permission will be required to access these areas. Surveyors should work quietly and check the buildings in a systematic manner working from the point of entry through the main body of the church. Underground areas, towers and roof voids should also be surveyed where access permits.

Surveyors should pay particular attention to:
- the floor and surfaces of church furniture;
- behind pictures, hymn boards, posters, plaques, curtains across doors and ornate wall hangings;
- lintels above doors and windows;
- the junction of wall and roof timber panelling and the stone or brick walls of the church;
- pots and other receptacles;
- polished wood, stone and metal surfaces for urine splashes discolouration; and
- clean swept floors and other surfaces.

Frequently-used roost locations within churches include:
- the void between roof panelling and the roof covering;
- the junction of wooden panelling and walls;
- behind wall hangings, pictures and plaque;
- roof voids, crypts, bell towers; and
- between tiles and/or lead flashing and the roof lining.

Notes

Bat Conservation Trust

The Bat Conservation Trust (BCT) is the only national organisation soley devoted to the conservation of bats and their habitats in the UK. BCT's vision is a world where bats and people live in harmony, and it is working to ensure these amazing mammals are around for future generations to enjoy.

Bat Helpline: 0845 1300 228
www.bats.org.uk

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