A Review of Bat Mitigation in Relation to Highway Severance

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1 Executive Summary

All bat species and their roosts receive legislative protection. It is widely accepted in the UK and Europe that severance of their flight/commuting routes by roads is of key concern for the conservation of bat populations.

Highways Agency commissioned Halcrow Group Ltd and Richard Green Ecology Ltd to undertake an evidence-based review of the mitigation of effects on bats of severance by roads. The review is intended to report on practice in the UK to inform future decision making, providing information on the range of mitigation measures that have been adopted, together with information on outcomes from any monitoring. This report is intended to supplement previous work, in particular Bickmore (2003) 'Review of work carried out on the trunk road network in Wales for bats'.

The review has been informed by published and unpublished literature and case study monitoring reports. The review of case studies included consideration of mitigation measures that have been installed as part of roads projects principally in England and Wales, from 2002. The report considers structures that have been adapted to accommodate use by bats, as well as purpose built bat structures.

It is intended to help inform decision-making when selecting mitigation measures for severance of bat flight/commuting routes. Such mitigation measures are collated into the following examples:

- Underpasses;
- Over-bridges;
- Wire bridges;
- Hop-overs; and
- Temporary crossing measures.

The literature review supported the view that road severance is a key concern for the conservation of bat populations, but that such considerations are unlikely to apply uniformly to all species. The need for specific measures to mitigate fragmentation and the likely success of those measures, appears to vary between species, possibly as a result of factors such as flight pattern and feeding behaviour. Other location-specific factors are likely to influence the need for and approach to mitigation provision, including:

- proximity to features that contribute to a critical phase (a seasonal activity or behaviour), in a species life cycle, upon which survival or reproduction depends eg roost sites;
- proximity to features that facilitate feeding or movement such as watercourses and vegetation;
- surrounding land-use, as well as the potential for bats to use and move through the wider landscape; and
- the design, including size and type, of any features that are intended to mitigation for fragmentation effects.

The review of case studies confirmed that a range of mitigation approaches have been adopted throughout the UK, on roads of various widths. Their provision has generally been informed by baseline surveys that were undertaken as part of environmental impact assessments undertaken during the development of projects. The performance of the mitigation has in some cases been informed by post-construction monitoring. The review highlighted that the case studies, to various degrees, show:

- there are a number of inconsistencies between baseline surveys undertaken to inform environmental impact assessments and post-construction monitoring, including survey timing, effort, equipment, location etc;
- the methodology for assessing use varied considerably;
- the information recorded during monitoring varied;
- the use of the mitigation measures varied between species;
- the measurement and reporting of the success of mitigation has been shown to be inconsistent;
- the validity of evaluating or comparing (statistical analysis) the relative success of the range of mitigation measures is limited by factors including the low number of occasions when measures have been used (sample size), and by the available survey data; and
- the longer term performance of the mitigation measures, in particular when landscape planting measures have matured, has not been subject to evaluation.

Recommendations are then made on improvements in assessment of the effects of fragmentation on bats, as well as the monitoring where relevant of any mitigation measures contained in future road schemes. In particular the report recommends:

- the design of pre and post-construction surveys should be carefully designed, to where feasible allow comparison of the movement of bats;
- survey reports would benefit from increased consistency, in particular in the level and type of information recorded;
- surveys provide an opportunity to increase understanding of the relative value or likely success of the range of mitigation measures; and
- survey reports should make it clear how the survey timing relates to key impacts such as site clearance, construction of mitigation measures and when roads are open to traffic.

2 Introduction

2.1 Objectives and approach

All bat species and their roosts receive legislative protection. It is widely accepted in the UK and Europe that severance of their flight/commuting routes by roads is of key concern for the conservation of bat populations. The review of approaches to the provision of bat mitigation can be considered to support the Highways Agency's biodiversity duty, and is available to help inform provision of future mitigation, in particular its efficacy, whilst maintaining measures that are proportionate and cost-effective.

Existing literature supports the view, at both a UK and European level, that severance of flight/commuting routes by roads is a key concern for the conservation of bat populations (Bach et al 2004, Schorcht et al 2008; and Kerth and Melber 2009).

The review was undertaken between 2010 and 2011 and focussed on severance associated with construction and improvement of roads.

This report also supplements previous work carried out in relation to severance, such as Bickmore (2003) 'Review of work carried out on the trunk road network in Wales for bats'.

2.2 Report outline

The review is structured as follows:

- Methodology;
- Literature review;
- Overview of approaches to mitigation of severance in the UK;
- Discussion/conclusions; and
- Recommendations.

2.3 Highways Agency

The Highways Agency is an executive agency of the Department for Transport. It is responsible for managing, maintaining and improving the strategic road network in England on behalf of the Secretary of State for Transport. The strategic road network consists of motorways and major trunk roads; other roads in England are managed by local authorities.

3 Methodology

This review considered published and unpublished information from the UK and, where translations were available, from wider Europe. Information was gathered from scientific journals and UK highway project bat survey and monitoring reports. The review focussed on case studies of mitigation for severance of bat commuting routes.

The following consultees were also contacted for relevant information:

- bat groups from UK and Europe;
- ecological consultants and university scientists from the UK and Europe;
- Highways Agency Regional Environmental Advisors;
- other highway professionals, such as those from local highway authorities and the devolved administrations of Scotland, Wales and Northern Ireland; and
- statutory nature conservation organisations.

A total of 24 consultees were contacted and responses were received from 14 of these.

Europe has more bat species than are present in the UK but these include all of the UK species, although not all of Europe has all of the species present in the UK. There may be some behavioural differences between populations of the same species in the UK and Europe; however, it is considered, from comparisons of research findings in the UK and Europe and from discussion with European bat ecologists, that the findings of research in Europe are relevant and valuable to this review. Where literature from Europe had not been fully translated, the information available for this review is limited .

4 Literature Review

This section provides an overview of the ecology of bats associated with bat flight commuting routes to underline their fundamental importance to bats, with a broad overview of the issues facing bat populations in proximity to roads before focussing upon the effects of severance.

4.1 Commuting routes and other linear features

A comprehensive account of bat conservation status and legal protection, biology and habitat preferences in the UK is provided within Altringham (1996, 2003) and Bickmore (2003), and therefore is not duplicated in this report. Although it should be noted that in April 2010 The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) in England and Wales (and to a limited degree, Scotland - as regards reserved matters), which afforded protection to bats, has been replaced by The Conservation of Habitats and Species Regulations 2010. This updates the legislation and consolidates all the many amendments which had been made to the Regulations since they were first made in 1994 (Defra, March 2011).

Flight/commuting routes are important for access between foraging habitat and seasonal roosts (Bickmore, 2003; Mitchell-Jones et al., 2003). It is well documented that bats use linear habitat features such as hedgerows, watercourses and road verges, not only as a food source but as a means to access other insect rich habitats such as woodlands, pasture, wetlands and standing water (Bickmore, 2003; Verboom & Huitema, 1997). Within the landscape there will be numerous flight paths used on a nightly basis between the roost and foraging habitat (Limpens, 2005); this can be in the range of 2-20km in the summer, depending on the species (Altringham, 2003). For pipistrelles at least, there is evidence to indicate that the greatest foraging efficiency occurs immediately after emergence (Rydell et al. 1996; Swift et al., 1985), indicating a pressure for pipistrelles (Pipistrellus spp.) to reach foraging areas as soon as possible following emergence (pers.comm. Nick Downs, March 2011). Most species are highly faithful to their roosting and foraging sites, the flight commuting routes between them, and can be used by bats over many generations (Altringham, 2008).

Although bats will use several roosts and several major feeding areas in the same season (Altringham, 2008) bat roosting habits vary over the year in order to take advantage of seasonal changes in food availability or for hibernation (Wray, 2005). At the end of the summer, migration to autumn mating and winter hibernation sites can be in the range of 60 km and is likely to be further than this (e.g. Rivers et al. 2006). Linear features provide links between these summer, autumn mating (swarming sites) and hibernation roosts (Limpens et al 2005, Lesiński, 2007). Linear features also provide dispersal corridors between colonies (Lundy and Montgomery, 2009), thus linear features are important for maintaining genetic variability within a population.

Different bat species morphology influences how bat species move and forage in the landscape (Norberg et al. 1987, Fenton et al. 2002, Verboom & Huitema, 1997, Altringham 1996). Different European bat species feeding strategies are summarised within Table 1 of Limpens (2005). Although some bat species exploit open areas, there is evidence to suggest that bat activity away from linear habitat features declines even for high-flying bats such as noctules (Natural England, 2009) and serotines (Verboom

and Huitema, 1997). Verboom and Huitema (1997) attributed this behaviour to landscape features providing one or a combination of the following ecological functions:

- navigational aids: bats traditionally use specific flight routes suggested to be informed by an echolocation orientation map and spatial memory. This primarily enables an efficient foraging strategy to be developed, reducing energy expenditure when searching for suitable foraging habitat;
- foraging habitat: it has been shown that the relative density of insects alongside landscape features is higher than the surrounding open land; and
- shelter from wind or predators: bats have been observed to fly in the leeward side of linear features possibly to minimise energy expenditure in windy conditions and/or to avoid avian predators.

4.2 Effects of roads on bats

Roads can have several adverse effects on bat populations including: direct loss of foraging habitat and/or decline in quality (e.g. through change in land use or pollution) affecting insect abundance (Limpens, 2005, Luell et al, 2003); direct loss of roosts (Wray, 2005); severance of flight commuting routes for foraging and dispersal (Bach et al 2004; Altringham 2008; Kerth and Melber, 2009), and bat/vehicle collision mortalities (Limpens 2005, Lesiński, 2007; Lesiński, 2008, Geisler, 2009, Lesiński, 2010, Abbott, 2010).

There can also be complete fragmentation of a sub-population by a road, with two effects: (1) reducing the genetic diversity within it (interbreeding) making a whole population susceptible to extinction (O' Brien, 2009); and (2) isolating the sub population such that individuals have a low chance of moving between sub populations, making recovery from localised population collapse an impossibility (Luell et al, 2003, Altringham 2008). Altringham (2008) indicates that the latter fragmentation effect could be relevant to rare species with small and fragmented populations, such as horseshoe bats (Rhinolophus spp.), Bechstein's bats (Myotis bechsteinii) and barbastelle bats (Barbastella barbastellus).

Once roads are operational additional barrier effects can exacerbate fragmentation for bats, these include vehicle activity/volume, noise and lighting (Limpens 2005, Brinkmann et al, 2003; Altringham 2008). Siemers & Schaub, (2008, 2010) indicate that traffic noise decreases the foraging efficiency of the greater mouse-eared bat (Myotis myotis). Species sensitivity to such factors varies dependant upon behavioural aspects, pipistrelle, serotine (Eptesicus serotinus) and noctule bats (Nyctalus noctula) are preferentially attracted to feed on insects around street lights (Limpens 2005), which may increase the risk of animal vehicle collisions. Other species such as greater (Rhinolophus ferrumequinum) and lesser horseshoe bats (Rhinolophus hipposideros) (Stone et al., 2009; Wray et al., 2005) avoid light, which can exacerbate fragmentation effects, by increasing the distance between suitable habitat.

4.3 Effects of severance on bats

Existing literature indicates that in the UK and Europe severance of flight/commuting routes by roads is considered to be a key concern for the conservation of bat populations (Bach et al 2004, Schorcht et al 2008; and Kerth and Melber 2009) and that

severance of flight paths can additionally lead to a decline in bat populations (Bach et al, 2004).

In relation to highways, the severance of linear features used as bat flight/commuting routes can be caused by:

- the construction and operation of new roads;
- the removal of habitat features along verges as part of highway maintenance; and
- improvements and/or widening of existing roads and the associated infrastructure, such as lighting, which may cause severance (DMRB Volume 10 Section 4 Part 2, Nature Conservation Advice in Relation to Mammals – Bats Technical Appendix, 2011).

The severance or loss of existing landscape features, or sudden dramatic change in such features, can introduce a range of issues for bats (Limpens 2005), including fundamental effects on their livelihood (Altringham, 2008). Linear features provide a network for bats which supports foraging activity and access to roosts, throughout the year.

The literature indicates that both pipistrelles (Downs & Racey, 2006) and lesser horseshoes (Wells, et al., 2004) cross gaps in excess of 200m, where conditions in particular levels of darkness are suitable. These species are active earlier in dark areas than they are in the open (Downs & Racey, 2006; Schofield, 1996; Schofield, 2008; Stone et al., 2009). The severance of a linear feature, can introduce changes in factors such as light levels and wind exposure (Limpens 2005), leading to increased reticent to cross, leading to a combination of one or more of the following effects:

- severance between foraging and roosting location resulting in the use of suboptimal foraging and roosting locations leading to increased energy costs for the bat;
- increased risk of road mortality when crossing the road;
- localised population decline; and
- increased risk of interbreeding and localised extinction.

The severance of linear features can result in bat/vehicle collision mortalities when bats continue to be faithful to traditional flight commuting routes once the road is operational (Lesiński, 2007; Limpens 2005). Altringham (2008) indicates that there are difficulties in any analysis of bat road kills as finding and monitoring bat road kills is influenced by animal scavenging and deflection of bats by vehicles at speed. Work in Poland (Lesiński, 2007) provides an indication of the complex effects of severance on bat ecology and populations, including that:

- there were regional differences in the composition of species found in road kills reflecting the local bat species of that area;
- that young individuals were more likely to be killed than adults;
- that there were seasonal trends in road mortalities, with the highest mortality occurring when there was dispersal of young bats;
- that the highest rate of mortality was where roads approached tree stands or severed forest (linear features), and lowest within built up areas; and

- road casualties were frequent for 'low-flying gleaner[1]' Daubenton's bat (Myotis daubentonii) (39.5%) but rare for 'high-flying' noctule(1.9%).

Abbott (pers.comm. March 2011) investigated bat movements across a recently-constructed motorway at sites where the motorway severed potential bat commuting routes along prominent linear landscape elements (i.e. treelines along hedgerows, minor roads and rivers). For a subset of ten nights, acoustic recordings were made where bats crossed directly over the motorway traffic lanes and the time between the end of each bat pass and the next passing vehicle was quantified. The proportion of bat passes that coincided with passing vehicles was also quantified. This allowed an assessment of whether bats timed their flights across motorways so as to avoid vehicles. Abbott indicated that the risk of collision mortality may outweigh any potential connectivity benefit gained by bats persisting in using flight routes between severed treelines. For all types of crossing route, the flight path of a minority of bats took them into potential risk of motorway traffic collision, dependent on species-specific flight behaviour. There was no evidence that bats timed crossing flights so as to avoid passing motorway vehicles. These results highlight the importance of incidental (non-wildlife) crossing routes along motorways, and also the need to locate and design crossing structures to minimise the potential risk of traffic mortality for bats.

Geisler et al. (2009) indicated that even "medium-flying species have been very frequent ''roadkills" and Lesiński et al. (2010) recorded high flying species.

Furthermore, Bickmore (2003) indicates that severance may have more serious implications the nearer it occurs to a maternity roost, as the critical sectors of the population, the breeding females and young are affected. This could have an effect on the favourable conservation status of the species locally and may also have wider implications for the species at a regional and possibly national level dependent on the rarity of species concerned (pers.com Natural England, March 2011).

4.4 Methods used to counter the effects of severance

A comprehensive handbook to designing appropriate mitigation for wildlife to counter severance by roads is set out within Luel et al (2003). More specific recommendations in relation to bats and roads are set out by Limpens (2005) and Brinkmann et al. (2008). Limpens (2005) indicates the fundamental importance of understanding the local bat populations' use of the landscape, locations for foraging and roosting and their seasonal behaviour, before being able to extrapolate the effects of a road development on bats. This is key to designing the appropriate severance mitigation.

Brinkmann et al (2003) refined in Brinkmann et al. (2008) undertook a review of case studies where there had been severance of flight commuting routes by roads and identified the following approach for the development of mitigation measures and their quick up take by bats:

- mitigation must be along existing flying routes, since many bat species exhibit conservative behaviour in choosing and using foraging habitats, roosts and flying routes and continue to try to use the same flying routes;

[1] Gleaning bats generally take invertebrate prey from foliage, water surface or ground.

- mitigation should be linked into the landscape by suitable guiding structures;
- in the case of culverts they should be sufficiently large to be considered by the bat as an option for crossing;
- mitigation measures should be undisturbed and free of danger during the night (for example no illumination); and
- be developed and capable of functioning before the barrier effect occurs including mature vegetation structures when the new route is first used.

4.5 Landscape permeability

Limpens (2005) states that although it is important to maintain established commuting routes, bats will continue to seek new connections in a changing landscape. Therefore it is not only important to maintain the existing and highly important routes but seek to maintain permeability at a range of scales.

Various mitigation strategies have been adopted in the UK to reduce the effects of severance and retain connectivity of the landscape, these strategies have been achieved through integrated road design and include underpasses, overpasses and hop-overs. The following sections review the research and monitoring undertaken for these mitigation measures and provides design details and reference to species where available.

4.6 Underpasses

Underpasses have been utilised in a range of circumstances, in particular where a new road is carried upon a raised embankment allowing insertion of a tunnel (culvert) beneath the road, or the topography allows the building of a bridge over a hedge, stream or other feature that represents an existing flight line (Altringham 2008).

It is well documented that bats use underpasses (Bach et al 2004, Brinkmann et al 2003) and spacious unlit tunnels (Limpens 2005). This behaviour has been commonly observed for the 'low level gleaning' species of bats that prefer to fly close to cover (Schorcht et al 2008; Kerth & Melber, 2009). Some bat species have been recorded flying longer distances to use a culvert rather than fly a shorter route over the motorway. Krull et al. (1991) and Brinkmann et al. (2001) observed this of Geoffroy's bat Myotis emarginatus; Fuhrmann (1991) of brown long-eared bat (Plecotus auritus), and Hausler & Kalko (1991) of Daubenton's bat and common pipistrelle (Pipistrellus pipistrellus). Kerth and Melber (2009) radiotracked a Bechstein's bat on one occasion commuting 3.5km to cross the motorway through an underpass, while on another occasion the same bat flew over the two lane road with relatively high levels of traffic.

Bach et al (2004) reviewed studies and anecdotal observations in Germany and although this did not allow quantitative analysis, it indicated that tunnels under motorways were used by nine species of bats. Common pipistrelle, Natterer's, Bechstein's, barbastelle, noctule and whiskered (Myotis mystacinus)/ Brandt's bats (Myotis brandtii) were found flying through tunnels of 4.5m wide, 4m high and 31m long. Whereas Natterer's and Daubenton's bats were also recorded using quite low (1.5m high) and narrow (2m wide) tunnels even if they were long (>30m); and greater mouse-eared bats used tunnels more frequently when they were at least 3.5m high. Bach et al (2004) also indicated that Daubenton's bat will ''especially'' use tunnels when a stream is flowing through it. However it is noted by Bach that rather than just size of culvert

other factors such as the vicinity of the tunnel in relation to roosts and adjacent foraging habitat, illumination of tunnels and use by traffic may bias such results.

Abbott (unpublished data, 2009) is undertaking a study in Ireland and although quantitative analysis is not available at this time, the results are indicating that bat activity is higher for underpasses than control sites, and that bat crossing activity was markedly higher beneath road river bridges relative to other potential crossing routes, as also indicated by Bach et al (2004).

In Germany, Kerth and Melber (2009) compared two distinct types of bat with different wing morphology and feeding strategies: the barbastelle, which forages in open space, and Bechstein's bat, which gleans prey from vegetation. Mist netting established that at least 7 bat species were using underpasses for crossing a motorway, including barbastelle, Bechstein's, greater mouse-eared, whiskered, Natterer's, pipistrelle sp., and brown long eared bats. But that species which foraged near to vegetation or ground (Bechstein's, greater mouse-eared, whiskered, Natterer's and brown long eared bat) dominated the bats captures in the underpasses. Although the underpasses were used by Bechstein's bats, the evidence indicated that their home range reduced and reproductive success was lowered (pers.comm. Altringham, March 2011). No noctules or Leisler's bats (Nyctalus leisleri) were captured despite roosting in the area. Both of these species are aerial insectivores, flying high above the ground in open space. The results of radio-tracking indicated greater severance impacts of a motorway on the habitat use by low-flying gleaner species, such as Bechstein's bats, than by species that forage in more open space, such as barbastelle bats.

Abbott (pers.comm, March 2011) is currently undertaking a study in Ireland (as yet unpublished). Bat activity has been acoustically recorded during 66 detector nights in three adjacent passageways under a motorway and in the area surrounding the passageways. The passageways consist of one large underpass for a minor road, and two long, narrow drainage pipes. Concurrent radio-tracking of lesser horseshoe bats (R. hipposideros) was also completed. A behavioural response to passageway dimensions has been found. Only the most clutter-adapted species in the local bat assemblage (R. hipposideros, Myotis nattereri, Plecotus auritus) were found to be flying through the long, narrow drainage pipes. Other species adapted for flight and foraging in more open air-space (Pipistrellus pipistrellus, Pipistrellus pygmaeus, Nyctalus leisleri) were abundant in the surrounding area, but did not cross through narrow pipes. In contrast, all species, except N. leisleri, flew through the large underpass. Simultaneous all-night recordings (16 nights) above and below the large underpass indicated that the tendency to cross over the structure was inversely related to the degree of clutter-adaptation of the bat species. Radio-tracked R. hipposideros used all passageways for road-crossing, but also crossed over the motorway traffic lanes at locations between available passageways. If the target species for mitigation of road impacts are clutter-adapted bats, Abbott indicates that incorporation of several well-placed small tunnels into new roads may enhance connectivity more than fewer large underpasses. This indicates the existence and importance of bat flyways through narrow underground passages should not be overlooked during development projects.

Wray et al (2005) reported that as part of the A477 Sageston to Redberth Bypass two culverts were installed within a road embankment on the alignment of existing flight

lines of greater horseshoe bats in an area of optimal foraging and seasonal roosts. It was reported that the culverts were used by greater and lesser horseshoe bats in very low numbers initially whilst increasing in later surveys. The culverts were also used by Myotis sp. and Pipistrellus sp. bats.Particular attention was given to the location and funnel shaped landscaping design leading to the culvert entrances; there was planting leading bats to the culverts and an absence of lighting to try to maximise bat use. Tunnels were 2.2 m diameter and 1.8 m diameter. In addition, bats were discouraged from foraging along the road edge by planting hedgerows to lure bats away and creating wide verges of unsuitable habitat, such as amenity grassland and hard standing alongside the road. As part of the scheme, an existing culvert was also lengthened. Prior to the scheme, this was extensively used by greater horseshoe bats flying between seasonal roosts. However, lighting installed near the culvert may have been the cause for a decline in usage post-scheme; the lighting was later modified as part of the scheme, no evidence of monitoring was considered in this review.

A survey was undertaken in south west England by Halcrow (unpublished 2008), using hand-held bat detectors and Anabat automated remote bat detectors, of six culverts less than 1.5m diameter (small culverts) and six culverts between 1.5 and 5m diameter (medium culverts) and six control sites with no structures to facilitate crossing. Culverts had not been built to facilitate bat crossings but were for drainage or access purposes. They were selected at random but were chosen as they had potential bat flight corridors leading to and from them, such as hedges, a stream or lines of trees. Control sites were similarly selected, usually along the same stretch of road as the culvert so that the same number and species of bats would be expected in the surrounding landscape. The only bats recorded flying through the small culverts with hand-held detectors were three lesser horseshoe bats in one of the small culverts. More bats were recorded flying through the medium culverts, with five of the six culverts used by bats, consisting of one common pipistrelle, two Pipistrellus bats, 56 Myotis bats and one lesser horseshoe bat. The Anabat detectors were placed in two culverts (one small and one medium culvert) and were left from the 8th to the 17th October 2007. At the small culvert there were 11 records of lesser horseshoe bats, four records of greater horseshoe bats and one record of a pipistrelle spp., which due to the weak signal recorded may not have flown through the culvert. At the medium culvert, high levels of bat activity were recorded throughout the study period. This activity comprised 538 records of Myotis bats, 25 records of lesser horseshoe bats and six records of bats that were not identified. At four out of six control sites bats were observed crossing the carriageway, consisting of a total of three common pipistrelles, three serotines and one unidentified species.

4.7 **Over-bridges**

Over-bridges have been utilised where topography allows, such as when the road is in cutting, to link the severed ends of known flight lines. They may be vegetated but can also carry minor roads/ pedestrian walkways or farm tracks (Altringham 2008).

Bach et al. (2004) found low usage of over-bridges and attributed the low use to the open sided structure and lack of guiding or sheltering vegetation along the bridge.

Furhmann & Keifer (1996) found that nearly 90% of greater mouse-eared bats used a bridge that the authors constructed to facilitate bats crossing the road. However any interpretation of these results needs to take account of the atypical proximity of the

structure and the roost. The bridge was 2m high and 16m wide using tarpaulin to give the impression to bats of solid sides (Furhmann & Keifer, 1996).

Halcrow (unpublished 2008) recorded bats flying along five out of six vehicle and pedestrian bridges (5-15m wide) surveyed, including a total of 21 common pipistrelles, two soprano pipistrelles (Pipistrellus pygmaeus), six pipistrelle sp., one horseshoe sp., seven noctules and seven unidentified bats. Bats were also observed crossing four out of six footbridges (<5m wide), consisting of one common pipistrelle, seven pipistrelle sp., two serotines, one Myotis sp. and three unidentified sp. The bridges were not built or adapted for bat use and were selected in the same way as the culverts in the study (refer to section above). At one of the sites, several serotines were observed crossing the road but not following the bridge. These bats were observed crossing the road diagonally between the vegetation along the road verges at a height of approximately 2-5m above the footbridge.

In Europe green bridges, over-bridges designed with vegetation to recreate a semi-natural flight line (Altringham, 2008) have generally been designed between wooded areas for medium to large mammals such as deer (Bach et al 2005). Bats were not considered the primary user, but in recent years evidence has shown that bats use green bridges as guiding features similar to hedges and rows of trees in the countryside and that it warranted further research (Bach et al 2005).

Bach et al (2005) compared green bridges to road bridges that did not include any specific ecological measures. Results were not statistically analysed but the results indicated that green bridges had a higher usage rate than road bridges, and that wider green bridges (> 50 m) had the highest usage. There were exceptions to this, as bridges differed in connecting habitat and their usage between foraging and commuting. Ten bat species were recorded using the bridges see Table 1 below.

Table 1: Use of green bridges by bats in Germany (Bach et al, 2005)

Species	**Flying over**	**Foraging over**
Noctule bat	X	X
Whiskered/Brandts bats	X	X
Bechstein's bat	X	-
Serotine bat	X	-
Natterer's bat	X	X
Greater mouse-eared bat	X	X
Long-eared bats	X	X
Nathusius pipistrelle (Pipistrellus nathusii)	X	X
Daubenton's bat	X	-
Common pipistrelle bat	X	X

Abbott (pers.comm. March 2011) surveyed potential bat activity both over and under built motorway crossing structures (minor road underpasses, minor road overbridges and river bridges). Abbott found that more bats flew directly over the motorway at severed treelines than at spanning overbridges. Bats crossing between severed treelines included 'clutter-adapted' species that are usually considered to avoid open air-space, (e.g. Plecotus auritus and Myotis nattereri), as well as species adapted to

flight and foraging in more open-airspace (e.g. Pipistrellus pipistrellus, Pipistrellus pygmaeus and Nyctalus leisleri). A minority of P. pipistrellus, P. pygmaeus and Myotis spp. flew above, rather than below, underpasses and river bridges, and approximately half of the bats crossing at overbridges were detected flying below, rather than above, the overbridges. The tendency of bat species to fly over, rather than under, built structures was inversely related to the degree of clutter-adaptation of the species in terms of wing morphology and echolocation signal design. Abbott indicated this had implications for the design of 'green bridges' in that potential flight paths beneath the structure, rather than the intended flight path along the top of the structure.

4.8 **Hop-overs**

Limpens (2005) provides recommendations for hop-over design based upon an understanding of bat behaviour, however there are few known studies on their effectiveness.
Hop-overs are where tall vegetation/ trees exist or have been planted either side of a road with the aim of keeping bats flying at height over the road or may also include planting in the central reservationLimpens (2005) makes the following recommendations based upon an understanding of bat behaviour, on the design of hop-overs. It should be noted that the effectiveness of these recommendations has not yet been fully established.

- For high-flying species, such as pipistrelles, serotines, Leisler's and noctules the crowns of the existing trees either side of the road should meet to maximise the success of it working.
- To improve effectiveness of the hop-over for the relatively low-flying bat species such as greater mouse-eared, whiskered, Brandt's, barbastelle, Daubenton's and pond bat (Myotis dasycneme) it is necessary to plant dense thickets up to 6m high to force the bats to fly high and escape lorry collisions.
- Where the flight path is being used by bat species that will fly though vegetation, such as greater and lesser horseshoes, long-eared or Bechstein's bat it is necessary to use a wooden screen/mesh 4-5 m high with the addition of lighting at the location of the hop-over. The lighting must shine down on the road and must not light the surrounding area. This could be enhanced furthered by creating an embankment, so the road is within a false cutting.

5 Overview of approaches to mitigation of severance in the UK

5.1 Introduction

The results of case studies from the UK, gathered as part of the consultation exercise, are summarised below. More detailed analyses of case studies are presented in Appendix A and these should be read in conjunction with the summaries below. It is important to note that numbers of bats, bat activity indices and percentages are taken directly from scheme reports and have not been verified. As this is a summary of data, numbers and percentages should be viewed with caution and it is recommended that the scheme reports be referred to for a full picture of survey and mitigation performance. Unfortunately, in many cases, the monitoring reports did not include details of bat crossing structures, such as size and dimensions. This data will be available in other scheme reports but it was not possible to gather this data in the time available for this review.

5.2 Underpasses

The case studies reviewed show mixed levels of use for different species. It is difficult to make valid conclusions without knowing the dimensions of some of the structures or details of other environmental factors, including weather and adjacent habitat/land use. However, the following observations are made.

Barrows Green Underpass on the A590 High and Low Newton Bypass showed some use, with 29.3% of bats crossing through the underpass in 2007, increasing to 40.6% in 2008 but then dropping to 34.3% in 2009. Bats seen crossing over the road decreased noticeably over these three years, as follows: 2007 – 21.3%; 2008 – 5.9%; 2009 – 2.1%. No information is provided on which species crossed through the underpass or over the road, other than some comment on the flight height of pipistrelles over the road. Percentage figures should also be treated with caution as it is thought that these are of the total number of bats recorded, whether they be flying parrallel with the road or across the road, rather than just of the total number of bats seen to cross the road.

Ayeside Underpass, on the same scheme as Barrows Green Underpass, did not show much use with only upto 1% of bats seen to cross through the underpass and upto 64.5% of bats crossing over the road. Again, species were not identified in the report and percentage figure should be treated with caution.

Pendre Culvert on the A479 showed almost 100% of between 10 and 17 lesser horshoe bats repeatedly crossing through the culvert, although there was a possible lesser horseshoe bat recorded crossing over the road in 2009. There was also partial use by Myotis bats, including Natterer's bat, with three Myotis and two Natterer's recorded crossing through the culvert and one Natterer's recorded crossing over the road. However, pipistrelles (common and soprano) were only recorded crossing over the road, with no flight height information provided, although some were observed 'close to the dormouse bridge'.

Hopyard Farm Underpass on the A465 Heads of the Valleys, Section 1 continued to be used by lesser horseshoe bats to cross the road but showed a gradual decline in the numbers from 2005 to 2008, although this may have been due to poor weather and the

temporary fixing of grilles to the entrances of the culvert, when bats were observed flying over the road.

Evesham Nurseries Underpass on the A465 Section 1 continued to be used by lesser horseshoe bats to cross the road but showed a gradual decline in the numbers from 2005 to 2008. This may have been due to poor weather in 2007 and 2008.
Baiden Brook on the A465 appeared to be used by only a small number of lesser horseshoe bats prior to construction and Baiden Brook Culvert continued to be used sporadically by a small number of lesser horseshoe bats, as did Cwm Shenking Brook Culvert and Monmouth and Brecon Canal Underpass on the same scheme.

Many factors are likely to affect levels of use and the 'attractiveness' of underpasses for bats, including size, alignment, connection to existing flight lines, roadside vegetation and land use.

5.3 **Overbridges**

Havett Road Bridge on the A38 does not appear to have been used by many bats, although the amount of monitoring undertaken is very limited and the results from 2009 are very vague; not specifying if bats crossing the road were 'using' the bridge or not. Whilst at least one common pipistrelle bat was seen to fly directly above the bridge, others were seen to cross the road 'close' to the bridge and also to fly over the bridge parapet descending towards the road.

5.4 **Wire bridges**

The Beck Bat Conduit on the A66 Stainburn and Great Clifton Bypass appears to have had mixed levels of use, with 0 out of 53 crossing bats recorded 'near' to the structure in 2006; 39 out of 91 (43%) & 21 out of 57 (37%) of bats, including soprano and common pipistrelles and Myotis bats, crossing 'using' the structure in 2007; and bats rarely seen 'utilising' the structure in 2008. Whilst detail is provided for species, unfortunately detail with regard to bats proximity to the structure and flight height is very limited. Bats are reported as 'using' the structure but there is no definition of use, i.e., how close bats were to the structure and what height they were flying at.

Post-construction monitoring of structures on the A38 Dobwalls Bypass recorded bat movements directly over Havett Road Bridge, and both Havett Farm and Lantoom Quarry bat bridges. Surveys in June 2008 and 2009 recorded low levels of movements directly over Havett Road Bridge (2008 only) and recorded relatively low numbers of movements either directly over or within 5m of either bat structure. The monitoring indicated use by common pipistrelle, Myotis sp., serotine and brown long-eared bats. Surveys in July and September 2009 recorded a single common pipistrelle movement over Havett Road Bridge, as well as increased levels of movements over both of the bat structures. Survey observations have indicated that surveys only detected a small proportion of the bats crossing, that pipistrelle bats were flying high, close to the bridge structure and Myotis bats were flying low over the road within the traffic zone. Casualties are liable to be occurring of Myotis and possibly long-eared bats. Bats have also been recorded flying over the road cutting, away from the bat bridge since the hedgerow was fragmented in 2007, although numbers of bats crossing not using the structure have not been consistently recorded or reported.

Low Newton Bat Bridge on the A590 High and Low Newton Bypass showed limited use, with 4.4% of bats crossing 'using' the structure in 2007, increasing to 16.6% in 2008 but then dropping to 12.4% in 2009. Numbers of bats seen crossing over the road remained similar in 2007 and 2008, with a slight decrease in 2009, as follows: 2007 – 30.6%; 2008 – 30.3%; 2009 – 24.9%. Percentage figures should be treated with caution, as discussed for Barrows Green Underpass on the A590.

Bat activity indices increased slightly from 2005 to 2006 for Cadfor Bat Bridge on the A465, although numbers are lower than the 2004 baseline. All levels of activity are relatively low (e.g.1 bat in 2005 & 3 in 2006) and therefore conclusions are difficult to draw. It is not stated whether the bats were confirmed crossing the road 'using' the wire bridge or just recorded in the vicinity. No activity was recorded in 2007 or 2008 using hand-held detectors.

Bat activity indices increased gradually from 2005 to 2008 for Pen-y-Worlod Farm Bat Bridge on the A465. All levels of activity are relatively low (e.g.1 bat in 2005 & 6 in 2006) and therefore conclusions are difficult to draw. It is not stated whether the bats were confirmed crossing the road 'using' the wire bridge or just recorded in the vicinity.

5.5 Hop-overs

Of 25 bats recorded crossing the A38 Glyn Valley during 5 nights in May and June 2008, 16 (64%) were recorded at the hop-overs. Of these 16 bats, 3 were recorded crossing low over the road, with the remaining 13 crossing high enough to be unaffected by passing traffic.

5.6 Temporary crossing measures

No bats were recorded using the temporary rope bridge on the A69 Haydon Bridge Bypass. Bats were recorded continuing to fly along the established commuting route, but at locations up to 20m away from the temporary crossing structures.

Whilst lesser horseshoe bats were recorded crossing the construction area using the temporary Heras fencing on the A487 Porthmadog, Minffordd and Tremadog Bypass, numbers appeared to have declined in comparison to baseline data. This may be because several of the original flight routes zig-zagged across the line of the road and the bats may have chosen to follow an alternative route, rather than crossing the construction area several times.

6 Discussion/conclusions

Professor John Altringham, in his proof of evidence on behalf of the White Horse Alliance at the public inquiry into the A350 Westbury Bypass (2008) reviewed available case studies in the UK and Europe to comment on the effectiveness of mitigation techniques used and made the following relevant statement that ‘’Mitigation features may be used by bats, but this does not mean that they are necessarily effective. To take a hypothetical example, 50% of bats crossing a new road may do so via a safe ‘green bridge’, showing that it is used. However, if the remaining 50% cross the new road itself and mortality increases to levels that lead to population decline, then the feature is clearly not effective. It is therefore important to distinguish between use and effectiveness. This is linked with the distinction between assessing mitigation at the individual and population levels. Conservation is the protection of species and ecosystems at the population level: maintaining favourable conservation status means maintaining stable populations. Assessment at the individual level is not a guide to what is happening at the population level. Studies that examine the effectiveness of mitigation at maintaining bat populations are the ideal, but are difficult. Studies of use by individuals are easier to carry out, but less valuable. However, if well-planned and quantitative they can be of considerable value.’’

The review of case studies has indicated that a range of survey methods have been undertaken for baseline and monitoring surveys, including use of different bat detectors, including hand-held detectors (sometimes with recording devices for further analysis of calls) and remote recording devices, such as Anabat detectors. Methods also differ in the timing and number of surveys undertaken and the numbers of surveyors used to monitor flight-lines/crossing points. There is often little consistency between baseline surveys and subsequent monitoring surveys, making it difficult to make direct comparisons of bat activity before, during and after scheme construction. Even where baseline and monitoring survey methods are comparable, little information is provided on the precise behaviour of bats crossing the road using mitigation structures, crossing not using mitigation structures or not crossing the road. For example, few of the studies identify the height of bat flight as they cross over the road or the proximity of bats to crossing structures, with the term ‘used the structure’ often used but with no reference to what constitutes ‘use’. This could involve bats flying under a crossing bridge, at risk of collision with traffic, or even flying up to 5 m from the structure.

No proper statistical analysis has been undertaken in any of the case studies. This is possibly due to an insufficient sample size or the design of the survey precluding suitable analysis. Even without statistical analysis it is sometimes difficult to make direct comparisons of baseline and monitoring results where survey methods, survey timing, survey effort and weather conditions differ. In such examples, there may not be sufficient repeat surveys or detail provided of bat activity to make valid conclusions.

There is no discussion of maintenance of structures in any of the case study reports reviewed but this may be due to the fact that the reports provided by consultees tend to consist of monitoring reports only, with little information on the actual structures, e.g., dimensions, dates installed and proposed maintenance, which are likely to be stated in construction contract documents, not provided or referred to as part of this review.

The intended design life of structures is seen to vary, based on their objective. Some effectively provide temporary mitigation that serves to facilitate crossing until landscape planting matures or bat behaviour and/or local distribution adapts to other elements such as roost sites and foraging areas that may have been put in place, others have a longer term objective in ensuring connectivity is maintained. The decision over the duration for which mitigation is provided would need to be informed by an understanding of the likely effects of fragmentation including during operation of the road. The influence, on crossing behaviour and use of structures, of the mid to long-term condition of landscape planting is not established in the literature as monitoring focuses on the establishment phase of projects immediately, which is the period following construction. A longer term view would serve to increase understanding of the long term influence of roads.

Other than recording individual use of the structures, very few of the monitoring studies considered the population effects on bats caused by the road schemes. The A465(T) Heads of the Valleys Dualling; Stage 1, the A487 Llanwnda to Llanllyfni Improvement and the A487 Porthmadog, Tremadog and Minffordd Bypass schemes included monitoring of numbers of lesser horseshoe bats in known nearby maternity roosts, as well as consideration and comparison of CCW records of known lesser horseshoe maternity roosts in the local area.

7 Recommendations

Bats have been protected under the 'Habitats Regulations' since 1994, although they were protected under the Wildlife and Countryside Act before this. They are therefore an important consideration in the new construction, improvement and maintenance of road schemes and, accordingly, considerable sums of tax-payers money have been spent on road mitigation for bats. However, given the relatively little time that bats have been such an important consideration and only the relatively recent advent of detailed bat surveys using developing technologies in bat detectors and recording devices, some of this mitigation has been designed and built based on the best available general knowledge and understanding of bat activity to predict how bats may react to such mitigation, rather than on actual results of specific highway severance mitigation examples or research.

The following recommendations from pre to post construction are based upon the most up to date understanding of bat ecology from the literature. There is, as yet, no scientific research or case study that enables the definitive success of these recommendations to be interpreted, but these recommendations are useful to guide an appropriate approach to mitigation and improve the quality of data gathered for the baseline and monitoring of schemes both during and post-construction pre and post construction monitoring.

7.1 Habitat Assessment

Desk studies and habitat suitability assessments should be undertaken at an early stage to inform route selection and design using GIS and aerial photographs to predict likely patterns of bat distribution. These should be backed up by activity surveys and searches of structures that may be used as roosts.

7.2 Preconstruction Surveys

Knowledge of the bat species present in the area, their use of the landscape, locations for foraging and roosting throughout the year is fundamental to predicting the potential effects of a road development on bats. Sufficient baseline information should be gathered to enable a robust assessment of impacts that can be tested by undertaking monitoring during and post-construction to compare predictions with what actually happens and determine the success of mitigation employed. Monitoring is discussed further under post monitoring.

7.3 Approach to Reducing Severance

It is essential that an integrated approach to road design between engineers and bat ecologists is undertaken. Luell (2003), Brinkmann (2003, 2008) and Limpens (2005) make the following relevant recommendations, collated below for consideration when designing mitigating structures:

7.4 Appropriate advance planning Mitigation

Mitigation should be along existing flight routes, since many bat species exhibit conservative behaviour in choosing and using foraging habitats, roosts and flight routes. Mitigation should be developed and capable of functioning before the barrier effect occurs including mature vegetation structures when the new route is first used. Mitigation should be linked into the landscape by suitable guiding structures.

7.5 Appropriate choice of mitigation strategy

The mitigation strategy (underpass/overpass/hop over) chosen should best reflect the bat species (and their flight strategies) found in the locality (Limpens, 2005).

The strategy (underpass/overpass/hop over) will need to be refined further to suit the bat species preferences, for example in the case of culverts they should be sufficiently large to be considered by some bat species as an option for crossing (refer to openness index approach Luell et al 2003; dimensions and design Brinkmann et al. 2008 & research by Bach et al 2004).

7.6 Avoidance and reduction in mortality

In conjunction with the above, a combination of one or more: fencing, lighting and landscape planting could be utilised to try to avoid/reduce animal mortality such as directing bats towards a mitigation structure or deterring bats from roads, the combination chosen should again reflect the local bat species behaviour and sensitivity to different factors. When using such additions the following considerations should be made:

- Illumination The design should take into account how lighting is used along the road and in the vicinity of the mitigating structure as different bats species have varying sensitivity to light. For example street lighting near an underpass may create a barrier effect discouraging horseshoes sp from using the mitigation structure and therefore should be removed/altered within the design (Stone et al, 2009: Wray et al, 2005). Of further consideration, is that certain street lighting could attract some bat species to forage alongside a road exposing them to the risk of traffic collisions (Limpens 2005).
- Landscape planting has been shown to be successful at directing bats towards a structure as well as used to lure bats away from the road towards a safe crossing point, or to try to provide an alternative foraging resource which does not entail crossing the road. Measures to reduce bat mortality, associated with foraging activity along roads, can include the use of features such as hard standing or amenity grassland (Wray 2005).
- Fencing has been utilised in conjunction with a mitigating structure. It should be noted that fencing has been shown to be successful at directing bats to a structure but does not always prevent them from flying over and crossing the highway. For example lesser horseshoes will fly high to surmount a fence but swoop low immediately after the fence potentially into the path of traffic (Wray 2005).
- Combination of illumination and fencing Down lighting was placed on the road side of a fence to deter horseshoe bats from swooping low after the fence into traffic. Down lights were used to discourage bat species that are attracted to foraging around lights from doing so in the road. (Wray 2005).

7.7 Continuing ecological multi-functionality

Within the literature review Verboom and Huitema (1997) indicated that a linear feature used by bats provides one or more of the following ecological functions: (1) a navigational aid; (2) foraging potential and (3) wind/predation cover. By continuing the ecological functionality of the lost/severed linear feature that the bats are using within the mitigation solution, the bats may be more attracted to use it rather than crossing an open road. For example, a culvert solution chosen to reflect the low flying gleaner bat

species in the local population such as Myotis sp. could be made more attractive by also passing a stream through it, this not only provides a navigational aid to the structure but also foraging potential for some species, increasing its attractiveness, whilst the culvert protects the bats from wind and predation and importantly from road kills. As another example, a footbridge to guide high flying species across the road may be planted with a double hedgerow, again to fulfil the lost ecological functions.

7.8 Maintaining a permeable landscape overall

Limpens (2005) emphasises the importance of not just restoring severed routes but maintaining a permeable landscape.

7.9 Post construction monitoring recommendations

It is extremely important that the investment already made undertaking baseline surveys and constructing mitigation on schemes is not wasted by not undertaking sufficient monitoring surveys to determine the level of success of mitigation and inform further developments where such mitigation does not work or is simply not appropriate. For this reason it is recommended that 'missing' information from the case study reports and information from additional case studies (that are known to exist but were not provided in time for this review) is gathered and further reviewed to enable a more precise assessment of mitigation success.

Altringham, (2008) noted

"*Until more structured and well-planned research is done, we lack the basic knowledge needed for making accurate predictions about levels of impact. In principle, and after appropriate research, prediction accuracy of some value is achievable. At present, prediction is little more than guesswork and terms such as slight and moderate have little meaning. For example, is the loss of say 5% of a bat colony to road deaths slight or moderate? Without an understanding of the long-term consequences of elevated mortality on population dynamics it is not possible to say. As yet, no study has taken the first step of estimating before or after mortality, let alone look at population dynamics. Most other measures of impact are even more difficult to interpret. If we wish mitigation to be founded on objective evidence then better research is essential. We should be using measureable effects of past schemes, to predict the consequences of future schemes. Whilst accepting the constraints of time and money, there are useful steps that can be taken that would facilitate more objective appraisal. These need not necessarily increase costs or delay work if carefully planned.*

- *Monitoring before, during and for some time after construction at a frequency/intensity sufficient to detect trends in often inherently 'noisy' ecological data.*
- *Systematic and standardised measurement (in terms of effort, location, protocols and equipment) of bat activity in key habitats and/or across an unbiased grid, before, during and after construction, on both sides of the development.*
- *Systematic and standardised measurement of bat activity on flightlines severed by the road and on their associated mitigation features. Again, before, during and after construction.*
- *Systematic and standardised measurement of bat activity on safe and unsafe routes at mitigation features.*

- *Systematic road kill searches.*
- *Quantitative and statistical analysis of the data generated rather than descriptive and/or anecdotal presentation with subjective interpretation.*
- *Collaboration between consultancies and practicing scientists to develop the most effective monitoring protocols and analysis methods.*
- *Systematic long-term monitoring of large and/or vulnerable bat roosts in the vicinity of the scheme.*
- *Monitoring of agreed mitigation measures. In past studies there are examples of uncompleted work, unscheduled changes in design and unrepaired vandalism that make data interpretation difficult.*

The results will always be subject to different interpretations and ambiguities, but analysis will at least be more objective, quantitative and based on assumptions. The current, largely implicit, criterion for the success of a mitigation feature is that it is used by bats. This is far too simplistic. At the very least, it must be demonstrated that the majority of bats are still using old flightlines to reach traditional feeding and roosting sites and in crossing new roads do so by safe routes. If this is not the case then a more detailed study is required to see if altered behaviour may be increasing road kills or is related to the loss of traditional foraging and roosting sites that might compromise the viability of local populations'"

Whilst it is recognised that each scheme is different, with different species and numbers of bats, it is recommended that some guidance on baseline and monitoring survey methods be developed to ensure that the best available information is gathered for further understanding of the effects of road severance on bats. Initial suggestions for discussion are provided below.

Surveys must be designed to provide unambiguous data to allow assessment of bat use of the landscape dissected by the road before construction and during operation. Desk studies and surveys should be undertaken at an early enough stage in the planning of a scheme to influence the route selection and design. Avoiding important bat flight routes and foraging areas may be easier and more cost-effective than trying to mitigate for predicted impacts. Sufficient replicate surveys should be undertaken before, during and after construction to allow for nightly, seasonal and yearly differences in bat behaviour, weather or other environmental factors to allow statistically valid conclusions to be made. Post-scheme monitoring should be undertaken for sufficient time to make valid assessments of the effects of a scheme.

Appropriate technology should be used and be consistent between baseline and monitoring surveys. It must be recognised that different technologies are available and each may lend itself more appropriately to particular situations. For example, remote Anabat detectors may be a relatively cheap method for gathering data over an extended time period but they cannot observe flight direction or behaviour and may not be as sensitive as human surveyors using hand-held detectors with less directional microphones. The use of 'bat-pods' has recently been described in edition 69 of In Practice (September 2010). This is a method of using two bat detectors and recorders to help determine flight direction of bats along a route. However, this does not allow observations of bat flight. Such devices may be appropriate to count bats flying through

suitably sized culverts but even then, the examples above have shown that some bats repeatedly fly into and back out of the same culvert entrance, particularly if foraging in the culvert entrance. This may, therefore, give an incorrect impression of bat activity as repeated foraging by a single bat could be confused with large numbers of bats commuting along a structure. It is therefore recommended that competent observers using sensitive bat detectors connected to recording devices be used in the majority of cases.

Surveyors must also record as much detail as possible about the bat activity they observe, including species (where possible), time of observation (including time range if bat is foraging in the same place and is observed for a duration of time, flight height, direction, proximity and relative position in relation to landscape features, including vegetation and crossing structures. In addition, weather conditions and temperature should be recorded at the beginning, during and at the end of the survey period. Half-hourly intervals are suggested between noting new weather conditions, although if there is a sudden change, e.g., it starts raining, this should be noted at the time it happens. Notes should also be made on other environmental factors that might affect bat activity, such as land-use and management and lighting, and any changes between surveys highlighted for consideration. The start and end time of the survey and the time of sunset and sunrise, if necessary, should also be recorded.

Monitoring survey methods should follow the baseline survey methods as closely as possible, although it is recognised that there may have to be changes made to surveyor locations as a scheme is constructed or if bat behaviour needs to be monitored at new locations because of a change in behaviour. If this is the case the change in method must be properly recorded and data gathered in such a way to provide meaningful/comparable results, recording data in detail, as above.

Survey and monitoring reports should provide details of the scheme in relation to bats and bat mitigation, including results of baseline monitoring, the dates of the construction period, including when a structure was installed, when landscaping was planted and established and when the road was opened to traffic, and the dimensions of any bat mitigation structure and the original landscape feature it replaces (or at least relevant reports should be referred to).

Monitoring protocols must be designed to enable analysis that can address specific and relevant questions appropriate to the site.

Continued monitoring, of temporary mitigation, during the construction phase, may inform development/modification of permanent mitigation, including the design or placement of mitigation structures.

7.10 **Further work**

The development of an expert working group consisting of bat researchers, bat consultants and bat specialists/ecologists from SNCOs and highway authorities may facilitate future development of proportionate guidance.

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Appendix A: Case Study Information – Underpasses

Case Study U1: A590 High & Low Newton Bypass, Barrows Green Underpass

Summary description

Barrows Green Underpass is a 6 metre wide by 5 metre high vehicular access beneath the A590 dual carriageway, and has a span/length of 30m. Landscape planting and a balancing pond were installed near to the entrances of this underpass.

Mitigation outcome

The results of the monitoring surveys recorded 34.3% of bat passes representing bats commuting through the underpass in 2009, compared with 40.6% in 2008 and 29.3% in 2007. Bats were also observed foraging in the entrance of the underpass. The proportion of bats flying over the carriageway without using the underpass decreased from 21.3% in 2007, to 5.9% in 2008, to 2.1% in 2009. Both the mean and peak Bat Event Index (BEI) has increased over the monitoring period.

Data limitations

A limited amount of bat survey data was available from the 2005 baseline surveys (only two surveys undertaken). For each minute of constant bat activity, it was assumed that three bat passes had been recorded. Variation in completion of the survey proforma meant that some interpretation of survey data was required. No statistical analysis of data was presented. Baseline counts in 2005 recorded bats using commuting routes, although subsequent monitoring counts recorded all bat passes, including those not using the commuting route, i.e., not crossing the road. Species using the underpass and flying over the road were not specified and raw data was not provided within the report.

Case Study U1	**A590 High & Low Newton Bypass, Barrows Green Underpass**		
Road & location	A590, Cumbria		
Carriageway type	Dual carriageway		
Structure Ref	26922		
Impact of scheme	Severed hedgerow used as bat commuting route		
Type of structure & span	Underpass; Length = 31.6m Width = 7.3m		
Installation date	2008 (road opened to traffic in April 2008)		
Baseline	Activity surveys were carried out on five bat commuting routes identified in previous surveys undertaken in 2003 & 2004 (results not provided). Two activity surveys were carried out in 2005 on each bat commuting route, one in May and one in June. Survey positions were selected to allow comparable repeat surveys to be carried out from the same positions during and following road construction. Each survey began 15 minutes before sunset and continued for 1.5 hours after sunset. Weather conditions were recorded.		
Number of bats recorded at baseline	Peak number of bat passes or bat event index (BEI) was 94 (May 2005), including common pipistrelle, soprano pipistrelle, Myotis sp., brown long-eared, noctule.		
Monitoring	**2007**	**2008**	**2009**
	19th & 20th April; 9th & 16th May; 13th June; 3rd & 10th July; 1st, 7th, 15th, 27th August; 5th & 28th September	24th April, 1st, 13th, 21st May; 3rd, 10th, 17th 25th June; 4th, 16th, 28th, 29th July; 5th, 12th, 19th, 26th August; 23rd & 30th September.	27th May; 2nd, 9th, 16th, 23rd, 24th, 30th June; 7th, 14th, 22nd, 29th July; 4th, 11th, 18th, 26th, 31st August; 8th & 15th September.
Weather conditions	Wind: none to moderate; Rain: none to light Cloud cover: 10% to 100% Temperature: 5C to 18C	Wind: none to moderate Rain: none to moderate Cloud cover: 0% to 100% Temperature: 6.5C to 16C	Wind: none to moderate Rain: none to light Cloud cover: 5% to 100% Temperature: 11C to 22C
Methodology	Similar method and equipment to baseline, where possible. One surveyor positioned on either side of road using Bat Box Duet bat detectors. Calls were recorded on MP3 recorders and analysed using BatScan software. For each bat pass recorded the following information was noted (where possible): species; height above ground; route of bat, i.e., following structure or over road; time; and behaviour, ie, foraging or commuting. The number of bat passes was converted into a Bat Event Index (BEI) where the number of passes recorded in one survey equates to the BEI.		

Case Study U1	A590 High & Low Newton Bypass, Barrows Green Underpass		
Monitoring results	Peak BEI was 103 (June), including common pipistrelle, soprano pipistrelle, pipistrelle sp., whiskered/ Brandt's, Myotis sp., noctule, unidentified sp. 31.8% of bat passes recorded as 'using' underpass, including bats foraging in entrance. 29.3% of passes recorded as commuting through underpass. 21.3% of passes recorded crossing road away from underpass, with a higher proportion of pipistrelles observed flying below 5m height.	Peak BEI was 192 (July), including common pipistrelle, soprano pipistrelle, pipistrelle sp., whiskered/ Brandt's, Natterer's, myotis sp., unidentified sp. 54.3% of bat passes recorded as 'using' underpass, including bats foraging in entrance. 40.6% of passes recorded as commuting through underpass. 5.9% of passes recorded crossing road away from underpass, with a higher proportion of pipistrelles observed flying below 5m height.	Peak BEI was 300 (September), including common pipistrelle, soprano pipistrelle, myotis sp., whiskered/ Brandt's, unidentified sp. 81.4% of bat passes recorded as 'using' underpass, including bats foraging in entrance. 34.3% of passes recorded as commuting through underpass. 2.1% of passes recorded crossing road away from underpass, with a higher proportion of pipistrelles observed flying above 5m height.

Case Study U2: A590 High & Low Newton Bypass, Ayside Underpass

Summary description
Ayside Underpass is a 6 metre wide by 3 metre high vehicular and pedestrian access beneath the A590 dual carriageway, and has a span of 30m. A hedgerow was planted which was designed to guide bats into the entrance of this underpass rather than flying over the carriageway. This hedgerow was described as 'immature' during the 2009 monitoring period. Monitoring surveys were undertaken around dusk and/ or dawn between April and September during 2007 to 2009.

Mitigation outcome
The proportion of bats recorded flying through the underpass was 0.9% in 2008 and 1% in 2009. The proportion of bats crossing the road along the original commuting route was 28.1% in 2007, 56.1% in 2008 and 43.2% in 2009.

Data limitations
A limited amount of bat survey data was available from the 2005 baseline surveys (only two surveys undertaken). For each minute of constant bat activity, it was assumed that three bat passes had been recorded. Variation in completion of the survey proforma meant that some interpretation of survey data was required. No statistical analysis of data was presented. Baseline counts in 2005 recorded bats using commuting routes, although subsequent monitoring counts recorded all bat passes, including those not using the commuting route, i.e., not crossing the road. Species using the underpass and flying over the road were not specified and raw data were not provided within the report.

Case Study U2	**A590 High & Low Newton Bypass, Ayside Underpass**		
Road & location	A590, Cumbria		
Carriageway type	Dual carriageway		
Structure Ref	26921		
Impact of scheme	Severed hedgerow used as bat commuting route		
Type of structure & width	Underpass Length = 30m Width = 6m		
Installation date	2008		
Baseline	Activity surveys were carried out on five bat commuting routes identified in previous surveys undertaken in 2003 & 2004 (results not provided). Two activity surveys were carried out in 2005 on each bat commuting route, one in May and one in June. Survey positions were selected to allow comparable repeat surveys to be carried out from the same positions during and following road construction. Each survey began 15 minutes before sunset and continued for 1.5 hours after sunset. Weather conditions were recorded.		
Number of bats recorded at baseline	Peak number of bat passes (BEI) was 51 (June 2005), including. common pipistrelle, Myotis sp., noctule		
Flight pattern at baseline	Not stated		
Monitoring	**2007**	**2008**	**2009**
Dates of surveys	19th & 20th April; 10th & 16th May; 13th & 20th June; 9th & 11th July; 8th, 15th, 26th, 30th August; 12th & 28th September.	30th April, 14th, 20th, 29th, 30th May; 4th, 18th, 24th June; 8th, 15th, 23rd, 30th July; 13th, 17th, 21st, 27th August; 24th & 29th September.	6th, 11th, 18th, 25th June; 2nd, 9th, 16th, 23rd, 30th July; 6th, 15th, 20th, 27th August; 3rd, 11th, 17th, 25th September.
Weather conditions	Wind: none to moderate; Rain: none to light; Cloud cover: 5% to 100%; Temperature: 6C to 16C	Wind: none to moderate; Rain: none to light (heavy on 1 occasion); Cloud cover: 0% to 100%; Temperature: 8C to 23C	Wind: none to moderate; Rain: none to moderate; Cloud cover: 10% to 100%; Temperature: 5C to 21.5C
Survey methodology	Similar method and equipment to baseline, where possible. One surveyor positioned on either side of road. Bat Box Duet heterodyne / frequency division bat detectors. Calls were recorded on MP3 recorders and analysed using BatScan software. For each bat pass recorded the following information was noted (where possible): species; height above ground; route of bat, i.e., following structure or over road; time; and behaviour, ie, foraging or commuting. The number of bat passes was converted into a BEI where the number of passes recorded in one survey equates to the BEI.		

Case Study U2	A590 High & Low Newton Bypass, Ayside Underpass		
Monitoring results	Peak BEI was 104 (April), including common pipistrelle, soprano pipistrelle, myotis sp., whiskered/ Brandt's. 0 bats were recorded 'using' underpass 28.1% of passes recorded crossing over road along original commuting route, away from underpass with Myotis sp. observed flying at a height below 5m and a smaller proportion of pipistrelles observed flying below 5m height.	Peak BEI was 31 (August), including common pipistrelle, soprano pipistrelle, myotis sp., whiskered/ Brandt's. 0.9% of bat passes recorded as commuting through underpass. 56.1% of passes recorded crossing over road along original commuting route, away from underpass, and 8.4% recorded crossing over road near to underpass with Myotis sp. observed flying at a height below 5m and an equal proportion of pipistrelles observed flying below and above 5m height.	Peak BEI was 54 (300 BEI was recorded in August but this was due to continuous feeding activity), including common pipistrelle, soprano pipistrelle, myotis sp. 15% of bat passes recorded as 'using' underpass, including bats foraging in entrance. 1% of bat passes recorded as commuting through underpass. 43.2% of passes recorded crossing over road along original commuting route, away from underpass, and 10.4% recorded crossing over road near to underpass with Myotis sp. observed flying at a height below 5m and a smaller proportion of pipistrelles observed flying below 5m height.

Case Study U3: A479 Talgarth Relief Road & Bronllys Bypass - Pendre Culvert

Summary description
Pendre Culvert is a 2.3m high elliptical arch, carrying a small seasonal watercourse beneath the A479 dual carriageway, and has a span/length of 25m. The road, constructed in 2007/2008, severed a hedgerow and watercourse used regularly by around 10 lesser horseshoe bats. The culvert is perpendicular to the road, whereas the original severed hedgerow was at a more acute angle, so the flightpath has been diverted. Diversion of the watercourse, hurdle fencing and shrub planting has been used to connect the culvert with the original hedgerow on the western side. The eastern entrance to the culvert lies on the original flightline. A mesh tube dormouse bridge was also constructed over the road at the same location. Monitoring survey is proposed for five years following construction, with two surveys per year.

Mitigation outcome
The surveys identified preferential use by lesser horseshoe bats of the culvert rather than the road. The level of activity increased when compared with the baseline surveys. Observations of 'light-sampling' suggest that lesser horseshoe bats may have been hesitant to leave the western portal of the culvert before connecting vegetation had become suitably established. Small numbers of Myotis sp. and Natterer's bats have been recorded flying through the culvert, whilst small numbers of Natterer's, common and soprano pipistrelles fly over the road 'close to' the dormouse bridge.

At the time of publication monitoring continues.

Data limitations
Despite restricting most of the surveys to the period following emergence, relatively few repeat surveys (1-2 surveys per year) and limited seasonal variation (see table below), the results consistently show all or the majority of lesser horseshoe bats fly through the culvert and therefore are conclusive with respect to this species. There is no detailed description of the flight paths taken by bats crossing over the road and, therefore, it cannot be concluded whether bats are crossing safely at the height of the dormouse bridge or are at risk of collision with traffic.

Case Study U3	**A479 Talgarth Relief Road & Bronllys Bypass - Pendre Culvert**		
Road & location	A479, Talgarth, Powys, Wales		
Carriageway type	Dual carriageway		
Impact of scheme	Severed hedgerow and watercourse used as bat commuting route		
Type of structure & width	Culvert, elliptical arch Length = 25m Width = 2.3m high		
Installation date	2007		
Baseline	Activity surveys undertaken on 27/09/2002, 08/05/2003, 08/05/2005, 03/06/2005, 10/06/2005		
Number of bats recorded at baseline	Sep '02 – 3 LHB flew through existing A479 culvert (approx. 1m high x 0.75m wide); 7 LHB flew over road. May '03 – 4-6 LHB through culvert; 3 over road. May '05 – 1 LHB through culvert; 0 over road. 3 Jun '05 – 6 LHB through culvert; some (inconclusive) over road. 10 Jun '05 – 1 LHB through culvert; 5 over road. Nearby LHB maternity roost contained approx. 40 bats @ 11/07/02, 40 bats in 2004, 80 bats in 2005, 106 bats in 2006, 120 bats in 2007 & 34 bats in 2009.		
Flight pattern at baseline	No more detail than above. During construction several LHB recorded flying into new culvert and –light-sampling' at western end before flying to existing mature hedge.		
Monitoring	**2008**	**2009**	**2010**
Dates/times of surveys	7 May (20:30h – 22:15h)	16 May (20:55h – 23:00h); 02 August (20:55h – 23:00h)	24 May (21:00h – 23:00h); 30 August (20:00h - 22:00h)
Weather conditions	No cloud or rain. Light southerly breeze. 16.5°C - 16° C. Sunset 20:46h	16 May No rain until 21:57h when brief light shower. Cloud cover or wind not given. 9°C – 6.5°C. Sunset 21:00h; 02 August Dry, BF2, 8/8 octars, 13°C. Sunset 21:03h	24 May Dry, BF0, 0/8 octars. 17°C - 14°C. Sunset 21:14h; 30 August Dry, BF0, 0/8 octars. 18°C - 11°C. Sunset 20:07h
Survey methodology	Four observers were used in positions at both road level and at culvert level. No other detail given.		As left but Anabat SD1 also left in culvert overnight in August

Case Study U3	A479 Talgarth Relief Road & Bronllys Bypass - Pendre Culvert		
Monitoring results	13 lesser horseshoe bat (LHB) and 1 common pipistrelle passes recorded through culvert. Eleven common pipistrelle bats were observed crossing over the road (heights/flightpaths not given).	16 May 10 LHB passes recorded through culvert. 0 LHB passes over road. 02 August 14 LHB passes recorded through culvert. 1 possible LHB pass over road. Other bats seen and heard but no data presented.	24 May 17 LHB passes observed through the culvert between 21:58h and 22:35h plus two LHB passes that entered and returned from the culvert at the same end (not passing through). Two Myotis sp. passes were recorded through the culvert. Two common pipistrelle bats were observed crossing over the road, one crossing north of the dormouse bridge and another at a height of 5-6m above the road. 30 August 16 LHB and 2 Natterer's passes through culvert during observed period and three further LHB passes recorded by Anabat later on. 1 soprano pipistrelle and 1 Natterer's pass recorded over road, close to dormouse bridge (no further detail given).

Case Study U4: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern – Hopyard Farm Underpass

Summary description
Hopyard Farm Underpass was extended in 2005 as part of dualling works to the previously single (three lane) carriageway. The dimensions of the original and new underpasses are not stated, although it is known that the original underpass was for vehicular access and photographs are provided below showing the original underpass and the extension during construction. Lesser horseshoe bats were known to regularly use the underpass as a commuting route between a nearby maternity roost and foraging areas.

Mitigation outcome
The average bat activity index results (for hand-held detectors only - to allow more accurate comparison) show a gradual decline in bat activity through the culvert from 2005 to 2008, although each of these years show a higher activity index than baseline surveys in 2004. However, the survey effort in 2004 was much less and the survey method was different. The decline in 2008 may be due to the installation of grilles over the culvert entrances, which appeared to cause some bats to fly over the road. Results are not provided for how many bats were recorded flying over the road, although a lesser horseshoe bat corpse was found on the road above the underpass in April 2008 and it is stated within the report that climatic factors are also likely to be responsible, the summers of both 2007 & 2008 being cool and extremely wet.

At the time of publication monitoring continues.

Data limitations
Survey methods during baseline and monitoring surveys differed in terms of effort, equipment, time and season of survey. Detailed results and weather conditions are not provided. Inconsistency between survey times and duration is likely to affect bat activity index scores, as activity is likely to be greater at dusk and dawn as bats leave and return to their roost. Therefore, the same number of bats may use the route on two given nights but if one of them was only surveyed at dawn and dusk, the resulting index is likely to be higher than if the route was surveyed all night, as reduced activity in the middle of the night will bring the index down.

Case Study U4	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Hopyard Farm Underpass**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	Entailed extending an existing underpass used by lesser horseshoe bats			
Type of structure & width	Underpass, square box-section Width (estimated) = 2-2.5m			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – 678; July 2004 – 600; September 2004 – 1856; average - 1045. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Existing underpass identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 3.5h; Late June/early July – 6.5h; Late July/early August – 8h; Late August/early September – 9.5h; October – 12h	May – 8h; June – 6.75h; July – 7h; August – 8h; September – 10.65h; October – 12.75h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated

Case Study U4	A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Hopyard Farm Underpass			
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. All night surveys were conducted for the last four survey periods.	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. All night surveys were conducted for each of the six survey periods. Surveys also involved the use of Anabat detectors.		As 2006/2007, plus additional surveys following the May 2008 survey as bats were observed flying over the road. It was thought that this was the result of metal grilles installed during the winter over the underpass entrances. Five additional surveys were undertaken between May and August during which various grille designs were tested overnight, none of which were suitable and subsequently removed.
Monitoring results	Bat activity index: May/June – 1771 June/July – 3262 July/August – 1713 August/September – 5200 October – 3058 Average - 3001	Bat activity index (hand-held detectors only) May – 2638 June – 2489 July – 2300 August – 3163 September – 3656 October – 1176 Average - 2570	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 2171	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months -1864

Photograph of Hopyard Farm Underpass at the beginning of the construction period

Photograph of Hopyard Farm Underpass in the process of extension

Case Study U5: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Evesham Nurseries Underpass

Summary description
Evesham Nurseries Underpass was extended in 2005 as part of dualling works to the previously single carriageway. The dimensions of the original and new underpasses are not stated. Lesser horseshoe bats were known to regularly use the underpass as a commuting route, although there was some uncertainty as to whether the bats were from the same maternity roost as the bats using Hopyard Farm Underpass.

The underpass is lit, under the control of a timer system.

Mitigation outcome
The average bat activity index results (for hand-held detectors only, to allow more accurate comparison) show a gradual decline in bat activity through the culvert from 2005 to 2008, although each of these years show a higher activity index that baseline surveys in 2004. However, the survey effort in 2004 was much less and the survey method was different. It is also stated within the report that climatic factors are also likely to be responsible, the summers of both 2007 & 2008 being cool and extremely wet.

At the time of publication monitoring continues.

Data limitations
Survey methods during baseline and monitoring surveys differed. Detailed results and weather conditions are not provided. Inconsistency between survey times and duration is likely to affect bat activity index scores, as activity is likely to be greater at dusk and dawn as bats leave and return to their roost. Therefore, the same number of bats may use the route on two given nights but if one of them was only surveyed at dawn and dusk, the resulting index is likely to be higher than if the route was surveyed all night, as reduced activity in the middle of the night will bring the index down.

Data interpretation is complicated by reported failures of the lighting system.

Case Study U5	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Evesham Nurseries Underpass**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	Entailed extending an existing underpass used by lesser horseshoe bats			
Type of structure & width	Underpass; dimensions not given			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – not surveyed; July 2004 – 0; September 2004 – 117; average - 59. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Existing underpass identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 3.25 h; Late June/early July – 3 h; Late July/early August – 3.5 h; Late August/early September – 3 h; October – 11.75 h	May – 4 h; June – 4 h; July – 4 h; August – 4 h; September – 4 h; October – 4 h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn, and all night in October 2005. The bat detectors were pointed towards the anticipated direction of arrival of the bats. Surveys also involved the use of Anabat detectors.			
Monitoring results	Bat activity index: May/June – 277; June/July – 333; July/August – 229; August/September – 400; October – 264; Average - 301	Bat activity index (hand-held detectors only); May – 150; June – 125; July – 375; August – 650; September – 250; October – 175; Average - 288	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 233	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months – 168

Case Study U6: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Baiden Brook Culvert

Summary description
Baiden Brook was culverted in 2005 as part of dualling works to the previously single (three lane) carriageway. The dimensions of the culvert are not stated. Small numbers of lesser horseshoe bats were known to use the brook as a commuting route from a nearby maternity roost.

Mitigation outcome
The activity indices obtained using just hand-held detectors in 2005 and 2006 are identical. The 2005 & 2006 results are greater than those in 2004, although the numbers involved are only very small. Activity peaked in 2007 and then dropped significantly in 2008. It appears that the culvert is used sporadically by a small number of bats, as the brook was before construction.

At the time of publication monitoring continues.

Data limitations
Survey methods during baseline and monitoring surveys differed. Detailed results and weather conditions are not provided. Low numbers of bats overall make it difficult for meaningful conclusions to be drawn.

Case Study U6	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Baiden Brook Culvert**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	Extension of existing culverted brook used by lesser horseshoe bats			
Type of structure & width	Culvert; dimensions not given			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – 0; July 2004 – 0; September 2004 – 11; average - 4. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Brook identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 2.75 h; Late June/early July – 3 h; Late July/early August – 3.5 h; Late August/early September – 3.25 h; October – 3.5 h	May – 4 h; June – 4 h; July – 4 h; August – 4 h; September – 4 h; October – 4 h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. Surveys also involved the use of Anabat detectors.			
Monitoring results	Bat activity index: May/June – 0; June/July – 33; July/August – 0 August/Sept; 31: October – 0; Average - 13	Bat activity index (hand-held detectors only) May – 0; June – 0; July – 0; August – 50; September – 0; October – 25; Average - 13	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 58	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 8

Case Study U7: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Cwm Shenkin Brook Culvert

Summary description
Cwm Shenkin Brook was culverted in 2005 as part of dualling works to the previously single (three lane) carriageway. The dimensions of the culvert are not stated. Small numbers of lesser horseshoe bats were known to use the brook as a commuting route from a nearby maternity roost.

Mitigation outcome
The activity indices obtained using just hand-held detectors dropped noticeably between 2005 and 2006. The activity indices for 2006 are still higher than those obtained during 2004; however, direct comparisons are not possible as remote Anabat detectors were used in 2004, as opposed to hand-held detectors. Results from 2007 show a slight increase in bat activity with a further increase in 2008. However, the numbers of bats involved are relatively small.

At the time of publication monitoring continues.

Data limitations
Survey methods during baseline and monitoring surveys differed. Detailed results and weather conditions are not provided.

Case Study U7	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Cwm Shenkin Brook Culvert**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	Extension of existing culverted brook used by lesser horseshoe bats			
Type of structure & width	Culvert; dimensions not given			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – 50; July 2004 – 0; September 2004 – 11; average - 20. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Brook identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 3.25 h; Late June/early July – 3 h; Late July/early August – 3.5 h; Late August/early Sept – 3 h; October – 4 h	May – 4 h; June – 4 h; July – 4 h; August – 4 h; September – 4 h; October – 4 h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. Surveys also involved the use of Anabat detectors.			
Monitoring results	Bat activity index: May/June – 154; June/July – 333; July/August – 86; August/Sept – 300; October – 350; Average - 245	Bat activity index (hand-held detectors only) May – 150; June – 50; July – 25; August – 25; September – 75; October – 75; Average - 67	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 79	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 100

Case Study U8: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Monmouth and Brecon Canal Underbridge

Summary description
A new bridge was constructed over the Monmouth and Brecon Canal in 2005 as part of dualling works to the previously single (three lane) carriageway. The dimensions of the bridge are not stated. Small numbers of lesser horseshoe bats were known to use the canal as a commuting route from a nearby maternity roost.

The towpath is lit.

Mitigation outcome
The activity indices decreased noticeably between 2004/2005 and 2006 (none were recorded in 2006). During 2007 bats were only detected during September, when there was a lot of activity, possibly involving only two bats. The 2008 results show a decrease in activity, although activity was recorded during two of the three surveys. Overall, the underbridge continues to be used sporadically by a small number of bats.

Data limitations
Survey methods during baseline and monitoring surveys differed. Detailed results and weather conditions are not provided.

The interpretation of results is complicated by the use of lighting, which is designed to provide unlit areas for bat usage.

Case Study U8	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Monmouth and Brecon Canal Underbridge**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	A new bridge over the canal used by lesser horseshoe bats			
Type of structure & width	Bridge; dimensions not given			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – no survey; July 2004 – no survey; September 2004 – 11; average - 11. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Canal identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 2.75 h Late June/early July – 3.75 h Late July/early August – 3.25 h Late August/early September – 3 h October – 3.5 h	May – 4 h June – 4 h July – 4 h August – 4 h September – 4 h October – 4 h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. Surveys also involved the use of Anabat detectors.			
Monitoring results	Bat activity index: May/June – 36 June/July – 0 July/August – 31 August/September – 0 October – 0 Average - 13	Bat activity index (hand-held detectors only) May – 0 June - 0 July – 0 August – 0 September – 0 October – 0 Average - 0	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 71	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 50

Case Study U9: A595 Parton to Lillyhall – Ulgill Underpass

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This underpass was constructed in 2008 as part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. It comprises a box culvert construction.

Mitigation outcome
Post construction monitoring undertaken in 2009 confirmed that bats were using the underpass to commute in both directions between either side of the road.

Species confirmed as using the underpass to cross under the road included:

- Common pipistrelle; and
- Daubenton's.

Data limitations
No comparison was made with baseline data.

Case Study U9	**A595 Parton to Lillyhall – Ulgill Underpass**					
Road & location	A595, Cumbria					
Carriageway type	Dual carriageway					
Structure Ref	26390					
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.					
Type of structure & width	Concrete box culvert, providing accommodation access under the A595. Width (clear internal) = 4.2m Height = 3.7m Length = 35.2m Skew = 8°					
Installation date	2008					
Baseline	Not available					
Monitoring						
2009	Survey Date	Dusk/ Dawn	Start	Finish	Temp	Weather
	24/08/09	Dusk	20.00	22.00	21°C	Clear skies, mild with slight breeze.
	25/08/09	Dawn	04.40	06.15	12°C	Clear skies, mild.
	15/09/09	Dusk	19.00	21.15	13°C (Min - 8°C)	Clear skies, mild.
	16/09/09	Dawn	05.30	07.00	8°C	Clear skies, air felt cold, slight breeze.
	08/10/09	Dusk	18.00	20.15	6°C (Min 1.5°C)	Low wind, some cloud cover, air felt cold.
Survey methodology	One surveyor in situ with Pettersson D240x handheld bat detectors surveyed the site at dusk and dawn.					
Monitoring results	Survey Date	Dusk/ Dawn	Species	Number Events	Activity	
	24/08/09	Dusk	Common pipistrelle	2	Bat commuting through underpass (both west to east)	
	25/08/09	Dawn	Common pipistrelle	1	Bat commuting through underpass (west to east)	
	15/09/09	Dusk	Common pipistrelle	3	Bat commuting through underpass (east to west)	
			Daubenton's	1	Bat commuting through underpass	
	16/09/09	Dawn	-	-	-	
	08/10/09	Dusk	Common pipistrelle	2	Bat commuting through underpass (both ways)	

Case Study U10: A595 Parton to Lillyhall – Ulgill Culvert

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This culvert was constructed in 2008 and lies directly north of the Ulgill Underpass. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. The structure comprises a box culvert with in-situ mammal ledge.

Mitigation outcome
Post construction monitoring undertaken in 2009 confirmed that bats were using the culvert to commute, from east to west between either side of the road.

Species confirmed as using the culvert to cross under the road included:

- Common pipistrelle.

Data limitations
No comparison was made with baseline data.

Case Study U10	**A595 Parton to Lillyhall – Ulgill Culvert**
Road & location	A595, Cumbria
Carriageway type	Dual carriageway
Structure Ref	27515
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.
Type of structure & width	Concrete box culvert, providing passage of waterway under the A595. Width (clear internal) = 2m Height = 2m Length = 35.5m Skew = 8°
Installation date	2008
Baseline	No information available
Monitoring	

2009

Survey Date	Dusk/ Dawn	Start	Finish	Temp	Weather
24/08/09	Dusk	20.00	22.00	21°C	Clear skies, mild with slight breeze.
25/08/09	Dawn	04.40	06.15	12°C	Clear skies, mild.
15/09/09	Dusk	19.00	21.15	13°C (Min -8°C)	Clear skies, mild.
16/09/09	Dawn	05.30	07.00	8°C	Clear skies, air felt cold, slight breeze.
08/10/09	Dusk	18.00	20.15	6°C (Min 1.5°C)	Low wind, some cloud cover, air felt cold.

Survey methodology	One surveyor in situ with Pettersson D240x handheld bat detectors surveyed the site at dusk and dawn.

Monitoring results

Survey Date	Dusk/ Dawn	Species	Number Events	Activity
24/08/09	Dusk	Common pipistrelle	1	Bat commuting through culvert (east to west)
25/08/09	Dawn	Common pipistrelle	1	Bat commuting through culvert (east to west)
15/09/09	Dusk	Common pipistrelle	-	-
		Daubenton's	-	-
16/09/09	Dawn	-	-	-
08/10/09	Dusk	Common pipistrelle	-	-

Case Study U11: A595 Parton to Lillyhall – Plough House Culvert

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This culvert was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. The structure consists of precast concrete pipe with in-situ mammal ledge.

Mitigation outcome
Post construction monitoring undertaken in 2009 confirmed bat activity within the culvert.

Data limitations
No comparison was made with baseline data. The data does not allow confirmation of commuting activity as the survey was based on use of a passive logging device.

Case Study U11	**A595 Parton to Lillyhall – Plough House Culvert**
Road & location	A595, Cumbria
Carriageway type	Dual carriageway
Structure Ref	27514
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.
Type of structure & width	Concrete pipe, providing passage of waterway under the A595. Width = 1.8m Length = 37.5m
Installation date	2008
Baseline	No information available
Monitoring	

2009

Survey Date	Dusk/ Dawn	Start	Finish	Temp	Weather
24/08/09	Dusk	21:08	-	21°C	Clear skies, mild with slight breeze.
25/08/09	Dawn	-	05:23	12°C	Clear skies, mild.
15/09/09	Dusk	20:04	-	13°C (Min -8°C)	Clear skies, mild.
16/09/09	Dawn	-	05:54	8°C	Clear skies, air felt cold, slight breeze.
08/10/09	Dusk	19:39	20:40	6°C (Min 1.5°C)	Low wind, some cloud cover, air felt cold.

Survey methodology	SD1 Anabat, set to record continuously dusk to dawn. Used as a passive logging device. Analysed using Analook.

Monitoring results

Survey Date	Dusk/ Dawn	Species	Number Events	Activity
24/08/09	Dusk-dawn	Common pipistrelle	37	Not definitive - passing/foraging
		Soprano pipistrelle	8	
		Daubenton's	1	
15/09/09	Dusk-dawn	Common pipistrelle	81	Not definitive - passing/foraging
		Soprano pipistrelle	24	
		Daubenton's	3	
		Natterer's	6	
		Myotis	2	
08/10/09	Dusk-dawn	Common pipistrelle	42	Not definitive - passing/foraging
		Daubenton's	1	

Case Study U12: A595 Parton to Lillyhall – Ghyll Beck Culvert

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This culvert was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. The structure consists of precast concrete pipe.

Mitigation outcome
Post construction monitoring undertaken in 2009 confirmed bat activity within the culvert.

Data limitations
No comparison was made with baseline data. The data does not allow confirmation of commuting activity as the survey was based on use of a passive logging device.

Case Study U12	**A595 Parton to Lillyhall – Ghyll Beck Culvert**
Road & location	A595, Cumbria
Carriageway type	Dual carriageway
Structure Ref	27517
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.
Type of structure & width	Concrete pipe, providing passage of waterway under the A595. Width = 0.9m Length = 39.0m
Installation date	2008
Baseline	No information available
Monitoring	

2009

Survey Date	Dusk/ Dawn	Start	Finish	Temp	Weather
24/08/09	Dusk	21:08	-	21°C	Clear skies, mild with slight breeze.
25/08/09	Dawn	-	05:23	12°C	Clear skies, mild.
15/09/09	Dusk	20:04	-	13°C (Min -8°C)	Clear skies, mild.
16/09/09	Dawn	-	05:54	8°C	Clear skies, air felt cold, slight breeze.
08/10/09	Dusk	19:39	20:40	6°C (Min 1.5°C)	Low wind, some cloud cover, air felt cold.

Survey methodology	SD1 Anabat, set to record continuously dusk to dawn. Used as a passive logging device. Analysed using Analook.

Monitoring results

Survey Date	Dusk/ Dawn	Species	Number Events	Activity
24/08/09	Dusk-dawn	Myotis	1	Not definitive - passing/ foraging
15/09/09	Dusk-dawn	Common pipistrelle	18	Not definitive - passing/ foraging
		Daubenton's	1	
08/10/09	Dusk-dawn	Common pipistrelle	3	Not definitive - passing/ foraging

Case Study U13: A595 Parton to Lillyhall – Lowca Beck Underbridge

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This underbridge was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. The structure comprises a highway bridge.

Mitigation outcome
Post construction monitoring undertaken in 2009 confirmed that bats were using the underbridge to commute in both directions between either side of the road.

Species confirmed as using the underbridge to cross under the road included:

- Common pipistrelle.

Data limitations
No comparison was made with baseline data.

Case Study U13	**A595 Parton to Lillyhall – Lowca Beck Underbridge**
Road & location	A595, Cumbria
Carriageway type	Dual carriageway
Structure Ref	26398
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.
Type of structure & width	Highway underbridge, providing passage of waterway (Lowca Beck), Accommodation Access (farm track) and cycleway under the A595. The cycleway and farm track are on opposite banks of the beck. Width (clear internal) = 18.6m Height = 3.7m Length = 28.5m
Installation date	2008
Baseline	No information available
Monitoring	

2009

Survey Date	Dusk/ Dawn	Start	Finish	Temp	Weather
24/08/09	Dusk	20.00	22.00	21°C	Clear skies, mild with slight breeze.
25/08/09	Dawn	04.40	06.15	12°C	Clear skies, mild.
15/09/09	Dusk	19.00	21.15	13°C (Min -8°C)	Clear skies, mild.
16/09/09	Dawn	05.30	07.00	8°C	Clear skies, air felt cold, slight breeze.
08/10/09	Dusk	18.00	20.15	6°C (Min 1.5°C)	Low wind, some cloud cover, air felt cold.

Survey methodology	One surveyor in situ with Pettersson D240x handheld bat detectors surveyed the site at dusk and dawn.

Monitoring results

Survey Date	Dusk/ Dawn	Species	Number Events	Activity
24/08/09	Dusk	Common pipistrelle	5	Bat commuting under bridge (either direction)
25/08/09	Dawn	Common pipistrelle	1	Bat commuting under bridge (east to west)
15/09/09	Dusk	-	-	-
16/09/09	Dawn	Common pipistrelle	1	Bat commuting under bridge (west to east)
08/10/09	Dusk	-	-	-

Case Study U14: A595 Parton to Lillyhall – Adjam Beck Culvert

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This culvert was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. The structure consists of precast concrete pipe with in-situ mammal ledge.

Mitigation outcome
Post construction monitoring undertaken in 2009 confirmed bat activity within the culvert.

Species confirmed as using the culvert included:

- Common pipistrelle.

Data limitations
No comparison was made with baseline data. The culvert opens out on the east side of the A595 before passing through an existing culvert under a disused railway. Any dimensions only relate to the culvert installed directly under the A595.

Case Study U14	**A595 Parton to Lillyhall – Adjam Beck Culvert**
Road & location	A595, Cumbria
Carriageway type	Dual carriageway
Structure Ref	27513
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.
Type of structure & width	Concrete pipe, providing passage of waterway under the A595. Width = 1.8m Length = 68.0m
Installation date	2008
Baseline	No information available
Monitoring	

2009

Survey Date	Dusk/ Dawn	Start	Finish	Temp	Weather
24/08/09	Dusk	21:08	-	21°C	Clear skies, mild with slight breeze.
25/08/09	Dawn	-	05:23	12°C	Clear skies, mild.
15/09/09	Dusk	20:04	-	13°C (Min -8°C)	Clear skies, mild.
16/09/09	Dawn	-	05:54	8°C	Clear skies, air felt cold, slight breeze.
08/10/09	Dusk	19:39	20:40	6°C (Min 1.5°C)	Low wind, some cloud cover, air felt cold.

Survey methodology	SD1 Anabat, set to record continuously dusk to dawn. Used as a passive logging device. Analysed using Analook.

Monitoring results

Survey Date	Dusk/ Dawn	Species	Number Events	Activity
24/08/09	Dusk	-	-	-
25/08/09	Dawn	Common pipistrelle	1	Bat commuting under bridge (west to east)
15/09/09	Dusk	-	-	-
16/09/09	Dawn	-	-	-
08/10/09	Dusk	-	-	-

Case Study U15: A69 Haydon Bridge Bypass – Haydon Viaduct

Summary description
The bypass is approximately 2.5km long and passes to the south of Haydon Bridge. The development severs the village of Haydon Bridge to the north, where roosts may be present, from areas of good quality foraging habitat to the south.

Habitats and features suitable for supporting foraging, and commuting were identified along the route of the bypass as part of the pre-construction surveys.
Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Noctule bat;
- Brown long-eared bat; and
- Myotis species.

The baseline surveys concluded that the River South Tyne, Cemetary Road and Gee's Wood form the main commuting routes used by bats to access roosts in Haydon Bridge and foraging areas to the south, west and east of the town. The River Tyne South and Gee's Wood are important bat feeding areas.

The viaduct was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes.

Mitigation outcome
Baseline surveys in 2004 & 2007 indicated that bat activity at this site was concentrated along the river and its bank. Monitoring in 2008, during the road construction, and in 2009, after opening of the road, concluded that similar levels of activity were maintained. It is however noted that while the functionality appears to have been maintained, activity appears to have been suppressed during construction (2008). It is not possible to draw any conclusions on whether activity has been suppressed between baseline surveys and construction/post construction surveys.

Data limitations
Weather conditions varied throughout the surveys period and between years.

Survey methods and transect locations do not directly align. Baseline surveys in 2004 consisted of spot and transect surveys, which were followed up in 2007 with roughly comparable transects. Survey effort was not consistent in terms of duration between years. Surveys in 2008 & 2009 consisted of spot (vantage point) surveys on either bank, which the authors indicate followed similar survey methodologies.

Case Study U15	**A69 Haydon Bridge Bypass – Haydon Viaduct**				
Road & location	A69, Cumbria				
Carriageway type	Single carriageway				
Structure Ref	27461				
Impact of scheme	Habitats and features suitable for supporting foraging, and commuting were identified along the route of the bypass as part of the pre-construction surveys.				
Type of structure & width	Highway underbridge, providing passage of waterway (Aire and Calder Navigation)) and a railway under the A69. Width (clear internal) = 167.9m Height = 5.5m - 15.1m Length (minimum) = 12.8m				
Installation date	2008				
Baseline					
2004	Transect	Survey Date	Start	Finish	Activity
	T2 – North bank, north railway	18/10/04	17:45	19:30	1 Pipistrelle sp 4 Common pipistrelle
	T3 – North bank, south railway	19/07/04	21:15	22:40	1 Soprano pipistrelle; >50 Pipistrelle sp
		17/08/04	21:35	22:45	4 Common pipistrelle; Several Soprano pipistrelle
		24/08/04	21:30	21:55	-
		18/10/04	19:30	20:45	Many Soprano pipistrelle; Many Myotis; Occasional Pipistrelle sp
	T5 – South bank	29/09/04	19:00	21:30	3 Noctules – commuting over river Frequent Common pipistrelle; Frequent Soprano pipistrelle; Many Myotis; 1 Daubenton's
	Survey Date	Temp	Weather		
	19/07/04	14°C	Light Rain, light wind		
	17/08/04	14°C	30% cloud, calm, mild		
	24/08/04	16°C	Calm, very light drizzle, mild		
	18/10/04	9°C	Clear, very W wind, cool		
	29/09/04	11°C	Overcast, light SE wind		
Survey methodology	Transect surveys. Batbox III (heterodyne), Batbox Duet (frequency division) and Petterson D (time expansion) bat detectors.				

Case Study U15	A69 Haydon Bridge Bypass – Haydon Viaduct				
2007	Transect	Survey Date	Start	Finish	Activity
	T2 – North bank, north railway	31/05/07	22:24	23:09	34 bat passes – mainly Common pipistrelle, others included Soprano pipistrelle, Daunbenton's, Noctule
			22:49	23:25	40 bat passes – Common pipistrelle, Soprano pipistrelle, Daunbenton's, Noctule Note: Second surveyor
		03/07/07	22:31	22:44	6 bat passes – Common pipistrelle, Soprano pipistrelle
			22:22	22:26	No activity (unsuitable weather) Note: Second surveyor
		01/08/07	21:54	22:37	65 bat passes – Common pipistrelle, Soprano pipistrelle, Noctule
			21:54	22:37	30 bat passes – Common pipistrelle, Soprano pipistrelle, Noctule Note: Second surveyor
		30/08/07	20:37	21:40	70 bat passes – Common pipistrelle, Soprano pipistrelle, Noctule, Daubenton's
			20:16	21:45	81 bat passes – Common pipistrelle, Soprano pipistrelle, Noctule Note: Second surveyor
		27/09/07	19:35	20:23	19 bat passes – Common pipistrelle, Soprano pipistrelle, Daubenton's
			19:20	20:29	81 bat passes – Common pipistrelle, Soprano pipistrelle, Noctule Note: Second surveyor

Case Study U15	A69 Haydon Bridge Bypass – Haydon Viaduct				
	Transect	Survey Date	Start	Finish	Activity
	T3 – North bank, south railway	31/05/07	23:34	00:20	53 bat passes – Common pipistrelle, Soprano pipistrelle, Daunbenton's
		01/08/07	22:41	23:30	74 bat passes – Common pipistrelle, Soprano pipistrelle, Daunbenton's, Noctule
		30/08/07	21:40	22:35	74 bat passes – Common pipistrelle, Soprano pipistrelle, Daunbenton's, Noctule
		30/08/07	20:16	21:45	>49 bat passes – Common pipistrelle, Soprano pipistrelle, Daunbenton's, Noctule
		27/09/07	20:23	21:21	36 – Common pipistrelle, Soprano pipistrelle, Daunbenton's

	Survey Date	Temp Start	Temp End	Weather
	31/05/07	16°C	12°C	Dry, still,
	20/06/07	16°C	15°C	Dry-heavy rain, 4W
	01/08/07	17°C	13°C	Dry, 2W
	30/08/07	16°C	14°C	Dry, 3W
	27/09/07	12°C	10°C	Dry-drizzle, 1N-3W
Survey methodology	Transect surveys. Duet detectors linked to MP3 recorders. Analysed using Batsounds.			

Case Study U15	A69 Haydon Bridge Bypass – Haydon Viaduct				
Monitoring					
2008	Survey Date	Dusk/ Dawn	Species	Number Events	Activity
	05/08	Dusk	Common pipistrelle	3	Foraging and commuting
			Soprano pipistrelle	5	
			Noctule	2	
	06/08	Dusk	Common pipistrelle	5	Foraging and commuting
			Soprano pipistrelle	9	
			Myotis	3	
			Noctule	7	
			Other	1	
	07/08	Dusk	Common pipistrelle	6	Foraging and commuting
			Soprano pipistrelle	2	
			Myotis	1	
			Noctule	4	
	08/08	Dusk	Common pipistrelle	3	Foraging and commuting
			Soprano pipistrelle	4	
			Myotis	3	
	09/08	Dusk	Common pipistrelle	1	Foraging and commuting
			Soprano pipistrelle	2	
			Myotis	6	
			Noctule	3	
Weather conditions	Not available				
Survey methodology	Vantage point surveys. Duet bat detectors linked to MP3 recorders. Analysed using Batsounds.				

Case Study U15	A69 Haydon Bridge Bypass – Haydon Viaduct				
2009	Survey Date 12/05/09 18/06/09 16/07/09 24/08/09 17/09/09	Start 21:00 21:45 21:30 20:20 19:15	End 22:20 22:50 22:40 21:25 20:25		
	Survey Date	Dusk/ Dawn	Species	Number Events	Activity
	12/05/09	Dusk	Common pipistrelle	6	Foraging and commuting
			Myotis,	3	
			Noctule	8	
	18/06/09	Dusk	Common pipistrelle	16	Foraging and commuting
			Soprano pipistrelle	9	
			Myotis	2	
			Noctule	5	
	16/07/09	Dusk	Common pipistrelle	13	Foraging and commuting
			Soprano pipistrelle	6	
			Myotis	12	
	24/08/09	Dusk	Common pipistrelle	11	Foraging and commuting
			Myotis	7	
			Noctule	6	
	17/09/09	Dusk	Common pipistrelle	2	Foraging and commuting
			Soprano pipistrelle	5	
			Myotis	8	
			Noctule	4	
Weather conditions	Survey Date	Temp Start	Temp End	Weather	
	12/05/09	11°C	8°C	Dry, 1	
	18/06/09	14°C	9°C	Dry, 1NE	
	16/07/09	17°C	16°C	Drizzle	
	24/08/09	18°C	11°C	Dry	
	17/09/09	12°C	10°C	Dry	
Survey methodology	Vantage point surveys. Duet bat detectors linked to MP3 recorders. Analysed using Batsounds.				

Case Study U16: A69 Haydon Bridge Bypass – Gee's Wood Underbridge

Summary description
The bypass is approximately 2.5km long and passes to the south of Haydon Bridge. The development severs the village of Haydon Bridge to the north, where roosts may be present, from areas of good quality foraging habitat to the south.

Habitats and features suitable for supporting foraging, and commuting were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Noctule bat;
- Brown long-eared bat; and
- Myotis species.

The baseline surveys concluded that the River South Tyne, Cemetary Road and Gee's Wood form the main commuting routes used by bats to access roosts in Haydon Bridge and foraging areas to the south, west and east of the town. The River Tyne South and Gee's Wood are important bat feeding areas.

The highway underbridge was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes.

Mitigation outcome
Baseline surveys in 2004 indicated that Gee's Wood was considered to be a major commuting route for Soprano pipistrelle and to a lesser extent Common pipistrelle. Flightlines were typified by north-west to south-east movement at dusk. The 2007 survey report indicates a section of Gee's Wood was removed, the timing of which is not specified, although it is concluded this had little effect on the levels of bat activity. Monitoring in 2008, during the road construction, and in 2009, after opening of the road, indicated a reduced level of commuting activity along the woodland edge. Bats were noted as generally flying under the new bypass, although small numbers were noted as flying over the new bypass at a height at which vehicle collisions could occur. While the functionality of this route has been maintained, activity appears to have reduced from the levels recorded in 2007, with the lowest levels of activity recorded in 2009.

Data limitations
Survey methods, transect locations and timings do not directly align. Baseline surveys in 2004 consisted of spot and transect surveys, which were followed up in 2007 with roughly comparable transects. Survey effort was not consistent in terms of duration between years. Surveys in 2008 & 2009 consisted of spot (vantage point) surveys, which the authors indicate followed similar survey methodologies. Anabat surveys were also undertaken at this location although these are not summarised.

Case Study U16	**A69 Haydon Bridge Bypass – Gee's Wood Underbridge**					
Road & location	A69, Cumbria					
Carriageway type	Single carriageway					
Structure Ref	27465					
Impact of scheme	Habitats and features suitable for supporting foraging, and commuting were identified along the route of the bypass as part of the pre-construction surveys.					
Type of structure & width	Highway underbridge, providing passage of waterway under the A69. Width (clear internal) = 68.0m Height = 8.8m – 10.7m					
Installation date	2008					
Baseline						
2004	Transect		Survey Date	Start	Finish	Activity
	T17 – South of stream		16/08/04	20:40	21:50	4 Common pipistrelle >2 Soprano pipistrelle
	T18 – North of stream		20/07/04	22:54	23:11	4 Common pipistrelle
			16/08/04	20:40	21:58	>4 Common pipistrelle >15 Soprano pipistrelle
				22:15	22:23	8 Soprano pipistrelle
			22/08/04	20:30	21:20	>6 Common pipistrelle >1 Soprano pipistrelle
				22:35	23:02	3 Common pipistrelle 1 Soprano pipistrelle
			27/09/04	19:30	20:45	Common pipistrelle Soprano pipistrelle
			26/10/04	18:55	19:20	1 bat sp
Weather conditions	Survey Date	Temp	Weather			
	20/07/04	17°C	Heavy Rain, calm, mild			
	16/08/04	16°C	Cloudy, calm, mild			
	22/08/04	14°C	Overcast, calm-very light, mild			
	27/09/04	16°C	Mod W wind, mild			
	26/10/04	5°C	Clear, calm, cool			
Survey methodology	Transect surveys. Batbox III (heterodyne), Batbox Duet (frequency division) and Petterson D (time expansion) bat detectors.					

Case Study U16	**A69 Haydon Bridge Bypass – Gee's Wood Underbridge**					
Baseline						
2007	Transect		Survey Date	Start	Finish	Activity
	T2 Points 6-11		29/05/07	22:43	23:43	14 Common pipistrelle 18 pipistrelle sp
				22:17	23:03	30 Common pipistrelle 1 Soprano pipistrelle 13 pipistrelle sp
			20/06/07	22:53	23:34	14 Common pipistrelle 11 pipistrelle sp 7 pipistrelle sp/Noctule
				22:29	23:16	19 Common pipistrelle 34 pipistrelle sp
			31/07/07	22:12	22:55	15 Common pipistrelle 27 pipistrelle sp
				21:41	22:29	23 Common pipistrelle 52 pipistrelle sp
			23/08/07	21:24	22:09	4 Common pipistrelle 8 pipistrelle sp 3 Common pipistrelle/ Noctule
				20:54	21:40	6 Common pipistrelle 13 pipistrelle sp 6 pipistrelle sp/Noctule
			17/09/07	20:19	21:00	9 Common pipistrelle 1 Soprano pipistrelle 19 pipistrelle sp 5 pipistrelle sp/Noctule
				19:49	20:35	8 Common pipistrelle 19 pipistrelle sp/Noctule
Weather conditions	Survey Date	Temp Start	Temp End	Weather		
	29/05/07	15°C	12°C	Dry, still,		
	20/06/07	22°C	16°C	Dry, still,		
	31/07/07	19°C	16°C	Dry, 2W		
	23/08/07	20°C	15°C	Dry, 1S		
	17/09/07	13°C	7°C	Dry-showers, 1N-4E		
Survey methodology	Transect surveys. Duet detectors linked to MP3 recorders. Analysed using Batsounds.					
Species recorded at baseline	• Common pipstrelle; • Soprano pipistrelle; • Noctule bat.					

Case Study U16	A69 Haydon Bridge Bypass – Gee's Wood Underbridge				
Monitoring					
2008	Survey Date	Dusk/ Dawn	Species	Number Events	Activity
	05/08	Dusk	Common pipistrelle	41	Foraging and commuting
			Noctule	1	
	06/08	Dusk	Common pipistrelle	23	Foraging and commuting
			Soprano pipistrelle	1	
			Myotis	1	
	07/08	Dusk	Common pipistrelle	39	Foraging and commuting
			Soprano pipistrelle	9	
			Myotis	2	
			Noctule	1	
	08/08	Dusk	Common pipistrelle	13	Foraging and commuting
			Soprano pipistrelle	11	
			Myotis	1	
	09/08	Dusk	Common pipistrelle	13	Foraging and commuting
			Soprano pipistrelle	8	
			Myotis	2	
			Noctule	2	
			Other	1	
Weather conditions	Not available				
Survey methodology	Vantage point surveys. Duet bat detectors linked to MP3 recorders. Analysed using Batsounds.				

Case Study U16	A69 Haydon Bridge Bypass – Gee's Wood Underbridge				
2009	Survey Date	Dusk/ Dawn	Species	Number Events	Activity
	26/05/09	Dusk	Common pipistrelle	6	Foraging and commuting
			Soprano pipistrelle	3	
	18/06/09	Dusk	Common pipistrelle	8	Foraging and commuting
			Soprano pipistrelle	2	
			Noctule	1	
			Other	1	
	23/07/09	Dusk	Common pipistrelle	6	Foraging and commuting
			Soprano pipistrelle	8	
			Myotis	1	
	24/08/09	Dusk	Common pipistrelle	4	Foraging and commuting
			Soprano pipistrelle	5	
			Myotis	4	
			Noctule	1	
	15/09/09	Dusk	Common pipistrelle	5	Foraging and commuting
			Soprano pipistrelle	5	
Weather conditions	Survey Date	Temp Start	Temp End	Weather	
	26/05/08	11°C	7°C	Heavy at times, 1	
	18/06/08	14°C	9°C	Dry, 1NE	
	23/07/08	18°C	15°C	Dry	
	25/08/08	22°C	18°C	Dry, 1W	
	15/09/08	16°C	11°C	Dry	
Survey methodology	Vantage point surveys. Duet bat detectors linked to MP3 recorders. Analysed using Batsounds.				

Appendix B: Case Study Information - Overbridges

Schemes where over-bridges have been provided as mitigation or are already present
The search for case studies did not identify any green bridges in the UK that had been installed for bat mitigation or any other green bridges in the UK that had been subject to bat monitoring.

Case Study B1: A38 Dobwalls Bypass - Havett Road Bridge

Summary description
The Havett Road Bridge was constructed to carry a minor road across and above the bypass. A hedgerow along the existing minor road, which was identified as a brown long-eared and common pipistrelle bats commuting route from an adjacent maternity roost, was severed in order to create the cutting for the bypass. The road bridge was installed with a solid equestrian parapet that was designed to reduce wind and the amount of light spill from car headlights on to the bridge, thereby serving to increase the suitability of the bridge for use by commuting bats.

Mitigation outcome
Although few bats have been recorded during the monitoring surveys, two common pipistrelle bats were recorded flying directly over the road bridge (and therefore assumed to be using it for navigation) in 2008, which was the year that the bridge was installed. Similarly, one common pipistrelle bat was observed flying directly over the bridge in 2009.

Data limitations
The number of bats using the flight line before construction is not stated and subsequent monitoring surveys were undertaken using different methods and by different companies, i.e., there was no continuity of personnel for each survey, which may influence results. The amount of monitoring survey undertaken is very limited and the 2009 report states, “only a brief ‘snapshot’ of bat activity on a very small number of sample nights. Bats with quieter or more directional echolocation systems, e.g., horseshoe, long-eared and Myotis sp. crossing a short distance away from the structures may not have been detected.” The 2009 results do not specify if bats crossing the road were using the bridge or not.

Case Study B1	**A38 Dobwalls Bypass - Havett Road Bridge**	
Road & location	A38, near Liskeard, Cornwall	
Carriageway type	Dual carriageway.	
Structure Ref	27542	
Impact of scheme	Construction of the dual carriageway cutting severed a hedgerow identified as a commuting route for brown long-eared and common pipistrelle bats commuting route from an adjacent maternity roost.	
Type of structure & span	Steel composite road bridge carrying an unclassified road over the A38. Aluminimum post and rail bridge parapets with mesh infill panels (western parapet = 1m high; eastern parapet = 1.8m high). Clear span/length = 43m Width = 9-10m Skew = 23°	
Installation date	Constructed: 2008 Road open to traffic in 2009	
Baseline	Not specified. The hedgerow ('Hedgerow C') was a key commuting route, particularly for common pipistrelle and brown long-eared bats in maternity roosts at Havett View. Some foraging behaviour also recorded at this hedgerow.	
Species recorded at baseline	Common pipistrelle, brown long-eared, noctule	
Monitoring	**2008**	**2009**
Dates and duration of surveys	23rd June from 30 minutes before until 90 minutes after sunset. Sunset was at approx 21:35h.	15 September (dusk), 19:25h – 22:45h.
Weather conditions	12.8C to 11.1C; 5% high cloud cover; Clear, dry after warm day.	No rain. Cloud cover 30-60 %. Wind BF 1-5. 15.6C-15C
Survey methodology	One surveyor positioned at the bat crossing point. Pettersson D240x time expansion detector and Sony minidisk recorder.	Two surveyors positioned at either end of the bridge using Batbox Duet bat detectors and radio sets.
Monitoring results	One common pipistrelle bat flew north to south (towards Havett View roost) directly above the road bridge (height not given). Two other common pipistrelle bats were seen to cross the bypass close to the bridge (distance not given), one flying north to south, and one south to north. A single common pipistrelle flew halfway across the road bridge from the south, and then went over the side of the bridge, descending towards the road. A single long-eared bat was heard but not seen.	One common pipistrelle bat 'crossed' south to north (not specified if using bridge or distance from it). A further two common pipistrelles 'possibly crossed north to south'.

Case Study B1	A38 Dobwalls Bypass - Havett Road Bridge	
Monitoring summary figures	2 movements ‘confirmed’ directly over structure; 1 movement ‘possible’ directly over structure; 2 movements ‘away’ >5m from structure	1 movement south to north over structure.

Case Study B2: A69 Haydon Bridge Bypass – Cemetery Road Overbridge

Summary description
The bypass is approximately 2.5km long and passes to the south of Haydon Bridge. The development severs the village of Haydon Bridge to the north, where roosts may be present, from areas of good quality foraging habitat to the south.

Habitats and features suitable for supporting foraging, and commuting were identified along the route of the bypass as part of the pre-construction surveys.
Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Noctule bat; and
- Myotis species.

The baseline surveys concluded that the River South Tyne, Cemetery Road and Gee's Wood form the main commuting routes used by bats to access roosts in Haydon Bridge and foraging areas to the south, west and east of the town. The River Tyne South and Gee's Wood are important bat feeding areas.

The overbridge was constructed in 2008. It forms part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes.

Mitigation outcome
Baseline surveys in 2004 & 2007 indicated that bat activity at this site was concentrated along Cemetery Road. Monitoring in 2008, during the road construction, and in 2009, after opening of the road, concluded that Cemetery Road is still used by commuting bats. It is however noted that while the functionality appears to have been maintained, the overall number of bat passes was seen to decrease after construction of the bypass. The number of bat passes reduced in 2009 compared to 2008 or 2007. A similar pattern is seen in the number of bat passes recorded in 2009 compared to 2007. It is not possible to make any comparisons with the baseline survey in 2004.

Data limitations
Survey methods and transect locations do not directly align. Baseline surveys in 2004 consisted of spot and transect surveys, which were followed up in 2007 with roughly comparable transects. Survey effort was not consistent in terms of duration between years. While data on the 2008 survey duration and weather conditions was not available, surveys in 2008 & 2009 consisted of transect surveys, which the authors indicate followed similar survey methodologies.

Case Study B2	**A69 Haydon Bridge Bypass – Cemetery Road Overbridge**				
Road & location	A69, Cumbria				
Carriageway type	Single carriageway				
Structure Ref	27464				
Impact of scheme	Habitats and features suitable for supporting foraging, and commuting were identified along the route of the bypass as part of the pre-construction surveys.				
Type of structure & width	Highway overbridge, providing accommodation access over the A69. Width (clear internal) = Not available Length (minimum) = 12.4m				
Installation date	2008				
Baseline					
2004	Survey	Survey Date	Start	Finish	Activity
	Transect 10 – Cemetery Road	20/07/04	21:15	22:32	87 Common pipistrelle 2 Soprano pipistrelle 1 Myotis
		22/08/04	23:15	23:25	Common pipistrelle Soprano pipistrelle Myotis
		23/08/04	20:15	20:55	>9 Common pipistrelle Soprano pipistrelle
Weather conditions	Survey Date	Temp	Weather		
	20/07/04	17°C	Light Rain, calm mild		
	22/08/04	14°C	Overcast, calm, mild30% cloud, calm, mild		
	23/08/04	14°C	Light drizzle-heavy rain, light E breeze		
Survey methodology	Transect surveys. Batbox III (heterodyne), Batbox Duet (frequency division) and Petterson D (time expansion) bat detectors.				
Baseline					
2007	Survey	Survey Date	Start	Finish	Activity
	Transect 2 – Cemetery Road (Points 1-2)	29/05/07	21:41	22:12	6 Common pipistrelle
		20/06/07	21:58	22:29	24 Common pipistrelle, 12 Common pipistrelle or Myotis
		31/07/07	21:15	21:35	13 Common pipistrelle, 5 Common pipistrelle or Noctule
		23/08/07	20:25	20:57	26 Common pipistrelle 2 Common pipistrelle or Noctule
		17/09/07	19:23	19:55	2 Common pipistrelle 1 Noctule

Case Study B2	**A69 Haydon Bridge Bypass – Cemetery Road Overbridge**			
Weather conditions	Survey Date	Temp Start	Temp End	Weather
	29/05/07	15°C	12°C	Dry, still
	20/06/07	22°C	16°C	Dry, still
	31/07/07	19°C	16°C	Dry, 2W
	23/08/07	19°C	15°C	Dry, 1S
	17/09/07	13°C	7°C	Dry with some drizzle, 1N-3W
Survey methodology	Transect surveys. Duet detectors linked to MP3 recorders. Analysed using Batsounds.			
Baseline				
2008	Transect	Survey Date	Start	Finish	Activity
	Vantage Point – Cemetery Road	05/08			10 Common pipistrelle
		06/08			12 Common pipistrelle 3 Soprano pipistrelle
		07/08			9 Common pipistrelle 1 Noctule
		08/08			6 Common pipistrelle 3 Noctule
		09/08			7 Common pipistrelle 2 Soprano pipistrelle 5 Noctule
Survey methodology	Transect surveys. Duet detectors linked to MP3 recorders. Analysed using Batsounds.				
Species recorded at baseline	• Common pipstrelle; • Soprano pipistrelle; • Noctule bat; and • Myotis species.				
Monitoring					
2009	Transect	Survey Date	Start	Finish	Activity
	Vantage Point – Cemetery Road	26/05/08	21:25	22:40	2 Common pipistrelle
		18/06/08	21:45	22:50	0
		23/07/08	21:25	22:40	4 Common pipistrelle
		25/08/08	20:10	21:25	8 Common pipistrelle 5 Soprano pipistrelle 1 Myotis 2 Noctule
		15/09/08	19:25	20:30	7 Common pipistrelle 5 Noctule
Weather conditions	Survey Date	Temp Start	Temp End	Weather	
	26/05/08	11°C	7°C	Heavy at times, 1	
	18/06/08	14°C	9°C	Dry, 1NE	
	23/07/08	18°C	15°C	Dry	
	25/08/08	22°C	18°C	Dry, 1W	
	15/09/08	16°C	11°C	Dry	
Survey methodology	Vantage point surveys. Duet bat detectors linked to MP3 recorders. Analysed using Batsounds.				

Appendix C: Case Study Information – Wire Bridges

Schemes where wire bridges have been provided as mitigation or are already present

Case Study W1: A66 Stainburn and Great Clifton Bypass - Beck Bat Conduit

Summary description
This structure comprises a pylon at each side of the road, with six connecting stainless steel wires (12mm diameter) in three vertically arranged pairs, supporting plastic spheres at 2m intervals, positioned above and across the carriageway. A timber panel fence (approx. 2m high) has been constructed on either side of the road in an attempt to lift the flight path of bats flying out of the woodland. Beck Bat Conduit was installed in line with the western edge of a section of woodland in order to provide linkage between two fragmented woodland sections. Prior to construction of the A66 bypass, a bridleway was present within this woodland, which had been identified as a commuting route for bats. Rather than providing the bat crossing structure in a location that would provide a continuous link between the severed ends of the bridleway, it was placed so as to provide a continuous link with the western edge of the woodland.

Mitigation outcome
During the monitoring surveys, the majority of bats flying across the road were recorded flying along the line of the bridleway; no bats were recorded flying across the road within 2m of the structure.

Data limitations
Limited information on flight height and distance from structure. Criteria for ‘use’ of structure not stated.

Case Study W1	**A66 Stainburn and Great Clifton Bypass - Beck Bat Conduit**			
Road & location	A66, Cumbria			
Carriageway type	Single carriageway plus over-taking lane (3 lanes in total)			
Structure Ref	23267			
Impact of scheme	Bypass bisected a bridleway through woodland			
Type of structure & width	Steel wire bat bridge. 6 stainless steel ropes supporting small plastic spheres at 2m centres. Length = 22m			
Installation date	2002			
Baseline	Not available			
Flight pattern at baseline	Bridleway identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2006**	**2007**	**2007**	**2009**
Dates and duration of surveys	20th September: 19:15h to 20:30h	5th June: 21:30 to 23:00	10th July: 03:20 to 04:40	29 April: dawn and dusk. 13 May: dawn and dusk. 08 June: dawn and dusk. 13 July: dawn and dusk. 10 August: dawn and dusk. Dusk =1 hour from sunset Dawn = 1 hour prior to sunrise
Weather conditions	14°C to 12°C; 50% cloud cover; wind Beaufort force 3; dry.	16C, 20% cloud cover, wind Beaufort force 1, dry.	9C, 10% cloud cover, wind Beaufort force 1, dry.	Various – suitable for bats to be active
Survey methodology	One surveyor on south side of bridleway using Peterssen D100 or Batbox III bat detector.	One surveyor on south side of bridleway using Peterssen D100 or Batbox III bat detector.	One surveyor on south side of bridleway; one surveyor initially identified direction of flight upon leaving the bridleway, followed by activity survey of estate to identify roosts. Using Peterssen D100 and Batbox III bat detector.	Surveys conducted monthly (April – August) to monitor bat use of crossing points. Species, behaviour (foraging/commuting), time of bat activity and use of crossing structure were recorded, along with the number of bat passes to indicate level of bat activity.

Case Study W1	A66 Stainburn and Great Clifton Bypass - Beck Bat Conduit			
Monitoring results	53 bats were recorded crossing the road, as follows: 29 soprano pipistrelle, 12 common pipistrelle, 6 pipistrelle sp., 4 Myotis sp., 1 brown long-eared, 1 unidentified. 0 bats were recorded crossing 'near to' the wires of the structure. 2 soprano pipistrelles and 1 common pipistrelle were recorded crossing through a nearby culvert. 79% of bats followed the line of the bridleway. 14% used other parts of the tree line. All bats were recorded flying below tree canopy height. This is the only detail on height given, apart from 1 soprano pipistrelle, observed flying approx 2.5m above road surface, and 'some bats crossed the road at the height of the fence panelling (height not given). This is well within the range of a truck'.	91 bats were recorded crossing the road, as follows: 42 soprano pipistrelle, 37 common pipistrelle, 2 pipistrelle sp., 4 Myotis sp., 2 brown long-eared, , 1 noctule, 3 unidentified. The following bats were recorded crossing 'using' the structure (criteria for 'use' not stated): 22 soprano pipistrelles, 15 common pipistrelles, 1 Myotis sp. & 1 Pipistrellus sp. (total 43%). 53% were observed following the line of the bridle path, the tree canopy or the east or west edge of the tree line. 4% used the culvert. All bats were recorded flying below tree canopy height. This is the only detail on height given, apart from 5 common pipistrelles and 4 soprano pipistrelles flying 1.5m above road, 2 soprano pipistrelles and 1 Myotis sp. flying 2m above road.	57 bats were recorded. Soprano pipistrelle, common pipistrelle and Myotis sp. were observed crossing the bypass. 21 bats (37%) were deemed to have crossed 'using' the structure, including 2 Pipistrellus sp., 9 soprano pipistrelles, 6 common pipistrelles, 3 Myotis sp. & 1 'big bat'. 26 bats (46% were deemed to have crossed not 'using' the structure, including 1 unidentified bat, 17 soprano pipistrelles, 5 common pipistrelles, 1 Myotis sp. 7 2 Pipistrellus sp. 9 bats were observed foraging over the road, including 6 soprano pipistrelles & 3 common pipistrelles. 1 soprano pipistrelle was observed using the culvert. Bats flew between 3 & 8m above ground.	Only common & soprano pipistrelles & noctules recorded and far fewer numbers of bats observed than previous surveys. Bats were rarely seen 'utilising' the structure.

Case Study W2: A38 Dobwalls Bypass, Havett Farm Bat Bridge

Summary description
The Havett Farm Bat Bridge comprises a U-shaped mesh structure, spanning 70m, above and across the carriageway. It comprises stainless steel wire mesh of 1.5mm diameter connected to four corner cables that extend (slightly skewed) across the road and are attached to steel supports at either side of the road. The height of the steel supports is similar to that of the ends of a severed hedgerow, although the supports are enclosed by a 2.5 m high palisade fence, which is approximately two metres from the adjacent hedge. The U-shape of the structure incorporates 1-1.5m height sides, which are designed to provide shelter to bats using it to cross the road.

Mitigation outcome
Bats have been recorded crossing directly over the Havett Farm Bat Bridge on the A38 Dobwalls Bypass in 2008 and 2009, including common pipistrelles, Pipistrellus sp., brown long-eared and Myotis sp., although it is not clearly stated whether some of the bats recorded in 2009 crossed directly over the structure. Survey observations from July/September 2009 stated

"*Only a small proportion of the bats crossing were able to be observed almost all of them were at Havett View bat bridge. The impression was that the pipistrelle bats were flying high, close to the bridge structure and Myotis bats were flying low over the road within the traffic zone. Casualties are liable to be occurring of Myotis and possibly long-eared bats*".

Bats have also been recorded flying over the road cutting, away from the bat bridge since the hedgerow was fragmented in 2007, although numbers of bats crossing not using the structure have not been consistently recorded or reported.

Data limitations
The actual number of bats using the severed flight line before construction is not stated and subsequent monitoring surveys were undertaken using different methods and by different companies. The duration of monitoring is limited and weather conditions were poor during some of the surveys. The 2009 report states, "only a brief 'snapshot' of bat activity on a very small number of sample nights. Bats with quieter or more directional echolocation systems, e.g., horseshoe, long-eared and Myotis sp. crossing a short distance away from the structures may not have been detected." The definition of 'crossing using the structure' was not defined.

Case Study W2	**A38 Dobwalls Bypass, Havett Farm Bat Bridge**
Road & location	A38, near Liskeard Cornwall
Carriageway type	Dual carriageway. Top of cutting width approx. 70m
Structure Ref	27543
Impact of scheme	Construction of the dual carriageway cutting severed a hedgerow identified as a commuting route for bats, with recorded foraging.
Type of structure & width	Fabricated steel bat bridge. Stainless steel mesh supported by cables, forming trough cross-section. HDPE attached to steel mesh at both ends. Length = 70m Width = 1-1.5m
Installation date	Temporary structure installed in 2007 (single cable with camouflage netting draped from it). Permanent structure installed in 2008 (road open to traffic in 2009)
Baseline	2003, 2004
Species recorded at baseline	Common pipistrelle, brown long-eared, myotis sp.
Flight pattern at baseline	The hedgerow ('Hedgerow B') was described in 2004 as a key commuting route, particularly for common pipistrelle and brown long-eared bats in maternity roosts at Havett View. Some foraging behaviour also recorded at this hedgerow.

Case Study W2	**A38 Dobwalls Bypass, Havett Farm Bat Bridge**			
Monitoring	**2008**	**2009**		
Dates and duration of surveys	23/06/08 (dusk); 24/06/08 (dawn/dusk)	15/06/09 (dusk); 16/06/08 (dawn/dusk)	27/07/09 (dusk)	15/09/09 (dusk); 16/09/09 (dawn)
Weather conditions	13-11°C, 5% high cloud, clear dry; 11-10°C, 10% cloud, clear dry; 14-13°C, 100% cloud, constant drizzle.	Not specified	12-11°C, wind 1-3 beaufort, 0% rain, 40-100% cloud.	16-15°C, wind 1-5 beaufort, 0% rain, 20-60% cloud; 13°C, wind 2-3 beaufort, 0% rain, 50-60% cloud.
Survey methodology	One surveyor positioned at the bat crossing point. Pettersson D240x time expansion detector and Minidisk recorder.	Not specified	3 surveyors, position either side of structure. Duet bat detectors, with additional use of Ananbat SDI, Petersson D240X and D1000X detectors and mini disc, MP3 or internal SD/CF cards. Analysis using BatSound V3.3l & 4.0 and Analook. 2 infra red flood lights with DVD player. Night vision scope.	3 surveyors, position either side of structure. Duet bat detectors, with additional use of Ananbat SDI, Petersson D240X and D1000X detectors and mini disc, MP3 or internal SD/CF cards. Analysis using BatSound V3.3l & 4.0 and Analook. 2 infra red flood lights with DVD player. Night vision scope.
Monitoring results	0 bats recorded flying directly over structure; 10 common pipistrelle & 1 brown long-eared <5m of structure; 2 common pipistrelle >5m from structure.	2 common pipistrelle & 2 brown long-eared recorded flying directly over structure; 1 myotis species <5m of structure; 1 brown long-eared >5m from structure; 3 brown long-eared 'unconfirmed' crossings	14 common pipistrelle, 6 Myotis, 4 Pipistrelle species, 2 unidentified recorded using bridge; 6 common pipistrelle, 2 Pipistrelle species 'unconfirmed' crossings	17 common pipistrelle, 12 Myotis, 1 Natterer's, 1 long-eared species recorded using bridge; 1 common pipistrelle, 1 Myotis species 'unconfirmed' crossings

Case Study W3: A38 Dobwalls Bypass, Lantoom Quarry Bat Bridge

Summary description
The Lantoom Quarry Bat Bridge spans 37m across the A38 and comprises the same structural design as the Havett Farm Bat Bridge described above. A new distributor road was constructed parallel and adjacent to the A38 in this location. As such, an additional bat guidance structure, spanning 27m, was installed above and across the distributor road. The two structures are connected via a central 'hop-over' point between the two roads where mature trees were planted to encourage bats flying over the roads to maintain sufficient height in order to reduce the risk of collisions with traffic.

Mitigation outcome
Common pipistrelles were recorded flying directly over, to either side of the structure in 2008. Common pipistrelles, Pipistrellus sp., myotis sp. Natterer's, and long-eared sp. were recorded 'crossing' in 2009, although it is not clearly stated whether these bats crossed using the structure or not. Survey observations from July/September 2009 stated

"*Only a small proportion of the bats crossing were able to be observed almost all of them were at Havett View bat bridge. The impression was that the pipistrelle bats were flying high, close to the bridge structure and Myotis bats were flying low over the road within the traffic zone. Casualties are liable to be occurring of Myotis and possibly long-eared bats*".

Data limitations
The actual number of bats using the severed flight line before construction is not stated and subsequent monitoring surveys were undertaken using different methods and by different companies. The duration of monitoring is limited and weather conditions were poor during some of the surveys. The 2009 report states, "only a brief 'snapshot' of bat activity on a very small number of sample nights. Bats with quieter or more directional echolocation systems, e.g., horseshoe, long-eared and Myotis sp. crossing a short distance away from the structures may not have been detected." The definition of 'crossing using the structure' was not defined.

Case Study W3	**A38 Dobwalls Bypass, Lantoom Quarry Bat Bridge**
Road & location	A38, near Liskeard Cornwall
Carriageway type	Dual carriageway and distributor road.
Structure Ref	27547
Impact of scheme	Increased width of severance through widening of existing A38. Considered likely to prevent bats from crossing the road at this point, and/or increasing the risk of collision of bats with traffic.
Type of structure & width	Fabricated steel two span bat bridge. Stainless steel mesh supported by cables, forming trough cross-section. HDPE attached to steel mesh at both ends. Length = 60m (37m over A38; 23m over distributor road).
Installation date	2008
Baseline	2003, 2004
Species recorded at baseline	Common pipistrelle, whiskered (assumed), lesser horseshoe. Pipistrelle and Whiskered bats from the Toll House and adjacent roost sites crossed the A38 at Lantoom Quarry; foraging activity was also recorded.

Case Study W3	**A38 Dobwalls Bypass, Lantoom Quarry Bat Bridge**			
Monitoring	**2008**	**2009**		
Dates and duration of surveys	23/06/08 (dusk); 24/06/08 (dawn/dusk)	15/06/09 (dusk); 16/06/08 (dawn/dusk)	28/07/09 (dusk)	16/09/09 (dusk); 17/09/09 (dawn)
Weather conditions	13-11°C, 5% high cloud, clear dry; 11-10°C, 10% cloud, clear dry; 14-13°C, 100% cloud, constant drizzle.	Not specified	15°C, wind 0-1 beaufort, 0% or light rain, 100% cloud.	15-12°C, wind 0-1 beaufort, 0% rain, 0% cloud; 10°C, wind 1 beaufort, 0% rain, 0% cloud.
Survey methodology	One surveyor positioned at the bat crossing point. Pettersson D240x time expansion detector and Minidisk recorder.	Not specified	3 surveyors, position either side of structure. Duet bat detectors, with additional use of Ananbat SDI, Petersson D240X and D1000X detectors and mini disc, MP3 or internal SD/CF cards. Analysis using BatSound V3.3l & 4.0 and Analook. 2 infra red flood lights with DVD player. Night vision scope.	3 surveyors, position either side of structure. Duet bat detectors, with additional use of Ananbat SDI, Petersson D240X and D1000X detectors and mini disc, MP3 or internal SD/CF cards. Analysis using BatSound V3.3l & 4.0 and Analook. 2 infra red flood lights with DVD player. Night vision scope.
Monitoring results	2 common pipistrelle recorded flying directly over structure; 1 common pipistrelle <5m of structure; 1 common pipistrelle recorded as ‘possibly’ flying directly over structure	1 common pipistrelle recorded flying directly over structure	7 common pipistrelle & 2 Myotis sp. confirmed as crossing (assumed) bridge; 17 common pipistrelle, 5 Myotis sp., 4 Pipistrelle sp., 3 unidentified, 2 Natterer’s, 1 Soprano pipistrelle recorded as ‘possible’ crossings	52 common pipistrelle, 1 Pipistrelle sp., 10 Myotis sp., 3 Natterer’s & 2 long-eared sp. confirmed as crossing (assumed) bridge; 1 common pipistrelle & 1 Myotis sp. recorded as crossing in unknown direction and therefore assumed ‘possible’ crossings.

Case Study W4: A590 High & Low Newton Bypass, Low Newton Bat Bridge

Summary description
A wire bridge, spanning 30m, was constructed across the A590 dual carriageway at the location of a severed hedgerow. The bat bridge comprised six stainless steel wires (10mm diameter) in three vertically arranged pairs, supporting plastic spheres at 2m intervals and staggered horizontally, positioned above and across the carriageway. In addition, semi-mature trees were planted on the road embankments at either side of the structure. During the 2007 surveys only a temporary single cable with ribbons tied to it spanned the road.

Mitigation outcome
Surveys were undertaken around dusk and/or dawn during April, May and September in 2007, 2008, and 2009. Bat passes were recorded as a bat event index (BEI) score, equating to the number of bat passes. Bats were recorded crossing the road 'using' the bat guidance structure, however the criteria for determining 'use' of the structure were not specified. The level of use was slightly higher in 2008 and 2009 compared with 2007. Bats were also recorded crossing the road away from the structure, at heights of both over and under 5m.

Data limitations
A limited amount of bat survey data was available from the 2005 baseline surveys (only two surveys undertaken). For each minute of constant bat activity, it was assumed that three bat passes had been recorded. Variation in completion of the survey proforma meant that some interpretation of survey data was required. No statistical analysis of data was presented. Baseline counts in 2005 recorded bats using commuting routes, although subsequent monitoring counts recorded all bat passes, including those not using the commuting route, i.e., not crossing the road.

Temporary bat guidance structure (2007)

Permanent bat guidance structure (2009)

Case Study W4	**A590 High & Low Newton Bypass, Low Newton Bat Bridge**		
Road & location	A590, Cumbria		
Carriageway type	Dual carriageway		
Structure Ref			
Impact of scheme	Severed a hedgerow used as a bat commuting route		
Type of structure & span	Wire structure; 33m span. Adjacent semi-mature planting planted in winter 2007/2008 to link to severed hedgerow still not fully mature as a landscape feature. Clear span/length = Width =		
Installation date	2007 (road opened to traffic in April 2008)		
Baseline	Activity surveys were carried out on five bat commuting routes identified in previous surveys undertaken in 2003 & 2004 (results not provided). Two activity surveys were carried out in 2005 on each bat commuting route, one in May and one in June. Survey positions were selected to allow comparable repeat surveys to be carried out from the same positions during and following road construction. Each survey began 15 minutes before sunset and continued for 1.5 hours after sunset. Weather conditions were recorded.		
Number of bats recorded at baseline	Peak number of bat passes (BEI) was 63 (June 2005), including common pipistrelle, Myotis sp. and brown long-eared bats		
Flight pattern at baseline	Not stated		
Monitoring	**2007**	**2008**	**2009**
Dates and duration of surveys	Dusk &/or dawn 9th, 10th, 16th, 17th May; 13th June; 3rd & 10th July; 1st, 7th, 15th, 27th August; 5th & 28th September. Dusk – 15m before sunset until 1.5h after sunset. Dawn – 1.25h before sunrise until sunrise.	Dusk &/or dawn 23rd & 29th April; 5th and 17th May; 1st, 17th, 23rd, & 28th June; 13th, 19th, 24th, & 29th July; 2nd, 11th, 19th, & 26th August; 11th & 29th September. Dusk – 15m before sunset until 1.5h after sunset. Dawn – 1.25h before sunrise until sunrise.	Dusk &/or dawn 29th April; 10th, 14th, 23rd, & 30th June; 7th, 15th, 20th, & 25th July; 5th, 12th, 18th, & 22nd August; 1st, 5th, 9th, 10th, & 21st September. Dusk – 15m before sunset until 1.5h after sunset. Dawn – 1.25h before sunrise until sunrise.
Weather conditions	Wind: none to moderate Rain: heavy on one occasion Cloud cover: 0% to 100% Temperature: 8C to 18C.	Wind: none to moderate Rain: none to light Cloud cover: 0% to 100% Temperature: 7C to 19C.	Wind: none to moderate Rain: none to light Cloud cover: 0% to 100% Temperature: 7C to 20C.

Case Study W4	A590 High & Low Newton Bypass, Low Newton Bat Bridge		
Survey methodology	Similar method and equipment to baseline, where possible. One surveyor positioned on either side of road. Bat Box Duet heterodyne / frequency division bat detectors. Calls were recorded on MP3 recorders and analysed using BatScan software. For each bat pass recorded the following information was noted (where possible): species; height above ground; route of bat, i.e., following structure or over road; time; and behaviour, ie, foraging or commuting. The number of bat passes was converted into a Bat Event Index (BEI) where the number of passes recorded in one survey equates to the BEI.		
Monitoring results[2]	Peak BEI was 60 (July), including common pipistrelle, soprano pipistrelle, whiskered/ Brandt's, Myotis sp., noctule. 4.4% of bat passes recorded as 'using the bat guidance structure', although criteria for definition of 'use' or 'close to' not stated. 30.6% of bat passes recorded as crossing road away from bat guidance structure	Peak BEI was 68 (September), including common pipistrelle, soprano pipistrelle, pipistrelle sp., whiskered/ Brandt's, Myotis sp., noctule. 16.6% of bat passes recorded as 'using the bat guidance structure', although criteria for definition of 'use' or 'close to' not stated. 30.3% of bat passes recorded as crossing road away from bat guidance structure	Peak BEI was 189 (August), including common pipistrelle, soprano pipistrelle, pipistrelle sp., Natterer's, Myotis sp., brown long-eared, noctule, unidentified species. 12.4% of bat passes recorded as 'using the bat guidance structure', although criteria for definition of 'use' or 'close to' not stated 24.9% of bat passes recorded as crossing road away from bat guidance structure
Height of bat flight	Highest proportion of bats crossed the road above 5m, but a small proportion of common pipistrelle, soprano pipistrelle and myotis sp. were observed flying less than 5m above the road. Bats were observed dropping down the embankment to cross the road.		

[2] Noctule, common pipistrelle, soprano pipistrelle, whiskered/Brandt's, brown long-eared and Myotis sp. were recorded crossing the road away from the guidance structure over the three years.

Case Study W5: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern, Cadfor Bat Bridge

Summary description
As part of dualling works to the previously single (three lane) carriageway a wire bridge was constructed over the A465 to replace a farm access bridge that was used by lesser horseshoe bats to cross the road. The dimensions of the bridge are not stated, although a photograph is provided after the summary table.

Mitigation outcome
The activity indices increased slightly from 2005 to 2006, although numbers are lower than 2004. All activity is relatively low (e.g.1 bat in 2005 & 3 in 2006) and therefore inconclusive. It is not stated whether the bats were confirmed crossing the road 'using' the wire bridge or just recorded in the vicinity. No activity was recorded in 2007 or 2008 using hand-held detectors.

At the time of publication monitoring continues.

Data limitations
Survey methods during baseline and monitoring surveys differed. Detailed results and weather conditions are not provided.

Photograph of Cadfor Bat Bridge

Case Study W5	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern, Cadfor Bat Bridge**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	A farm access bridge used by lesser horseshoe bats was lost and replaced with a wire bridge			
Type of structure & width	Wire bridge; dimensions not given but a photograph is provided below.			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – no survey; July 2004 – no survey; September 2004 – 22; average - 22. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Farm access bridge identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 3.25 h Late June/early July –2.75 h Late July/early August – 3.25 h Late August/early September – 3.5 h October – 3.75 h	May – 4 h June – 4 h July – 4 h August – 4 h September – 4 h October – 4 h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. Surveys also involved the use of Anabat detectors.			
Monitoring results	Bat activity index: May/June – 0 June/July – 0 July/August – 0 August/September – 29 October – 0 Average – 6	Bat activity index (hand-held detectors only) May – 0 June - 75 July – 0 August – 0 September – 0 October – 0 Average - 13	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 0	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 0

Case Study W6: A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Pen-y-Worlod Farm Bat Bridge

Summary description
As part of dualling works to the previously single (three lane) carriageway a wire bridge was constructed over the A465 to replace a farm access bridge that was used by lesser horseshoe bats to cross the road. The dimensions of the bridge are not stated, although the structure is believed to be similar to Cadfor Bat Bridge, of which a photograph is provided above.

Mitigation outcome
The activity indices increased gradually from 2005 to 2008. All activity is relatively low (e.g.1 bat in 2005 & 6 in 2006) and therefore conclusions are difficult to draw. It is not stated whether the bats were confirmed crossing the road 'using' the wire bridge or just recorded in the vicinity.

At the time of publication monitoring continues.

Data limitations
Survey methods during baseline and monitoring surveys differed. Detailed results and weather conditions are not provided.

Case Study W6	**A465 (T) Heads of the Valleys Dualling; Section 1: Abergavenny to Gilwern - Pen-y-Worlod Farm Bat Bridge**			
Road & location	A465, Section 1: Abergavenny to Gilwern, Wales			
Carriageway type	Dual carriageway			
Impact of scheme	A farm access bridge used by lesser horseshoe bats was lost and replaced with a wire bridge			
Type of structure & width	Wire bridge; dimensions not given			
Installation date	2005			
Baseline	As survey effort differed throughout the survey periods, numbers are not directly comparable so a bat activity index (BAI) was calculated from the number of bat passes and survey effort, as follows: May 2004 – no survey; July 2004 – 17; September 2004 – 67; average - 42. For an idea of how the bat activity index relates to numbers, a bat activity index of 25 equates to 1 bat in 4 hours.			
Species recorded at baseline	Lesser horseshoe bat			
Flight pattern at baseline	Farm access bridge identified as bat commuting route. Flight pattern not stated.			
Monitoring	**2005**	**2006**	**2007**	**2008**
Dates and duration of surveys	Late May/early June – 3.25 h Late June/early July –3 h Late July/early August – 3.25 h Late August/ early September – 3.5 h October – 3.75 h	May – 4 h June – 4 h July – 4 h August – 4 h September – 4 h October – 4 h	Not stated	Not stated
Weather conditions	Not stated	Not stated	Not stated	Not stated
Survey methodology	Two personnel using Batbox Duet and Pettersson D230 handheld bat detectors set at 110 kHz surveyed the site at dusk and dawn. The bat detectors were pointed towards the anticipated direction of arrival of the bats. Surveys also involved the use of Anabat detectors.			
Monitoring results	Bat activity index: May/June – 0 June/July – 0 July/August – 0 August/September – 29 October – 0 Average – 6	Bat activity index (hand-held detectors only) May – 0 June - 0 July – 0 August – 50 September – 0 October – 100 Average - 25	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 67	Bat activity index (hand-held detectors only). Monthly figures not provided, only average figure for all months - 92

Case Study W7: A69 Haydon Bridge Bypass – Bat Conduit

Summary description
The bypass is approximately 2.5km long and passes to the south of Haydon Bridge. The development severs the village of Haydon Bridge to the north, where roosts may be present, from areas of good quality foraging habitat to the south.

Mitigation outcome
Monitoring in 2009 concluded that the commuting route continued to be utlised after installation of the bat concourse. Activity levels appeared to be consistent with those recorded in 2008 prior to installation of the bat concourse. The activity indices increased gradually from 2005 to 2008. All activity is relatively low (e.g.1 bat in 2005 & 6 in 2006) and therefore conclusions are difficult to draw. It is not stated whether the bats were confirmed crossing the road 'using' the wire bridge or just recorded in the vicinity.

Data limitations
Weather conditions varied throughout the surveys period and between years.
Reliance on Anabat monitoring meant that the exact species of bat could not be determined from the recordings.
Vantage point manual surveys were undertaken by a single surveyor, although comparison was not possible with baseline data as no vantage point survey was undertaken in 2008.

Case Study W7	**A69 Haydon Bridge Bypass – Bat Conduit**
Road & location	A69, Yorkshire
Carriageway type	Single carriageway
Structure Ref	27463
Impact of scheme	Severance of "western" hedgerow, which served as a commuting route.
Type of structure & width	Steel wire bat bridge/concourse; 6 stainless steel ropes supporting small plastic spheres at 2m centres; Length = 36.7m; Timber masts (height) = 7.0m
Installation date	2008
Baseline	
2004	Transect survey. Duet bat detector linked to MP3 recorder. 28/09/2004 1 Soprano pipistelle Regular Common pipistrelle
Flight pattern	Along hedges
2007	Anabat surveys 05/09/2007-19/09/2007 Dusk-dawn 209 bat passes recorded Average passes/night = 15; Common pip passes/24hr (max) = 24 Soprano pip passes/24hr (max) = 7; Myotid passes/24hr (max) = 6; Noctule passes/24hr (max) = 4; Brown long eared passes/24hr (max) = 1
Species recorded at baseline	Common pipistrelle; Soprano pipistrelle; Myotis; Noctule; & Brown long-eared.
Flight pattern at baseline	Former hedgerow (removed prior to survey) identified as bat commuting route. Flight pattern not stated.
Monitoring	
2009	Vantage point: 26/05; 18/06; 23/07; 24/08; 15/09. >1 hr duration Anabat 5th-19th June; dusk-dawn.
Weather conditions	Date: 26.05.09; 18.06.09; 23.07.09; 24.08.09; 15.09.09 Start Temp: 11.2; 14.2; 18.2; 17.7; 16.1 End Temp: 7.1; 9; 15.3; 10.8; 10.8 Cloud Cover: 50; 100; 75; 5; 5 Precipitation: Heavy at times; Dry; Dry; Dry; Dry Wind Conditions: 1; 1NE; -; -; -
Survey methodology	Single surveyor at vantage point using Duet bat detector linked to MP3 recorder. Anabat surveys – single position to south of bat concourse for duration of survey.

Case Study W7	A69 Haydon Bridge Bypass – Bat Conduit				
Vantage Point	Survey Date	Dusk/ Dawn	Species	Number Events	Activity
	26/05/09	Dusk	Common pipistrelle	2	Foraging and commuting
			Noctule	1	
	18/06/09	Dusk	Unknown	1	Foraging and commuting
	23/07/09	Dusk	Common pipistrelle	3	Foraging and commuting
			Soprano pipistrelle	3	
			Myotis	1	
			Noctule	1	
	24/08/09		Common pipistrelle	4	Foraging and commuting
			Soprano pipistrelle	2	
	15/09/09		Common pipistrelle	8	Foraging and commuting
			Soprano pipistrelle	5	
			Myotis	1	
			Noctule	1	

Case Study W7	A69 Haydon Bridge Bypass – Bat Conduit		
Anabat	Survey Date	Species	Bat Passes
	05/06/09	Common pipistrelle	4
	06/06/09	Common pipistrelle	50
		Soprano pipistrelle	5
		Myotis	5
	07/06/09	Common pipistrelle	10
		Soprano pipistrelle	2
		Myotis	2
		Noctule	2
	08/06/09	Common pipistrelle	4
		Soprano pipistrelle	1
		Myotis	2
	09/06/09	Common pipistrelle	20
		Myotis	4
		Noctule	4
	10/06/09	Common pipistrelle	4
		Myotis	1
		Noctule	1
	11/06/09	Common pipistrelle	20
		Soprano pipistrelle	8
		Noctule	1
	12/06/09	Common pipistrelle	41
		Soprano pipistrelle	7
		Myotis	7
		Noctule	2
		Pipistrelle sp	1
	13/06/09	Common pipistrelle	28
		Soprano pipistrelle	4
		Myotis	3
		Noctule	3
	14/06/09	Common pipistrelle	15
		Soprano pipistrelle	24
		Myotis	4
		Noctule	2
	15/06/09	Common pipistrelle	43
		Soprano pipistrelle	18
		Myotis	5
		Noctule	2
	16/06/09	Common pipistrelle	13
		Soprano pipistrelle	27
		Myotis	5
	17/06/09	Common pipistrelle	7
		Soprano pipistrelle	1
	18/06/09	Noctule	11

Case Study W8: A595 Parton to Lillyhall bypass - Bat Guidance Flyover

Summary description
The A595 between Parton and Lillyhall is a 3 mile long improvement including a bypass and online widening. The bypass section of the scheme, was opened to traffic on 17 December 2008. The online widening of the A595 between the A596 and A597 junctions was completed on 12 March 2009.

Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys. Species identified included:

- Common pipstrelle;
- Soprano pipistrelle;
- Daubenton's bat;
- Natterer's bat;
- Brown long-eared bat; and
- Myotis species.

The assessment concluded that the bypass would result in the loss of a significant area of habitat which was of value to foraging and commuting bats.

This bat guidance flyover was constructed after June 2008 as part of the mitigation measures intended to provide safe crossing points and to maintain commuting routes. It comprises 2 square steel hollow section posts connected via 6 stainless steel ropes with plastic spheres at 2m centres.

Mitigation outcome
Construction activity surveys were undertaken in 2007 and identified commuting by Common pipistrelles at the location of the proposed structure. Prior to installation of the bat guidance structure additional activity surveys in 2008 concluded that activity levels were much reduced, when compared to equivalent surveys in 2007. Some incidental records were also made of Borwn long-eared and Myotis bats.

Data limitations
No monitoring data was available post-construction of the guidance structure and baseline data weather conditions varied between years.

Case Study W8	A595 Parton to Lillyhall bypass - Bat Guidance Flyover
Road & location	A595, Cumbria
Carriageway type	Dual carriageway
Structure Ref	27065
Impact of scheme	Habitats and features suitable for supporting foraging, commuting and roosting bats were identified along the route of the bypass as part of the pre-construction surveys.
Type of structure & width	Steel wire rope (6 No.) bat bridge supporting plastic spheres at 2m centres Length = 34.1m 2 square steel hollow section posts.
Installation date	2008
Baseline	
2007	May/early June.
Monitoring	
2008	May & June <2 Common pipistrelle commuting across road (prior to bat bridge installation) Mid & late September 1 Common pipistrelle commuting across road (at location of bat bridge)
Weather conditions	Not available
Survey methodology	Not available

Appendix D: Case Study Information – Hop-overs

Schemes where hop-overs have been provided as mitigation or are already present

Case Study H1: A38 Glyn Valley, Cornwall - Glyn Valley Hop-over

Summary description
An area of approximately 5000 m sq. of woodland was felled as part of the A38 Glyn Valley road-strengthening scheme, affecting trees up to 25m from the road on the north side. A scheme was devised to mitigate for the loss of trees close to the most significant bat crossing areas that were identified from roadside surveys carried out before the tree removal took place. The scheme involved planting a group of five native 'super' semi-mature trees, which were around 12m in height, deadwood and branches with bat features were strapped to existing trees and smaller native trees and shrubs of varying sizes - 0.6 - 3m in height were planted, with species including ash, hazel, oak, beech to attempt to maintain a higher and safer bat flight route across the road after the existing tree removal had taken place.

Mitigation outcome
There were 25 bats recorded in total crossing the road during the 5 nights surveyed in May and June 2008, despite cold weather and a reduced level of bat activity overall. Of these 25 bats, 16 (64%) were recorded at the hop-overs. Of these 16 bats, 3 were recorded crossing low over the road, with the remaining 13 crossing high enough to be unaffected by passing traffic.

Data limitations
Bats flying through the tree canopy may not have been recorded, particularly the quieter species with more directional echolocation calls, e.g., horseshoes.

Case Study H1	A38 Glyn Valley, Cornwall - Glyn Valley Hop-over
Road & location	A38, Glyn Valley, Cornwall
Carriageway type	Single carriageway.
Impact of scheme	Strengthening works required the removal of trees up to 25 m from the road on the north side affecting bat crossing locations over the road.
Type of structure & width	Five planted semi-mature trees and deadwood close to road.
Installation date	Winter 2007/2008
Baseline	11 bats recorded crossing road over two nights in May/June 2007, including 6 common pipistrelle, 2 lesser horseshoe, 1 Myotis sp., 2 unidentified, plus possible crossings by 1 barbastelle, 2 lesser horseshoe and 1 common pipistrelle
Flight pattern at baseline	Majority of bats crossed at tree canopy height
Monitoring	
2008	See below for dates. Surveys undertaken for 3 hours from dusk

Weather conditions

Date	Start Temp	End Temp	Cloud Cover	Precipitation	Wind Conditions
19/05/08	8.5	5.7	0-80	0	0
20/05/08	10.1	5.6	20-0	0	0
21/05/08	12.7	11.2	50-100	0	0
23/06/08	12	9	45-25	0	0
24/06/08	13	10	100-60	10-20%	2

Survey methodology	6 static manned monitoring locations surveyed in May and June over 5 evenings. Using a bat detector and recording the calls for post survey computer analysis, surveyors recorded all bat passes and behaviour; whether the bat crossed the road, how high the bat flew over the road, which species were present and the times were noted wherever possible. Surveyors were equipped with radio communication to enable accurate determination of numbers of bats and their routes.
Monitoring results	There were 25 bats recorded in total crossing the road, including 1 noctule, 1 Daubenton's, 6 unidentified, 3 noctule/Leisler's, 5 soprano pipistrelle, 4 common pipistrelle, 2 Pipistrellus sp. & 3 Myotis sp. during the 5 nights surveyed in May and June 2008, despite cold weather and a reduced level of bat activity overall. Of these 25 bats, 16 (64%) were recorded at the hop-overs, including 5 unidentified, 3 noctule/Leisler's, 4 soprano pipistrelle, 2 common pipistrelle & 2 Myotis sp.. Of these 16 bats, 3 were recorded crossing low over the road, with the remaining 13 crossing high enough to be unaffected by passing traffic.

Appendix E: Case Study Information – Temporary crossing measures

Schemes where hop-overs have been provided as mitigation or are already present

Case Study T1: A69 Haydon Bridge Bypass – Temporary Mitigation

Summary description
Temporary crossing structures were installed during the construction of the A69 Haydon Bridge Bypass where bat commuting routes were severed, and prior to the implementation of permanent mitigation measures. These crossings comprised three ropes, arranged in either on a horizontal or vertical plane, with short pieces of plastic attached to the ropes at set intervals. The ropes were installed at 2m to 6m above ground level and extended across the gap created by the severed feature. Surveys were undertaken of these structures during 2007 (two surveys per month during May to September) following vegetation clearance, but prior to construction of the new road.

Mitigation outcome
No bats were recorded using the temporary crossing structures during this time. Bats were recorded continuing to fly along the established commuting route, but at locations up to 20m away from the temporary crossing structures.

Data limitations
None stated.

Case Study T1:	**A69 Haydon Bridge Bypass– Temporary Mitigation**
Road & location	A69, Haydon Bridge, Northumberland
Carriageway type & width	Single carriageway;
Impact of scheme	Severance of commuting routes
Type of structure & span	Rope structure; various spans.
Installation date	Temporary crossing structures installed following vegetation clearance and prior to construction in 2007.
Baseline	Not stated
Species recorded at baseline	Daubentons, Natterer's, brown long-eared, soprano pipistrelle, common pipistrelle, noctule, Myotis sp.
Flight pattern at baseline	Not stated
Monitoring	**2007**
Dates and duration of surveys	Two surveys per month between May & September
Weather conditions	Not specified
Survey methodology	Walking two established transects using a Duet bat detector with MP3 recording device. An Anabat was also positioned at the location of a severed hedgerow for a two-week period during September 2007.
Monitoring results	No bats were recorded using the temporary crossing structures. Bats were recorded crossing the road construction area approximately 20m away from the temporary crossing structures flying at heights of 5m to 6m above ground level across the road construction area.

Case Study T2: A487 Porthmadog, Minffordd and Tremadog Bypass – Temporary Mitigation

Summary description
Heras fencing with netlon covering was used during construction to provide temporary crossing structures along known commuting routes from a lesser horseshoe maternity roost close to the route of the new road. Surveys were undertaken, one each month of each crossing point between April and October 2010.

Mitigation outcome
Whilst lesser horseshoe bats were recorded crossing the construction area using the temporary Heras fencing, numbers declined by over 50% in comparison to baseline data. This may be because several of the original flight routes zig-zagged across the line of the road and the bats may have chosen to follow an alternative route, rather than crossing the construction area several times.

At the time of publication monitoring continued.

Data limitations
None stated.

Note
Construction of this project was ongoing at the time of review.

Case Study T2:	**A487 Porthmadog, Minffordd and Tremadog – Temporary Mitigation**
Road & location	A487, Minffordd, Wales
Carriageway type & width	Single carriageway;
Impact of scheme	Severance of commuting routes
Type of structure & span	Hera fencing; various spans.
Installation date	Temporary crossing structures installed during construction in 2010.
Baseline	Locations correspond with proposed crossing structures, as follows: Culvert 17 - 30 or more lesser horseshoe bats were recorded between May and September, with >50 bats recorded in May and August 2009; Culvert 18 - more than 20 lesser horseshoe bats were recorded using this feature during five of the surveys, with a peak count of 60 bats recorded in June 2009; Environmental overbridge - a peak count of >100 bats was recorded using this flightline in August 2009. With high numbers >50 recorded in June, July and September.
Species recorded at baseline	Lesser horseshoe
Flight pattern at baseline	Hugging vegetation along flightlines and flying around 1m above ground level.
Monitoring	**2010**
Dates and duration of surveys	One survey per month at each location between April & October, starting at sunset and lasting for 1.5 hours. Replicating baseline surveys
Weather conditions	Various
Survey methodology	One surveyor positioned at each crossing point using Pettersson D240 bat detector and minidisk/digital recorders.
Monitoring results	Culvert 17 - although lesser horseshoe bats were recorded using this feature throughout the monitoring surveys, only small numbers (<5) were recorded for the majority of months, with a peak count of 16 bats recorded in May; Culvert 18 - although lesser horseshoe bats were recorded using this feature throughout the monitoring surveys, only small numbers (<5) were recorded for the majority of months, with a peak count of 11 bats recorded in April; Environmental overbridge - Between 18 and 51 bats were recorded using this flightline during the monitoring surveys, with the largest numbers recorded in April, July and August.

Case Study T3: A38 Dobwalls Bypass – Havett Road Temporary Mitigation

Summary description
Temporary crossing structures were installed during the construction of the A38 Dobwalls Bypass at three locations where bat commuting routes were severed, and prior to the implementation of permanent mitigation measures. Vegetation clearance at this location was undertaken in winter 2006/07. At Havett Road the line of a hedge was maintained by the provision of Hera fencing. A monitoring survey was undertaken in June 2007.

Mitigation outcome
No bats were recorded using the temporary crossing structure.

Data limitations
None stated.

Case Study T3:	**A38 Dobwalls Bypass – Havett Road Temporary Mitigation**
Road & location	A38, near Liskeard, Cornwall
Carriageway type & width	Dual carriageway
Impact of scheme	Removal (and therefore severance) of hedge
Type of structure & span	Heras fencing; not stated
Installation date	Not stated, assumed early 2007
Baseline	Location corresponded with Havett Road Bridge. With permanent road bridge installed late 2007. Foraging and commuting activity recorded.
Species recorded at baseline	Brown long eared; common pipistrelle
Flight pattern at baseline	Commuting along line of hedge
Monitoring	**2007**
Dates and duration of surveys	June 3 nights and 2 dawn surveys.
Weather conditions	Not stated
Survey methodology	1 surveyors at dusk and 2 surveyors at dawn. First evening used a fixed-point detector (Tranquillity transect) fixed to a minidisk. Other surveys used Petterson D240x time expansion recorders and minidisks. Mixture of fixed point and transect surveys.
Monitoring results	No bats were recorded using the temporary structure

Case Study T4: A38 Dobwalls Bypass – Havett Farm Temporary Mitigation

Summary description
Temporary crossing structures were installed during the construction of the A38 Dobwalls Bypass at three locations where bat commuting routes were severed, and prior to the implementation of permanent mitigation measures. Vegetation clearance at this location was undertaken in winter 2006/07. At Havett Farm the line of a hedge was maintained by the provision of camouflage netting approximately 3m high. A monitoring survey was undertaken in June 2007.

Mitigation outcome
No bats were recorded using the temporary crossing structure.

Data limitations
None stated.

Case Study T4:	**A38 Dobwalls Bypass – Havett Farm Temporary Mitigation**
Road & location	A38, near Liskeard, Cornwall
Carriageway type & width	Dual carriageway
Impact of scheme	Removal (and therefore severance) of hedge
Type of structure & span	Camouflage netting; not stated
Installation date	Not stated, assumed early 2007
Baseline	Location corresponded with Havett Farm Bat Bridge. Foraging and commuting activity recorded.
Species recorded at baseline	Common pipistrelle
Flight pattern at baseline	Commuting along line of hedge
Monitoring	**2007**
Dates and duration of surveys	June 3 nights and 2 dawn surveys.
Weather conditions	Not stated
Survey methodology	1 surveyors at dusk and 2 surveyors at dawn. First evening used a fixed-point detector (Tranquillity transect) fixed to a minidisk. Other surveys used Petterson D240x time expansion recorders and minidisks. Mixture of fixed point and transect surveys.
Monitoring results	No bats were recorded using the temporary structure

Case Study T5: A38 Dobwalls Bypass – Lantoom Quarry Temporary Mitigation

Summary description
Temporary crossing structures were installed during the construction of the A38 Dobwalls Bypass at three locations where bat commuting routes were severed, and prior to the implementation of permanent mitigation measures. The distributor road was excavated and vegetation cleared in June 2007, with further felling of 5 trees after survey. At Lantoom Quarry . moveable temporary trees were used to bridge the distributor road and a central island of trees was maintained. A monitoring survey was undertaken in June 2007.

Mitigation outcome
Limited numbers of bats were recorded using the location of the moveable temporary trees and retained central island of trees to cross the road.

Data limitations
None stated.

Case Study T4:	**A38 Dobwalls Bypass – Lantoom Quarry Temporary Mitigation**
Road & location	A38, near Liskeard, Cornwall
Carriageway type & width	Single carriageway distributor road and dual carriageway
Impact of scheme	Removal of vegetation
Type of structure & span	Moveable temporary trees in oil drums, retention of clump of 30-40 trees left as hop-over
Installation date	Evenings, throughout construction
Baseline	Location corresponded with Lantoom Quarry Bat Bridge.
Species recorded at baseline	Pipistrelle species
Flight pattern at baseline	Foraging along vegetation on either side of road
Monitoring	**2007**
Dates and duration of surveys	June 3 nights and 2 dawn surveys.
Weather conditions	Not stated
Survey methodology	1 surveyors at dusk and 2 surveyors at dawn. First evening used a fixed-point detector (Tranquillity transect) fixed to a minidisk. Other surveys used Petterson D240x time expansion recorders and minidisks. Mixture of fixed point and transect surveys.
Monitoring results	1 unidentified bat south to north; 1 common pipistrelle south to north; Indication of Myotis species use