Designing a new access point for lesser horseshoe bats, Gloucestershire, UK

Paola F. Reason[1]*

[1] *Arcadis Consulting (UK) Ltd. The Mill, Brimscombe Port, Brimscombe, Stroud, GL5 2QG, UK*

SUMMARY

The aim of this intervention was to create a new flight-path and roost access point for lesser horseshoe bats (*Rhinolophus hipposideros*) in Gloucestershire, UK. Their existing access point was to be enclosed within an extension to the building they occupied, as part of a redevelopment project. Two designs were tried, and detailed observations were made of bats exiting and attempting to return to their roost. The initial design required the bats to execute a 90° turn at the base of a short vertical shaft, and very few bats returned to the roost through this access point design. The final design provided a clear 'line-of-sight' through the structure enclosing the flight-path; bats did return to the roost via this access point. Before the intervention colony numbers did not exceed 35 bats (adults and young); during the construction period, numbers dropped to just seven individuals. Post-intervention (after 15 years), numbers of lesser horseshoe bats (adults and young) have exceeded 400 individuals.

BACKGROUND

Under UK law, actions such as destroying or modifying a bat roost, or obstructing access to a roost, normally constitute an offence. Actions which may be detrimental to bats (including those arising from development) can be undertaken under a derogation licence, which usually requires appropriate mitigation to be incorporated into any development proposals. However, evidence of the value of many commonly applied mitigation techniques is limited. There is no published evidence on whether actions to retain a bat roost location but alter its entrance points work in practice, or whether bats no longer use a roost once the access points have been changed (Berthinussen *et al*. 2017). This paper reports on the consequences of altering the access points to an existing single-species roost.

A small maternity roost of lesser horseshoe bats (*Rhinolophus hipposideros*) occupied the basement of a large manor house in Gloucestershire which had been converted into a nursing home. The roost had been monitored by the Gloucestershire Bat Group (GBG) between 1993 and 2000, with up to 25 adult individuals recorded. From late 2000, the property was subject to a radical conversion into a luxury hotel, which called for improved kitchen facilities within an extension to the building footprint.

The bats roosted within two adjoining former wine cellars and, to a lesser degree, in a small boiler house roof separated from the main house. To exit the wine cellars, they flew along ducts within the basement, into a small rectangular underground room, up steps, over the top of a cut-down door into a large courtyard, turned left to fly along the adjacent garden wall, entered the boiler-house roof via its open eaves, and exited the other side into garden/woodland (Figure 1).

The proposed footprint of the kitchen extension enclosed the underground room and steps, so bats would no longer be able use this route post-construction. The initial mitigation entailed dividing the underground room, redirecting the bats around the retained section, 'following' the line of the garden wall whilst still underground (Figure 2), and exiting via a 'chute' (Figure 3). The intention was to allow the bats to continue to use the wine cellars without significantly altering the proposals for the kitchen layout. This paper describes the diversion of the flight route and the design and installation of the new access point, which all took place after construction had started.

ACTION

Construction activities relevant to the new access point were: i) separating the underground room into two parts, one dedicated to use by bats; (ii) digging the underground trench along which bats would fly; (iii) linking that service trench to the underground room; and (iv) installing the initial (i.e. vertical) design of the chute as the new roost access point (Figure 4a). In October 2000, the training period began. The original access point was temporarily blocked during the emergence period, forcing' bats to use the newly provided chute to emerge. It was then unblocked after the colony had left, so bats were not

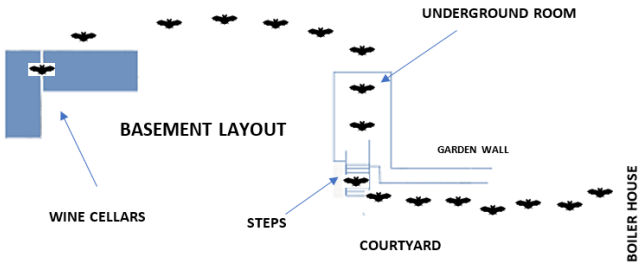

Figure 1. Pre-intervention lesser horseshoe bat roost location (pre-2000). Bats were located within two adjoining former wine cellars (shaded) and in a separate small boiler house roof. To exit the roost, they flew along ducts within the basement, into a small rectangular underground room, up steps, over the top of a cut-down door into a large courtyard, turned left to fly along the adjacent garden wall, entered the boiler house roof via its eaves, and exited the other side into garden/woodland.

*To whom correspondence should be addressed: paola.reason@arcadis.com

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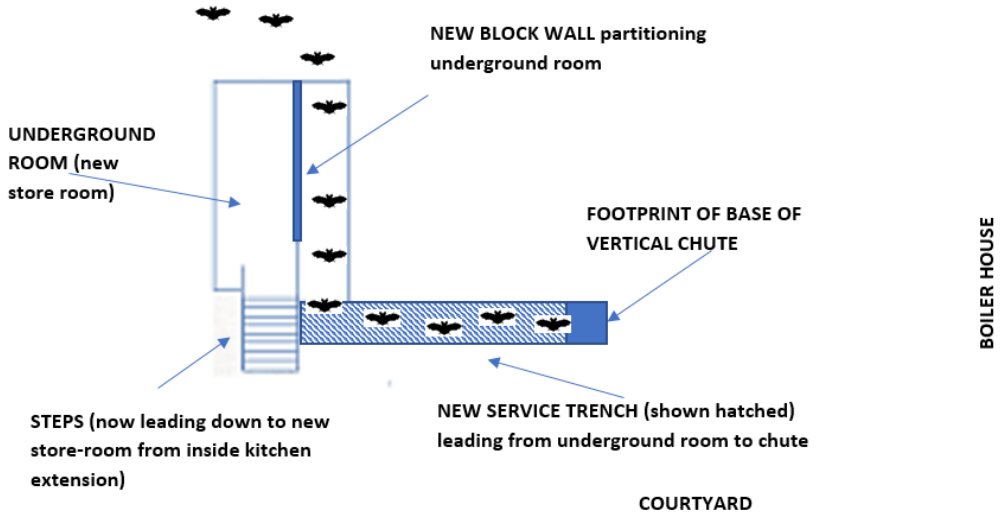

Figure 2. Amended lesser horseshoe bat flight path (post 2000), diverted around the now-divided underground room. This no longer leads up the steps, but alongside them in a separate 'compartment'. On emerging from the chute, the bats would, in theory, continue to fly along the garden wall to enter the boiler house roof via its eaves, exiting the other side into garden/woodland. There were initially two 90º turns in this flight-path; one at each end of the service trench. One is at grade (i.e. on the same level), as the bats turn to enter the service trench from the basement; the other as the bats make a vertical ascent into the chute from the horizontal service trench.

prevented from coming and going during the night. An hour before dawn, the original access point was re-blocked to stop bats returning to the roost from entering other than by the chute

The bats used the vertical chute to exit, but would not use it to return, even after several minor modifications. These included: creating a matching access gap at the rear (to allow the bats to enter from either side); painting the chute with horseshoe bat droppings from the roost made into a slurry to make the exit route smell of bats; throwing in dry droppings for the same reason; and lining the chute with egg boxes to change/improve the way echoes were 'perceived' by returning lesser horseshoe bats.

The chute entrance was bigger than the minimum size specified for lesser horseshoe bats (Mitchell-Jones & McLeish 1999), and they were readily using the new flight-path to exit the roost, so it was clearly navigable in principle. However, they did not return to their roost via the vertical chute.

The return journey required the bats to drop down then navigate a 90° bend; it was considered possible that the echolocation signals produced by the chute's shape did not allow the bats to sense a way through. The chute was therefore substantially modified (Figure 4b and Figure 5) to give the bats a clear 'line of sight' through the structure (the sharp bend between the service trench and the basement was also enlarged to 'soften' the turn). Full modification of all of the components of the chute and flight-path took several months, and the first full trials did not take place until September 2001.

Observations of bat behaviour: During construction, monitoring to assess the impacts of the alterations to the access points on the bats' behaviour took place between 6 and 15 October 2000 and between 22 May and 22 October 2001. Methods included dusk emergence and pre-dawn (return) surveys (using observers equipped with bat detectors). As these data were gathered to observe whether bats were using the new access points and not to determine numbers, the data are described qualitatively but not included in the tables or graphs presented below.

Dusk emergence observations were made from 5-15 minutes prior to sunset until at least 60 minutes after sunset, or until 15 minutes after the last bat had emerged (whichever was the later). At least two observers were used for each observation period, both located within the courtyard (Figure 1).

Pre-dawn counts in 2000-2001 were made from 65-70 minutes prior to sunrise until 15-25 minutes after sunrise, again using observers equipped with bat detectors.

Figure 3. Initial chute design (implemented in 2000). The photograph shows a temporary chute (initial design), the doorway (just visible behind chute) leading to the steps down into the basement, and the courtyard (garden) wall. The boiler house is behind the photographer (photo taken prior to work on the new kitchen extension).

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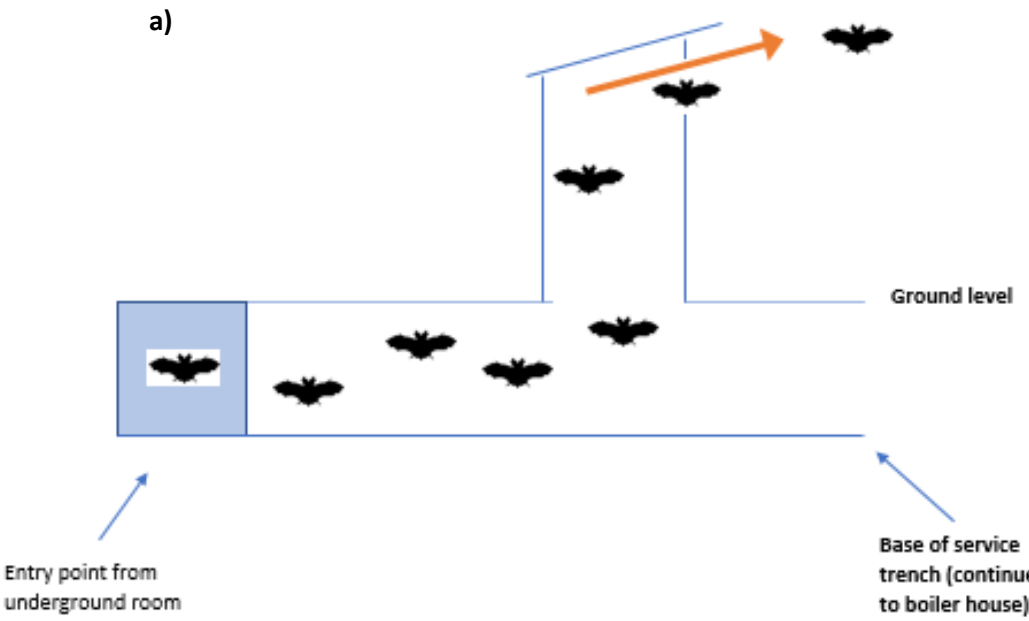

Figure 4a. The vertical chute design, above the service trench. Bats had to negotiate a 90º turn to enter the service trench at the point shaded blue, and again at the base of the chute. Bats used this design to exit but not re-enter. One of the unsuccessful modifications was to create an access gap at the rear of the chute.

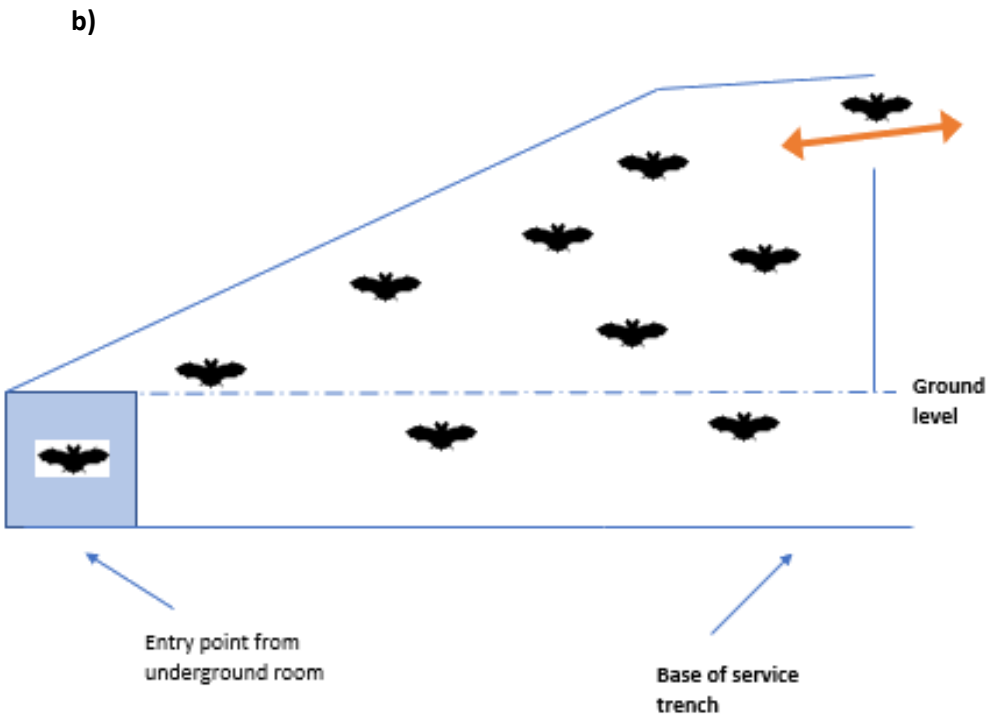

Figure 4b. The line of the new sloped chute design. Bats have a clear line-of-'sight' through to the basement. The two 90º turns (see Figure 2) were 'softened': firstly, by enlarging the link between the underground room and the service trench by removing a section of wall; and secondly, by significantly modifying the shape of the chute. Bats exited and re-entered this design of chute.

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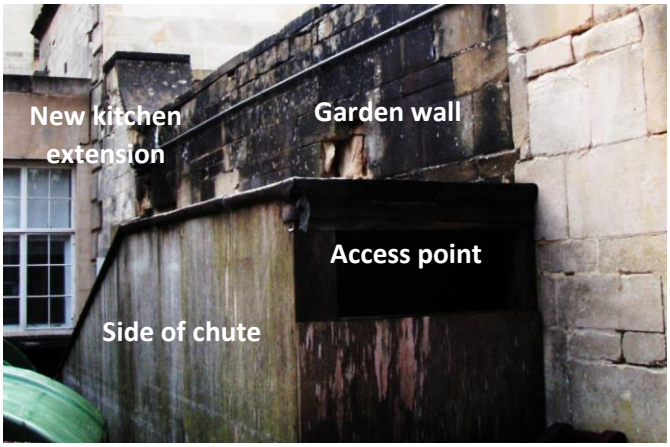

Figure 5. Current chute in place (after several years).

Counts of bat numbers: Initial roost counts were undertaken from 1993-2000 by Gloucestershire Bat Group. Based on their comments that counts included adults and young from July and August in several years, it is assumed that at least some of these data are based on internal roost inspections. These would have recorded the majority of individuals, as lesser horseshoe bats roost by hanging in the open. These data are comparable to emergence survey data gathered subsequently, except that emergence surveys earlier in the year would not include non-flying young, and internal roost counts would. From late July, young would be flying, so emergence surveys would generally count the majority of individuals occupying the roost. In both years of construction, we undertook emergence counts where no modifications were made to the existing roost access point, either to get a baseline count or to allow bats to 'regroup' after blocking the access had dispersed them into more than one location (see 'Consequences'). On these occasions, a third observer was situated outside of the courtyard, on the 'far' side of the boiler house, observing emergence from the boiler house roof to provide a full count of all the bats in the roost. During construction, full counts of the number of bats exiting the roost were made in June, July, and August 2000 and in May and July 2001 (Table 1).

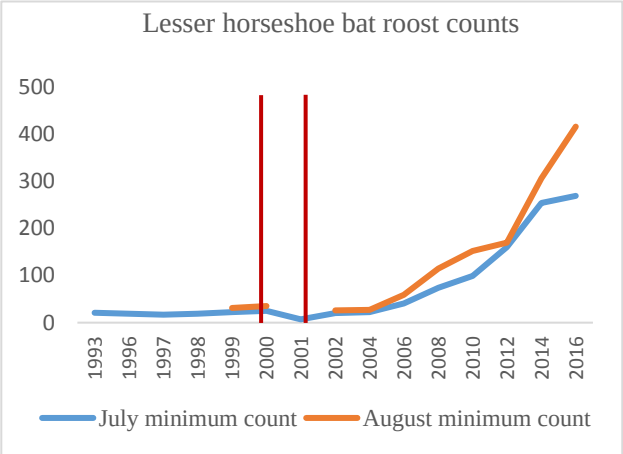

Figure 6. Lesser horseshoe bat roost counts (for raw data see Table 1). For the earliest counts (1993-2000), the maximum count recorded in the period May-July is plotted. The red lines show the period of intervention.

From 2001, all monitoring consisted of dusk emergence counts, with observers equipped with bat detectors. Post-construction, from 2002 to 2017, dusk emergence counts were made in July and August. One observer counted bats exiting the access chute while the other counted bats exiting from the far side of the boiler house eaves to ensure a full count. Dusk emergence counts were made from 5-15 minutes prior to sunset until at least 60 minutes after sunset, or until 15 minutes after the last bat had emerged (whichever was the later).

CONSEQUENCES

Bat behaviour: By the end of the 2000 trial of the altered flight path and new vertical chute (the initial design), only two individuals (on different nights) had returned to the basement roost via the new access chute. Detailed observations were made of the bats in the courtyard as they attempted to return to their roost. During pre-dawn surveys of bats returning to the courtyard, it appeared that bats were attempting to return via the chute, as they skimmed the chute front and back, passing within 10 cm of the access points. However, they did not enter, and after several such circuits, they moved away. After several attempts, some bats clustered in the open by their original, temporarily blocked access point, exposing themselves to daylight as dawn approached. At this point, the existing access point was unblocked, allowing the bats to return to their roost via their traditional route. Bats that did not cluster by the existing access either entered the boiler house, or disappeared into the main house (many access points were created by construction activities) or to an unknown location.

In 2001, when the roost access point was modified so that there was a direct 'line-of-sight' through the structure, bats (in low numbers) again readily used this new chute to emerge, with some individuals exiting and re-entering before finally emerging. They were still not seen to return via the new chute at dawn during this first year; nonetheless, they clearly did return to the roost (as shown by internal roost counts). Importantly, in contrast to the previous year, bats no longer clustered around the former access point during pre-dawn surveys (i.e. they were no longer attempting to use the previous route when temporarily blocked). This was the case even when the existing access point was left blocked between the dusk and pre-dawn surveys. Works continued throughout 2001 and 2002, and bats continued to use the roost. The builders left the site in spring 2002 and the hotel opened in the same year. Regular post-construction monitoring enabled early problems with security and internal lighting to be addressed. These included new lighting in the courtyard which covered the chute access point in its reach, and lighting in the changing rooms (the former boiler house) which was often left on, again illuminating the access point. Modifications included amending the location / reach of the security lighting to ensure the chute access point was not lit; ensuring both security and internal lighting were activated by motion sensors (not permanently on); and requesting that the period during which lighting remained on after activation was reduced, in order to reduce the lighting on the bat access points.

Bat numbers: The roost has remained *in situ* throughout the period. The colony, which numbered around 20 prior to construction, and dipped to below ten individuals during construction, now comprises several hundred individuals (Table 1 and Figure 6).

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Table 1. Lesser horseshoe bat population monitoring from 1993 to 2016.

Stage	Source	Year	May to July counts	August counts
Pre-construction	GBG	**1993**	8 [24/05] 21 [28/05]	No count
Pre-construction	GBG	**1996**	12 [31/05] 17 [08/06] 16 [15/06] 19 [24/06] 14 [27/07]	No count
Pre-construction	GBG	**1997**	17 [29/06]	4 [15/08] Partial count?
Pre-construction	GBG	**1998**	19 [05/06] 18 [11/06]	No count
Pre-construction	GBG	**1999**	22 [07/06] 21 [15/06]	31 [23/08]
Early construction	GBG	**2000**	22 [02/06] 22 [15/06] 25 [31/07]	35 [30/08]
Construction	Arcadis	**2001**	7 [23/05] 7 [03/07] 7 [23/07]	No August count. [15 bats present on 10/09, after the breeding season]
Post-construction	Arcadis	**2002**	20-22 [25/07]	26-27 [21/08]
Post-construction	Arcadis	**2004**	22 [29/07]	27-29 [19/08]
Post-construction	Arcadis	**2006**	41-45 [13/07]	59 [18/08]
Post-construction	Arcadis	**2008**	74-76 [31/07]	115 [26/08]
Post-construction	Arcadis	**2010**	99 [19/07]	152 [16/08]
Post-construction	Arcadis	**2012**	160 [25/07]	170 [13/08]
Post-construction	Arcadis	**2014**	254 [24/07]	306 [20/08]
Post-construction	Arcadis	**2016**	269 [27/07]	416 [17/08]

Column 1 shows the stage of construction (pre-construction; early construction; construction main works; post-construction).

Column 2 identifies the source of the data. Where there was more than one count in May to July, the highest count achieved was plotted in Figure 6.

Counts prior to August are assumed to be largely adults in most years. The later in July a count takes place, the more likely it is that the count includes early flying young. Emergence counts in August assume most young are flying; however, bats are sometimes heard in the chute after the count has finished, indicating not all individuals have emerged, even late in August.

DISCUSSION

The lesser horseshoe bat colony has not only stayed *in situ*, but has increased substantially (over 400 adults and young in the most recent survey). Breeding was confirmed before and after the intervention. During the year of construction, greater numbers were seen after rather than during the breeding season (i.e. in the autumn). This suggests that there were one or more additional roost sites in the vicinity of the project at that time, with individuals moving between roosts. It is possible that individuals have joined the study roost from other roosts, in addition to a population increase from breeding. Whatever the reason for the increase in numbers, the fact that bats returned to pre-construction numbers in the months immediately after construction ceased indicates that the bats fully adopted the final design of the new flight-path and access point.

The reasons for the decrease in numbers of bats in the roost during construction were probably a combination of the lack of heating for the 2001 breeding season (heating was provided pre-construction, and from spring 2002), and disruption due to construction (e.g. noise, lighting, human presence, changes to the building footprint).

From the bats' initial avoidance behaviour in response to the original chute design, there appeared to be a need for a clear 'line of sight' through the chute. It is suggested that future projects attempting to modify roost access points for lesser horseshoe bats should also employ a 'line of sight' entrance where possible, avoiding sharp angles in the flight path at the access point, although this is based on a single study.

The 'training period', whereby bats were only permitted to leave the roost via the new access point, but were allowed to return through their original access point, is likely to have been important in alerting the bats to the existence of the new flight path and exit. Study into the value of providing a training period for bats where access points are modified is recommended. Roost access manipulation needs careful monitoring to ensure bats are not trapped in their roost.

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