MOTT MACDONALD

NDR Ecological Post-Construction Monitoring: Year Three

Bat Mitigation Monitoring

April 2021

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Executive summary

The Norwich Northern Distributer Road (NDR) is a 22km dual carriageway which runs between Fakenham Road (A1067), west of the city (near Attlebridge) to the A47 east of the city (near Postwick). Construction was largely completed over winter 2017/2018 and opened to traffic in April 2018, with on-going localised construction until August 2018. The design included a number of different mitigation measures for commuting bats. The post-construction monitoring of these measures is a requirement of the Development Consent Order.

Bats are protected under the Conservation of Habitats and Species Regulations 2017 (as amended) and the Wildlife and Countryside Act 1981 (as amended). This report provides information on the year three (2020) post-construction monitoring of the bat crossing locations, including seven gantries, two green bridges, two dark corridors and one underpass.

Manned monitoring has demonstrated that the number of observed bats crossing the NDR at the various crossing locations in year three has increased compared to year one and year two. Some crossing locations have seen increased numbers of recorded calls compared to years one and two. The frequency of safe crossings made by bats – those above the height at which there is a risk of vehicle collision mortality – are similar to years one and two, with some crossing locations showing an increase in safe crossings, and others a decrease.

Unmanned monitoring of the crossing locations shows that at least nine species of bat are using the habitat either side of the gantries. This replicates the year one and year two survey findings, again with local variations in activity levels.

It will be necessary to continue to monitor the crossing locations for several more years until their conclusions can be drawn. Future surveys may also identify changes in bat activity as the landscape planting either side of the crossing locations establishes and matures. Monitoring and caring for the vegetation that has been planted as part of the landscaping design is therefore paramount to ensuring that the mitigation functions as intended, with replanting recommended where necessary. Without all aspects of the design, the mitigative effects will be diminished.

1 Introduction

1.1 Project description

Mott MacDonald Ltd has been appointed by Norfolk County Council to undertake the monitoring of bat populations as part of the Norwich Northern Distributor Road (NDR), now known as Broadland Northway. This monitoring consists of post-construction surveys as detailed in the Development Consent Order (DCO) mitigation table. The NDR runs from the Fakenham Road (A1067) to the west of the city (near Attlebridge), eastwards around the north of the city to join with the A47 at Postwick. The route is approximately 22km in length. A map of the route is provided in Appendix A, Figure A1.

1.2 Baseline data

As part of the environmental impact assessment, extensive bat surveys were undertaken between 2008 and 2013, by a team of experienced ecologists from Mott MacDonald and various sub-consultancies; 2008 (EcoGraphics and Kepwick Ecological Surveys), 2009 and 2010 (Mott MacDonald and BSG, with Greena Ecological Consultancy, Geckoella and Corylus Ecology) and 2012 (Mott MacDonald and Greena Ecological Consultancy). These surveys were to support the assessment of the potential impacts of the NDR scheme on local bat populations and to determine required mitigation and licencing requirements. Detailed information can be found in the Norwich Northern Distributer Road – Technical Appendix for Bats from the Environmental Statement.

1.3 Study area

The study area is comprised of 12 different bat crossing mitigation locations along the NDR, including green bridges, bat gantries, dark corridors, and an underpass. The survey type for each location are listed in Table 1 below. The individual survey locations are listed in Section 1.4 with associated location in longitude and latitude and can be found on maps in Appendix A.

Table 1 Survey types conducted for 2020 monitoring surveys.

Survey type	Locations	Notes
Manned static monitoring of bat crossings	12 bat crossing mitigation locations	Surveys were carried out on both sides of the NDR concurrently. Each crossing was surveyed three times, with surveys spaced throughout the season.
Un-manned static monitoring of bat crossings	12 bat crossing mitigation locations	Static detectors were positioned on both sides of the NDR concurrently. Each crossing was surveyed three times, with surveys spaced throughout the season.
Roost emergence/re-entry	15 known roosts	Two roosts (trees) no longer exist. A tree containing roost 8 was felled before the year one monitoring. A branch containing roost 14 was lost in high winds before the start of year two monitoring. Each roost was surveyed twice, with surveys spaced throughout the season.

Survey type	Locations	Notes
Bat box occupancy checks	23 bat boxes	Two checks for each bat box was proposed, however the impacts of the Covid-19 pandemic meant that only one check was possible. To compensate for this each bat box was also subject to an emergence/re-entry survey.
Bat house monitoring	Rackheath bat houses	None
Collision mortality checks	20m each side of all 12 crossings	None

1.4 Survey locations

1.4.1 Crossing locations

- G1 – Gantry 1 (Shooting school access, near Attlebridge). Located: 52.694486, 1.179520.
- GB1 – Green Bridge 1 (Marriot's Way, near Taverham). Located: 52.695989, 1.202887.
- G2 – Gantry 2 (Glebe Farm access, near Horsford). Located: 52.684595, 1.246794.
- G3 – Gantry 3 (St Faith's Road, near Spixworth). Located: 52.679710, 1.300287.
- DC1 – Dark Corridor 1 (Buxton Road, near Spixworth). Located: 52.679369, 1.313574.
- G4 – Gantry 4 (near Beeston Hall cottages). Located: 52.679813, 1.338375.
- G5 – Gantry 5 (near Beeston Hall). Located: 52.678152, 1.344984.
- UP1 – Underpass, (near Rackheath). Located: 52.670320, 1.364544.
- DC2 – Dark Corridor 2 (Newman Road, near Rackheath). Located: 52.664721, 1.367467.
- G6 – Gantry 6 (access off Middle Road, near Great Plumstead). Located: 52.647092, 1.380806
- GB2 – Green Bridge 2 (Middle road, near Great Plumstead). Located: 52.644090, 1.380211.
- G7 – Gantry 7 (Smee Lane, near Great Plumstead). Located: 52.635926, 1.383667.

Maps showing the specific locations can be found in Appendix A.

1.4.2 Roost locations

- Roost 1 – B5 (Shooting School Pig Barn). Located: 52.695566, 1.179788.
- Roost 2 – B55 (Quaker Barn). Located: 52.681103, 1.301882.
- Roost 3 - GB5 (Cottages on Beeston Park). Located: 52.678855, 1.336587.
- Roost 4 - B81 (House on Plumstead Road). Located: 52.655102, 1.384384.
- Roost 5 - B82 (House on Plumstead Road). Located: 52.655136, 1.384616.
- Roost 6 - B85 (House on Plumstead Road). Located: 52.655062, 1.385599.
- Roost 7 - B90 (outbuilding, Red House, Low Road). Located: 52.641534, 1.382674.
- Roost 8 – (W11B, woodland on Buxton Road) - Tree was felled before the start of year one monitoring. Located: 52.681888, 1.313340, approximately.
- Roost 9 - W11D (Woodland on Buxton Road). Located: 52.681888, 1.313340, approximately.
- Roost 10 - W11N (Woodland on Buxton Road). Located: 52.681888, 1.313340, approximately.

- Roost 11 – T475B (Triangle woodland of Spixworth Plantation). Located: 52.679469, 1.326206, approximately.
- Roost 12 – T490 (Tree roost close to Gantry 4). Located: 52.680278, 1.338203.
- Roost 13 – T290 (Tree north east of sewage works). Located: 52.677672, 1.349858.
- Roost 14 – (T511 Tree east of Wroxham Road roundabout) – Roost was lost in high wind between year one monitoring and year two monitoring. Located: 52.674804, 1.360804.
- Roost 15 – T380 (Off Toad Lane, immediately east of Gantry 6). Located: 52.646810, 1.381248.
- Roost 16 – T415 (Low Road, between NDR and Red House). Located: 52.641432, 1.382359.
- Roost 17 – T451 (Smee Lane, immediate east of NDR). Located: 52.635853, 1.384344.

1.4.3 Bat box locations

- Shooting school - 52.695265, 1.173976.
- Spring farm - 52.696661, 1.186970.
- Quaker farm - 52.681514, 1.301585.
- Spixworth plantation - 52.679333, 1.326201.

1.5 Scope of the report

The scope of this report is to:

- Present the results of the 2020 (year three post-construction) surveys of all bat crossing mitigation locations.
- Provide a comparison to the 2018 and 2019 (year one and year two post-construction) survey results, where possible.
- Inform the levels of usage of the mitigation measures over time.
- Provide recommendations for further mitigation and enhancement.
- Provide recommendations for additional future surveys, alongside those already required under the terms of the DCO post-construction monitoring regime and the EPS licence.

1.6 Legislation

All bats and their roosts are fully protected under the Conservation of Habitats and Species Regulations, 2017 (as amended) and the Wildlife and Countryside Act 1981 (as amended). In summary, it is an offence to:

- Take, transport, kill, injure, or disturb any bats when they are at a roost; or
- Damage, destroy or obstruct access to any structure used for breeding or resting by bats.

2 Methodology

All surveys were undertaken in accordance with the Mitigation Tables for post-construction ecological monitoring surveys as presented in both the Norwich Northern Distributor Road Environmental Statement Volume 1 (Mott MacDonald, 2013) and the Construction Environmental Management Plan (Mott MacDonald, 2013). These dictate the number, type and outline methodologies of surveys required. Specific methodologies were based on a combination of Berthinussen & Altringham (2012) and the Bat Conservation Trust Bat Surveys for Professional Ecologists: Good Practice Guidelines 3rd Edition (2016), hereafter referred to as the 'BCT guidelines', as appropriate.

Where deviations from the standard methodologies occur, these are described in section 2.10.

2.1 Manned static monitoring of bat crossings

Dusk and dawn crossing surveys were undertaken three times at all 12 crossing points (Appendix A). For each of the crossings, it was ensured that both dusk and dawn surveys were included. Dusk surveys began 15 minutes before sunset and ended 90 minutes after and dawn surveys began 90 minutes before sunrise, ending 15 minutes after.

Where possible (weather and access permitting) surveys were completed with at least a space of at least two weeks between each survey and were conducted in suitable weather conditions. Those being:

- Temperature above 10°C
- No or sporadic light rain
- Low wind speeds

At each crossing point two surveyors conducted the survey, one either side of the NDR. They positioned themselves at locations where bats crossing the mitigation features could be seen and the flight path identified. For the gantries, this was generally at the top of the carriageway embankment. For the green bridges and dark corridors, this was towards the top of the approach ramp, around 5m back from the end of the bridge deck, to allow bats flying along and either side of the crossing feature to be identified. For the underpass, this was around 5m from (and slightly offset from) the entrance to the underpass. Each surveyor was equipped with time synchronised Batlogger M (handheld bat detectors) with built-in temperature recording capability.

For each bat call and/or sighting, a number of variables were recorded, including the species, date and time of record, direction of travel, vertical distance from the crossing structure (gantry, green bridge, etc) and horizontal distance from the crossing structure. When it could be confirmed that the same bat was recorded by the surveyors either side of the NDR (either end of the crossing mitigation feature), then duplicate records in the survey results were removed to prevent double counting. Vertical and horizontal distance estimations were recorded to the nearest half metre.

For all bat gantries, the flight height from the road was then calculated by taking the vertical distance from the gantry away from the overall height of the gantry (defined as the bottom wire over the road and therefore the gantry's lowest point).

In addition to the above, the direction of the crossing movement was also recorded. The NDR loosely forms an arc around Norwich therefore "inside" refers to the side closest to Norwich and

"outside" refers to that furthest away, so movements were recorded as either inside to outside (i.e. away from Norwich) or outside to inside (i.e. towards Norwich). The activity of bats not crossing the road was also recorded.

2.2 Manned static data analysis

Based on the methodology used in Berthinussen & Altringham (2012), 'safe' and 'unsafe' crossing heights were defined as being greater or less than 5m from the road surface respectively. This is due to the maximum height of heavy goods vehicles being 4.9m in the UK (Department of Transport, 2011). Bats crossing at unsafe heights (less than 5m) are therefore at risk of collision.

For bats which were crossing at a safe height, a definition of using the gantries was taken to be flying within 5m horizontally, if bats were flying within 2m this was also recorded (Berthinussen & Altringham, 2012). These classifications are based on species observations within the literature. Holderied *et al.* (2006) observed whiskered bats *Myotis mystacinus* flying within 1.7m of a hedgerow and Schaub & Schnitzler (2007) found that Daubenton's bat *Myotis daubentonii* flew within 2.1 - 4.5m from a linear feature.

For the green bridges and dark corridors, the height of each bat crossing was recorded in relation to the deck of the bridge. The horizontal distance was taken from the bridge parapet (the safety barrier at the edge of the bridge); the route of each bat crossing was also recorded. The nature of the specific green bridge/dark corridor was then considered, to assess whether or not the bat crossing was either safe or unsafe, depending on whether or not the feature carries vehicle traffic. For example the Marriott's Way green bridge does not carry traffic, so even bats using it at a height of 1 metre would not be at risk of vehicle collision, whereas the Middle Road green bridge and the two dark corridors do carry traffic, so judgement in terms of height and horizontal position were used.

Bats crossing at the underpass were considered to be safe when the underpass was used, allowing the bat to cross beneath the road. Any bats flying over the road at a height of less than 5m were considered to be crossing at an unsafe height; those crossing above 5m were considered to be safe, although they were not using the underpass.

2.3 Unmanned static monitoring of bat crossings

Static acoustic detectors were deployed at the 12 bat crossing locations along the Scheme. At each location, detectors were deployed on both sides of the NDR. Where possible, detector microphones were attached at the bat crossing facing away from the road. In areas where there is public access, or if works (i.e. landscaping) were ongoing in the immediate area, then detectors were placed close to the crossing. The 12 locations can be found in Figures A1 to A3, Appendix A. At each location, detectors were deployed for at least five consecutive nights on three separate occasions between May and September. The increase in the number of survey nights from 2019 is contributed to equipment upgrades. Poor battery life was a limitation in 2019; an issue rectified for the 2020 season. Due to several instances of memory card failure two surveys were repeated, extending the programme into the first week of October. Seasonal (autumn) behaviours such as swarming, has the potential to skew data.

2.4 Call analysis

One bat pass was defined as one track on the Batlogger. The Batlogger detectors are set up so that if there is at least a one second gap between a call a new track is started and therefore can be deemed to be a new pass.

All call analysis was undertaken by experienced ecologists using Kaleidoscope Pro to identify calls to species level where possible. Where needed, British Bat Calls: A Guide to Species Identification (Ross, 2012) was used to aid analysis. All calls excluding those from pipistrelles were then checked using Bat Explorer to verify the identification. Within the genus *Myotis*, call parameters overlap markedly, making their identification to species level very difficult. Where it has been possible to identify these species, this has been done. In all other cases, the calls have been grouped under '*Myotis spp'*.

2.5 Unmanned static detector analysis

Once call analysis was completed, the total number of passes were calculated for each location for each species. To account for variations in the total number of days of recording (caused by failure of the equipment for example), an average daily level of bat activity was calculated by dividing the total number of passes recorded by the number of full nights they were deployed. This allowed for the number of survey nights to be accounted for across the locations, and the average number of calls per night calculated. The data are displayed in Table 7, section 3.3. It should be noted that Year Three includes data from October, as mentioned in section 2.3.

2.6 Known roost surveys

Emergence/re-entry surveys were undertaken on all known roosts within 50m of the Scheme boundary. Surveys were completed by a team of experienced ecologists. Two surveys were undertaken between May and September for each of the roosts. As detailed in Section 2.1, surveys were only conducted in suitable weather conditions.

Surveyors were positioned around the tree or structure to provide coverage of all known roost features, and bat activity was recorded using a combination of visual observation and full spectrum bat detectors. Each surveyor used a Batlogger M with built in GPS, clock and temperature recording capability. Bat activity, including emergence or re-entry from roosting locations, passes and foraging activity were recorded as were bat species and number. Dusk emergence surveys started 15 minutes before sunset and ended between 1.5 to 2 hours after sunset. Re-entry surveys began 1.5 hours before sunrise and ended 15 mins after.

Locations for each of the known roosts can be found in Appendix B.

2.7 Bat house surveys

One dusk and one dawn survey was undertaken on each bat house. Surveys were undertaken in July and again in September. Surveys were only conducted in suitable weather conditions, detailed in section 2.1. Surveyors were positioned around the bat houses to provide coverage of all the potential roost features (PRFs) and bat activity was recorded using a combination of visual observation and aural full spectrum bat detectors. Each surveyor used a Batlogger M+ with built in GPS, clock and temperature recording capability. Bat activity, including emergence from roosting locations, passes and foraging activity were recorded as were bat species and numbers. Dusk emergence surveys started 15 minutes before sunset and ended 1.5hrs after sunset.

2.8 Bat box occupancy checks

23 bat boxes across four separate sites were surveyed for bat activity. The four sites were all located within 150m of the scheme as follows:

- Fakenham Road – Boxes 1 - 3
- Spring Farm – Boxes 4 - 6

- Quaker Farm – Boxes 7 - 11
- Spixworth Plantation – Boxes 12 - 23

Where rope assisted tree climbing was required, it was done so following the methods outlined in the NPTC 206 and 306 (CS38) aerial tree climbing and aerial rescue course. This involved two surveyors, one on the ground at all times and another using a rope or ladder to gain access to the bat box. Once at the correct height, the surveyor opened the box to inspect internally. Any boxes that were occupied were quickly closed again after the species and number were recorded. Where boxes had been occupied by other creatures such as insects or birds, if safe to do so, the bat box was cleaned.

2.9 Bat – vehicle collision checks

Two bat vehicle collision surveys were undertaken at each of the crossing points between May and August. Surveys began approximately 20 minutes after sunrise and involved a pair of surveyors slowly searching the hard shoulder and bank vegetation for bat remains 20m either side of the crossing on both sides of the road.

2.10 Survey limitations

2.10.1 Manned static monitoring

Collecting data on distances from the crossing features relies on the estimation and judgement of several ecologists; consequently, there is unknown variance that cannot fully be controlled for. Furthermore, the positioning of the surveyor can alter the perceived perspective of a crossing bat's position relative to a gantry. In previous years at gantry 2 the survey was only conducted from the inside. In year three both sides were used to survey this crossing location. These limitations were accounted for as far as possible by consistent positioning of the surveyors, and by providing surveyors with information on the dimension of various parts of the gantries, to use as reference. For example, the height and width of the mesh of the gantry, the width between gantry tower supports, the height of bridge parapets etc.

When light levels became low, bats became harder to see, especially when bats were flying in front of a dark landscape (e.g. woodland). It is therefore possible that some bats were missed during the surveys.

Each survey conducted on the underpass was done from the 'inside' of the NDR, i.e. the western side of the road. This was due to high water levels on the eastern side. To combat this limitation, one surveyor was positioned facing the underpass opening, while the other was positioned 20m south of the inside entrance to the underpass. This allowed the detection of bats crossing above the underpass, over the road.

2.10.2 Unmanned static monitoring

Due to the proximity to the road, static detectors would often record the noise from traffic, resulting in memory cards becoming full before completion of the full survey period. Repeating the survey did not guarantee that the same issue would not occur.

On a number of occasions, some detectors' memory cards failed while out in the field, reducing the total number of nights of recording. More regular visits to the static detectors were employed to combat this issue as far as practicable. Table 2 below, demonstrates the improvement in total number of survey nights.

Table 2 The total number of survey nights for each static detector deployment.

Location	Total nights of deployment in 2019	Total nights of deployment in 2020
Gantry 1	12	18
Gantry 2	12	17
Gantry 3	10	23
Gantry 4	9	23
Gantry 5	11	23
Gantry 6	9	20
Gantry 7	12	22
Buxton road dark corridor	8	21
Newman road dark corridor	12	19
Marriot's way green bridge	12	21
Middle road green bridge	7.5	21
Underpass	10	21

2.10.3 Bat box checks

Bat box checks were limited due to surveyor availability; a surveyor with the correct licence was not available to conduct the first of the two checks due to restrictions on movement associated with the Covid-19 pandemic. These checks were replaced with emergence/re-entry surveys.

3 Results

Across all 2020 bats surveys, at least nine species were recorded using the study area, in some instances, species in the genus *Myotis* were unable to be identified to species level:

Common pipistrelle *Pipistrellus pipistrellus*	Widespread and common throughout Britain. Common pipistrelles forage across a range of habitats including deciduous woodland, parkland, gardens and fresh water.
Soprano pipistrelle *Pipistrellus pygmaeus*	Widespread and common throughout Britain. Soprano pipistrelles are generally more specific in their habitat choice when compared to common pipistrelles, often choosing to forage over freshwater habitats.
Nathusius' pipistrelle *Pipistrellus nathusii*	An uncommon species although relatively widespread throughout England. Forages along woodland edges and over fresh water.
Daubenton's bat *Myotis daubentonii*	Common and widespread throughout Britain. Daubenton's bats will regularly forage over fresh water where they trawl insects from the water's surface. They can also be found in other habitats such as open woodland and tree lines.
Natterer's bat *Myotis nattereri*	Widespread throughout England. Natterer's bats can be found foraging close to vegetation gleaning insects from surfaces. Will often forage in deciduous woodland, along treelines and above water
Barbastelle *Barbastella barbastellus*	A rare species generally confined to the southern half of Britain. Forages both beneath and over the tree canopy, often flying lower earlier in the night and moving higher later. Main foraging habitat is deciduous woodland but does forage in other areas.
Brown-long eared bat *Plecotus auritus*	Common and widespread throughout Britain. Brown long-eared bats will forage by gleaning insects off surfaces of vegetation. They are found in habitats that include deciduous and coniferous woodland, parkland and gardens.
Serotine *Eptesicus serotinus*	An uncommon species generally restricted to the south and south-east of England. Serotines generally forage between 4 and 12m from the ground. They will often feed along linear features including woodland edges and large hedgerows.
Noctule *Nyctalus noctula*	Widespread throughout England. The UK's largest bat, noctules will generally feed between 10 and 50m from the ground. They feed over a range of habitats including deciduous woodland, parkland and freshwater.

Due to the considerable overlap in call parameters of some *Myotis* species, many calls were only identified to genus, and are recorded in the tables below as *Myotis spp*.

3.1 Manned static monitoring of bat crossings

Below is a summary of the total numbers of bats recorded crossing the NDR, during the three manned surveys at each location. More details can be found in the tables in Section 3.2, as described below.

3.1.1 Bat gantries

Below is a summary of the gantry crossings. Only bats that crossed within 5m of the gantry were considered.

- Gantry 1 - A total of 19 bats were recorded crossing, of these four bats crossed safely at heights above five meters, while using the gantry. This equates to 21% safely crossing.
- Gantry 2 – A total of 28 bats were recorded crossing, of these, seven crossed at a safe height, while using the gantry. This equates to 25% safely crossing.
- Gantry 3 – Sixteen bats were recorded crossing; eight of these crossings were at a safe height, while using the gantry. This equates to 68.8% safely crossing.
- Gantry 4 – This location had the most observed activity, with 45 bats crossing; 27 of these crossings were at a safe height, while using the gantry. This equates to 60% safely crossing.
- Gantry 5 – A total of five bats were recorded crossing. Four of these crossing were at a safe height, while using the gantry. This equates to 80% safely crossing.
- Gantry 6 – Twenty-two bats were witnessed to cross during surveys of Gantry 6. Of the 22 bats, 14 crossed safely, while using the gantry. This equates to 63.6% safely crossing.
- Gantry 7 – A total of 32 bats were recorded crossing, of these 11 bats crossed safely, while using the gantry. This equates to 34.4% safely crossing.

Full details of all crossings at the bat gantries observed during the manned surveys can be found in Table 3, in Section 3.2.1.

3.1.2 Green bridges

The Marriott's Way green bridge had 15 bat crossings during the three visits in the 2020 season, more than three times the number of observed crossings from 2019. In contrast, only two crossings were recorded at the Middle Road green bridge. Full details of all crossings at the green bridges observed during the manned surveys can be found in Table 4, in Section 3.2.1.

3.1.3 Dark corridors

The Newman Road dark corridor had two recorded crossings recorded from three visits in 2020, both of which were at a safe height. One bat, a noctule, did not cross using the dark corridor. The other, a brown long eared, crossed within 4m of the bridge parapet.

The Buxton Road dark corridor had four bats crossings during the three visits in the 2020 survey season. Of these four bats, three crossed safely and one crossed unsafely. The unsafe crossing

was centrally down Buxton Road at an estimated height of 1.8m, putting the bat at risk of being hit by vans or large cars.

3.1.4 Underpass

There were twenty-three recorded bats crossing at the underpass location, however of these, 10 used the tunnel itself. Full details of all crossings at the underpass observed during the manned surveys can be found in Table 3, in Section 3.2.1.

3.2 Observed crossings during manned crossing surveys

3.2.1 Observed crossings at bat gantries

Table 3 Observed crossings at each of the seven gantries across the NDR

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
Gantry 1	18.05.20	21:10	Noctule	Out – in	20	7.923	Safe	10+	No	No	Crossed diagonally. Not using feature.
		21:30	Common pipistrelle	In – Out	4.5	7.923	Unsafe	4	No	Yes	
		21:40	Pipistrelle spp.	In - out	5	7.923	Safe	3	No	Yes	
		21:46	Myotis spp.	Out - in	3	7.923	Unsafe	2	Yes	Yes	
		21:28	Common pipistrelle	Out – in	4	7.923	Unsafe	4	No	Yes	Ascending crossing
		21:39	Common pipistrelle	Out – in	5	7.923	Unsafe	3	No	Yes	
	11.06.20	21:55	Common pipistrelle	In – out	3	7.923	Unsafe	10	No	No	Flew low, just over the fence. Not using feature.
		21:56	Common pipistrelle	In – out	5	7.923	Safe	2	Yes	Yes	
		21:58	Soprano pipistrelle	Out – in	3	7.923	Unsafe	4	No	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		22:16	Soprano pipistrelle	Out – in		7.923					No information
		22:18	Brown long eared	Out – in	3	7.923	Unsafe	4	No	Yes	
		22:31	Soprano pipistrelle	Out - in	8	7.923	Safe	0	Yes	Yes	
	02.07.20	03:45	Common pipistrelle	Out – in	4	7.923	Unsafe	2	Yes	Yes	
		03:55	Common pipistrelle	Out - in	6	7.923	Safe	10	**	**	
	06.07.20	21:53	Common pipistrelle	In - out	4	7.923	Unsafe	1	Yes	Yes	
		22:05	Soprano pipistrelle	In - out	11	7.923	Safe	0	Yes	Yes	
		22:07	Soprano pipistrelle	In – out	4	7.923	Unsafe	8	No	No	Not using feature.
		22:13	Pipistrelle spp.	In – out	4	7.923	Unsafe	1	Yes	Yes	
		22:17	Soprano pipistrelle	Out - in	4	7.923	Unsafe	10	No	No	
Gantry 2	21.05.20	Not given	Common pipistrelle	Out - in	2.5	8.420	Unsafe	2	Yes	Yes	
		21:26	Common pipistrelle	Out – in	1.5	8.420	Unsafe	4	No	Yes	
		21:30	Common pipistrelle	Out - in	2.5	8.420	Unsafe	0	Yes	Yes	
		21:31	Common pipistrelle	Out - in	3	8.420	Unsafe	1	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		21:32	Common pipistrelle	Out – in	2.5	8.420	Unsafe	4	No	Yes	
		21:33	Pipistrelle spp.	Out - in	2.5	8.420	Unsafe	5	No	Yes	
		21:35	Common pipistrelle	In - out	2.5	8.420	Unsafe	2	Yes	Yes	
		21:36	Soprano pipistrelle	In - out	1.5	8.420	Unsafe	1	Yes	Yes	
		21:38	Common pipistrelle	In – out	2.5	8.420	Unsafe	1	Yes	Yes	
		21:39	Common pipistrelle	In - out	2.5	8.420	Unsafe	1	Yes	Yes	
		21:45	Common pipistrelle	Out- in	5.5	8.420	Safe	1	Yes	Yes	
		21:51	Barbastelle	In - out	4.5	8.420	Unsafe	0	Yes	Yes	
		21:52	Common pipistrelle	Out - in	2.5	8.420	Unsafe	0	Yes	Yes	
		21:57	Common pipistrelle	Out - in	8.5	8.420	Safe	3	No	Yes	
		22:09	Barbastelle	In – out	7.5	8.420	Safe	1	Yes	Yes	
	19.06.20	03:14	Unknown	Out – in	3.5	8.420	Unsafe	2	Yes	Yes	
		03:14	Unknown	Out - in	3.5	8.420	Unsafe	2	Yes	Yes	
		03:15	Common pipistrelle	Out – in	7.5	8.420	Safe	1	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		03:16	Soprano pipistrelle	Out – in	6.5	8.420	Safe	3	No	Yes	
		03:17	Unknown	In - out	3.5	8.420	Safe	1-3**	Yes**	Yes	
		03:24	Brown long eared	Out – in	2.5	8.420	Unsafe	1	Yes	Yes	
		03:30	Barbastelle	Out – in	2.5	8.420	Unsafe	1	Yes	Yes	
		03:33	Unknown	In – out	3.5	8.420	Unsafe	1	Yes	Yes	
		03:33	Unknown	In - out	4.5	8.420	Unsafe	1	Yes	Yes	
		03:38	Common pipistrelle	In – out	3.5	8.420	Unsafe	15	No	No	Not using feature.
		03:46	Pipistrelle spp.	In - out	2.5	8.420	Unsafe	3	No	Yes	
	02.07.20	22:16	Common pipistrelle	Out - in	3.5	8.420	Unsafe	2	Yes	Yes	
		22:25	Common pipistrelle	In – out	5.5	8.420	Safe	5	No	Yes	
Gantry 3	21.05.20	21:30	Pipistrelle spp.	In – out	4.5	8.519	Unsafe	4	No	Yes	
		21:33	Noctule	Out – in	23.5	8.519	Safe	15	No	No	Not using feature.
	25.06.20	Not given	Common pipistrelle	In – out	13.5	8.519	Safe	0	Yes	Yes	
		Not given	Common pipistrelle	In – out	13.5	8.519	Safe	0	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		22:08	Common pipistrelle	Out – in	11.5	8.519	Safe	0	Yes	Yes	
		22:08	Soprano pipistrelle	In - out	10.5	8.519	Safe	1	Yes	Yes	
		22:08	Common pipistrelle	Out – in	6.5	8.519	Safe	Not given**	N/A	N/A	
		22:12	Common pipistrelle	In - out	13.5	8.519	Safe	Not given**	N/A	N/A	
		22:17	Soprano pipistrelle	In - out	3.5	8.519	Unsafe	Not given**	N/A	N/A	
		22:21	Soprano pipistrelle	Out - in	4.5	8.519	Unsafe	2	Yes	Yes	
		22:23	Common pipistrelle	Out – in	7.5	8.519	Safe	2	Yes	Yes	
		22:23	Common pipistrelle	Out – in	5.5	8.519	Safe*	1	Yes	Yes	
		22:23	Soprano pipistrelle	Out - in	4.5	8.519	Unsafe	Not given**	N/A	N/A	
		22:37	Common pipistrelle	In - out	3.5	8.519	Unsafe	1	Yes	Yes	
	07.07.20	03:13	Common pipistrelle	In - out	9.5	8.519	Safe	2	Yes	Yes	
		03:50	Common pipistrelle	Out – in	5.5	8.519	Safe*	2	Yes	Yes	
Gantry 4	28.05.20	21:26	Common pipistrelle	In - out	6	8.950	Safe*	20	No	No	Not using feature.
		21:28	Common pipistrelle	In – out	6	8.950	Safe*	18	No	No	Not using feature.

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		21:34	Soprano pipistrelle	In – out	6	8.950	Safe*	18	No	No	Not using feature.
		21:35	Soprano pipistrelle	In – out	7	8.950	Safe	10	No	No	Not using feature.
		21:47	Soprano pipistrelle	In – out	6	8.950	Safe*	10	No	No	Not using feature.
		21:50	Common pipistrelle	In – out	6-9**	8.950	Safe*	0	Yes	Yes	
		21:53	Common pipistrelle	In – out	5	8.950	Safe	8	No	No	Not using feature.
		21:59	Common pipistrelle	In – out	5	8.950	Safe*	1	Yes	Yes	
		22:15	Common pipistrelle	In – out – in	3 – 7**	8.950	Unsafe*	10	No	No	Bat crossed halfway, then returned. Not using feature.
	10.06.20	21:37	Common pipistrelle	In - out	6	8.950	Safe*	4	No	Yes	
		21:38	Common pipistrelle	Out – in	10	8.950	Safe	3	No	Yes	
		21:40	Pipistrelle spp.	In – out	7	8.950	Safe	3	No	Yes	
		21:40	Soprano pipistrelle	Out- in	6	8.950	Safe*	5	No	Yes	
		21:41	Pipistrelle spp.	In – out	8	8.950	Safe	5	No	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		21:48	Soprano pipistrelle	In – out	4	8.950	Unsafe	4	No	Yes	
		21:54	Pipistrelle spp.	In – out	2.5	8.950	Unsafe	4	No	Yes	
		22:04	Soprano pipistrelle	In – out	10	8.950	Safe	3-6**	No	Yes	
		22:05	Common pipistrelle	In – out	10	8.950	Safe	3-6**	No	Yes	
		22:07	Soprano pipistrelle	In - out	10	8.950	Safe	3-6**	No	Yes	
		22:08	Common pipistrelle	In – out	2.5	8.950	Unsafe	2.5	No	Yes	
		22:09	Soprano pipistrelle	In- out	10	8.950	Safe	2-7**	**	**	
		22:10	Soprano pipistrelle	In – out	10	8.950	Safe	2-7**	**	**	
		22:12	Common pipistrelle	In - out	3	8.950	Unsafe	6	No	No	Not using feature.
		22:12	Common pipistrelle	In – out	6	8.950	Safe*	3	No	Yes	
		22:12	Common pipistrelle	In – out	7	8.950	Safe	5	No	Yes	
		22:12	Common pipistrelle	In – out	7	8.950	Safe	2	Yes	Yes	
		22:16	Common pipistrelle	In – out	8	8.950	Safe	3	No	Yes	
		22:17	Common pipistrelle	In - out	7	8.950	Safe	4	No	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		22:22	Common pipistrelle	In – out	10	8.950	Safe	4	No	Yes	
		22:42	Noctule	In – out	16	8.950	Safe	10+	No	No	Not using feature.
	23.06.20	03:03	Common pipistrelle	Out – in	5	8.950	Safe*	3	No	Yes	
		03:04	Pipistrelle spp.	Out – in	6	8.950	Safe*	2	Yes	Yes	
		03:09	Common pipistrelle	Out – in	8	8.950	Safe	1	Yes	Yes	
		03:09	Common pipistrelle	Out – in – out	6	8.950	Safe*	0.5	Yes	Yes	
		03:10	Common pipistrelle	Out – in	5	8.950	Safe*	2	Yes	Yes	
		03:12	Pipistrelle spp.	Out – in	6	8.950	Safe*	3	No	Yes	
		03:17	Common pipistrelle	Out- in	5	8.950	Safe*	1	Yes	Yes	
		03:18	Brown long eared	In – out	6	8.950	Safe*	10	No	No	Not using feature.
		03:20	Barbastelle	Out – in	5	8.950	Safe*	3	No	Yes	
		03:23	Common pipistrelle	Out – in	6	8.950	Safe*	3	No	Yes	
		03:26	Common pipistrelle	Out – in	6	8.950	Safe*	2	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		03:26	Common pipistrelle	Out – in	5	8.950	Safe*	2	Yes	Yes	
		03:38	Noctule	Out – in	8	8.950	Safe	12-15**	No	No	Not using feature.
		03:43	Common pipistrelle	Out – in	3	8.950	Unsafe	1	Yes	Yes	
		03:52	Common pipistrelle	Out - in	3	8.950	Unsafe	0	Yes	Yes	Flew in between the gantry poles, perfectly central crossing.
Gantry 5	01.05.20	22:30	Soprano pipistrelle	In - out	7	8.950	Safe	5	No	Yes	
		22:30	Soprano pipistrelle	In – out	7	8.950	Safe	5	No	Yes	
	26.06.20	02:57	Soprano pipistrelle	Out – in	8	8.950	Safe	0	Yes	Yes	
		03:02	Common pipistrelle	Out – in	6	8.950	Safe	8	No	No	Not using feature.
	07.07.20	22.05	Soprano pipistrelle	In – out	8	8.950	Safe	1	Yes	Yes	
Gantry 6	10.06.20	21:56	Common pipistrelle	In – out	2.5	8.350	Unsafe	6	No	No	Not using feature.
		21:54	Soprano pipistrelle	In – out	5.5	8.350	Safe*	1	Yes	Yes	
		22:09	Common pipistrelle	In - out	5.5	8.350	Safe*	1	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		22:15	Common pipistrelle	Out – in	5.5	8.350	Safe*	2	Yes	Yes	
		22:18	Common pipistrelle	Out – in	8.5	8.350	Safe	1	Yes	Yes	
		22:19	Barbastelle	Out - in	7.5	8.350	Safe	1	Yes	Yes	
		22:23	Soprano pipistrelle	In – out	7.5	8.350	Safe	2	Yes	Yes	
		22:24	Common pipistrelle	In – out	6.5	8.350	Safe	1	Yes	Yes	
		22:29	Common pipistrelle	In - out	9.5	8.350	Safe	3	Yes	Yes	
		22:33	Pipistrelle spp.	In - out	8.5	8.350	Safe	20	No	No	Not using feature.
		22:37	Barbastelle	Out - in	9.5	8.350	Safe	1-2**	Yes	Yes	
	08.07.20	21:37	Noctule	Out – in	10.5	8.350	Safe	10	No	No	
		21:40	Noctule	Out – in	11.5	8.350	Safe	5	No	Yes	
		21:43	Noctule	See notes	12.5	8.350	Safe	5	No	Yes	Direction not given.
		21:46	Noctule	In – out	2.5	8.350	Unsafe	2	Yes	Yes	
		21:46	Noctule	See notes	10.5	8.350	Safe	4	No	Yes	Direction not given.
		21:53	Myotis spp.	Out – in	2.5	8.350	Unsafe	1	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		21:56	Myotis spp.	In – out	1.5	8.350	Unsafe	1	Yes	Yes	
		22:03	Common pipistrelle	In – out	12.5	8.350	Safe	2	Yes	Yes	
		22:05	Common pipistrelle	In – out	7.5	8.350	Safe	1	Yes	Yes	
		22:11	Common pipistrelle	Out – in	4.5	8.350	Unsafe	10	No	No	Not using feature.
		22:11	Common pipistrelle	In – out	4.5	8.350	Unsafe	10	No	No	Not using feature.
Gantry 7	04.06.20	21:39	Common pipistrelle	Out – in	5.0	7.087	Safe*	6	No	No	Not using feature.
		21:43	Common pipistrelle	Out – in	2.0	7.087	Unsafe	2	Yes	Yes	
		21:44	Common pipistrelle	Out – in	7.0	7.087	Safe	2	Yes	Yes	
		21:48	Common pipistrelle	Out – in	7.0	7.087	Safe	2	Yes	Yes	
		21:57	Common pipistrelle	Out – in	3.0	7.087	Unsafe	2	Yes	Yes	
		21:58	Common pipistrelle	Out – in	7.0	7.087	Safe	3	No	Yes	
		21:59	Common pipistrelle	In – out	2.0	7.087	Unsafe	2	Yes	Yes	
		22:00	Common pipistrelle	In – out	11.0	7.087	Safe	1	Yes	Yes	
		22:04	Soprano pipistrelle	In – out	2.0	7.087	Unsafe	2	Yes	Yes	

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		22:05	Pipistrelle spp.	Out – in	6	7.087	Safe*	1	Yes	Yes	
		22:06	Common pipistrelle	In – out	1.0	7.087	Unsafe	3	No	Yes	
		22:06	Brown long eared	Out – in	1.0	7.087	Unsafe	1.5	Yes	Yes	
		22:06	Brown long eared	Out – in	1.0	7.087	Unsafe	1.5	Yes	Yes	
		22:08	Soprano pipistrelle	Out – in	13.0	7.087	Safe	2	Yes	Yes	
		22:18	Soprano pipistrelle	In – out	1.0	7.087	Unsafe	3	No	Yes	
		22:28	Common pipistrelle	In - out	7.0	7.087	Safe	1	Yes	Yes	
	01.07.20	03:40	Common pipistrelle	In – out	3.5	7.087	Unsafe	0	Yes	Yes	
		03:41	Common pipistrelle	In – out	3.5	7.087	Unsafe	2	Yes	Yes	
		03:41	Common pipistrelle	Out - in	3.5	7.087	Unsafe	2	Yes	Yes	
	03.09.20	19:59	Soprano pipistrelle	In – out	6.0	7.087	Safe	2	Yes	Yes	
		19:59	Soprano pipistrelle	In – out	7.0	7.087	Safe	2	Yes	Yes	
		19:59	Soprano pipistrelle	In – out	8.0	7.087	Safe	3	No	Yes	
		20:06	Common pipistrelle	Out- in	7.0	7.087	Safe	20	No	No	Not using feature.

Location	Date	Time	Species	Direction of crossing	Distance above road surface (m)	Height of gantry (m)	Safe / unsafe	Horizontal distance from centre (m)	Crossing within 2m (horizontal distance)	Crossing within 5m (horizontal distance)	Notes
		20:07	Common pipistrelle	In – out	3.0	7.087	Unsafe	1	Yes	Yes	
		20:09	Common pipistrelle	In – out	3.0	7.087	Unsafe	2	Yes	Yes	
		20:09	Common pipistrelle	Out – in	2.0	7.087	Unsafe	2	Yes	Yes	
		20:11	Common pipistrelle	Out - in	2.0	7.087	Unsafe	2	Yes	Yes	
		20:19	Common pipistrelle	Out – in	8.0	7.087	Safe	12	No	No	Not using feature.
	17.09.20	19:37	Common pipistrelle	In – out	6.0	7.087	Safe	4	No	No	Not using feature.
		19:43	Soprano pipistrelle	Out – in	1.0	7.087	Unsafe	1	Yes	Yes	
		19:51	Pipistrelle spp.	Out – in	6.0	7.087	Safe	15	No	No	Not using feature.
		19:52	Soprano pipistrelle	Out – in	5.0	7.087	Safe*	3	No	Yes	

* - These individual bat crossings are between 5 and 6 metres in height above the carriageway level, and so according to the methodology are considered to be safe. However, it is possible that bats crossing between these heights may be adversely affected by the air turbulence due to fast-moving HGVs.

** - Where bat crossing movements have included a variation on distance from the feature (horizontal or vertical), the range has been shown, in some cases these data were not captured.

*** - In some instances, the detectors did not record bat calls, despite a bat being observed as crossing the NDR. In these cases, an attempt at identification was made based on flight characteristics.

3.2.2 Green bridges, dark corridors and underpass

Table 4 Observed crossings at each of the green bridges, Marriott's Way and Middle Road

Location	Date	Time	Species	Direction	Approximate height above bridge (m)	Safe/ unsafe	Approximate horizontal distance from parapet (m)	Crossing within 2m	Crossing within 5m	Notes
Marriot's Way green bridge	19.05.20	21:38	Common pipistrelle	In – out	1	Safe	See notes	Yes	Yes	Central crossing
	01.07.20	22:11	Noctule	In – out	6	Safe		Yes	Yes	Central crossing
		22:15	Soprano pipistrelle	In – out	3	Safe		Yes	Yes	
		22:18	Common pipistrelle	Out – in	1	Safe		Yes	Yes	Central crossing
		22:20	Common pipistrelle	Out – in	2	Safe		Yes	Yes	
		22:20	Soprano pipistrelle	In – out	3	Safe		No	Yes	
		22:26	Common pipistrelle	Out- in	2.5	Safe		Yes	Yes	Central crossing
		22:28	Soprano pipistrelle	Out – in	2	Safe		Yes	Yes	Central crossing
		22:30	Common pipistrelle	Out – in – out	2	Safe		Yes	Yes	Central crossing
		22:32	Soprano pipistrelle	Out – in – out	2	Safe		Yes	Yes	Central crossing
		22:35	Pipistrelle spp.	Out – in – out	2	Safe		Yes	Yes	Central crossing
		22:36	Pipistrelle spp.	Out – in – out	2	Safe		Yes	Yes	Central crossing

Location	Date	Time	Species	Direction	Approximate height above bridge (m)	Safe/ unsafe	Approximate horizontal distance from parapet (m)	Crossing within 2m	Crossing within 5m	Notes
		22:37	Pipistrelle spp.	Out - in	1.5	Safe		Yes	Yes	Central crossing
		22:37	Common pipistrelle	In – out	4	Safe		No	Yes	Central crossing
		22:37	Common pipistrelle	Out – in	4	Safe		No	Yes	Central crossing
Middle Road green bridge	29.06.20	21:55	Noctule	In - out	5	Safe		No	Yes	Central crossing
		22:13	Noctule	Out – in	5	Safe		No	Yes	Central crossing

Table 5 Observed crossings at each of the dark corridors, Newman's Road and Buxton Road

Location	Date	Time	Species	Direction	Approximate height above bridge (m)	Safe/ unsafe	Approximate horizontal distance from parapet (m)	Crossing with 2m	Crossing within 5m	Notes
Buxton Road dark corridor	26.05.20	22:28	Noctule	Out – in	15	Safe	0	Yes	Yes	Crossed over road surface, centrally.
	23.06.20	22:35	Common pipistrelle	In – out	1.5	Safe	2	Yes	Yes	Crossed over the in-bound road curb.
		22:39	Soprano pipistrelle	In - out	1.8	Unsafe	4	Yes	Yes	Crossed over road surface, centrally.

Location	Date	Time	Species	Direction	Approximate height above bridge (m)	Safe/ unsafe	Approximate horizontal distance from parapet (m)	Crossing with 2m	Crossing within 5m	Notes
	01.09.20	20:09	Noctule	In – out	10	Safe	0 - 20+	No	No	Crossed diagonally. Not using feature.
Newman Road dark corridor	01.07.20	21:52	Unknown	In – out	3	Safe	30	No	No	Not using feature.
	03.09.20	22:00	Brown long eared	Out - in	4	Safe	4	No	Yes	Crossed over the road

Table 6 Observed crossings at the underpass

Location	Date	Time	Species	Direction	Approximate height	Safe/ unsafe	Approximate horizontal distance	Tunnel use or over road flight path	Notes
Underpass	02.06.20	21:22	Noctule	In – out	20	Safe	0	Over road	Not using feature.
		21:38	Pipistrelle sp.	Out – in	N/A	Safe	0	Tunnel	
		21:38	Soprano pipistrelle	In - out	20	Safe	2	Over road	Not using feature.
		21:38	Noctule	In - out	15	Safe	0	Over road	Not using feature.
		21:44	Myotis spp.	Out – in	N/A	Safe	0	Tunnel	
		21:45	Myotis spp.	Out - in – out	N/A	Safe	0	Tunnel	

Location	Date	Time	Species	Direction	Approximate height	Safe/ unsafe	Approximate horizontal distance	Tunnel use or over road flight path	Notes
		21:48	Soprano pipistrelle	In – out	2.5	Unsafe	2	Over road	Not using feature.
		21:50	Soprano pipistrelle	In – out	N/A	Safe	0	Tunnel	
		21:55	Soprano pipistrelle	In – out	3	Unsafe	0	Over road	Not using feature.
		21:55	Soprano pipistrelle	In – out	2	Unsafe	1	Over road	Not using feature.
		21:56	Soprano pipistrelle	In – out	2	Unsafe	1	Over road	Not using feature.
		21:58	Soprano pipistrelle	In - out	2	Unsafe	1	Over road	Not using feature.
		21:58	Soprano pipistrelle	In - out	2	Unsafe	1	Over road	Not using feature.
		21:58	Pipistrelle sp.	In – out	3	Unsafe	3	Over road	Not using feature.
		22:03	Soprano pipistrelle	Out – in	N/A	Safe	0	Tunnel	
		22:05	Pipistrelle sp.	In - out	N/A	Safe	0	Tunnel	
	03.07.20	03:15	Common pipistrelle	In – out	1	Safe	N/A	Tunnel	
		03:30	Soprano pipistrelle	In – out	Not given			Over road	Not using feature.
		03:33	Common pipistrelle	Out – in	Not given				
		03:36	Soprano pipistrelle	Out – in	1	Safe	N/A	Tunnel	

Location	Date	Time	Species	Direction	Approximate height	Safe/ unsafe	Approximate horizontal distance	Tunnel use or over road flight path	Notes
		03:38	Soprano pipistrelle	Out – in	Not given			Over road	Not using feature.
	02.09.20	20:09	Soprano pipistrelle	In – out	1	Safe	N/A	Tunnel	
		20:12	Soprano pipistrelle	In - out	1	Safe	N/A	Tunnel	

3.3 Un-manned monitoring of bat crossings

The total numbers of calls (for all species) recorded inside and outside of the NDR during the unmanned monitoring are shown in Table 7 below. This information is included to give some understanding of the bat species using the habitat either side of the crossing locations, and to provide some additional context to the number of bat crossings and species recorded in the above tables. The number of species recorded at each location is also included. Where applicable, species have been grouped together in the table below, the following comprise more than one species, Myotis sp., pipistrelles, and big bats. Big bats represents a combination of noctule and serotine.

Table 7 Mean calls per night inside and outside of the NDR, from each species detected at the 12 crossing locations during unmanned surveys

Location	Species	Total calls (inside)	Mean nightly calls (inside)	Total calls (outside)	Mean nightly calls (outside)
Gantry 1	Barbastelle	2	0.11	51	2.83
	Brown long-eared bat	0	0.00	2	0.11
	Common pipistrelle	2	0.11	16	0.89
	Daubenton's bat	0	0.00	3	0.17
	Myotis spp.	1	0.06	7	0.39
	Nathusius's pipistrelle	45	2.50	88	4.89
	Natterer's bat	0	0.00	23	1.28
	Noctule	678	37.67	616	34.22
	Serotine	182	10.11	316	17.56
	Soprano pipistrelle	48	2.67	48	2.67
Gantry 2	Barbastelle	78	4.59	38	2.24
	Brown long-eared bat	6	0.35	2	0.12
	Common pipistrelle	6	0.35	3	0.18
	Daubenton's bat	1	0.06	0	0.00
	Myotis spp.	1	0.06	0	0.00
	Nathusius's pipistrelle	30	1.76	36	2.12
	Natterer's bat	32	1.88	16	0.94
	Noctule	754	44.35	728	42.82
	Serotine	122	7.18	95	5.59
	Soprano pipistrelle	11	0.65	12	0.71
Gantry 3	Barbastelle	16	0.70	43	1.87
	Brown long-eared bat	5	0.22	1	0.04
	Common pipistrelle	4	0.17	14	0.61
	Daubenton's bat	4	0.17	3	0.13
	Myotis spp.	3	0.13	5	0.22
	Nathusius's pipistrelle	131	5.70	150	6.52
	Natterer's bat	24	1.04	27	1.17
	Noctule	5058	219.91	905	39.35
	Serotine	681	29.61	289	12.57

Location	Species	Total calls (inside)	Mean nightly calls (inside)	Total calls (outside)	Mean nightly calls (outside)
	Soprano pipistrelle	53	2.30	89	3.87
Gantry 4	Barbastelle	2	0.09	8	0.35
	Brown long-eared bat	4	0.17	7	0.30
	Common pipistrelle	12	0.52	19	0.83
	Daubenton's bat	0	0.00	2	0.09
	Myotis spp.	10	0.43	12	0.52
	Nathusius's pipistrelle	170	7.39	184	8.00
	Natterer's bat	33	1.43	7	0.30
	Noctule	7926	344.61	5419	235.61
	Serotine	790	34.35	1135	49.35
	Soprano pipistrelle	35	1.52	42	1.83
Gantry 5	Barbastelle	6	0.26	7	0.30
	Brown long-eared bat	3	0.13	2	0.09
	Common pipistrelle	7	0.30	4	0.17
	Daubenton's bat	1	0.04	0	0.00
	Myotis spp.	0	0.00	1	0.04
	Nathusius's pipistrelle	43	1.87	19	0.83
	Natterer's bat	3	0.13	1	0.04
	Noctule	159	6.91	25	1.09
	Serotine	357	15.52	46	2.00
	Soprano pipistrelle	7	0.30	12	0.52
Gantry 6	Barbastelle	7	0.35	1	0.05
	Brown long-eared bat	4	0.20	3	0.15
	Common pipistrelle	10	0.50	7	0.35
	Daubenton's bat	23	1.15	16	0.80
	Myotis spp.	4	0.20	3	0.15
	Nathusius's pipistrelle	117	5.85	103	5.15
	Natterer's bat	10	0.50	8	0.40
	Noctule	327	16.35	274	13.70
	Serotine	1218	60.90	799	39.95
	Soprano pipistrelle	26	1.30	0	0.00
Gantry 7	Barbastelle	18	0.82	4	0.18
	Brown long-eared bat	3	0.14	6	0.27
	Common pipistrelle	8	0.36	11	0.50
	Daubenton's bat	2	0.09	2	0.09
	Myotis spp.	2	0.09	3	0.14
	Nathusius's pipistrelle	317	14.41	333	15.14
	Natterer's bat	5	0.23	679	30.86
	Noctule	4576	208.00	6476	294.36
	Serotine	476	21.64	1874	85.18
	Soprano pipistrelle	258	11.73	358	16.27

Location	Species	Total calls (inside)	Mean nightly calls (inside)	Total calls (outside)	Mean nightly calls (outside)
Marriot's Way Green Bridge	Barbastelle	1	0.05	12	0.57
	Brown long-eared bat	1	0.05	4	0.19
	Common pipistrelle	1	0.05	4	0.19
	Daubenton's bat	1	0.05	4	0.19
	Myotis spp.	0	0.00	2	0.10
	Nathusius's pipistrelle	36	1.71	99	4.71
	Natterer's bat	3	0.14	16	0.76
	Noctule	266	12.67	1039	49.48
	Serotine	69	3.29	480	22.86
	Soprano pipistrelle	10	0.48	44	2.10
Middle Road Green Bridge	Barbastelle	4	0.19	0	0.00
	Brown long-eared bat	6	0.29	1	0.05
	Common pipistrelle	3	0.14	1	0.05
	Daubenton's bat	0	0.00	0	0.00
	Myotis spp.	0	0.00	0	0.00
	Nathusius's pipistrelle	295	14.05	44	2.10
	Natterer's bat	4	0.19	7	0.33
	Noctule	404	19.24	70	3.33
	Serotine	143	6.81	8	0.38
	Soprano pipistrelle	14	0.67	0	0.00
Buxton Road Fark Corridor	Barbastelle	8	0.42	1	0.05
	Brown long-eared bat	0	0.00	0	0.00
	Common pipistrelle	2	0.11	0	0.00
	Daubenton's bat	2	0.11	0	0.00
	Myotis spp.	1	0.05	0	0.00
	Nathusius's pipistrelle	39	2.05	6	0.32
	Natterer's bat	2	0.11	2	0.11
	Noctule	82	4.32	19	1.00
	Serotine	14	0.74	5	0.26
	Soprano pipistrelle	7	0.37	0	0.00
Newman Road Dark Corridor	Barbastelle	8	0.38	1	0.05
	Brown long-eared bat	0	0.00	0	0.00
	Common pipistrelle	2	0.10	0	0.00
	Daubenton's bat	2	0.10	0	0.00
	Myotis spp.	1	0.05	0	0.00
	Nathusius's pipistrelle	39	1.86	6	0.29
	Natterer's bat	2	0.10	2	0.10

Location	Species	Total calls (inside)	Mean nightly calls (inside)	Total calls (outside)	Mean nightly calls (outside)
	Noctule	82	3.90	19	0.90
	Serotine	14	0.67	5	0.24
	Soprano pipistrelle	7	0.33	0	0.00
Underpass	Barbastelle	44	2.10	36	1.71
	Brown long-eared bat	7	0.33	10	0.48
	Common pipistrelle	7	0.33	53	2.52
	Daubenton's bat	2	0.10	36	1.71
	Myotis spp.	5	0.24	9	0.43
	Nathusius's pipistrelle	122	5.81	275	13.10
	Natterer's bat	18	0.86	9	0.43
	Noctule	508	24.19	476	22.67
	Serotine	183	8.71	428	20.38
	Soprano pipistrelle	34	1.62	26	1.24

Table 8 Comparison of total number of calls inside and outside of the NDR at all crossing locations

Location	No of calls on inside of NDR	Number of species recorded	No of calls on outside of NDR	Number of species recorded
Gantry 1	958	7	1170	*9
Gantry 2	1041	*9	930	8
Gantry 3	5979	*9	1526	*9
Gantry 4	8982	*9	6835	*9
Gantry 5	593	9	117	9
Gantry 6	1746	*9	1214	9
Gantry 7	5665	*9	9746	*9
DC1	204	*9	352	9
DC2	157	9	32	5
GB1	388	9	1704	*9
GB2	873	8	131	6
UP	930	*9	1358	*9

* These instances include more than one *Myotis* call not identified to species level and therefore may not fully represent the true number of species.

3.4 Notable species

In 2018 three barbastelles were observed crossing the NDR during manned crossing surveys. These were observed at gantry 2, 3 and 6. In each instance they crossed at a safe height. The barbastelles crossing at gantry 3 and gantry 6 were within 2m of the gantry. The barbastelle crossing at gantry 2 crossed approximately 6m from the gantry.

In 2019 no barbastelles were observed to cross at any of the 12 crossing locations. Barbastelles were recorded both inside and outside of the NDR at each of the 12 crossing points either by the static detectors or on manned surveys, with the exception of Buxton Road dark corridor (inside only) and the underpass (inside only) during manned surveys and Middle Road green bridge during unmanned surveys (inside only).

In 2020 six barbastelles were observed crossing the NDR during manned crossing surveys. These were observed at gantry 2, gantry 4 and gantry 6. Two of the three barbastelles crossing at gantry 2 and 1 at gantry 4 were crossing at an unsafe height.. Finally, the two barbastelles at gantry 6 crossed safely.

3.5 Roost surveys

As with the year one post-construction monitoring, year three warrants the surveying of the known roosts within 50m of the NDR. Roost locations are shown in Appendix B.

Table 9 Known roost survey results from the 2020 survey season

Roost	Date	Roosting species	Other species activity
1 - Shooting School Pig Barn	15.06.20	Common pipistrelle (2), BLE (2)	Barbastelle, BLE, Common pipistrelle, Daubenton's, Myotis sp., Serotine.
	21.09.20	None	Barbastelle, BLE, Common pipistrelle, Noctule, Pipistrelle sp., Serotine, Soprano pipistrelle.
2 - Quaker Barn	24.06.20	Common pipistrelle (2), BLE (2)	BLE, Common pipistrelle, Myotis sp., Noctule, Soprano pipistrelle.
	24.09.20	Common pipistrelle (2), BLE (3)	BLE, Common pipistrelle.
3 - Cottages on Beeston Park	18.06.20	None	BLE, Common pipistrelle, Noctule, Soprano pipistrelle.
	30.09.20	None	Common pipistrelle, Leisler's, Noctule, Soprano pipistrelle.
4 - House on Plumstead Road	22.06.20	None	Common pipistrelle, Myotis sp., Noctule.
	10.09.20	BLE	BLE
5 - House on Plumstead Road	22.06.20	Common pipistrelle (1)	Common pipistrelle, Soprano pipistrelle.
	10.09.20	None	Common pipistrelle, Noctule, Soprano pipistrelle.
6 - House on Plumstead Road	09.09.20	None	BLE, Common pipistrelle, Noctule, Soprano pipistrelle
	22.09.20	Pipistrelle sp. (3)	Barbastelle, BLE, Common pipistrelle, Noctule, Soprano pipistrelle.
7 - Red House, Low Road	16.06.20	Noctule (3), Common pipistrelle (3).	BLE, Barbastelle, Common pipistrelle, Daubenton's, Noctule, Soprano pipistrelle.
	22.09.20	None	BLE, Common pipistrelle, Noctule, Soprano pipistrelle.
9 - Woodland on Buxton Road	23.06.20	None	Barbastelle, Common pipistrelle, *Myotis sp., Nyctalus*

Roost	Date	Roosting species	Other species activity
			sp., Noctule, Soprano pipistrelle
	08.09.20	None	Barbastelle, BLE, Common pipistrelle,
10 - Woodland on Buxton Road	23.06.20	None	Common pipistrelle, Myotis spp., Noctule, Soprano pipistrelle.
	08.09.20	None	BLE, Common pipistrelle, Myotis sp., Noctule, Soprano pipistrelle.
11 – Tree 475B, Spixworth Plantation	24.06.20	None	Common pipistrelle, Noctule.
	09.09.20	None	Soprano pipistrelle.
12 – Tree 490, close to Gantry 4	23.06.20	None	Common pipistrelle, Soprano pipistrelle.
	23.09.20	None	Common pipistrelle, Soprano pipistrelle.
13 – Tree 290, sewage works	24.06.20	None	Barbastelle, Common pipistrelle, Noctule, Soprano pipistrelle.
	08.09.20	None	Common pipistrelle, Soprano pipistrelle.
15 – Tree 380, Toad Lane	24.06.20	None	Common pipistrelle, Soprano pipistrelle.
	10.07.20	None	None
16 – Tree 415, Low Road	16.06.20	None	Barbastelle, Daubenton's, BLE, Common pipistrelle, Noctule, Serotine, Soprano pipistrelle.
	07.09.20	Common pipistrelle (3)	Common pipistrelle, Daubenton's, Serotine, Soprano pipistrelle.
17 – Tree 451, Smee Lane	16.06.20	None	Common pipistrelle, Soprano pipistrelle.
	25.06.20	None	Common pipistrelle, Soprano pipistrelle.

3.6 Bat house surveys

3.6.1 Large bat house

During the surveys conducted at the large bat house, common and soprano pipistrelles were observed to emerge from the building. Table 10 below shows the emergence and activity results. The location is shown in Appendix E. The 2020 season was the first year that bats were observed to be roosting in the large bat house.

3.6.2 Small bat house

Soprano pipistrelles were observed emerging from the building on both of the surveys in the 2020 season, see Table 10 below. These results are similar to the 2018 survey season when

soprano pipistrelles were also observed emerging from the building. The location is shown in Appendix E.

Table 10 Bat house emergence and re-entry survey results

Bat house	Date	Bats roosting?	Roosting species	Feature	Other activity
Large bat house	03.06.20	Yes	Common pipistrelle (3)	Apex roof tile at the gable end, East face South face	Barbastelle, Common pipistrelle, Myotis spp., Soprano pipistrelle.
Small bat house	09.06.20	Yes	Soprano pipistrelle (1)	East face shiplap	BLE, Common pipistrelle, Soprano pipistrelle.
Large bat house	23.09.20	Yes	Soprano pipistrelle (3)	Roof ridge tile	Soprano pipistrelle.
Small bat house	10.09.20	Yes	Soprano pipistrelle (3)	North west ridge line tile	Soprano pipistrelle.

The number in brackets under ‘Roosting species’ is the total number of bats observed to be roosting by all surveyors during that given survey.

3.7 Bat box occupancy checks

Due to Covid-19 and staff furloughing, surveyors with the correct level class licence were not available during the former half of the bat box checks. This meant that the first round of physical inspections were substituted for emergence/re-entry surveys. The results of these surveys, along with the results of the physical checks are presented in Table 11, below. Bat box locations are shown in Appendix C.

Table 11 Bat box emergence/re-entry surveys and occupancy checks

Bat box location	Bat box number	Dusk emergence date	Dusk emergence results	Occupancy check dates	Occupancy check results	Other notes
Fakenham road	1	30.06.2020	None	23.09.2020	None present	
Fakenham road	2	30.06.2020	None	23.09.2020	One soprano pipistrelle	
Fakenham road	3	30.06.2020	None	23.09.2020	One pipistrelle spp.	
Spring farm	4	No access granted	N/A	23.09.2020	None present	
Spring farm	5	No access granted	N/A	23.09.2020	None present	
Spring farm	6	No access granted	N/A	23.09.2020	Two soprano pipistrelles	
Quaker farm	7	17.06.2020	None	23.09.2020	None present	
Quaker farm	8	17.06.2020	None	23.09.2020	None present	
Quaker farm	9	17.06.2020	None	23.09.2020	None present	
Quaker farm	10	17.06.2020	None	23.09.2020	None present	
Quaker farm	11	17.06.2020	None	23.09.2020	Five pipistrelle spp.	
Spixworth plantation	12	17.06.2020	None	23.09.2020	None present	
Spixworth plantation	13	16.06.2020	None	23.09.2020	None present	
Spixworth plantation	14	16.06.2020	None	23.09.2020	None present	Box had fallen from the tree but was reinstated in the original location.
Spixworth plantation	15	16.06.2020	None	23.09.2020	Five pipistrelle spp.	Left box of a pair on an oak.
Spixworth plantation	16	16.06.2020	None	23.09.2020	None present	Right box of the pair on the oak tree (droppings present)
Spixworth plantation	17	16.06.2020	None	23.09.2020	None present	
Spixworth plantation	18	16.06.2020	None	23.09.2020	None present	

Bat box location	Bat box number	Dusk emergence date	Dusk emergence results	Occupancy check dates	Occupancy check results	Other notes
Spixworth plantation	19	16.06.2020	None	23.09.2020	None present	
Spixworth plantation	20	16.06.2020	None	23.09.2020	One pipistrelle spp.	
Spixworth plantation	21	15.06.2020	None	23.09.2020	None	
Spixworth plantation	22	15.06.2020	None	23.06.2020	None	
Spixworth plantation	23	15.06.2020	None	23.06.2020	One pipistrelle spp.	

4 Discussion

4.1 Manned crossings

Data from the 2020 survey season is best interpreted independently for each of the crossing structures. In general, more bats were observed crossing compared to the previous two years. There are still bats crossing the road unsafely. This means those bats are at risk of collisions with traffic such as haulage lorries.

4.1.1 Bat gantries

At each of the seven bat gantries, all have shown an increase in the number of safe crossings in 2020, when compared to 2019. However, the proportion of safe crossings has decreased between the 2019 and 2020 survey seasons. While more bats are being recorded crossing, a greater proportion (at all seven gantries) are crossing unsafely, when comparing 2019 to 2020.

Focusing solely on the 2020 data, at three of the seven gantries (gantry 1, gantry 2, and gantry 7) less than 50% of bats are crossing safely. The remaining four gantries (gantries 3, 4, 5 and 6) have more than 50% safely crossing. When interpreting Figures 4.1, 4.2 and 4.3 the kernel density plot demonstrates that the bats crossings lower than the 5m safe flight height are doing so in a similar spatial format across each of the seven gantries. Despite those crossings being unsafe, their clustering is suggestive of consistency in the flight path relative to the gantry

The gantry with the highest frequency of safe crossings was gantry 4. The higher number of safe crossings can be attributed to several factors. The first important aspect to note is the actual height above the carriageway which, at 8.95m, is one of the two tallest gantries on the NDR (gantry 4 and gantry 5). The overall height itself means that bats following the gantry within either 2 or 5m as per the criteria set out in section 2.2 are doing so further from the NDR road surface. The second is the high earth bank on the inside (southern side) of the road. A high earth bank guides the flight path of crossing bats up and away from the NDR road surface. Finally, the integration into the landscape. This gantry has been integrated into the landscape much more than its counterpart, gantry 5, a gantry of the same height. Gantry 5 has 80% safe crossings, however only five bats crossed at this location, likely due to the very immature surrounding vegetation. This gantry is isolated and very far removed from the linear feature, a hedge and farm track. The results surrounding these two gantries demonstrate the importance of how a gantry is utilised for mitigation, it must be implemented correctly.

As vegetation becomes increasingly established in the future, the ‘guiding’ effect should be increased. Creating a corridor for bats to follow via vegetation growth is key to ensuring the crossing locations operate as effectively as they can. Replanting failed vegetation and ensuring the landscape is created and maintained as intended is a crucial element in ensuring the success of the mitigation.

As the planted vegetating becomes increasingly established, the landscaping vegetation should aid in increasing the effect of the landform – the relative heights of the road and the embankments either side – which is important for guiding the bats over the road at a safe height. Along the majority of its length, the embankments either side of the NDR carriageway form a natural guide that raises up the flight path of bats, but this must be further assisted by the vegetation. Landform topography and well-established vegetation should work together to facilitate the safe use of the crossings over the NDR carriageway.

The impact on local bat populations depends (in part) on the mortality of bats crossing at an unsafe height. Maintaining the favourable conservation status of bat populations affected by the NDR can be impacted by the effectiveness of the crossing points. At the design and assessment stage of the project it was acknowledged that the habitat loss, habitat change and degradation as a result of the NDR, which is slowly being mitigated for as landscaping establishes, are factors which also impact local bat populations. Thus, highlighting the importance of maintaining the existing habitats and replacing the landscaping in areas with unacceptable failure rates is important.

4.1.2 Green bridges

The green bridges located at Marriott's Way and Middle Road differ in their observed use by bats. Typically, Marriott's Way has higher observed use than Middle Road (Table 13). This is not unsurprising when the integration of each feature into the landscape is considered. Marriott's Way has two lines of vegetation, one at each side of the bridge, compared to only one at Middle Road. These two planted lines mimic the habitat structure along Marriott's Way. Once this planting is mature, in the region of 15 years old, it will tie Marriott's Way green bridge into the surrounding habitat.

Middle Road is a carriageway and subject to much more disturbance than Marriott's Way. This can, in part, explain the fewer observed crossings when compared to Marriott's Way. In addition, Middle Road has one line of planted hawthorn. In effect this halves the linear features available to bats when compared to Marriott's Way.

Neither crossing has particularly mature planted vegetation leading up to the bridge. The planted linear features, i.e. the hedgerow, is not very substantial, this is to be expected when trees are still young. Furthermore, the distance between the pre-construction linear feature and the post-construction green bridge is considerable. This presents commuting bats with a more hostile environment post-construction; this is apparent at both green bridges. At the green bridges replanting has occurred during the 2020/2021 winter to replace failed specimens. Interplanting of larger specimens, at least 4 years older than their counterparts would be beneficial.

4.1.3 Dark corridors

The two dark corridors across the NDR had very few crossings in the past, the same is true for the 2020 survey season, both had less than five observed crossings. Newman's Road dark corridor has historically had the most crossings of the two, but despite having more optimal habitat either side of the NDR, in general, displayed a decrease in use. Conversely, although small, Buxton Road dark corridor has seen an increase in observed crossings. Until future survey seasons are completed, definitive conclusions cannot be drawn.

It should be noted that one of the unsafe crossings using the dark corridor was at an estimated height of 4m, while this is empirically unsafe as per the criterion set out in section 2.2, the weight restriction of the bridge prohibits large capacity trucks from using that road. Four meters in height is enough to avoid most permissive vehicles on Newman road. Full details of all crossings at the dark corridors observed during the manned surveys can be found in Table 5, in section 3.2.1

4.1.4 Underpass

From no use at all in 2018 (as the watercourse downstream of the underpass was not yet complete, and hence not functioning), to a single use in 2019, 2020 had the highest recorded use of any monitoring year. Ten bats were recorded to have used the underpass itself. These

data suggest that bats could be becoming more familiar with the underpass as a crossing feature. On the other hand, it could also suggest that more bats in general are crossing at the underpass location and by virtue of higher total crossings, more bats are using the underpass. The data collected in 2020 suggests that the latter is less likely. A higher proportion of all recorded crossings (underpass or over the road) were utilizing the underpass in 2020. As the surrounding habitat develops, future monitoring could see further increases in underpass use. Once the vegetation and habitat becomes semi-mature, the guiding effect into the underpass will be greatly enhanced. Planting has now been completed on all sides of the underpass (above and both sides of the underpass entrances) and can now be left to mature. As the planting matures the underpass will likely become more effective.

4.2 Comparison between 2018, 2019 and 2020

4.2.1 Bat gantries

During the surveys of the seven gantries, at least six difference species were recorded crossing at the gantry locations, double that of the previous year. Noctules were also recorded crossing at the gantries, although usually at a height that could not always be considered as using the crossings. (See Table 3 for further information).

In 2020, the third monitoring year, bats were observed to cross at all seven gantries. Bats were also observed crossing at all gantries during 2019, compared to the 2018 season where six out of the seven gantries had a crossing.

As with the 2018 and 2019 survey seasons, gantry 4 proved to be the most active, with 45 observed crossings in 2020. The number of crossings increased by 19 from 2018 to 2019 and again increased from 2019 to 2020. Table 12 shows the total number of crossings, and the number of safe crossings, at each of the gantry locations, in both 2019 and 2020.

Table 12 Total observed safe crossings within at least 5m (horizontally) at each of the seven gantries and the percentage of total crossings they represent.

Location	Number of observed safe crossings in 2018	Number of observed safe crossings in 2019	Number of observed safe crossings in 2020
Gantry 1	1 (33%)	3 (75%)	1 (16%)
Gantry 2	4 (44%)	4 (80%)	6 (20%)
Gantry 3	5 (45%)	2 (100%)	8 (50%)
Gantry 4	10 (52%)	19 (70%)	29 (64%)
Gantry 5	0 (0%)	1 (33%)	4 (80%)
Gantry 6	6 (85%)	0 (0%)	14 (63%)
Gantry 7	3 (27%)	2 (25%)	11 (34%)

4.2.2 Flight path density plots

Figure 4.1 (2020) below displays the distribution of crossing heights and distances from the seven gantries located across the NDR, relative to the range in gantry heights above the road. When comparing the data (2020) to the data from the 2019 survey season (Figure 4.2) and the data from the 2018 survey season (Figure 4.3) it is immediately clear that in general bats are crossing at a greater height. In section 3.1.1 the percentages of safe/unsafe crossings are

given. This can be used conjunction with the kernel density plots and tables 3, 4 and 5 to infer how the bats are crossing at the gantries.

Where bats were witnessed to cross over either a range of heights or range of horizontal distances from the gantry, an average value was assigned. This helped reduce the loss of data while still providing a representation of the crossing behaviour.

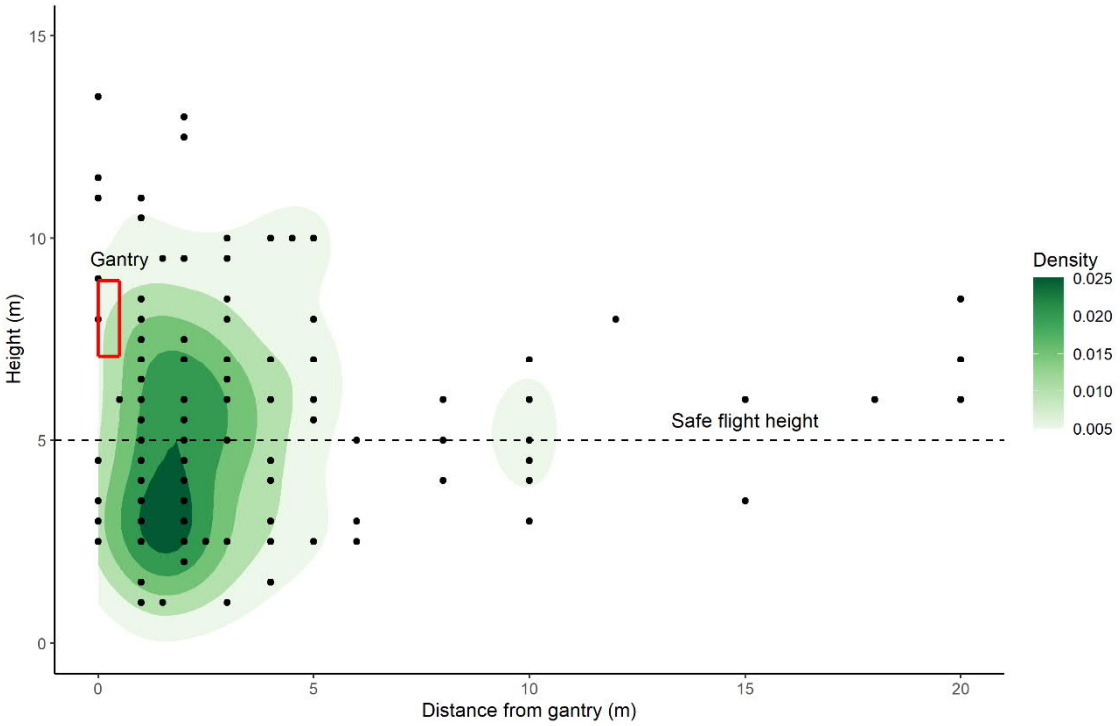

Figure 4.1 Height from the road and the horizontal distance from gantries for all crossing bats in 2020 excluding big bats (gantries one to seven) The range in gantry height above the road surface is shown in red and the minimum safe flight height is highlighted. Kernel density estimations have been applied.

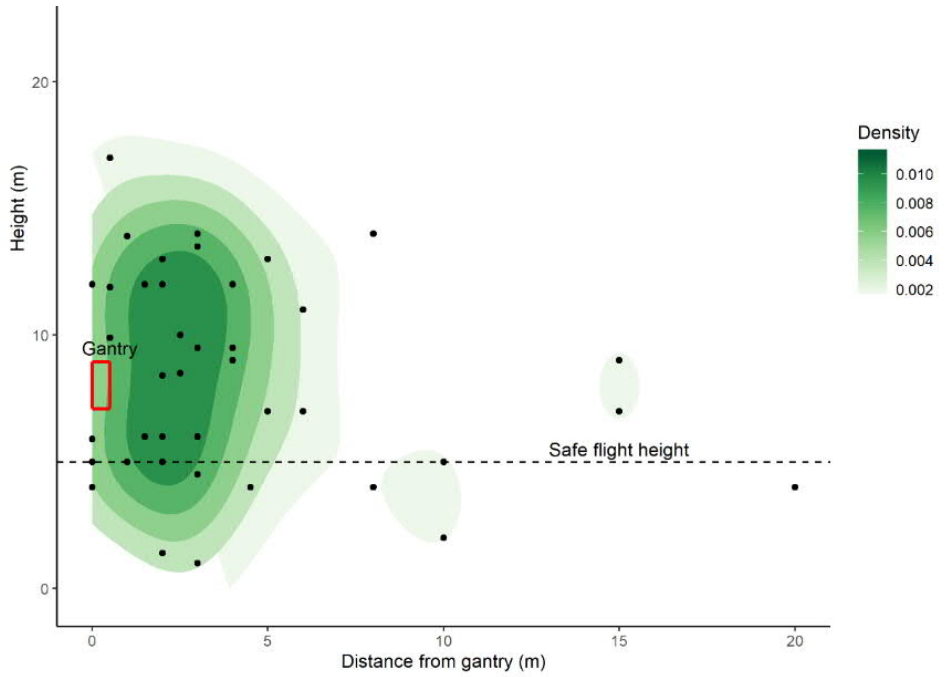

Figure 4.2 Height from the road and the horizontal distance from gantries for all crossing bats in 2019, excluding big bats (gantries one to seven) The range in gantry height above the road surface is shown in red and the minimum safe flight height is highlighted. Kernel density estimations have been applied.

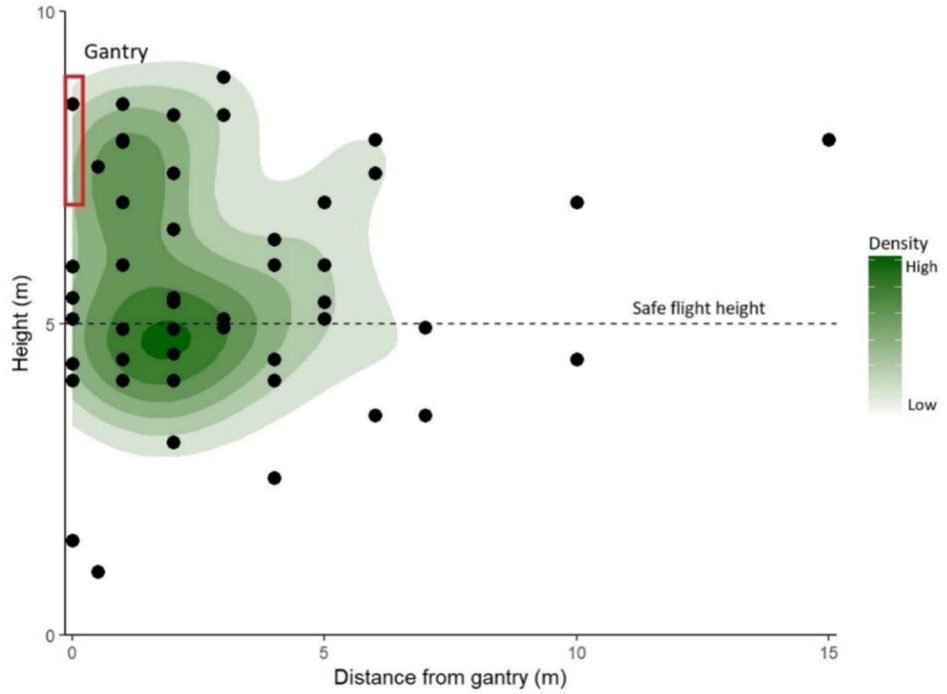

Figure 4.3 Height from the road and the horizontal distance from gantries for all crossing bats in 2018, excluding big bats (gantries one to seven). The range in gantry height above the road surface is shown in red and the minimum safe flight height is highlighted. Kernel density estimations have been applied.

4.2.3 Green bridges

In 2020 the total number of crossing bats observed was 17, the second highest since post-construction monitoring began. During the first year (2018) 19 bats were observed to cross at the green bridges, 13 at Marriott's Way and six at Middle road. In 2019 nine bats were observed to cross over the green bridges, four at Marriott's Way and five at Middle Road.

At Marriott's Way all bats were considered to cross safely due to the height of the crossings above the carriageway. The landscape naturally guides bats high over the NDR. At Middle Road, all bats crossed at least 5m above the NDR road surface.

Table 13 Total observed crossings at each of the green bridges in 2018, 2019 and 2020

Location	Number of observed crossings in 2018	Number of observed crossings in 2019	Number of observed crossings in 2020
Marriot's Way	13	4	15
Middle Road	6	5	2

4.2.4 Dark corridors

For the Buxton Road dark corridor crossing location, 2020 had the highest number of crossings since monitoring began. Furthermore, the number of observed crossings has increased each year. On the other hand, Newman's Road dark corridor has seen a decrease and stagnation in the number of observed crossings.

Table 14 Dark corridor crossings from each of the three monitoring years

Location	Number of observed crossings in 2018	Number of observed crossings in 2019	Number of observed crossings in 2020
Buxton Road	0	1	4
Newman's Road	5	2	2

4.2.5 Underpass

The underpass had 23 observed crossings during manned surveys in 2020, with a mixture of tunnel use and crossings over the road. Details can be found in Table 6, Section 3.2.2.

The first years' post-construction monitoring, in 2018, was undertaken when the vegetation on one side of the road had not yet been planted. By the second year of post-construction monitoring, in 2019, the landscaping at this location was in place. No bats were recorded using the underpass in 2018, although three unsafe crossings above the road were recorded. In 2019 the underpass had only one observed use during manned surveys.

4.3 Unmanned static monitoring

Table 8 in section 3.3 shows the number of calls at each of the 12 crossing locations both inside and outside of the NDR. The extension of the programme into October is a contributing factor to the lower number of recorded calls. October is outside of the core survey period, and during this period bat activity may be different to the rest of the season. Future survey seasons will continue to provide these data, allowing a longer-term analysis of the changes in recorded activity from unmanned static monitoring. Appendix D shows a table with data from years one and two alongside year three data.

4.4 Known roost monitoring

During the first year of monitoring, there were only four of the 16 roosts confirmed to still be in use. During the 2020 surveying season (year three) seven roosts were confirmed to be in use. Sometime between the two survey seasons a roost (Roost 14, tree 511) was lost, likely in severe weather. The increase in the number of roosts in use while a positive change, could be the result of inter-annual variations. Drawing conclusions from these data would need to be done so with caution. Before any meaningful conclusions can be drawn as to the effect on the NDR upon known roosts, several more years' worth of data will be required.

4.5 Bat house monitoring

4.5.1 Large bat house

The large bat house was confirmed as a roost during the 2020 survey season, compared to 2018, when no bats were observed to emerge or re-enter the structure. The uptake of the large bat house in 2020 demonstrates that the feature does indeed serve its function as a bat roost. The bat houses were implemented to replace the roosts lost during the construction of the NDR (buildings 67 and 77, both BLE roosts). No BLE activity has been recorded during surveys of the large bat house. This means that until BLE are confirmed to be roosting the mitigation is not functioning as intended.

4.5.2 Small bat house

The small bat house was again confirmed to be in use by bats during the 2020 survey season, as it was in 2018. However, despite brown long eared activity in the vicinity of the small bat house, it has not been shown that they are using this structure. As with the large bat house, until BLE are confirmed to be roosting the mitigation is not functioning as intended.

4.6 Bat box occupancy

Due to Covid-19 and staff furloughing, surveyors with the correct level class licence were not available during the former half of the bat box checks. As a result, the checks were replaced with emergence surveys.

The emergence surveys did not yield any confirmation of roosting activity. Surveyors were limited by fading light as many of the bat boxes are located in dense woodland. Light levels fade much quicker in woodland than open habitats. This may be a contributing factor towards the lack of confirmed bat box use. This does not mean there were not bats utilizing the bat boxes during those surveys.

During the actual physical occupancy checks, bats were confirmed in seven out of 23 bat boxes. At least one bat box at each of the four cluster locations was occupied by bats. The different results between the emergence surveys and physical checks is likely due to the survey methods themselves, with physical checks offering a better detection rate.

4.7 Collision mortality

As with 2018, the 2020 surveys for collision evidence were undertaken 20m each side of the 12 crossing locations. These are conducted just after dawn to minimise the likelihood of scavengers removing the carcass. The lack of detection is promising, in that it suggests no bat were killed the night prior to the surveys. However, the detection rate from human searching is poor, Arnett (2006) suggests as low as 14% are detected. Bats are small mammals and easily obscured by vegetation, even with a short sward. To improve the robustness of these data,

mortality checks could be completed more frequently or by employing other search methods. For example, detection dogs could greatly increase the success, as high as 71% (Arnett, 2006). Due to the low likelihood of human searches finding a carcass it is not possible to conclude that no bats have been killed by the NDR's road traffic.

4.8 Conclusions

The NDR has bisected a large area of countryside to the north of Norwich and has severed many linear features. This is highly likely to have reduced the permeability of the landscape, degrading the suitability for low flying species such as bats. Both Abbott et al. (2012) and Bennet & Zurcher (2013) have found that the absence of substantial vegetation, i.e. trees and shrubs, can be a determining factor in whether bats cross the road. It is therefore possible that, as current vegetation becomes more established, the numbers of bats using the crossing locations may increase. Increasing vegetation height should raise the flight path of bats leading up to the crossing locations but will take many years to become fully established; therefore, it must be cared for correctly, adhering to the Handover Environmental Management Plan (HEMP). Recommendations are made below in Table 15, to improve upon the current state of the landscape.

Ongoing monitoring and caring for the vegetation that has been planted as part of the landscaping design is paramount to ensuring that the mitigation functions as intended. Without all aspects of the design, the mitigative effects will be diminished. During winter of 2020/2021 planting occurred to bolster the landscaping where applicable.

Until several more survey seasons have been completed it is not appropriate to draw any conclusions about the effectiveness of the gantries and crossing features; they are not yet fully integrated into the landscape. Until the landscaping is mature and well established the desired effect will not be achieved. Continued monitoring will be essential for understanding the levels of crossing use in future seasons, as required in the DCO Mitigation and Monitoring Tables. As the landscaping establishes, it will be important to determine how it changes the way bats use the crossing points. Ongoing assessment of the extent of any failed vegetation will be essential for designing a strategy to replace those that have died. This is crucial for maintaining the intended function of the mitigation and increase the effectiveness as time passes. Recommendations are made in Table 15 below.

Table 15 Recommendations for future survey seasons and landscaping

	Survey recommendations	Landscape recommendations
1	Utilize specially trained survey dogs and handlers to increase the detections of bat carcasses when conducting mortality surveys around each crossing location.	Continue to monitor the landscaping, including the specimens re-planted in the winter of 2020/2021, and re-plant trees that have perished and failed to take root at all locations around the NDR, as necessary. This will serve to maintain the NDRs planting up to the design specification.
2	Increase collision mortality checks from twice a survey season to six times. To increase the probability of detection further.	Increase the number of trees around the crossing locations with semi-mature trees that are at least in their 6th year. This can be achieved by interplanting larger trees every 3m along the lines of hawthorn plantation. In particular, the following locations need increased planting to further integrate the crossings into the landscape: Gantry 1 (inside), Buxton Road dark corridor (both sides), gantry 5 (inside), underpass (both

	Survey recommendations	Landscape recommendations
		sides), gantry 6 (outside) and Middle road green bridge (both sides).
3	During year 5 conduct a suite of tree climbing inspection surveys on known tree roosts utilizing staff holding a CS38 tree climbing and aerial rescue certificate.	Where access is possible, supplement newly planted trees (in their first year after planting) with watering once in July. A second watering should be conducted during August in times of severe drought, such as the summer of 2018.
4	Re-assess the local population(s) of barbastelle through the use of simultaneous emergence surveys.	Interplant larger trees every 3m along the lines of hawthorn plantation leading up to both green bridges, both dark corridors, and all gantries. These trees would be in addition to the original planting specification and should be 4 years older than their counterparts. This is to introduce larger trees to promote the establishment of these tree lines and hedgerows. This should increase the effectiveness of the mitigation without the need to wait until the trees already planted naturally mature.

.

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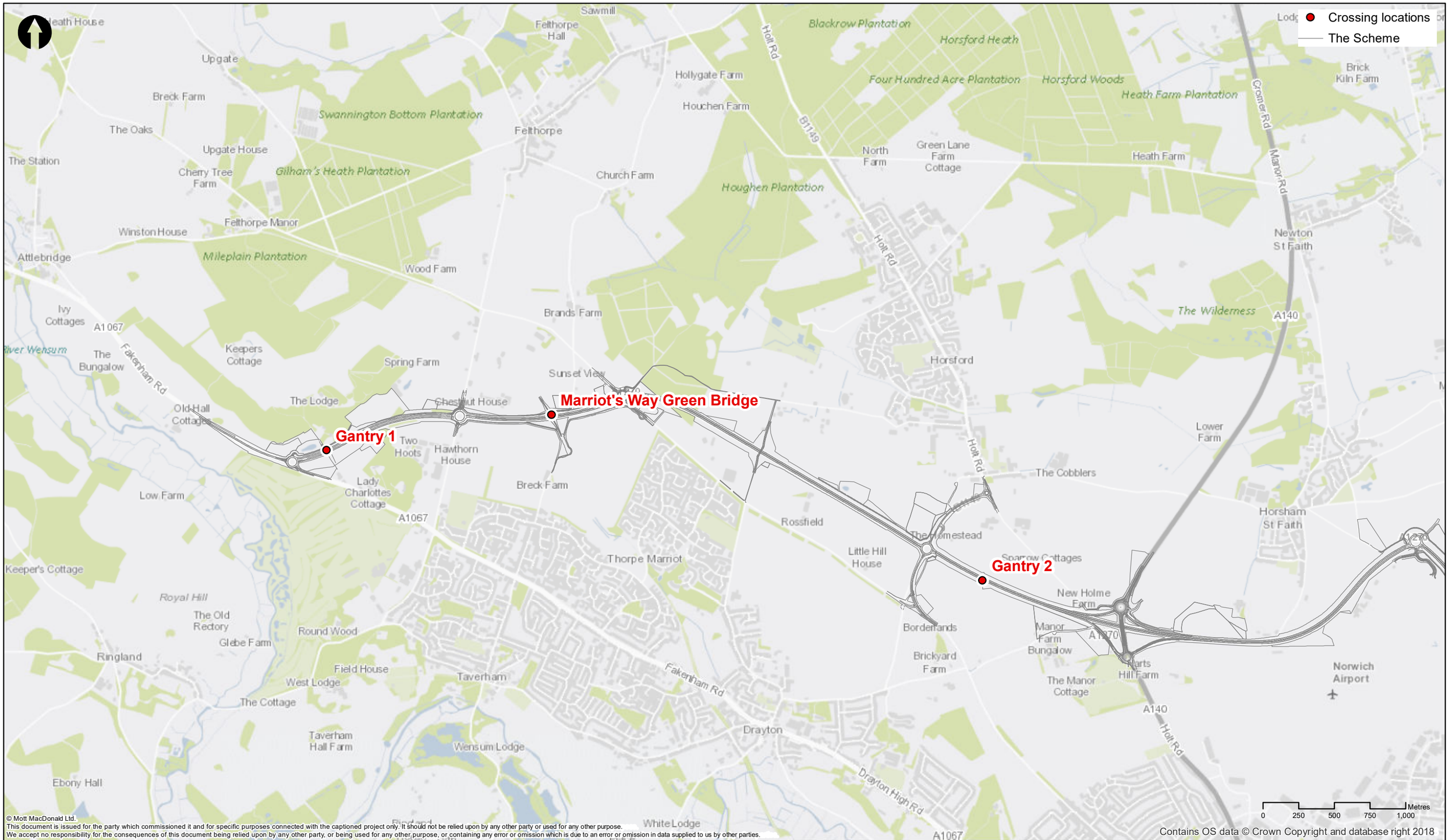
A. Crossing locations around the NDR

A.1 Western bat crossings

A.2 Central bat crossings

A.3 Eastern bat crossings



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Title

Figure 7.4

Bat Crossings - Western Extent

Drawn	B O'Hickey	
Checked	A Gagen	
Approved	S Allen	

Scale at A3: 1:25,000

Drawing Number: 366431-MMD-00-GIS-Y-0004

Security	Status	Rev
STD	PRE	P1

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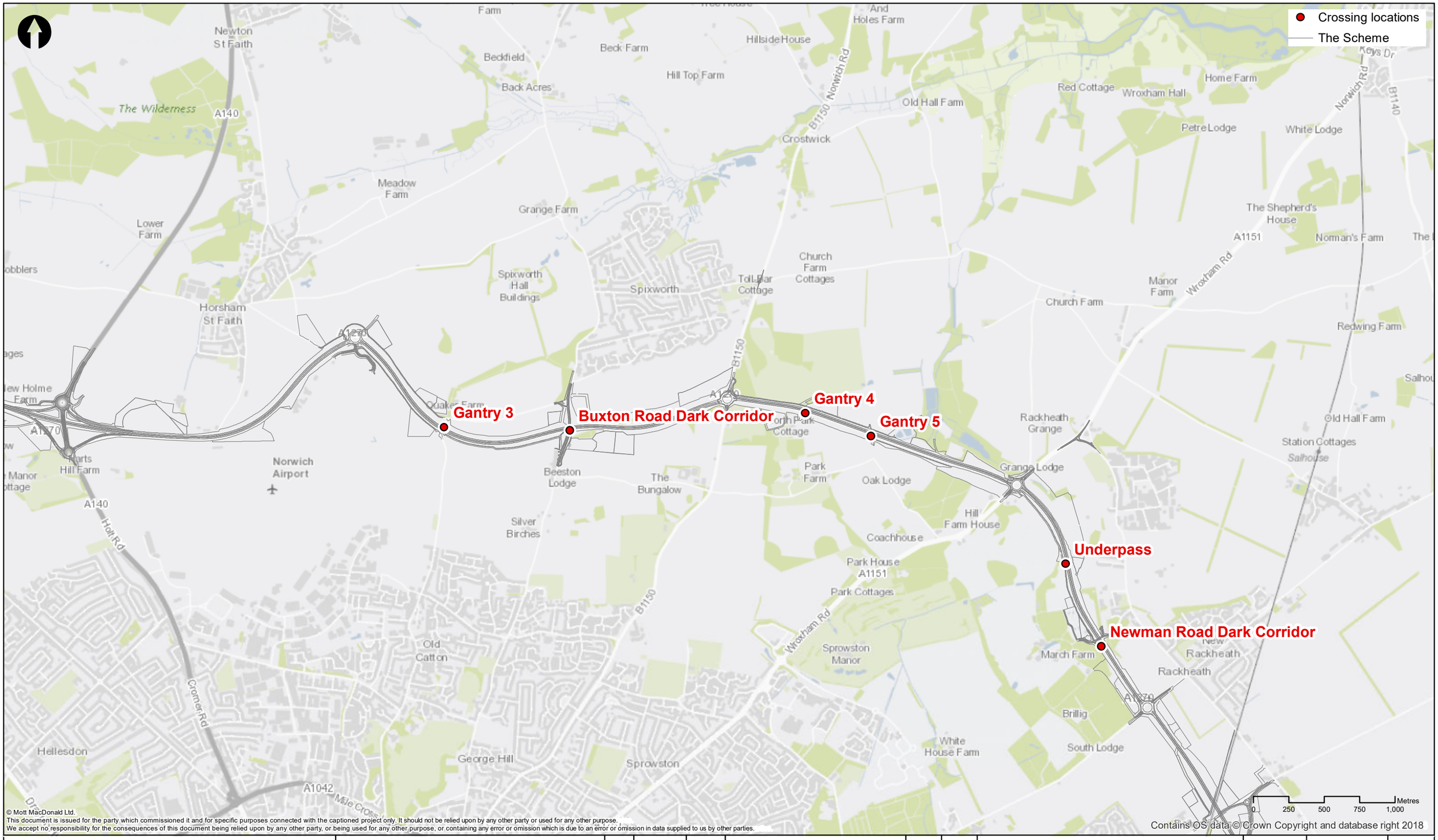

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Figure 7.5

Bat Crossings - Central Extent

Drawn	B O'Hickey	
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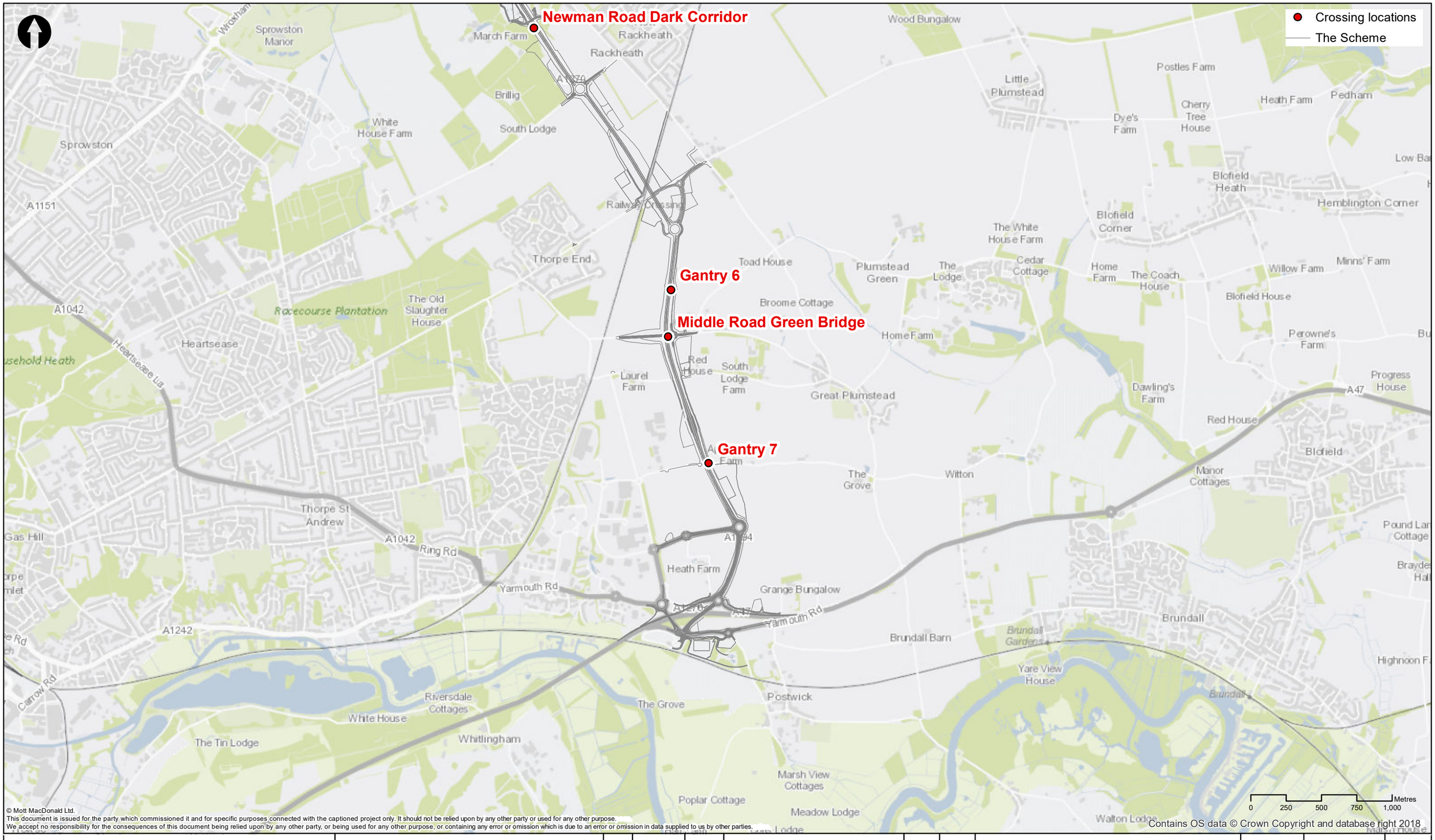

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Figure 7.6

Bat Crossings - Eastern Extent

Drawn	B O'Hickey	
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B. Roost locations

B.1 Western roost locations

B.2 Central roost locations

B.3 Eastern roost locations

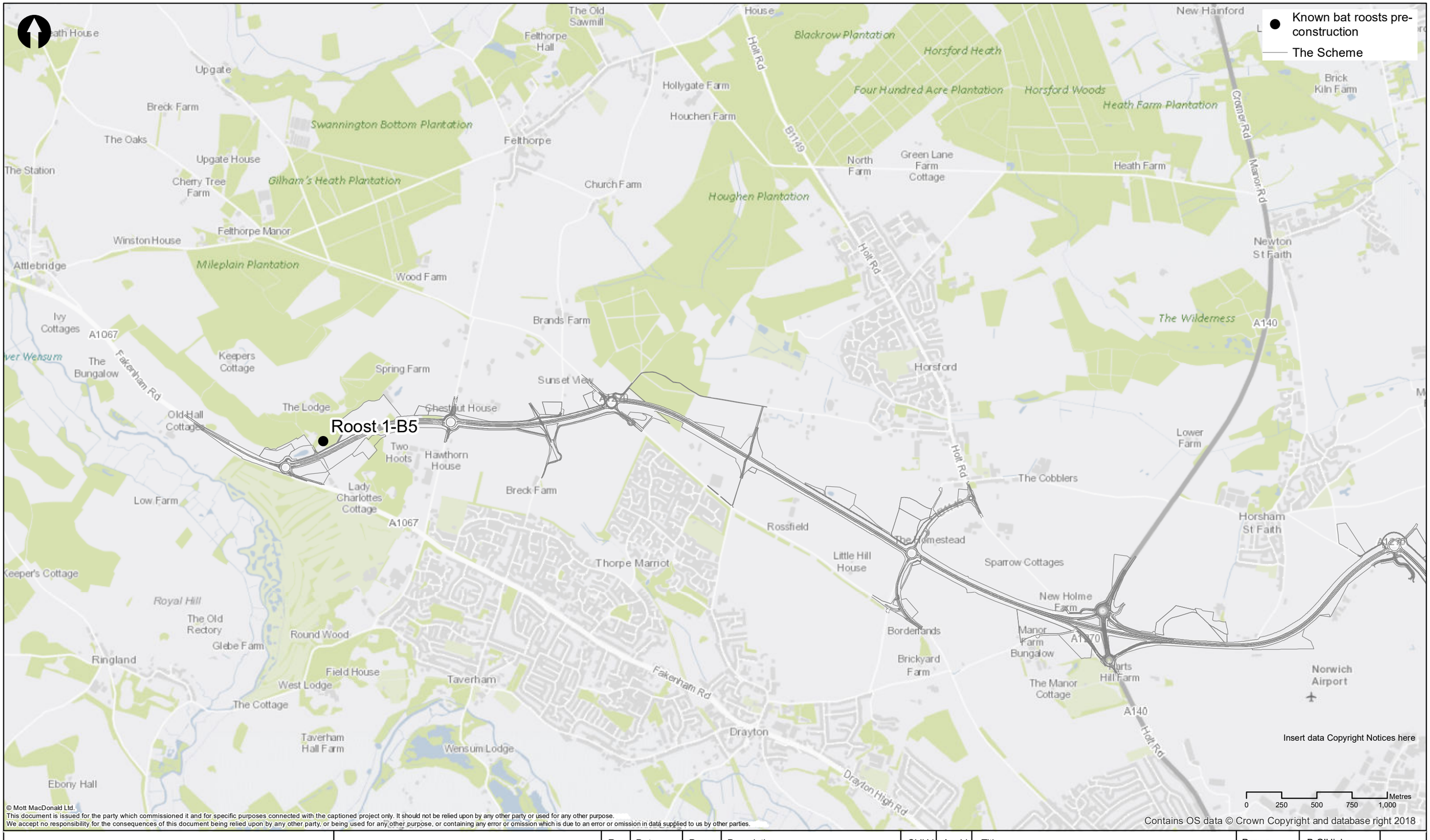

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Figure 7.1

Known Bat Roosts - Western Extent

Drawn	B O'Hickey	
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Approved	S Allen	

Scale at A3
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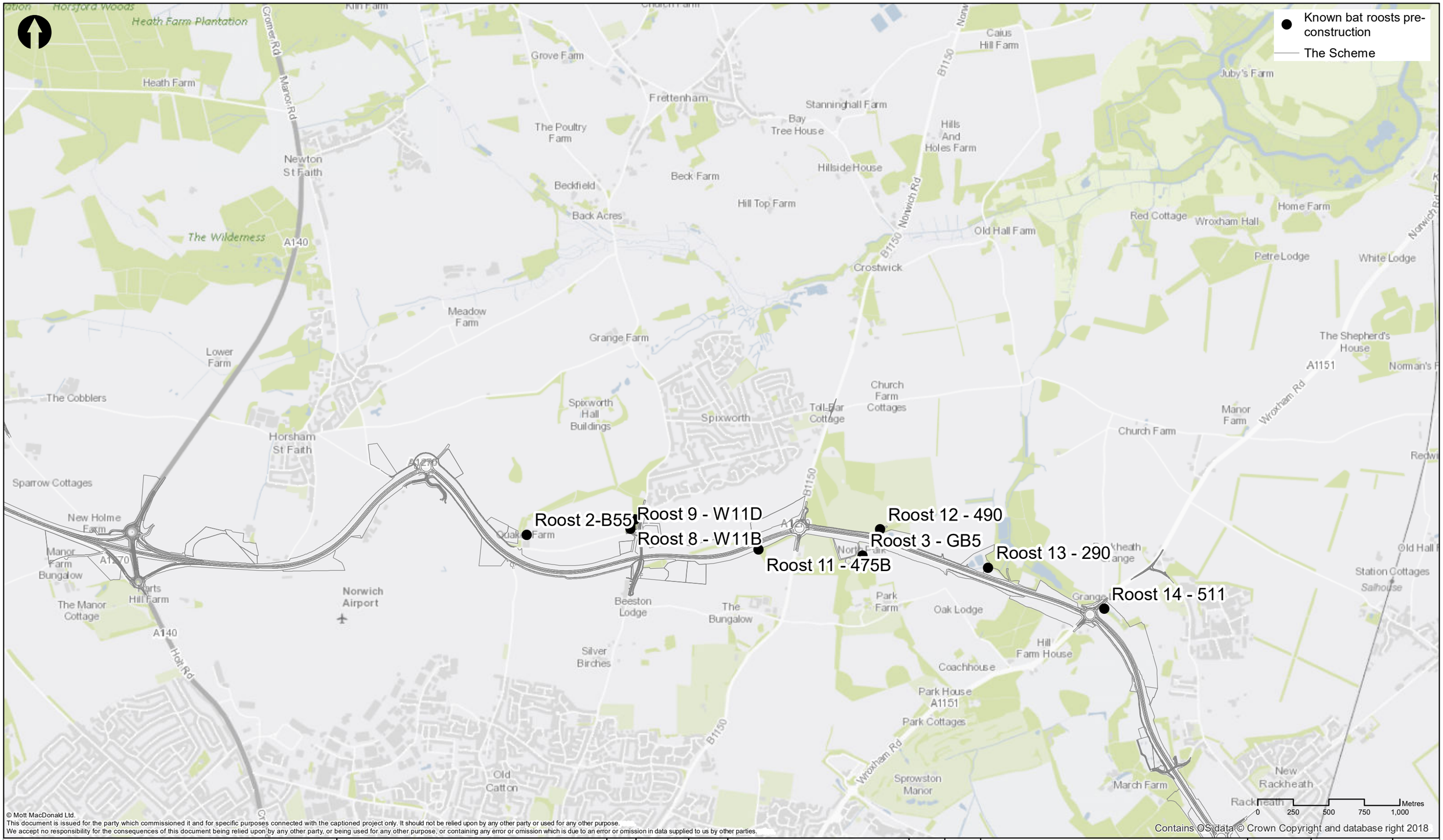

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Figure 7.2

Known Bat Roosts - Central Extent

Drawn	B O'Hickey	
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Approved	S Allen	

Scale at A3
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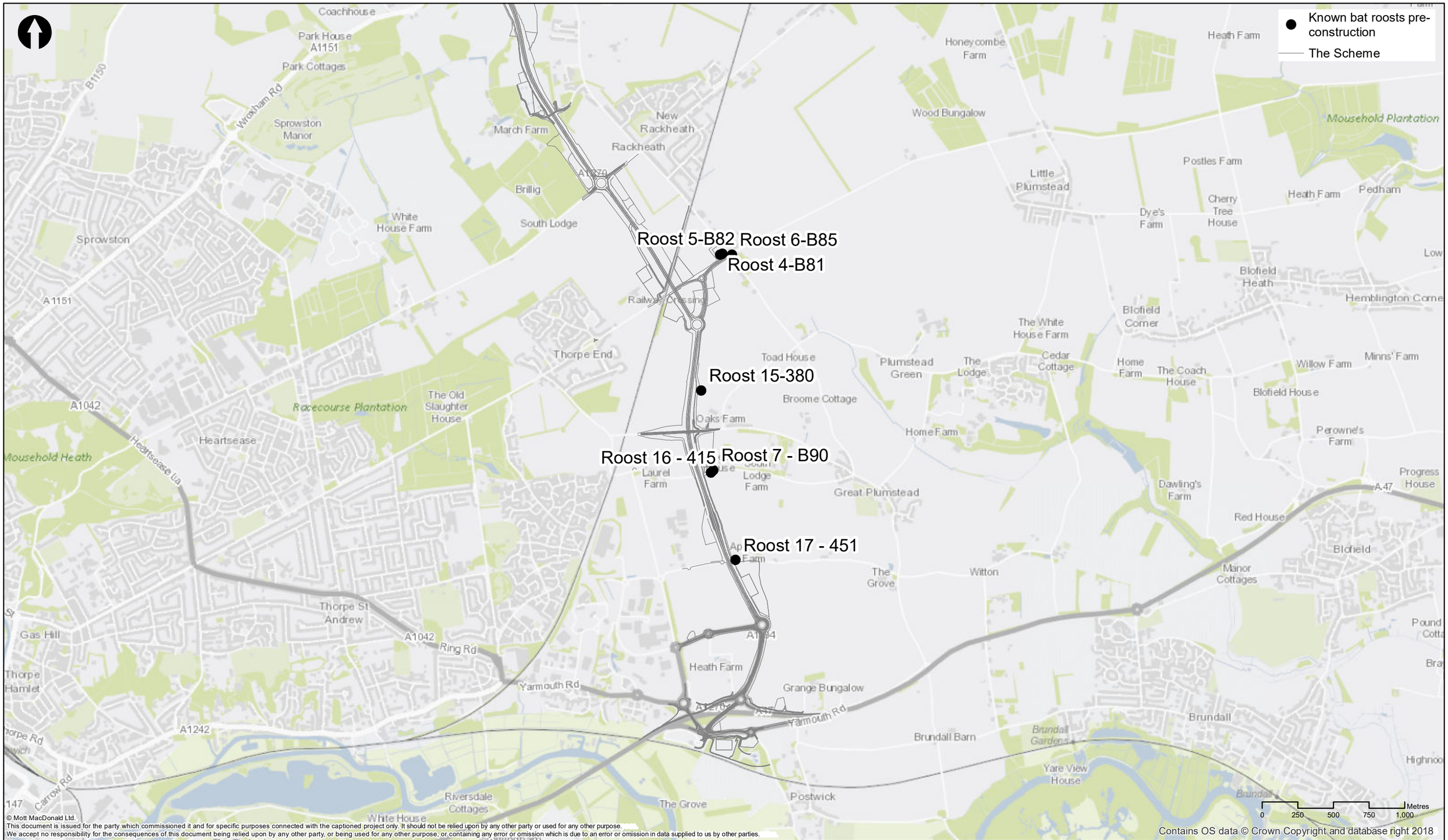

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Figure 7.3

Known Bat Roosts - Eastern Extent

Drawn	B O'Hickey	
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C. Bat box locations

C.1 Shooting school bat boxes

C.2 Spring farm bat boxes

C.3 Quaker farm bat boxes

C.4 Spixworth plantation bat boxes

C.5 Overall location map

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Figure 7.7

Bat Box Locations - Fakenham Road

Drawn	B O'Hickey	
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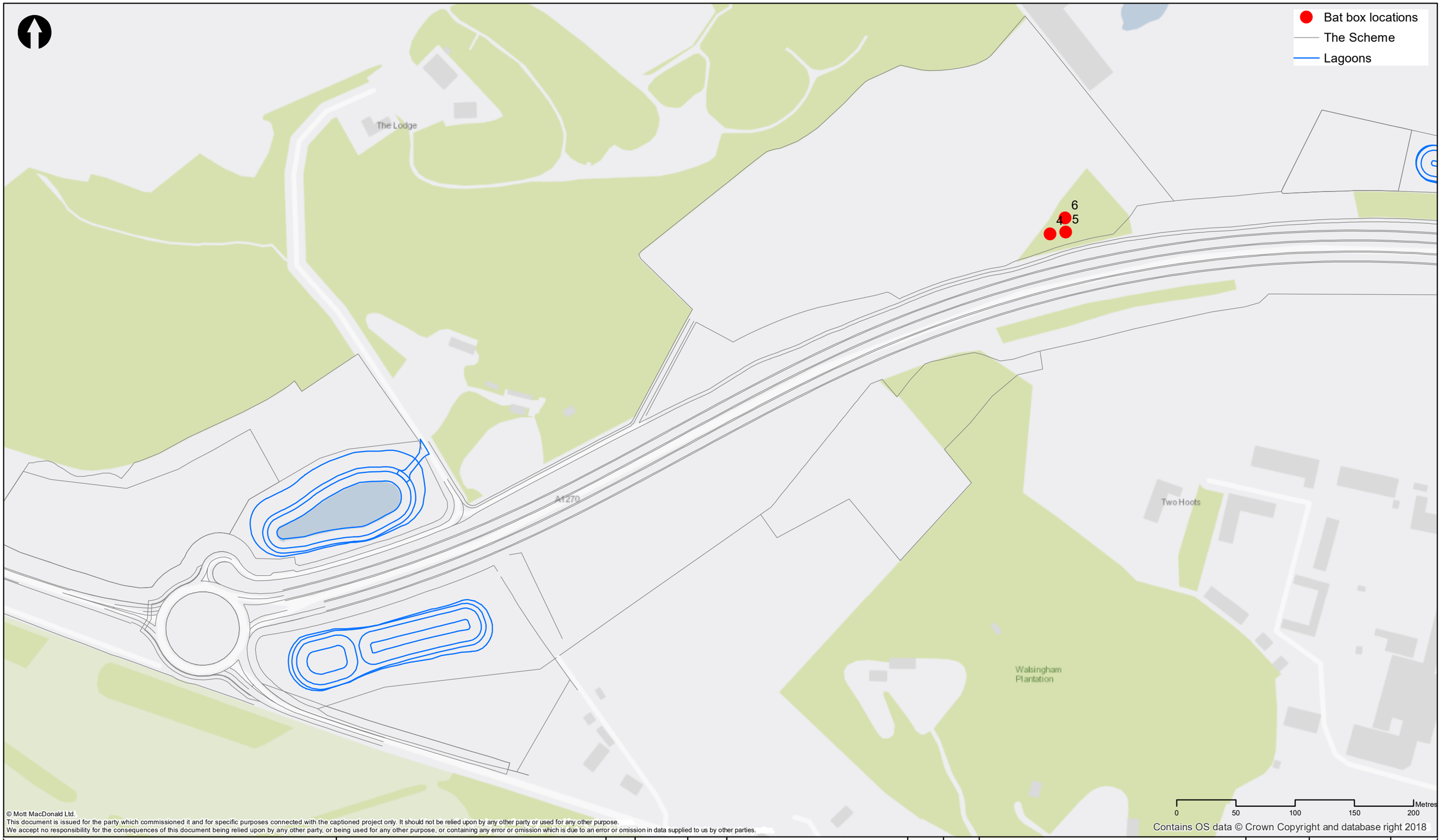

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Figure 7.8

Bat Box Locations - Spring Farm

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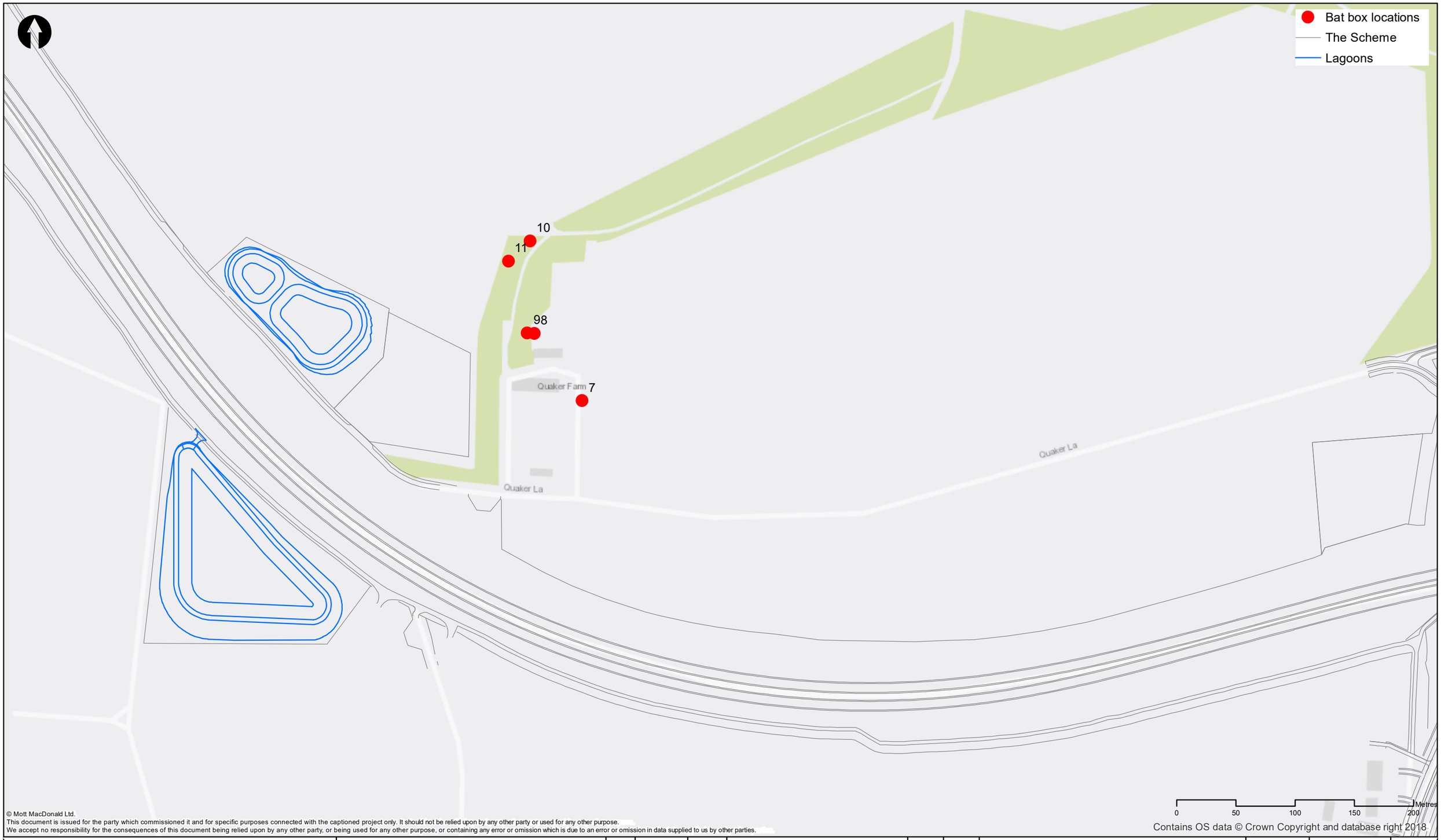

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Figure 7.9

Bat Box Locations - Quaker Farm

Drawn	B O'Hickey	
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Approved	S Allen	

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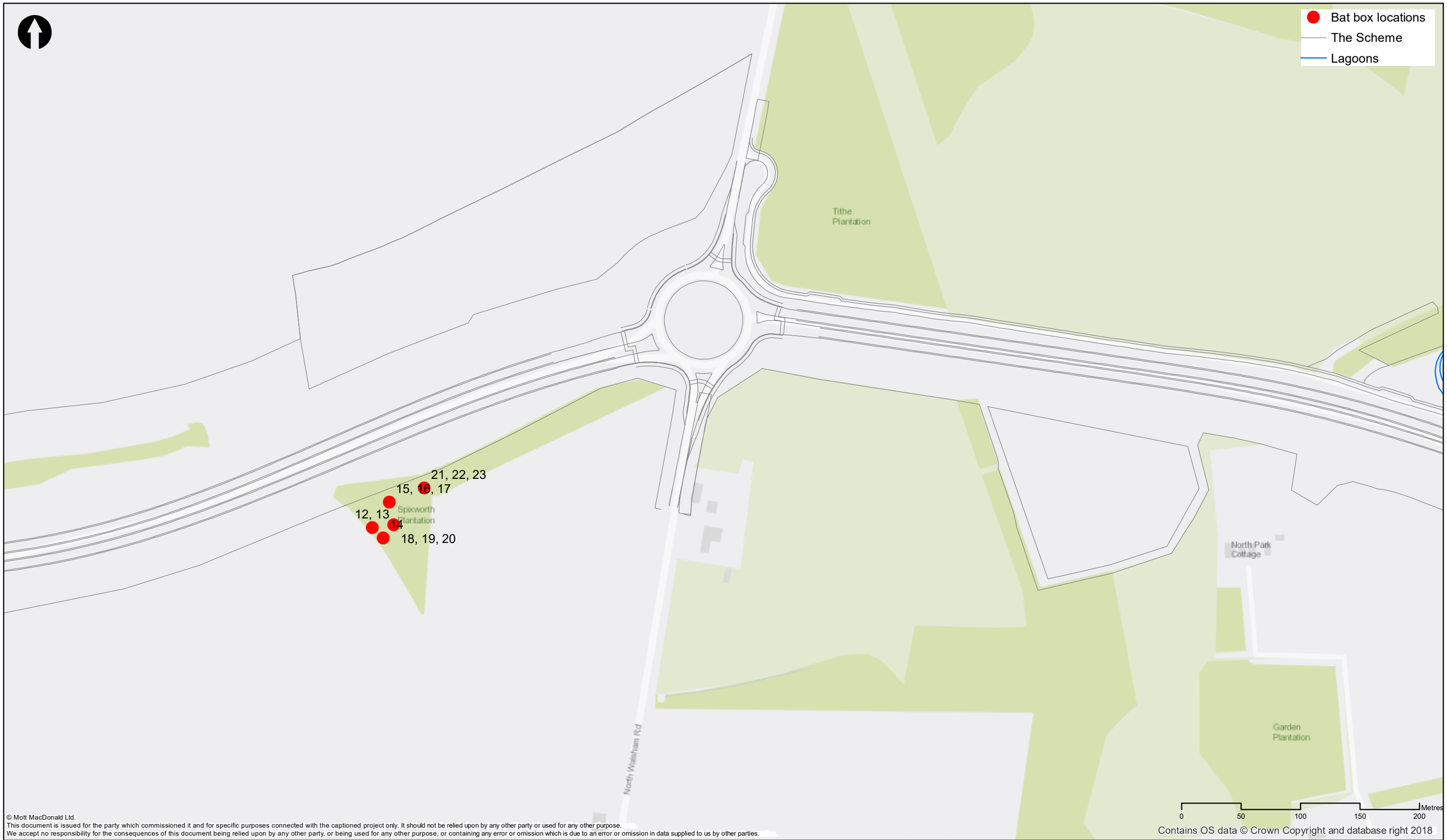

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Figure 7.10

Bat Box Locations - Spixworth Plantation

Drawn	B O'Hickey	
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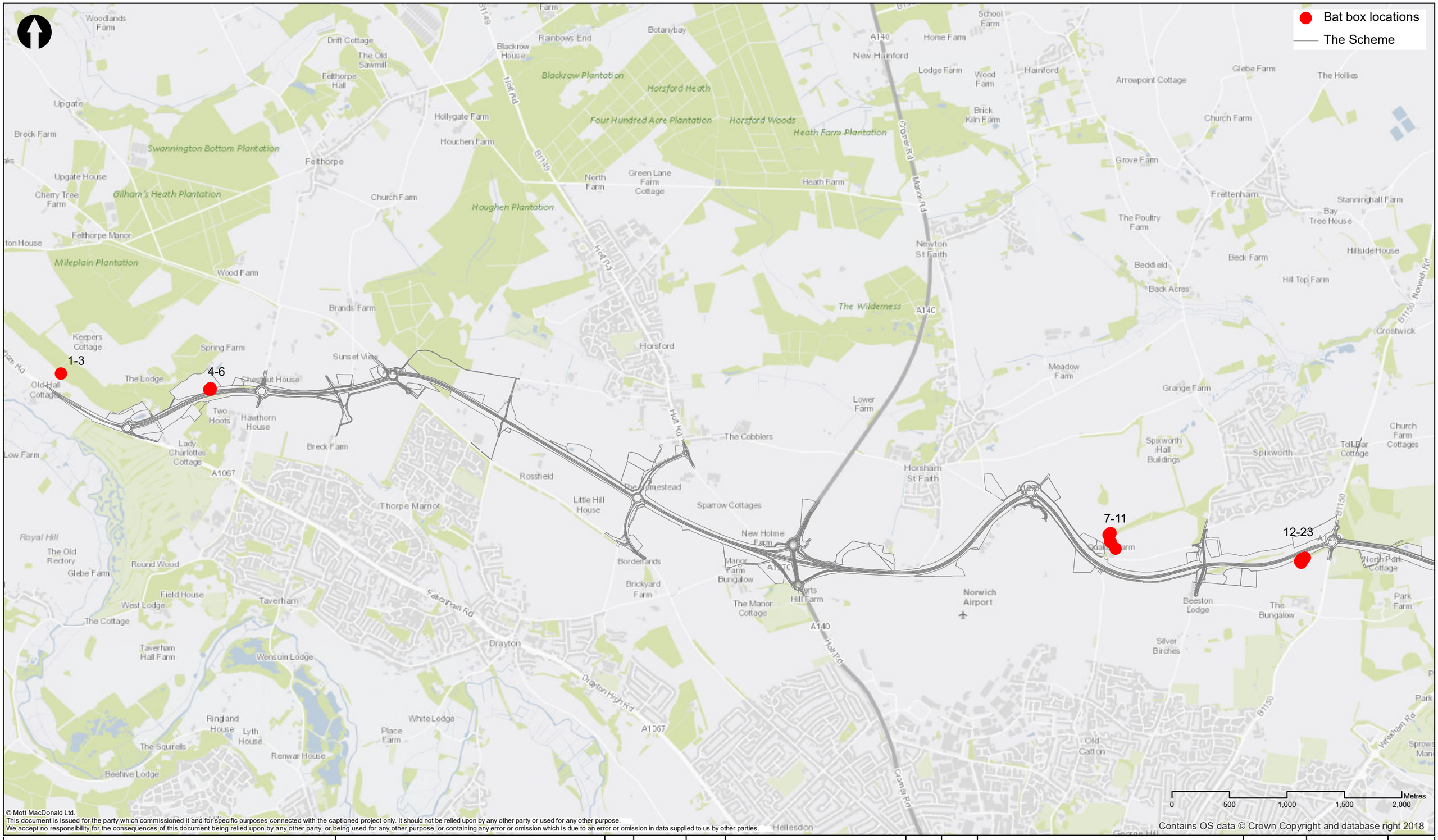

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Figure 7.11

Bat Boxes - Overview

Drawn	B O'Hickey	
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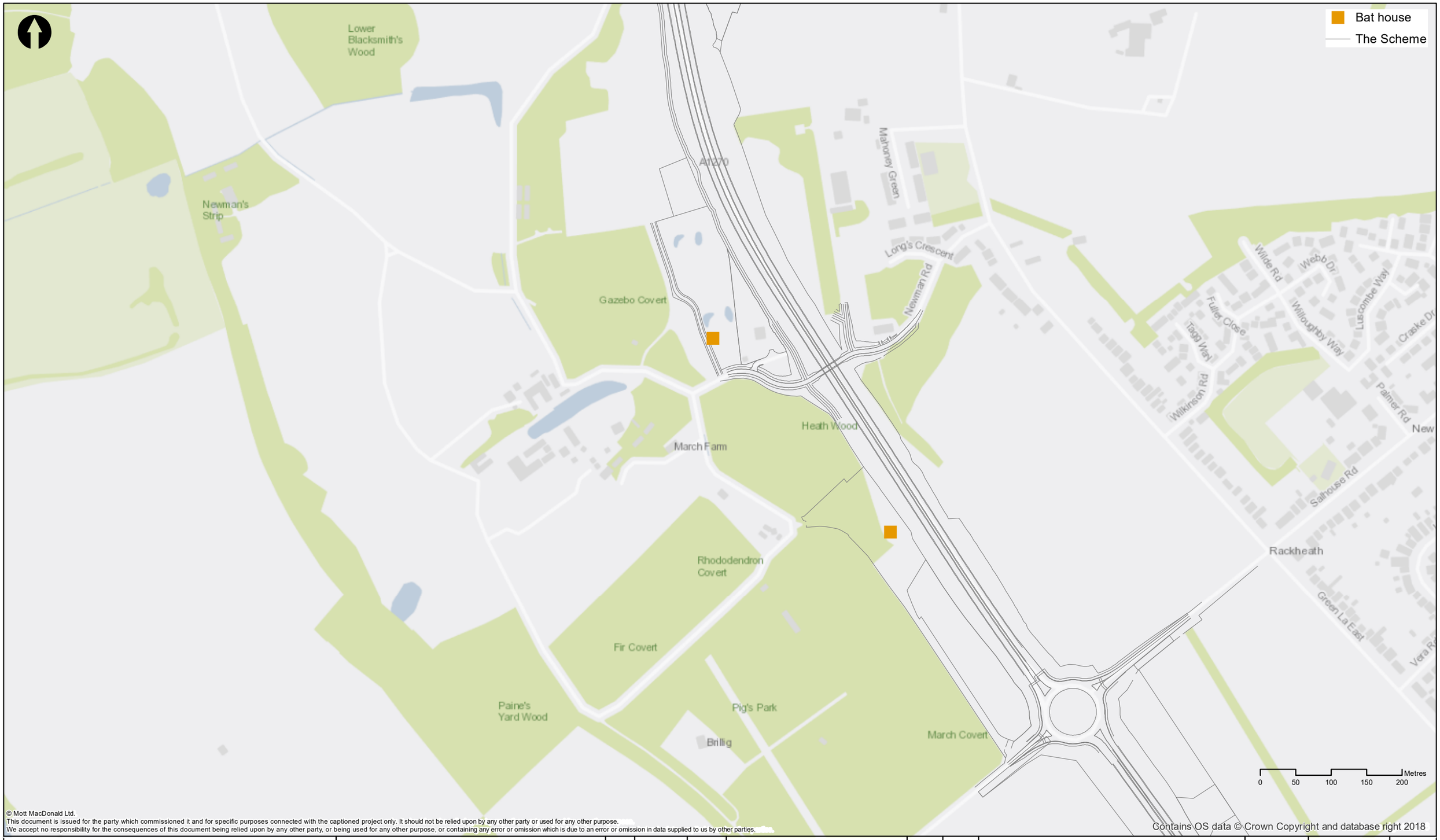
D. A comparison of the mean nightly calls from static detectors between year 1, 2 and year 3 at all crossing locations

Location	Mean nightly calls inside (2018)	Mean nightly calls outside (2018)	Mean nightly calls inside (2019)	Mean nightly calls outside (2019)	Mean nightly calls inside (2020)	Mean nightly calls outside (2020)
Gantry 1	41.67	52.50	43.08	50.00	53.22	65.00
Gantry 2	69.40	129.63	25.17	38.83	61.24	54.71
Gantry 3	191.10	69.33	469.70	537.40	259.96	66.35
Gantry 4	96.63	223.90	229.00	30.33	390.52	297.17
Gantry 5	38.08	38.08	27.73	36.00	25.78	5.09
Gantry 6	63.50	40.00	34.67	13.78	87.30	60.70
Gantry 7	311.00	330.50	1025.25	204.50	257.50	443.00
Marriott's Way Green Bridge	121.25	111.75	81.50	71.13	9.71	16.76
Middle Road Green Bridge	35.00	53.25	20.33	43.67	8.26	1.68
Buxton Road Dark Corridor	63.75	47.83	161.67	81.67	18.48	81.14
Newman's Road Dark Corridor	116.67	178.67	466.67	536.53	41.57	6.24
Underpass	90.38	74.42	201.20	192.90	44.29	64.67

E. Bat house locations



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Norfolk County Council

Rev	Date	Drawn	Description	Ch'k'd	App'd
P01	16/01/19	BOH	First Draft	AG	SA

Title

Figure 7.12

Bat House Locations - Overview

Drawn	B O'Hickey	
Checked	A Gagen	
Approved	S Allen	

Scale at A3
1:5,000

Drawing Number
366431-MMD-00-GIS-Y-0012

Security	Status	Rev
STD	PRE	P1

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