Appendix G

N6 Galway City Transport Project - Bat Radio-tracking and Roost Surveys 19th to 29th August 2014 (Geckoella Ltd., 2015b)

G1

Consultants for ecology and geology

N6 Galway City Transport Project
Bat Radio-tracking and Roost Surveys
19th to 29th August 2014

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Survey dates:	19th to 29th August 2014 (incl.)
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Authorised by:	Dr. Andy King
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Summary

Geckoella Ltd. were commissioned by Scott Cawley Ltd. to radiotrack bats to inform the environmental baseline of the N6 Galway City Transport Project. The specific objectives of the project were to find out more about the vesper bats that are present within the proposed scheme area, especially their roost locations, as well to gather data on lesser horseshoe bats outside the home range of the lesser horseshoe bats of Menlo Castle. The survey took place between 19th and 29th August 2014 (incl.) and 181 bats were caught from 6 sites on 6 nights. Of these, 11 bats of 5 species were tagged. Daytime positioning was used to identify roost locations. Roosts were found for 8 of the bats. Five of these individuals moved roosts within the survey period, and a total of 16 bat roosts were identified.

Acknowledgements

We thank the following contributors to the radio-tracking surveys and analysis:
Dr. Fiona Mathews, Dr. Elizabeth Bradshaw, Alison Johnston, Iain Hysom, Dan Buckley, Helen Saunders, and Kevin Hamel.

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1 Introduction

1.1 N6 Galway City Transport Project requires environmental baseline information in the scheme study area as part of the constraints study for the project. Information on bats is being collected as part of this process in accordance with local and European guidance and legislation (Kelleher & Marnell, 2006). A consortium led by Geckoella Ltd., with Helix Ecology and EcoPro was contracted by Scott Cawley Ltd. to carry out radio-tracking and other bat survey work to contribute to this baseline environmental information.

1.2 The specific objectives of the radio-tracking and other survey work carried out between 19th and the 29th August 2014 (incl.) were to:

- Gather data on vesper [1]bats across the 6,350 ha proposed scheme area, centred on the city of Galway.
- Gather data on lesser horseshoe bats *Rhinolophus hipposideros* across the proposed scheme area, excluding the home range of the lesser horseshoe bats of Menlo Castle.

1.3 The approach used was to catch bats using harp traps and mist nets and collect biometric data on all trapped bats. A subset of bats, most likely to provide information of relevance to the environmental baseline for the scheme, were fitted with small radio-transmitters. The tagged bats were re-found during the following days using radio-receivers, to establish their daytime roosting habits. Supplementary information on these roosts was also collected. The survey work was carried out under licence numbers C098/2014, 027/2014, C009/2014 and DER/BAT 2014-39 from the National Parks and Wildlife Service of Ireland.

[1] Vesper bats are of the family Vespertilionidae, and in Ireland include bats of the genera *Pipistrellus*, *Myotis*, *Plecotus* and *Nyctalus*.

2 Methodology

2.1 The proposed scheme area is located at Galway city on the west coast of Ireland and includes approximately 6,350ha as shown in Figure 1.

2.2 Six sites for trapping were selected using advice from local surveyors (Scott Cawley Ltd., pers. comm.), aerial photo interpretation and site visits. The best sites for trapping bats in late August are generally sheltered locations close to likely good feeding habitat and roost sites. This increases the potential for a large number of bats of a wide range of species to be present in a relatively enclosed environment which is suitable for trapping. Figure 1 shows the trapping locations selected across the site.

2.3 Harp traps and mist nets were set up at each site. Bat lures emitting ultrasound calls similar to bat calls were placed adjacent to the harp traps, to help attract bats and increase the catch rate (Sussex Autobat, and AT100 ultrasound speaker).

2.4 The species and sex of every bat caught was recorded. Additional biometric data was collected for species other than soprano pipistrelle, comprising forearm length, weight and reproductive status. Where practical, all trapped bats were fur-clipped, as a temporary marker (agitated or stressed bats were not fur-clipped). This reduced the likelihood of double-counting, since bats re-caught with clipped-fur could be excluded from the data-set.

2.5 Supplementary information on presence / absence of bat species at trapping locations was collected through the use of hand-held detectors during the trapping sessions. The detectors record sound files for subsequent analysis using specialist software (Kaleidoscope Pro), which can identify species found to genus level for *Myotis* species, and species level for other bats found in Ireland.

2.6 Captured bats most likely to provide information of relevance to the environmental baseline of the proposed scheme area, determined according to criteria defined by Scott Cawley Ltd., were tagged with 0.29g or 0.35g radio transmitters (Holohil Ltd. Canada and Biotrack UK). Breeding females of any species were tagged as first preference. Tags were then applied to bats in order to obtain results from both males and females, adult and juvenile, and from a range of species. Bats of the genus *Myotis* were of particular interest. Each tag was less than 7% of the bat's body weight, as a condition of the survey license from the National Parks and Wildlife Service. Most of the bats tagged were also ringed with a unique long-term identification number in case re-found at a later date.

2.7 Each tag emitted a pulse of a specific frequency that could be re-found using a radio-receiver. This enabled the identification of any re-found bats to individual level. Tagged bats were tracked using Australis, SIKA and Regal radio-receivers during the day to identify daytime roosts, using a combination of omni-directional and directional Yagi antennae. Bats were sought first of all close to their trapped location, with the search area increasing until a systematic city-wide sweep was carried out. Data from within 24hrs of trapping was disregarded as potentially non-representative of typical behaviour.

2.8 The detailed location of each roost was found by homing-in where close approach to the roost was practical. For daytime roosts, this involved simply following the direction of strongest signal until the source of the signal was found and is a recognised best-practice approach for a static signal (Amelon, et al., 2009). Where close approach to the roost was impractical, then triangulation was used. This involves taking readings from three or more locations around the likely source of the signal, and plotting their

intersection. The roost locations presented in this report, including the ITM[2] values, represent the actual likely locations of the roosts of the tagged bats; with confidences indicated to compensate for potential sources of bias and error (Bartolommei, et al., 2012).

2.9 A systematic search of the proposed scheme area was carried out on 27th and 28th August 2014 in order to try to find any additional roosts. Each kilometre square in the area was checked for any tag frequencies that had not already been found elsewhere on that day.

2.10 Failure to find a tagged bat would have been most likely due to the following reasons:

- the bat was roosting outside the proposed scheme area,
- the bat was roosting in locations that made detection of the signal difficult (for example in dense woodland or cellars),
- the surveyors missed a clear signal inside the proposed scheme area (the likelihood of this would be reduced due to the systematic approach to search – see 2.8),
- the tag was no longer working (could be discounted for bats found again later in the survey).

2.11 The survey team comprised Mrs Kate Jeffreys MCIEEM CEnv, Dr. Fiona Mathews, Dr Elizabeth Bradshaw, Ms Alison Johnston, Mr Iain Hysom and Dr Andy King. This team is very experienced in the use of radio-tracking survey techniques for bats.

2.12 The findings in this report are described using the CIEEM categorisation of confidence (CIEEM, 2006) as set out below:

- Certain/near-Certain: probability estimated at 95% chance or higher.
- Probable: probability estimated above 50% but below 95%.
- Unlikely: probability estimated above 5% but less than 50%.
- Extremely Unlikely: probability estimated at less than 5%

2.13 Weather conditions for Galway during the survey period are summarised in Appendix A, with site specific data collected for trapping sites and times. The likely effects of the weather on the confidence of the survey findings are indicated where appropriate, the main impact being on limiting the number of suitable trapping evenings during the survey period.

[2] Irish Transverse Mercator grid reference

3 Results

3.1 Overall, 181 bats of 7 species were trapped at 6 sites. Of these, 11 bats of 5 species were tagged, 9 of which were also ringed. Most of the bats caught were soprano pipistrelles (151, 83.4%). followed by common pipistrelle (11, 6.1%) and Daubenton's (10, 5.5%). Trapping sites, with numbers of bats captured and tagged are listed in Table 3.1, with the detail provided in Appendix B. Figure 1 shows the locations of each trapping site. The following species abbreviations apply to all tables in these results:

Md	*Myotis daubentonii*	Daubenton's bat
Mmy	*Myotis mystacinus*	whiskered bat
Mn	*Myotis nattereri*	Natterer's bat
Msp	*Myotis sp.*	a bat of the Myotis genera
Nl	*Nyctalus leisleri*	Leisler's bat
Paur	*Plecotus auritus*	brown long-eared bat
Pn	*Pipistrellus nathusii*	Nathusius's pipistrelle
Ppi	*Pipistrellus pipistrellus*	common pipistrelle
Ppy	*Pipistrellus pygmaeus*	soprano pipistrelle
Rh	*Rhinolophus hipposideros*	lesser horseshoe bat

3.2 Supplementary information on the presence of bat species at trapping locations was collected through the use of hand-held detectors during some of the trapping sessions. The detectors record sound files for subsequent analysis using specialist software (Kaleidoscope Pro), which can identify species found to genus level for *Myotis* species, and species level for other bats found in Ireland. Table 3.1 also lists the additional species recorded at each trapping site.

3.3 Trapping rates tended to be higher in sheltered, woodland locations. It was difficult to find suitable areas to trap bats in the area west of Lough Corrib. This area includes open bog and heath, too exposed for trapping bats. Elsewhere, for example around Tonabrocky, the patchwork of small fields, overgrown hedges and impenetrable woodland patches offered a few suitable locations for trapping, but these were still likely to experience a rapid drop in temperature in August, and also had access issues.

3.4 The eleven tagged bats comprised 5 species: whiskered, Daubenton's, Leisler's, brown long-eared and common pipistrelle bats. Six were adult bats, of which 4 were in breeding condition, including one post-lactating female brown long-eared bat. Table 3.2 lists the tagged bats in detail. No bats were tagged from the Sport's Ground because no target species were caught – the cool weather conditions led to a very low catch-rate; equipment issues prevented the tagging of bats from Menlo Woods although biometric data on trapped bats is presented.

3.5 Sixteen roost locations were identified for 8 of the tagged bats and are listed in Table 3.3, with the detail provided in Appendix B. Figures 2A to 2P show and describe each roost. Ten roosts (62.5%) were modern houses or bungalows built in the 20th or 21st centuries.

3.6 An emergence survey carried out at The Women's Study Centre (Roost F) on 22nd August, found that 3 bats, including the tagged male Daubenton's bat tracked to this roost, emerged from the eastern aspect of the building)and flew east towards the River Corrib, using the vegetated dark road-bank corridor between the Kingfisher Centre and the N6.

3.7 An emergence survey carried out at Menlo Castle (Roost E) on 26th August found that 11 lesser horseshoe bats emerged from the maternity roost in the chimney at this site. These bats and this roost are described in other bat reports for the GCTP.

3.8 An emergence survey carried out at Salmon Weir Bridge (Roost O) on 29th August 2014, found that the male Daubenton's bat using this roost emerged at 21:30 and foraged south of the Salmon Weir Bridge until the end of survey. Large numbers of soprano pipistrelles were using the stream/culvert between Roosts M (Cathedral Footbridge) and Roost O (Salmon Weir Bridge). soprano and common pipistrelle bats were also regularly and constantly foraging over the River Corrib, passing under the arches of Salmon Weir Bridge. Leisler's bats and more *Myotis* bats were also recorded constantly foraging over the river.

3.9 No roost was found for one of the male Leisler's bats caught and tagged at Barna Woods (frequency 173.438, Appendix B).There was a weak daytime signal to the north-east of Castlegar on 25th August, but this signal faded and was not found again during subsequent searches, suggesting a day roost with thick walls or some other impediment to signal transmission. This bat was recorded foraging north-west of the Sport's Field on the 23rd August (bearing 314º from ITM 528250 727680), and east of Oranmore (3 bearings) on the evening of the 25th August, suggesting a large home range including areas west, north and east of Galway city.

Table 3.1. Trapping sites in Galway

Location	Date	ITM	Species captured	Total Captured	Number ringed	Number Tagged	Species recorded by acoustic surveys at trap site
Merlin Woods	19-Aug	0533450 0725600	1xMmy, 1xMd, 25xPpy	27	none	1xMmy, 1xMd	Ppy, Ppi, Msp
Barna Woods	20-Aug	524400 723800	2 x Paur, 2xNl, 31 x Ppy	35	2xNl	2xNl	-
Cooper's Cave	21-Aug	531729 727476	1xPaur, 3xPpy	4	1x Paur	1x Paur	Ppi, Ppy, Msp
NUIG[3]	22-Aug	529178 726369	61xPpy, 1xMmy, 3xMd, 2xPpi	67	1xMmy, 3xMd, 2xPpi	1xMmy, 3xMd, 2xPpi	Ppy, Ppi, Paur, Msp, Nl
Sports fields	23-Aug	528250 727680	7xPpy, 2xPpi	9	none	none	Ppy, Ppi, Nl, Msp
Menlo Woods	26-Aug	528530 728000	29xPpy, 2xPpi, 1xMn, 6xMd 1xPaur	39	none	none	-
6 sites			**7 species**	**181**	**9 ringed, 5 species**	**11 tagged, 5 species**	

[3] National University of Ireland: Galway

Table 3.2. Bats tagged at sites in Galway

Tagging location	Date tagged	Species	Arm mm	Sex M/F	Age	Breeding condition[4] Y/N	Weight g	Ring N/number	Frequency of tag MHz 173.xxx	Roosts found
Merlin	19-Aug	Mmy	31.6	M	A	N	4.75	N	231	not found
Merlin	19-Aug	Md	38.2	F	J	N	8.5	N	459	D
Barna	20-Aug	Nl	44.1	M	A	Y	15.5	131726	438	Single, weak signal NW of Galway, foraging data
Barna	20-Aug	Nl	44.2	M	A	Y	15	131727	535	A, I
Cooper's Cave	21-Aug	Paur	38.8	F	A	Y	8.5	A4260	395	H
NUIG	22-Aug	Mmy	32.7	M	J	N	5	A4261	414	B, N
NUIG	22-Aug	Md	37.8	M	A	Y	8	A4262	513	not found
NUIG	22-Aug	Md	39.6	F	J	N	10	A4263	252	E
NUIG	22-Aug	Md	37.7	M	J	N	8	A4264	297	F, G, M, O
NUIG	22-Aug	Ppi	-	F	J	N	5	L00391	361	C, J, P
NUIG	22-Aug	Ppi	31.5	M	A	N	4.5	L00393	323	K, L
6 sites		**11 tagged 5 species**		**7 M, 4 F**	**6 A, 5 J**	**4 in breeding condition**		**9 ringed, 5 species**		

[4] 'Y' for breeding condition indicates post-lactating females or reproductively active males respectively.

Table 3.3. Bat roosts found through radio-tracking in Galway

Roost name	Roost ITM Easting / Northing	Dates in August	Bat Species / F[5]	Bat sex (M/F) age (A/J), breeding (Y/N)	Trapping site	Distance from trapping site (km)	Description	Confidence
A. Bungalow, Cappagh Road	524485 725124	24th, 25, 27th	Nl / 535	M/A/Y	Barna	1.2	Modern bungalow	High
B. Residence behind Sport's centre	524614 724182	24th, 25th, 26th	Mmy / 414	M/J/N	NUIG	5.0	Modern house	Moderate – location backs onto Roost N. Unlikely but possible that roost is at the back of Roost N.
C. Ballymoneen	526356 725344	24th, 25th	Ppi / 361	F/J/N	NUIG	3.0	Modern house	High
D. Killeen House	526370 728692	25th, 26th, 27th	Md / 459	F/J/N	Merlin	7.9	Farmhouse complex	Roost is within farm complex, but not sure which building. Tracked from road.
E. Menlo Castle	0528431 0727907	24th-29th	Md / 252	F/J/N	NUIG	1.7	Ruined castle	High
F. Women's Study Centre	528996 726229	24th	Md / 297	M/J/N	NUIG	0.3	1970s house	High
G. 51 St. Joseph's	529130 726060	25th	Md / 297	M/J/N	NUIG	0.4	Study centre	High

[5] F = frequency of bat tag, 173.xxx, to help indicate the specific bat.

Roost name	Roost ITM Easting / Northing	Dates in August	Bat Species / F[5]	Bat sex (M/F) age (A/J), breeding (Y/N)	Trapping site	Distance from trapping site (km)	Description	Confidence
H. Bungalow at Castle Gar	531925 728152	24th-29th	Paur / 395	F/A/Y	Coopers	0.8	Modern bungalow	High
I. Residence. Cappagh Road	524391 725205	26th	Nl / 535	M/A/Y	Barna	1.3	Modern bungalow	High
J. Residence. Ballymoneen. Sli Na Sruchan	526439 725313	26th, 27th	Ppi / 361	F/J/N	NUIG	3.0	Modern house	Moderate – dense housing estate, signal may bounce, houses close together. Judgement made on best indication from signal strength.
K. Cluanacauneen	533542 730077	25th, 26th	Ppi / 323	M/A/N	NUIG	5.7	Modern agricultural barn	High
L. barn nr roost K	0533503 0730071	28th	Ppi / 323	M/A/N	NUIG	5.7	Modern agricultural barn	High
M. Cathedral footbridge	0529520 0725588	28th	Md / 297	M/J/N	NUIG	0.9	Stone footbridge	Moderate – cluttered environment including thick stone structures. Possible bouncing signal.
N. Ard Na Coille. Residence behind Sport's centre	524591 724159	29th	Mmy / 414	M/J/N	NUIG	5.1	Modern house	Moderate – see notes on Roost B.

Roost name	Roost ITM Easting / Northing	Dates in August	Bat Species / F[5]	Bat sex (M/F) age (A/J), breeding (Y/N)	Trapping site	Distance from trapping site (km)	Description	Confidence
O. Salmon Weir Bridge	0529532 0725541	29th	Md / 297	M/J/N	NUIG	1.0	Stone roadbridge	High
P. Residence. Ballymoneen. Sli Na Sruchan	526324 725235	29th	Ppi / 361	F/J/N	NUIG	3.1	Modern house	Moderate – dense housing estate, signal may bounce, houses close together. Judgement made on best indication from signal strength.
16 bat roosts						**Mean distance 2.9km**		

4 Discussion and Analysis of Results

4.1 In total, 16 different roosts were identified by the surveys. Twelve of the 16 roosts (75%) were found in modern buildings; 5 roosts (31%) were likely to have been constructed within the last 10 years. This contrasts with suggestions that bats are more likely to be found in old buildings, especially those with multiple access spaces and different types of voids, and low levels of disturbance (Bat Conservation Trust, 2012).This difference may be due to one, or a combination of, the following reasons:

1) A general scarcity in the area of roosting sites with optimal features for bats.
2) A rapid change in the character and extent of Galway, changing the nature and availability of roost sites. The bats of Galway may be adapting to these changes, with unknown implications for population dynamics.
3) Local bat population preference. Mammal populations in different areas can have different habits. The findings from elsewhere in Europe with regard to roost preference and roost use by bats may not apply in Galway.
4) This survey was conducted outside the maternity season. Therefore a higher proportion of roosts would be expected in sites that would be suboptimal for maternity colonies (e.g. sites used by breeding males).

4.2 All roosts were located within 500m of open countryside, and/or close to the expansive natural watercourse and fringing habitat that comprises the River Corrib and which provides a 'blue corridor' flightpath and foraging area for bats which links the centre of Galway to open countryside.The roosts in Ballymoneen (C, J and P) were the most urban in location. No roosts were found within the heavily built-up areas of central Galway, despite a thorough city-wide sweep carried out by the team on 28th and 29th August 2014. Additional data would be required by other survey techniques to further evaluate the relative value of city-edge to city-centre locations for bats. However, the locations favoured for roosting by the bats tagged during this study suggests that roosts with good access to areas suitable for foraging are more likely to be used by bats.

4.3 Five of the 8 bats (63%) for which roosts were found moved roosts at least once during the period tracked. A male juvenile Daubenton's bat tagged at National University of Ireland Galway (NUIG) moved the most, occupying 4 different roosts over 6 days. In contrast, a post-breeding female brown long-eared bat was faithful to a single roost (H) over 6 days.

4.4 The roosts found during the surveys that had high potential to host maternity bat roosts were the bungalow (roost H) faithfully occupied by the post-lactating female brown long-eared bat (frequency 173.395), and Menlo Castle (Roost E) which was faithfully occupied by a female juvenile Daubenton's bat (frequency 173.252) for the duration of the survey and is a known maternity roost for at least one other species (lesser horseshoe bat). The farm complex (D) regularly occupied by another juvenile female Daubenton's bat (frequency 173.297) is also highly suitable for bats and well located to excellent foraging habitat and may well host a maternity roost. The extremely large numbers of soprano pipistrelle bats recorded at dusk during an emergence survey at Salmon Weir bridge, and a nearby stone footbridge (Roosts O and M) suggest a possible large maternity roost for this species somewhere in the vicinity of the old stone waterway that links these two features. A dawn track-back survey could help to clarify the exact roost location.

4.5 The location with low potential for a maternity roost comprised The modern agricultural barns (Roosts K and L) regularly occupied during the survey period by a juvenile female common pipistrelle bat, had low potential as maternity roosts, since the corrugated iron and other modern materials could lead to rapid changes in internal temperature in the structure. Other roosts found during the survey, comprising houses and bungalows, many modern, were of moderate potential for maternity roosts.

4.6 Rates of roost changing may be relatively high due to one, or a combination of, the following reasons, although further research would be required in order to test these theories:

- The time of year (August) is a period when the summer roosts of bats are breaking up, and bats are generally moving around more (Dietz, 2009).
- The area under study, comprising the fringes of Galway, have rapidly changed in the last few years. For example, a comparison of the area around roost F (Women's Study Centre, behind the Kingfisher complex) now with Google Maps aerial photographs dated 2012, shows substantial redevelopment in this area, including the removal of buildings. Bats may be adjusting to this changing environment by checking and exploring new roosts.
- The tagged bats including juvenile, non-breeding and male bats as a high proportion of the total tagged (5 out of 8 bats for which roosts were found were juveniles, 63%). These bats may tend to move roost more often than breeding female bats.
- Changes in bat behaviour due to fitting a tag. For this reason, data collected on tagged bats within 24hours of the tag being fitted was treated with caution.

4.7 Lesser horseshoe bats were present in the known roost at Menlo Castle and a survey carried out on this site counted 11 emerging lesser horseshoe bats. No lesser horseshoe bats were captured or detected acoustically at any of the trapping sites. Even taking into account species-specific bias against capturing lesser horseshoe bats, this low encounter rate is in line with the suggestion that lesser horseshoe bats are uncommon in the area. Acoustic survey data presented elsewhere also supports this suggestion (Geckoella, 2014).

4.8 There are substantial parts of the proposed scheme area which are generally open in character, and may be subject to low temperatures at night. Areas with open character also offer practical challenges to the use of mist nets and harp traps with regard to finding locations where bats are 'funnelled' into smaller areas. This makes other survey methods, such as acoustic techniques, potentially more appropriate in these areas. Trapping success improved in sheltered and warm areas.

5 References

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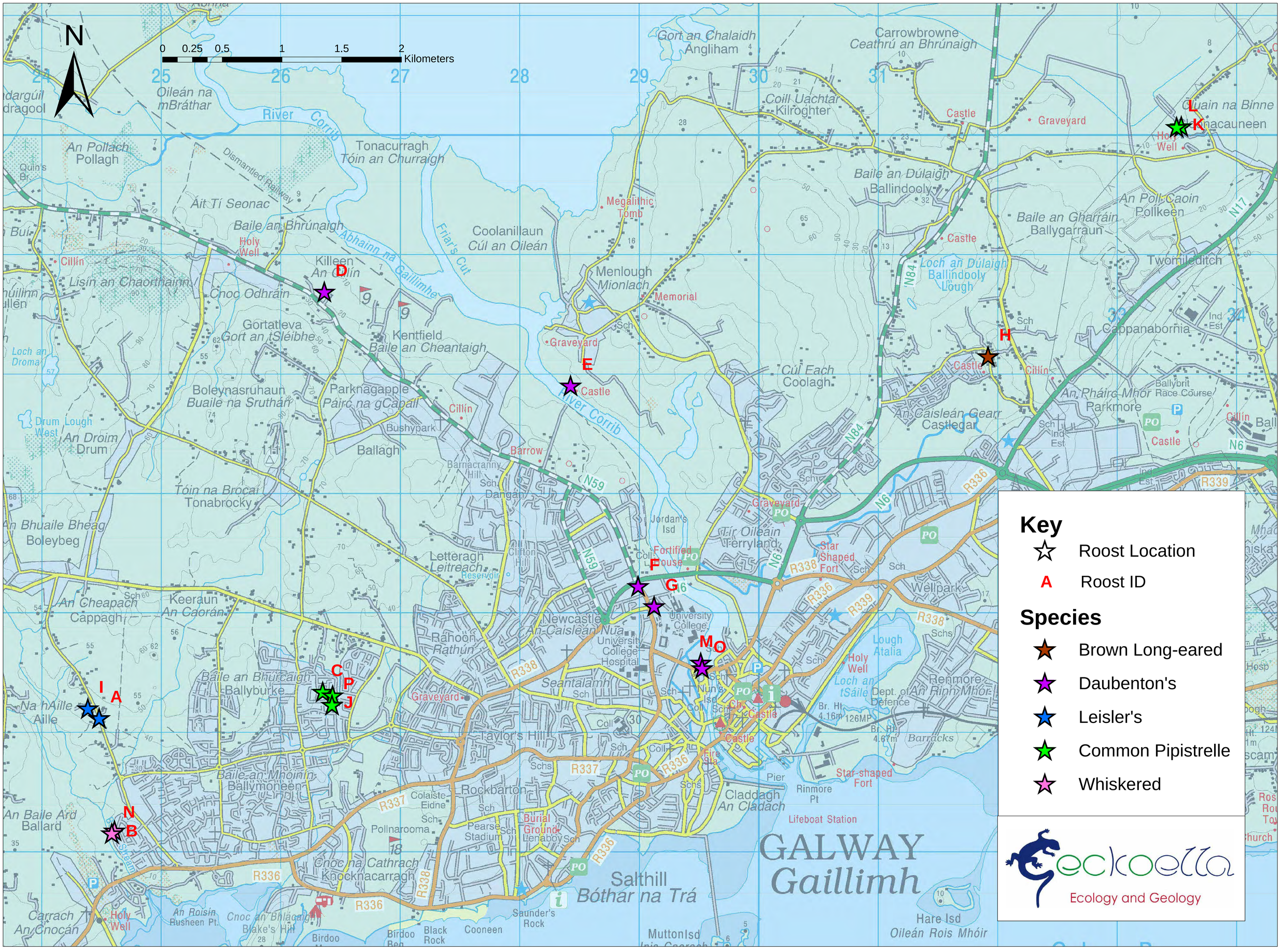
Figure 1. Trapping Sites and Proposed Scheme Area

Figure 2. Roost Locations From Radiotracking: Overview



GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

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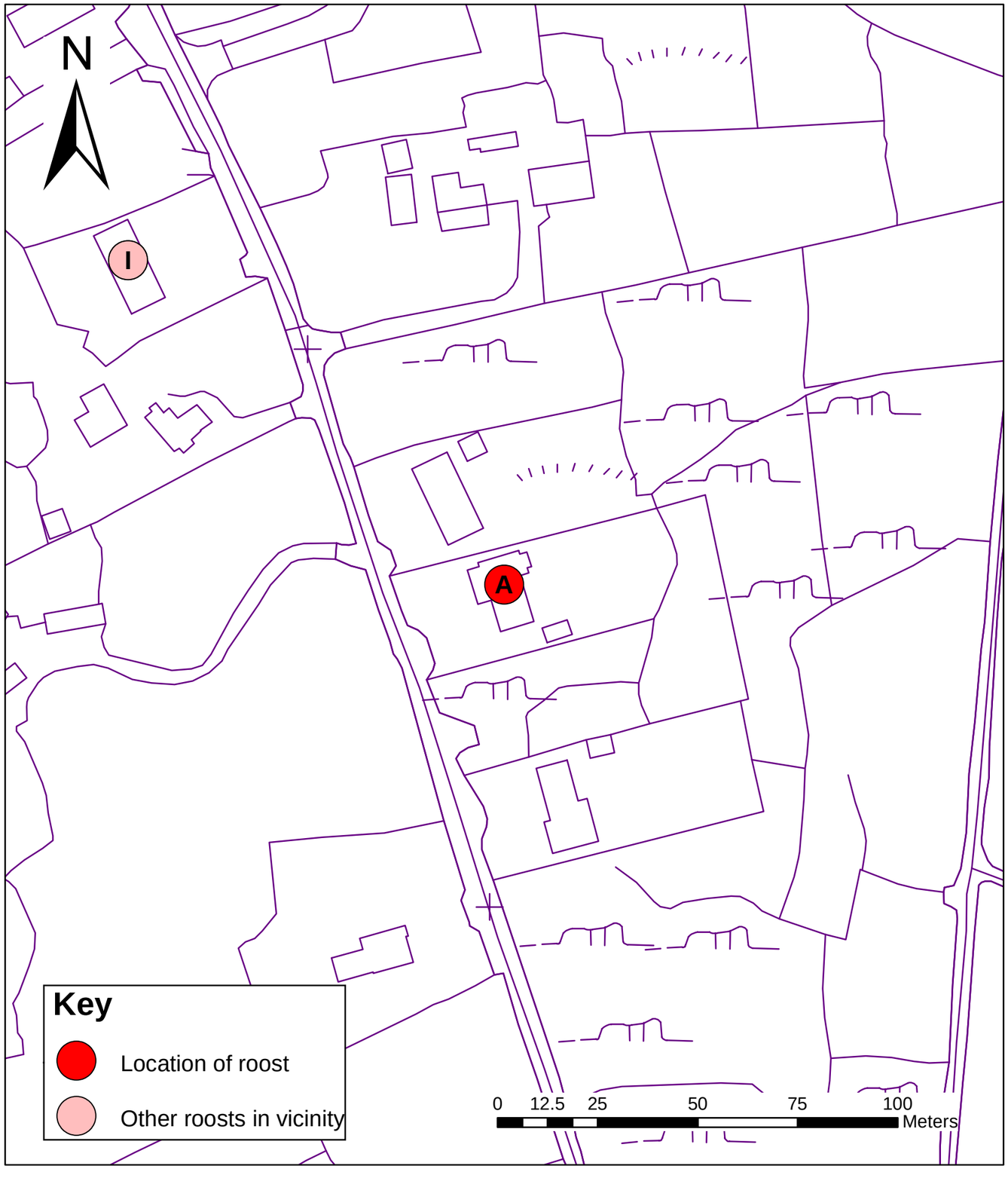

Roost A

GCTP Radiotracking
August 2014

ITM: 524485 725124
Location: Bungalow, Cappagh Road

Species: Leisler's Sex: Male
Dates bats confirmed resident: 22nd, 24th, 25th, 27th

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GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

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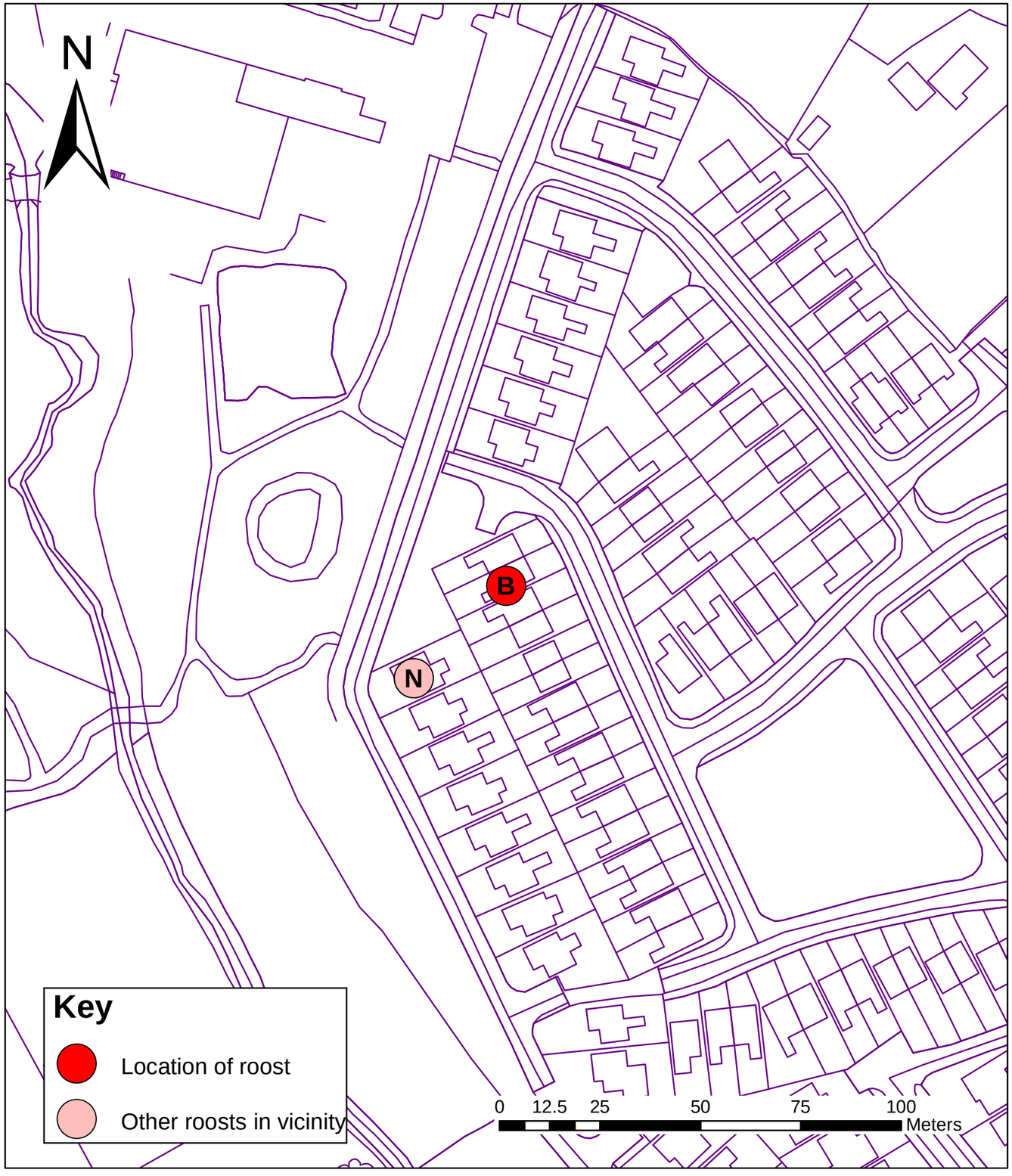
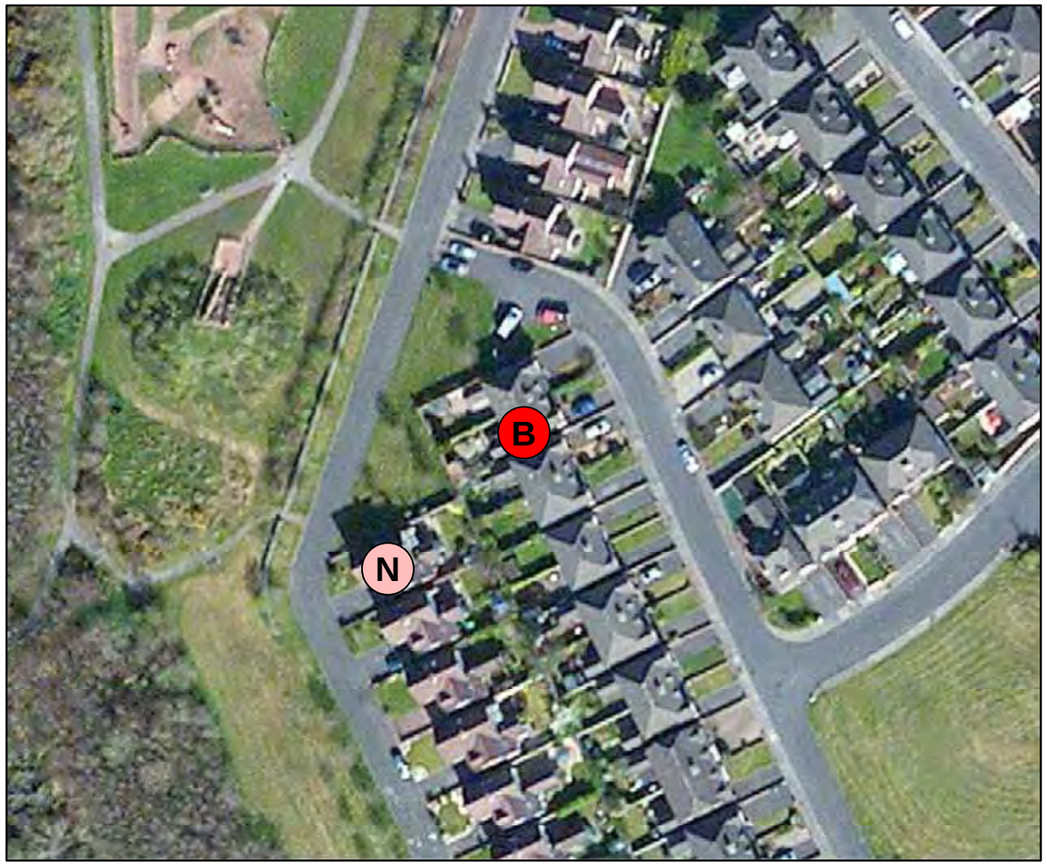




Roost B

GCTP Radiotracking
August 2014

ITM: 524614 724182
Location: Residence behind Sport's centre

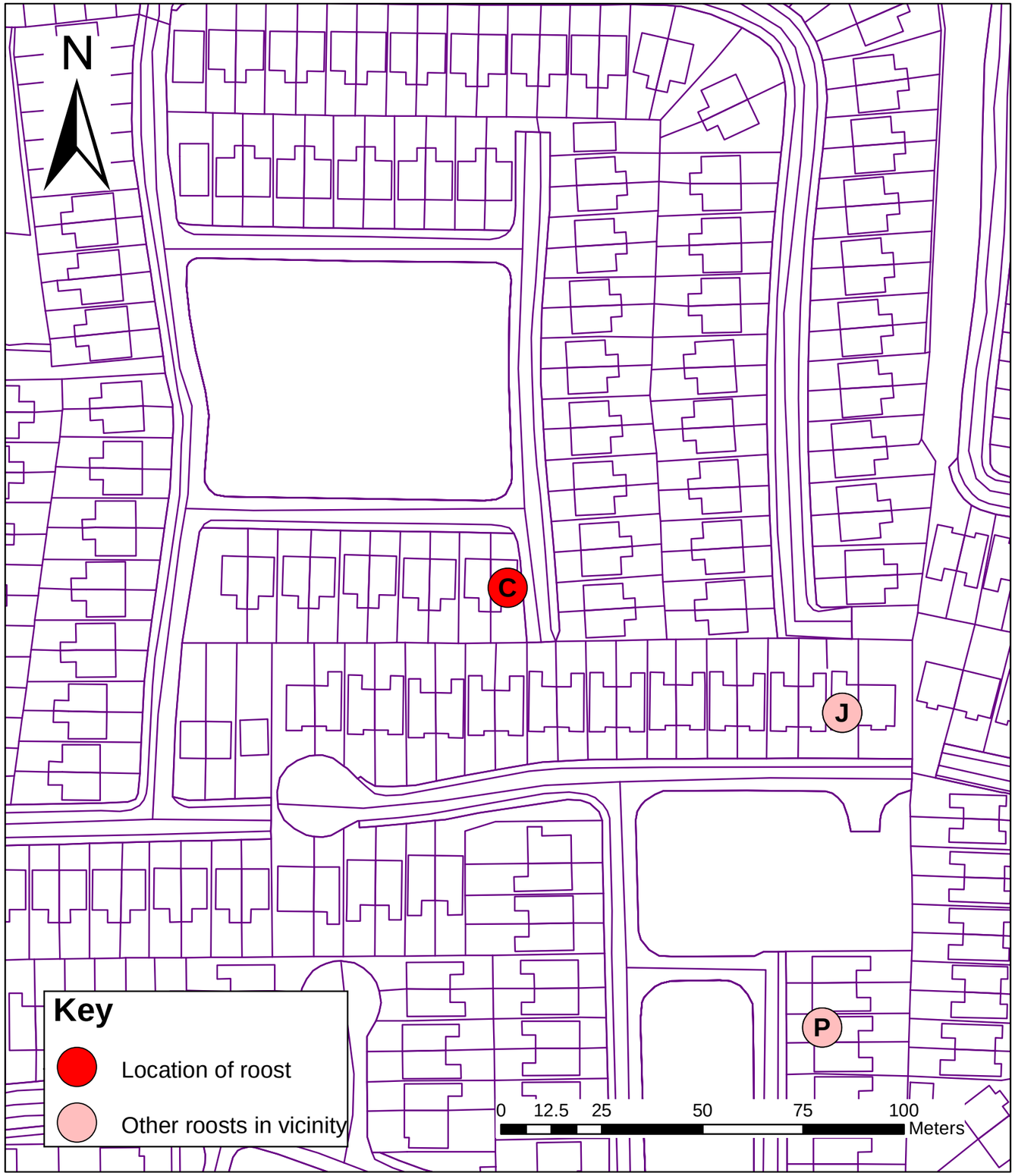
Species: Whiskered Sex: Male
Dates bats confirmed resident: 24th, 25th, 26th

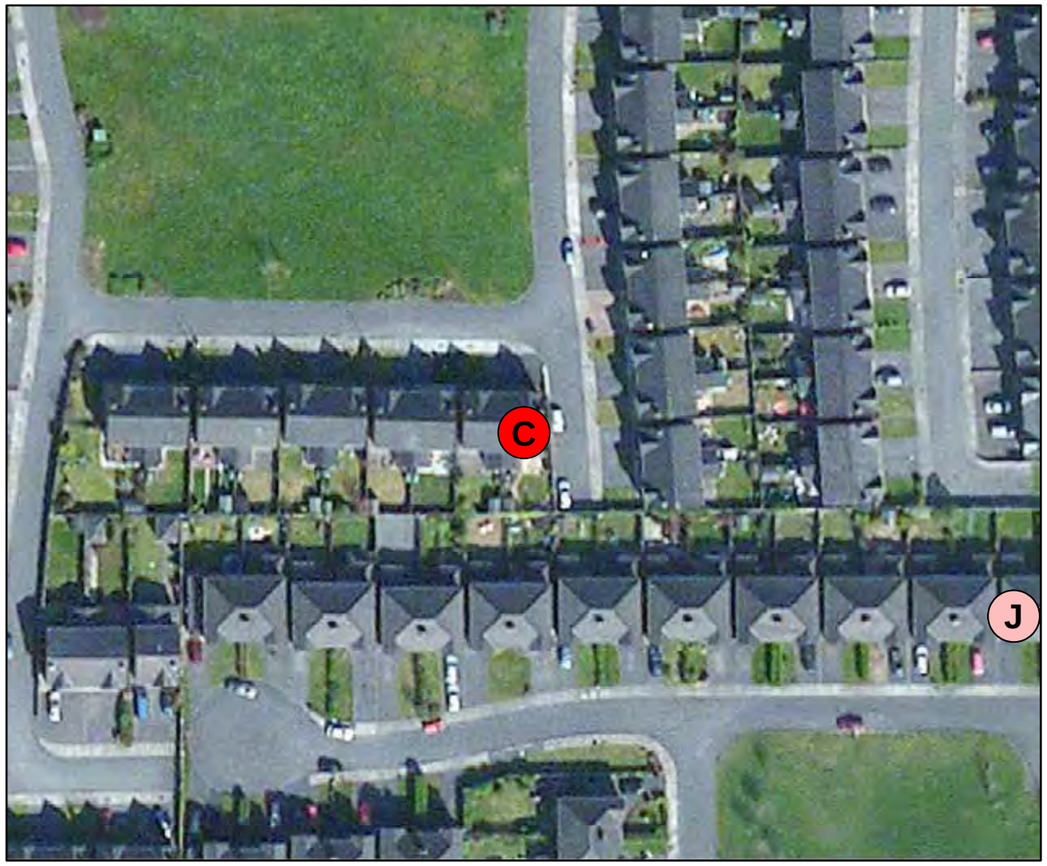
Note: Roost B backs on to Roost N. Although signal strength indicates separate roosts, would need to be between buildings to be certain.

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Eckoella
Ecology and Geology





Roost C

GCTP Radiotracking
August 2014

ITM: 526356 725344
Location: Ballymoneen

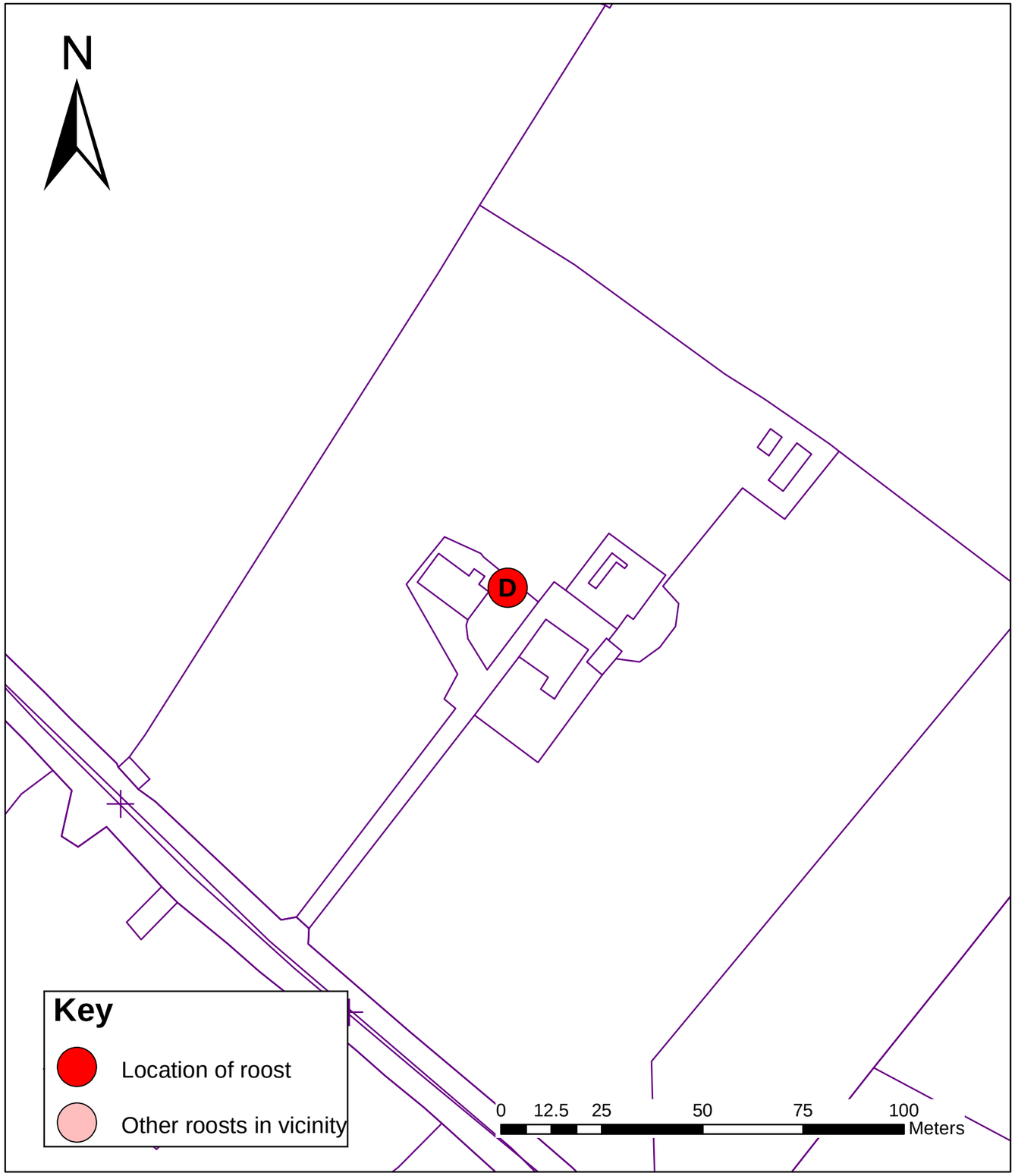
Species: Common Pipistrelle Sex: Female
Dates bats confirmed resident: 24th, 25th

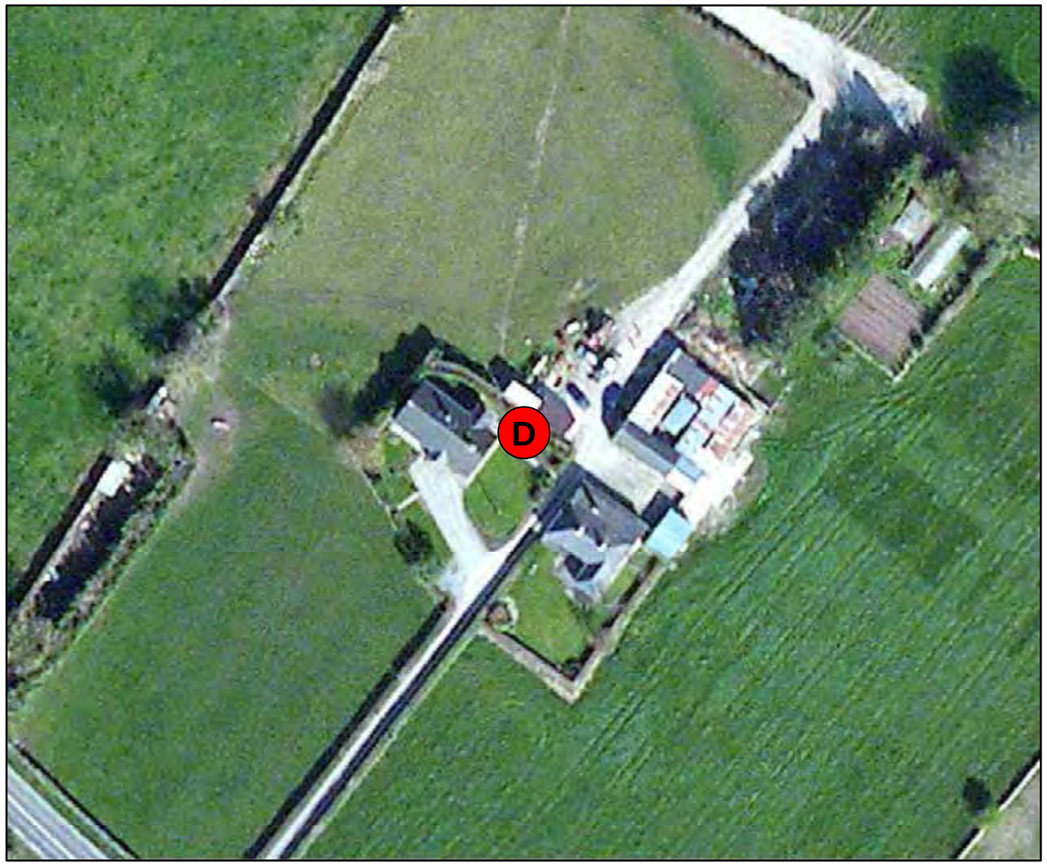
Sheet 3 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost D

GCTP Radiotracking
August 2014

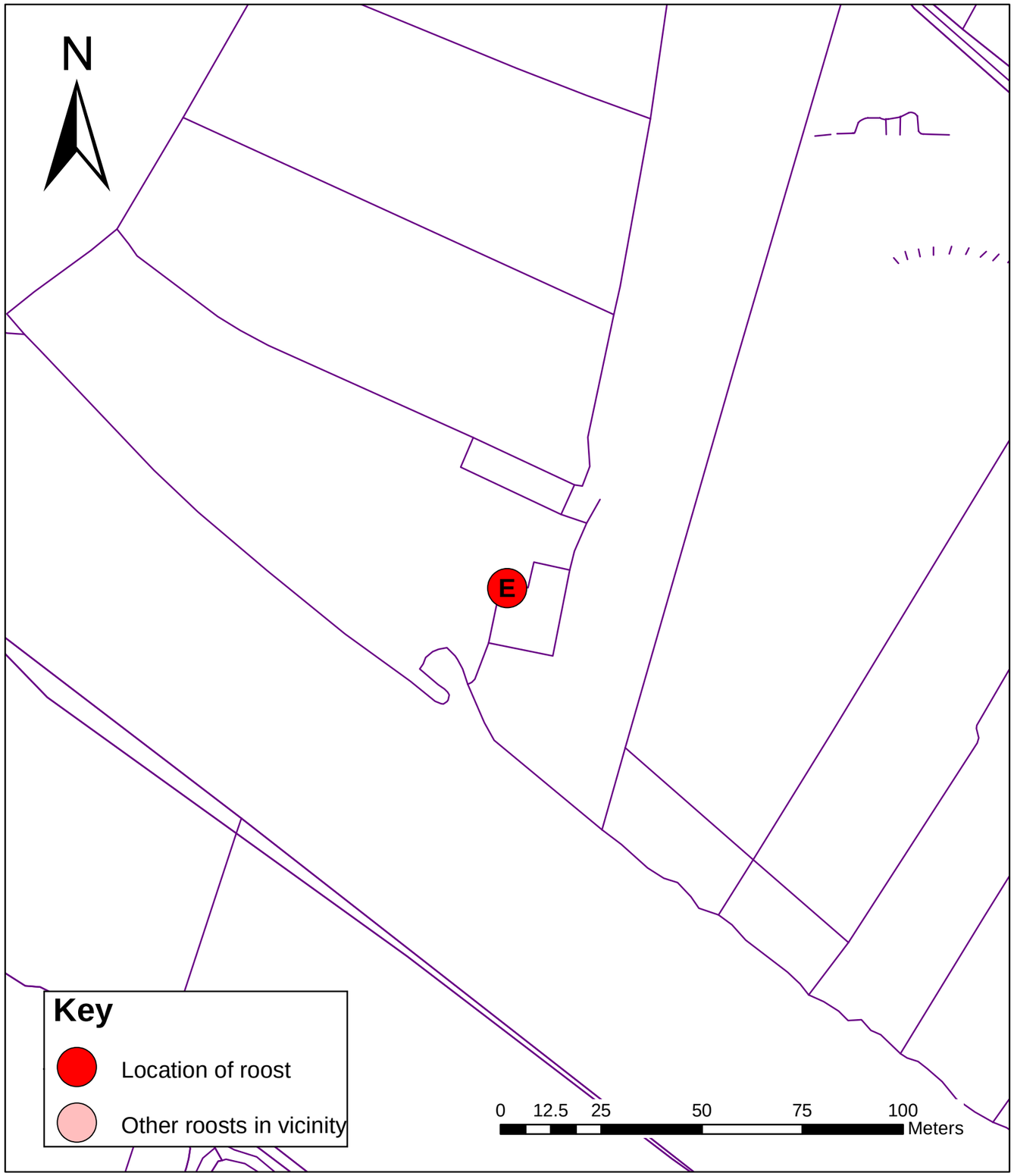
ITM: 526370 728692
Location: Killeen House

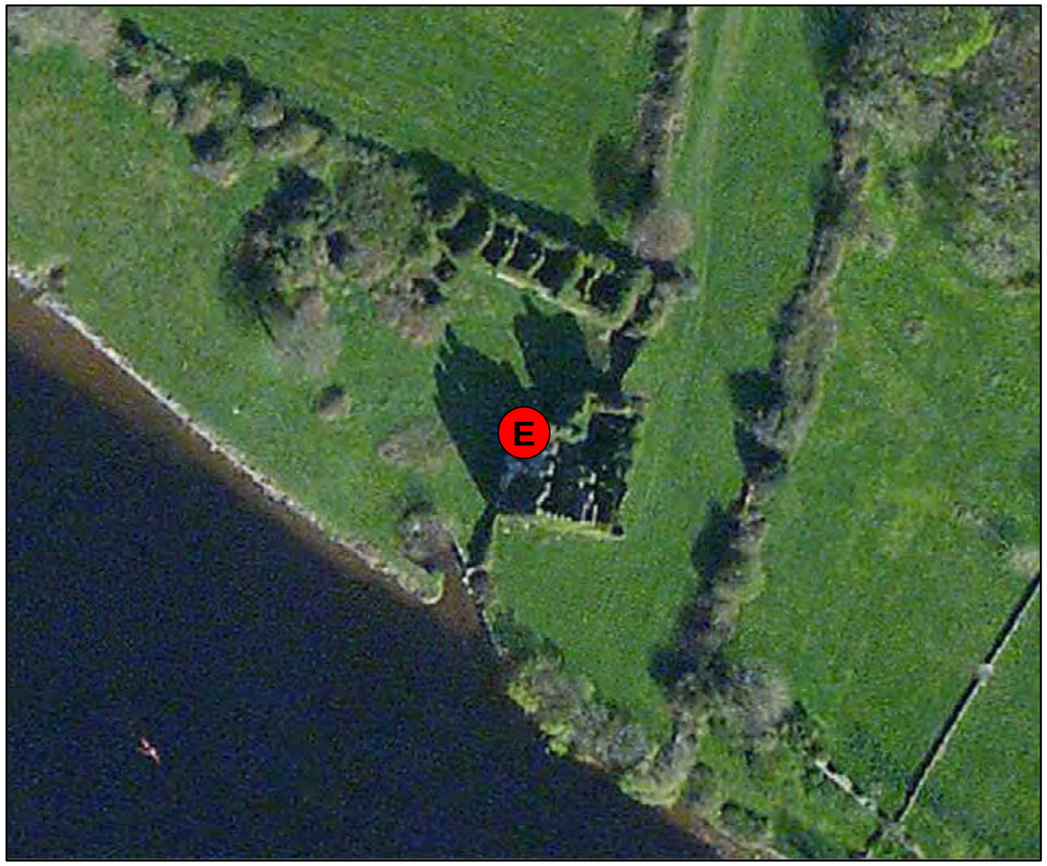
Species: Daubenton's Sex: Female
Dates bats confirmed resident: 25th, 26th, 27th

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost E

GCTP Radiotracking
August 2014

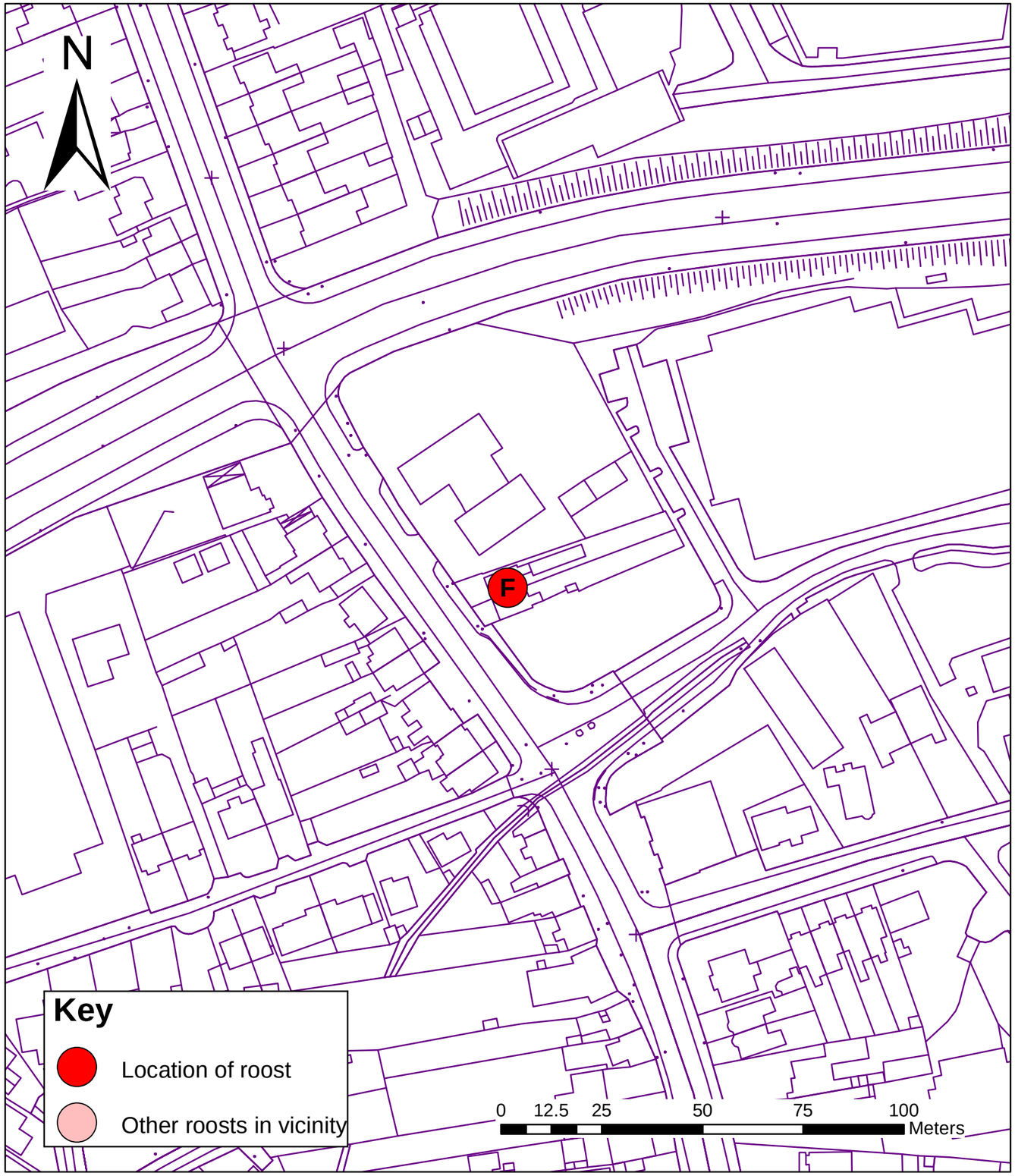
ITM: 528431 727907
Location: Menlo Castle

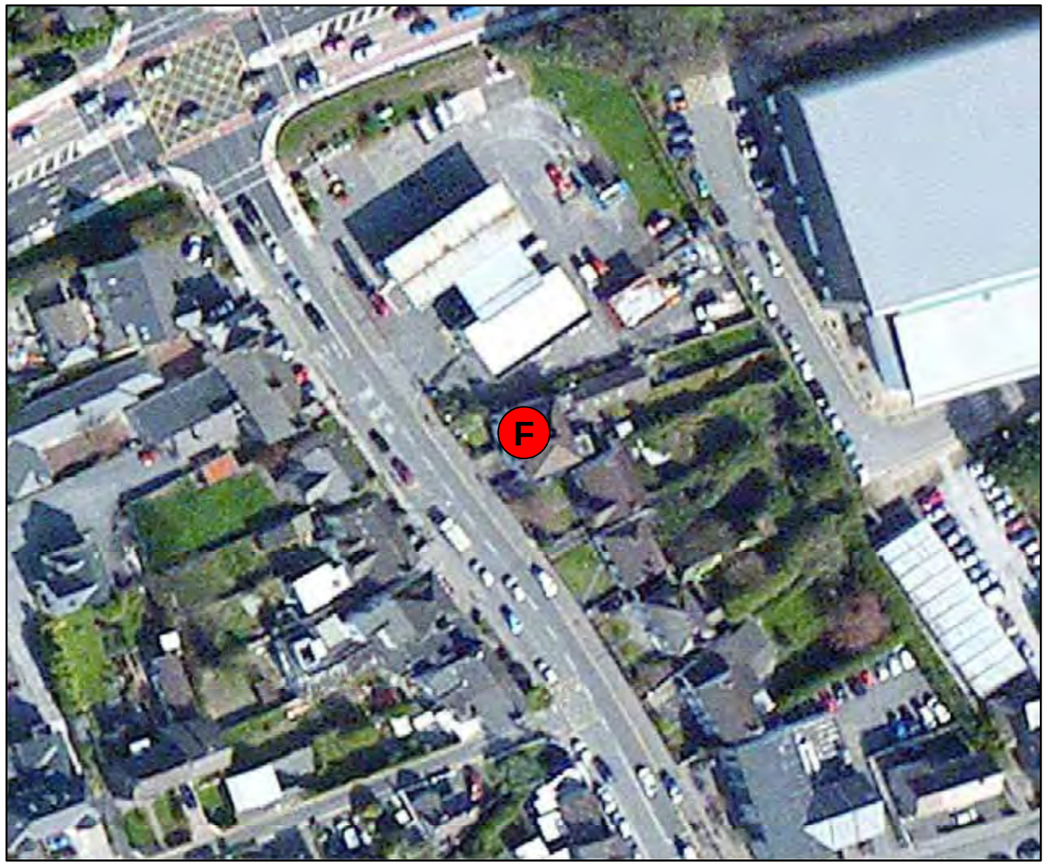
Species: Daubenton's Sex: Female
Dates bats confirmed resident: 24th, 25th, 26th, 27th, 28th, 29th

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost F

GCTP Radiotracking
August 2014

ITM: 528996 726229
Location: Women's Study Centre

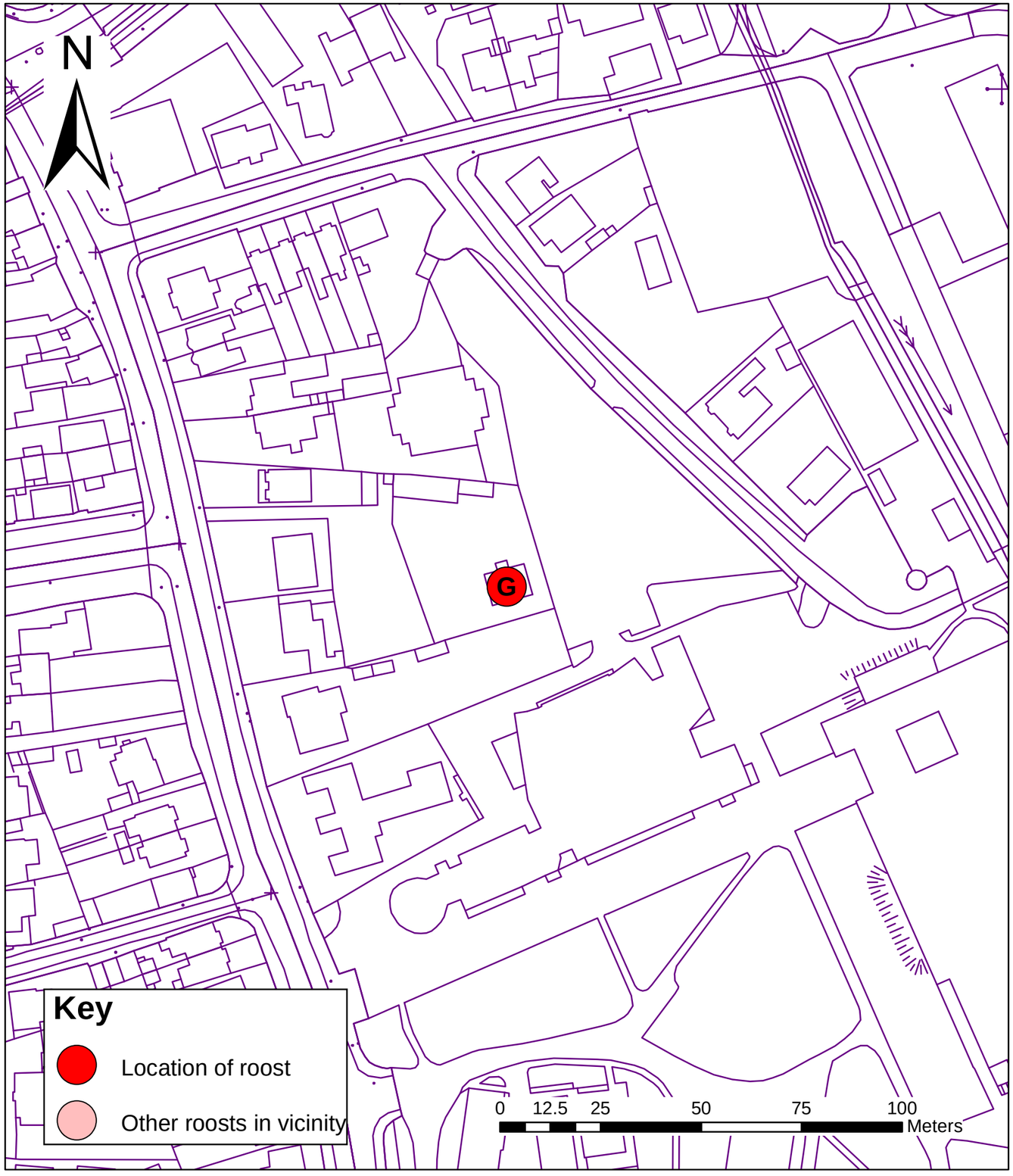
Species: Daubenton's Sex: Male
Dates bats confirmed resident: 23rd, 24th

Sheet 6 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology



Roost G

GCTP Radiotracking
August 2014

ITM: 529130 726060
Location: 51 St. Joseph's

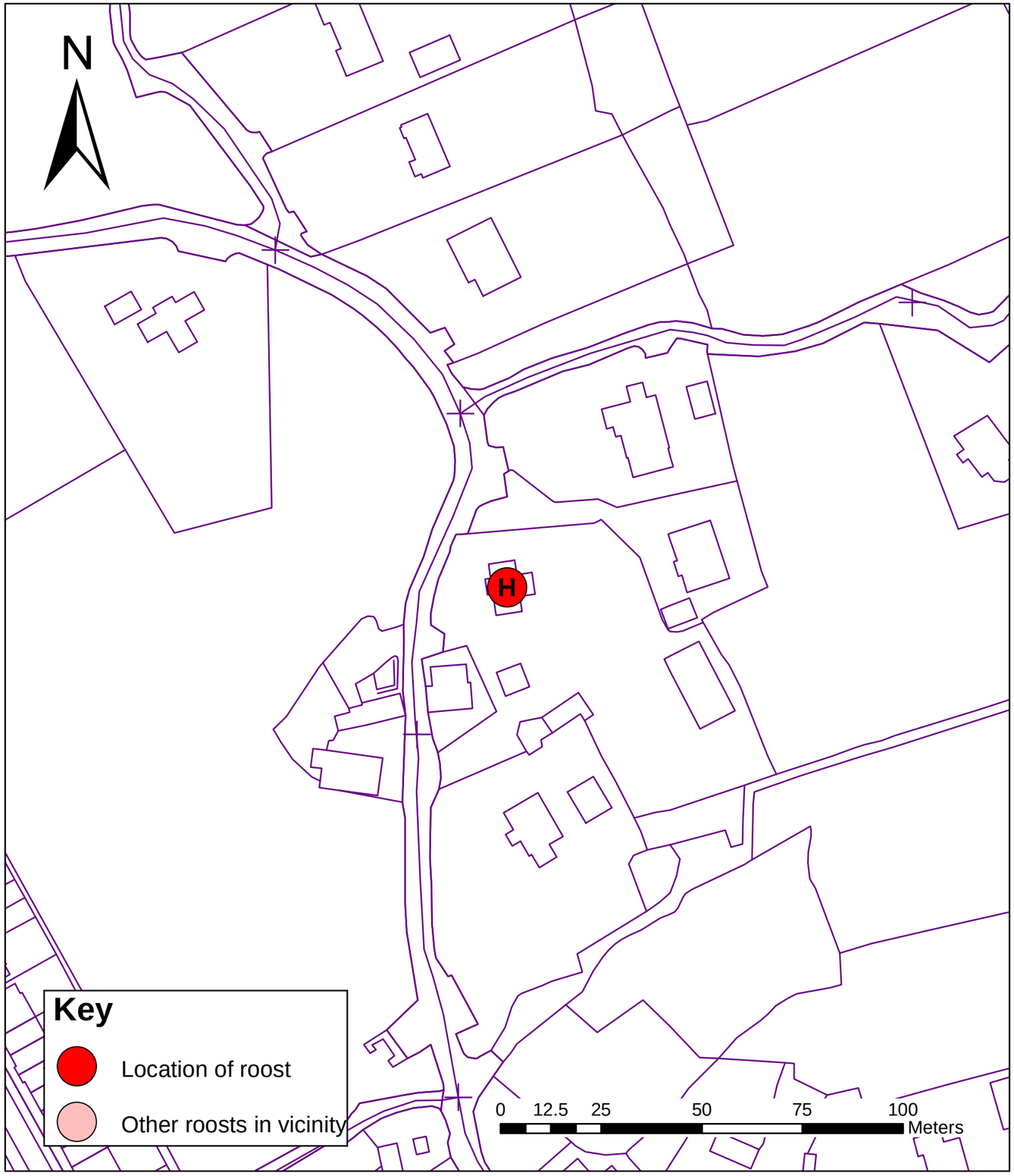
Species: Daubenton's Sex: Male
Dates bats confirmed resident: 25th

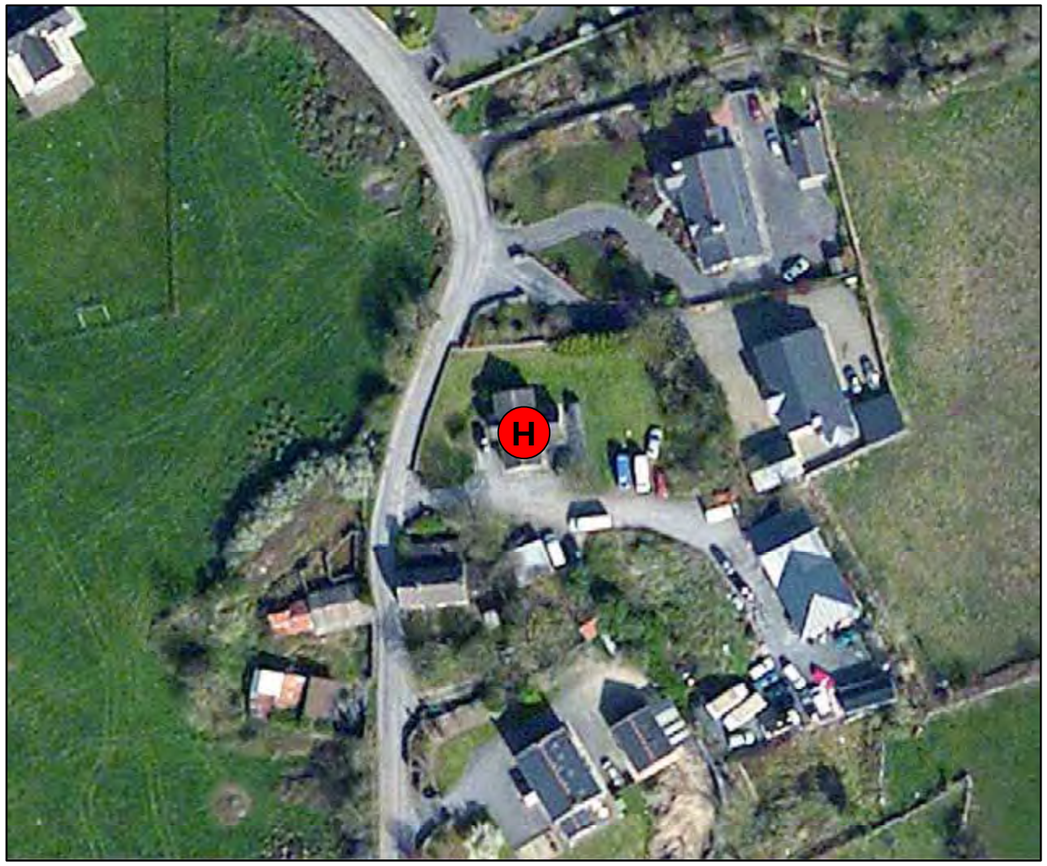
Sheet 7 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost H

GCTP Radiotracking
August 2014

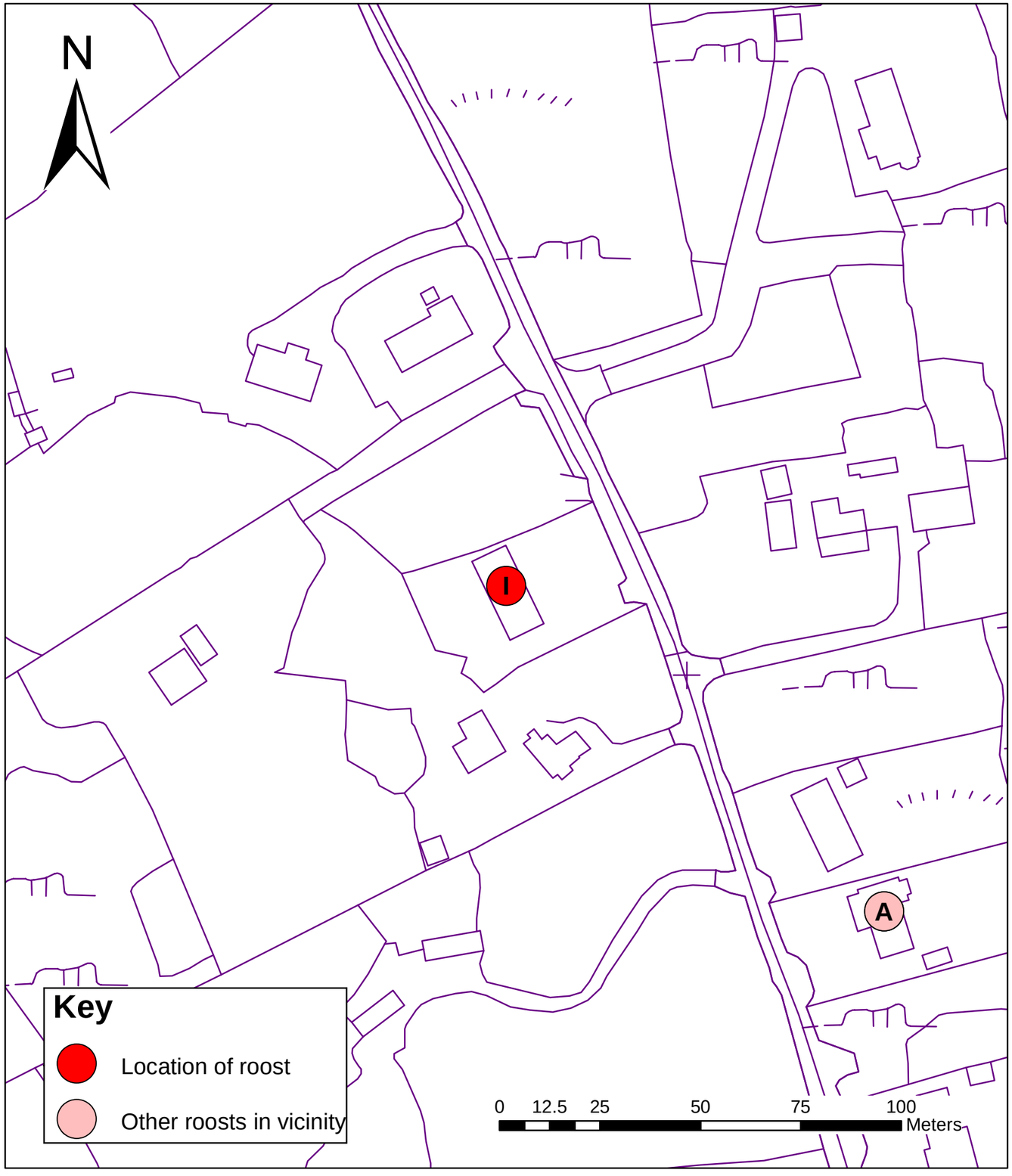
ITM: 531925 728152
Location: Bungalow at Castle Gar

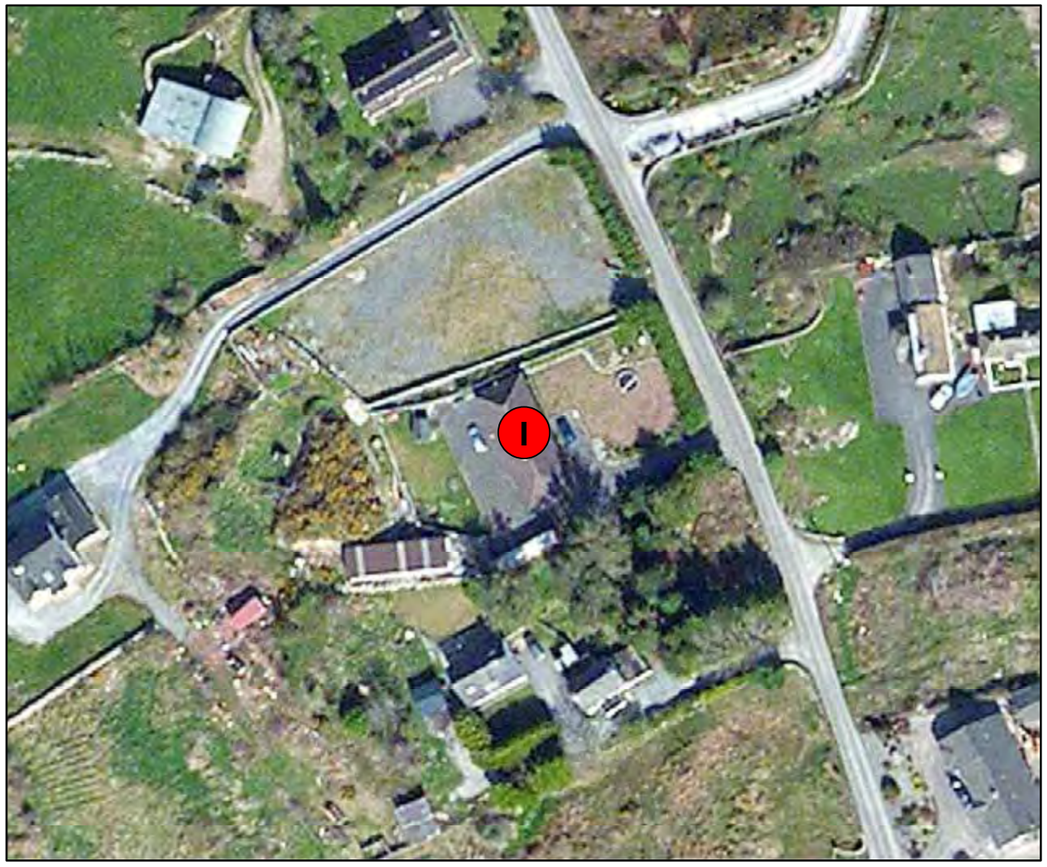
Species: Brown Long-eared Sex: Female
Dates bats confirmed resident: 24th, 25th, 26th, 27th, 28th, 29th

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost I

GCTP Radiotracking
August 2014

ITM: 524391 725205
Location: Residence. Cappagh Road

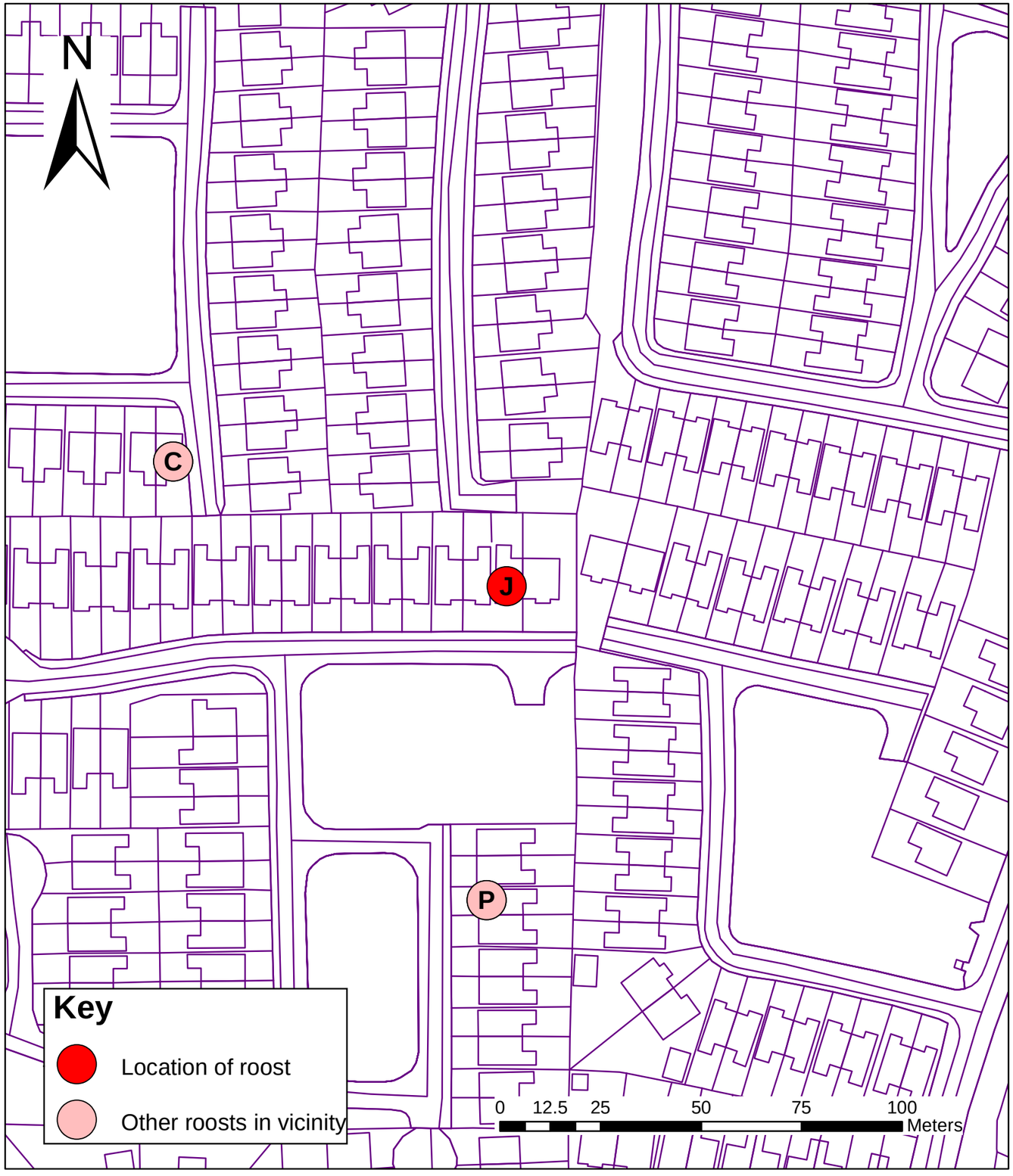
Species: Leisler's Sex: Male
Dates bats confirmed resident: 26th, 27th

Sheet 9 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology



Roost J

GCTP Radiotracking
August 2014

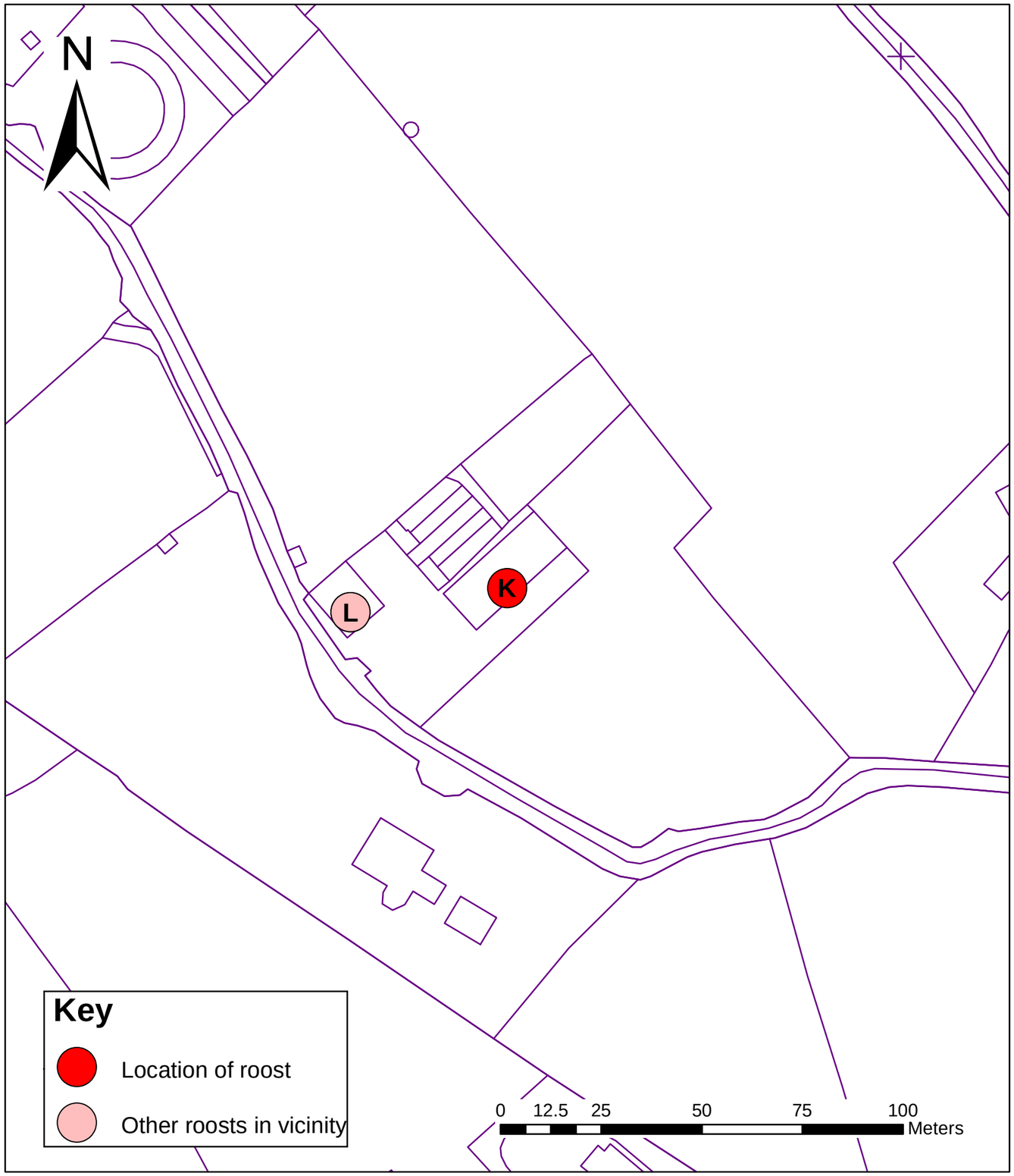
ITM: 526439 725313
Location: Residence. Ballymoneen. 64 Sli Na Sruchan

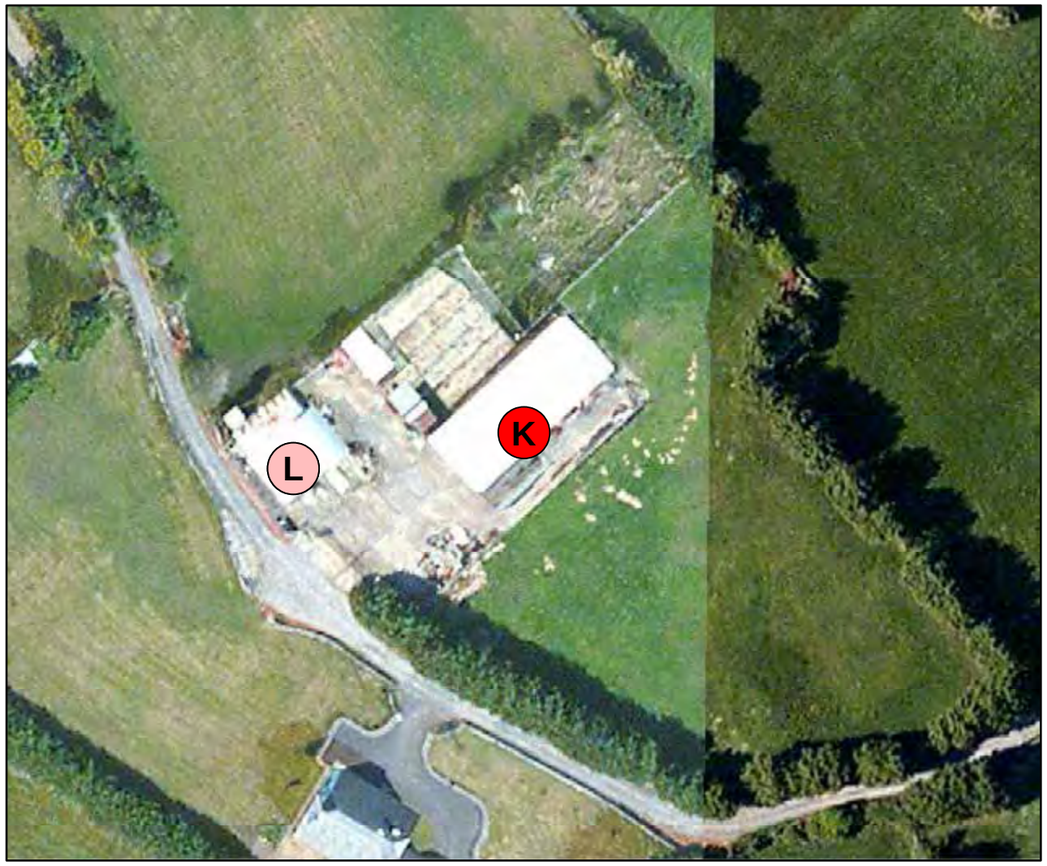
Species: Common Pipistrelle Sex: Female
Dates bats confirmed resident: 26th, 27th

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost K

GCTP Radiotracking
August 2014

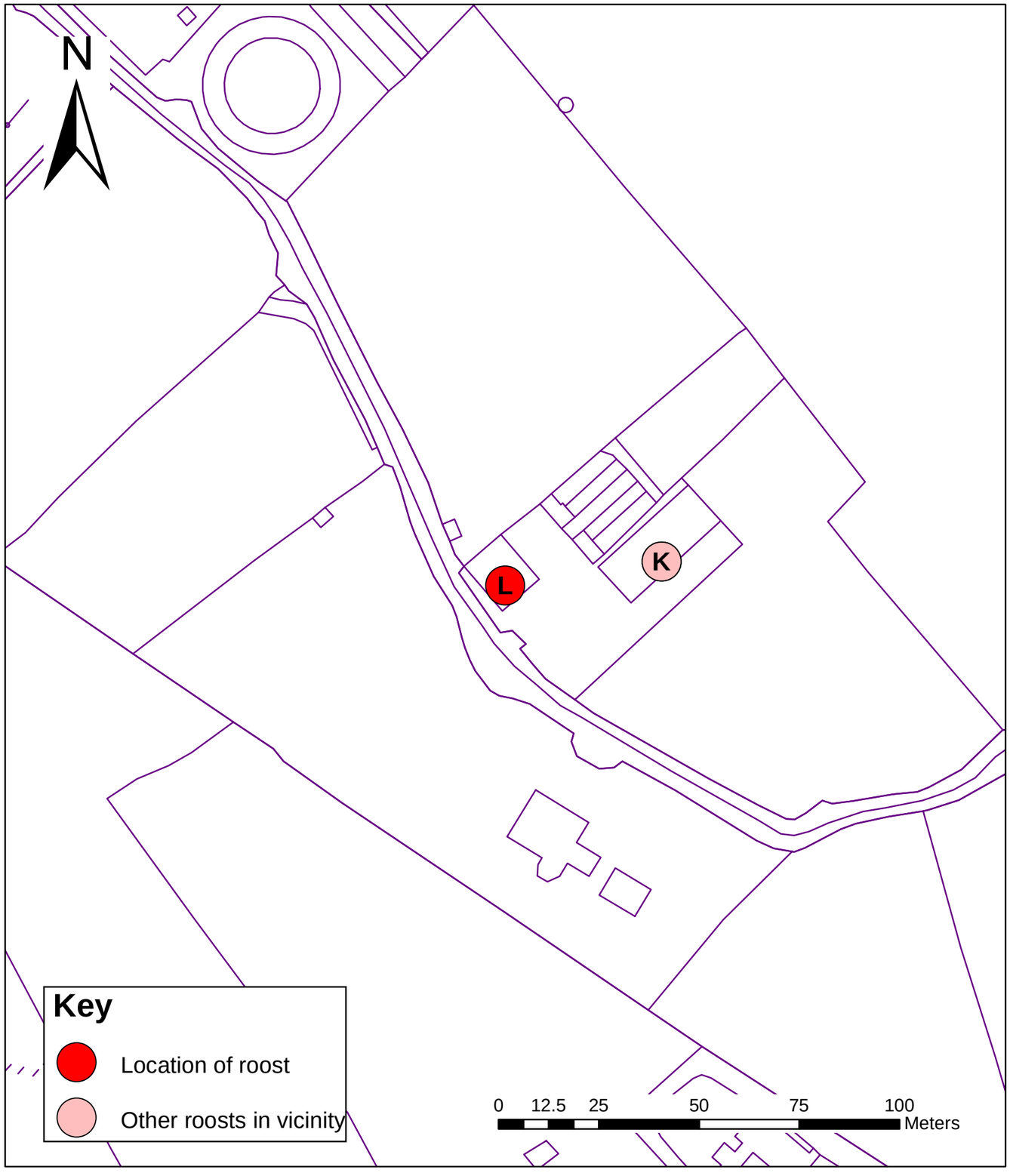
ITM: 533542 730077
Location: Cluanacauneen

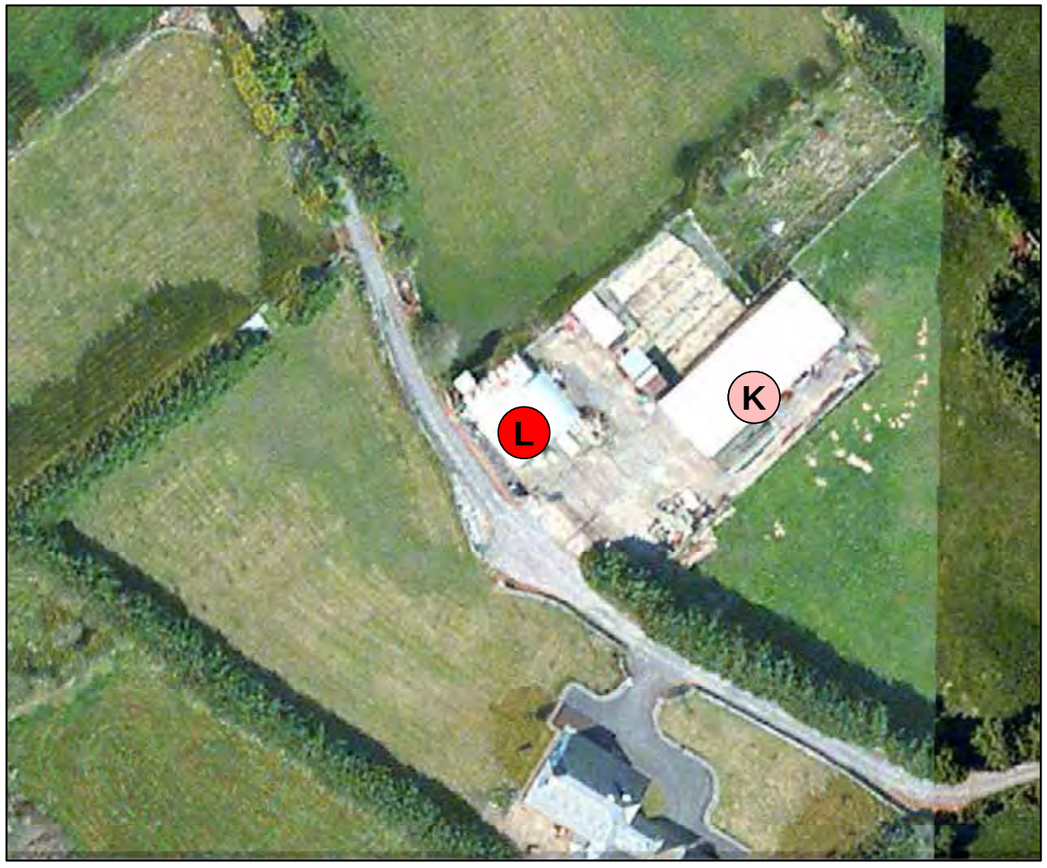
Species: Common Pipistrelle Sex: Male
Dates bats confirmed resident: 25th, 26th

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost L

GCTP Radiotracking
August 2014

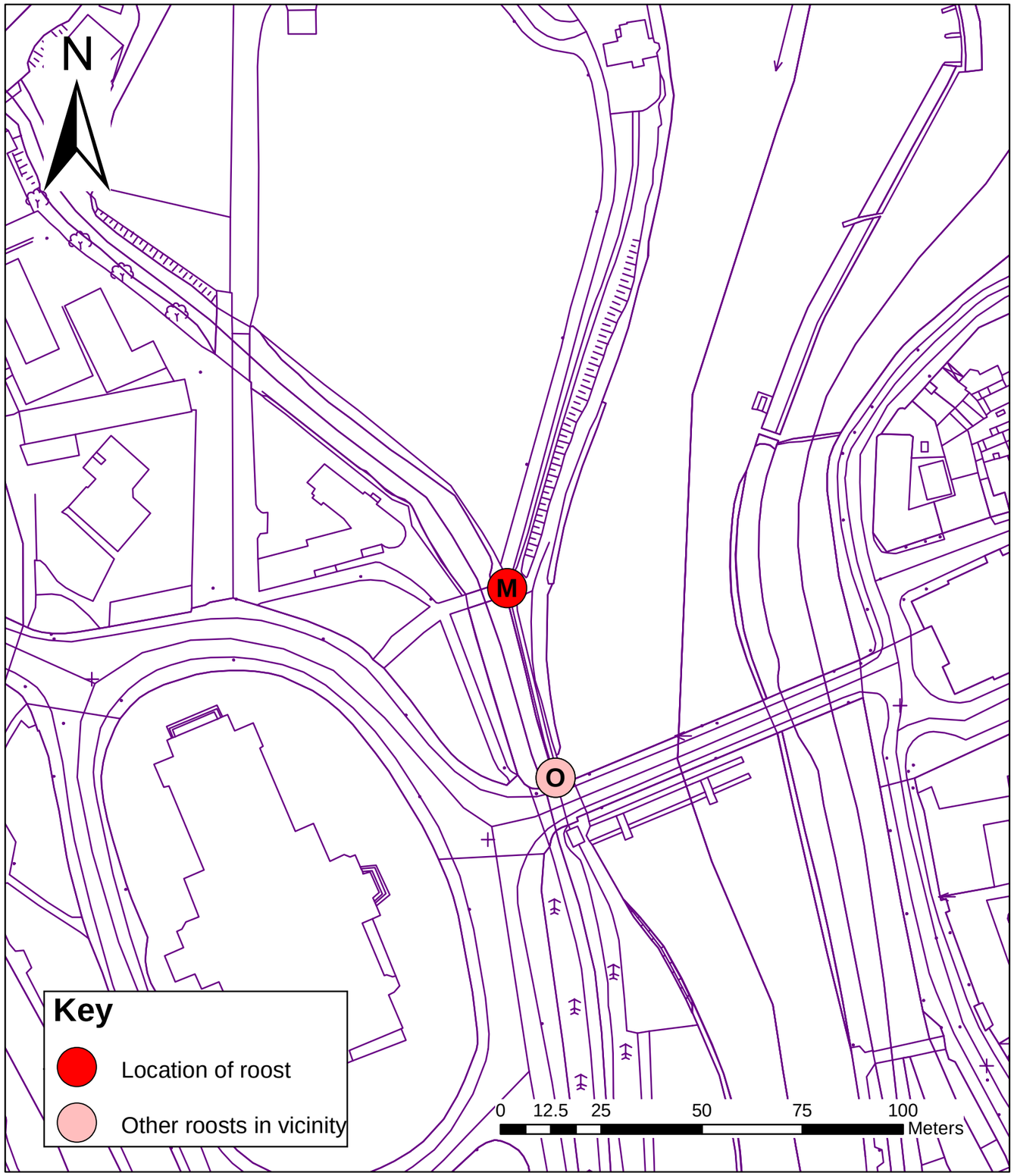
ITM: 533503 730071
Location: barn nr roost K

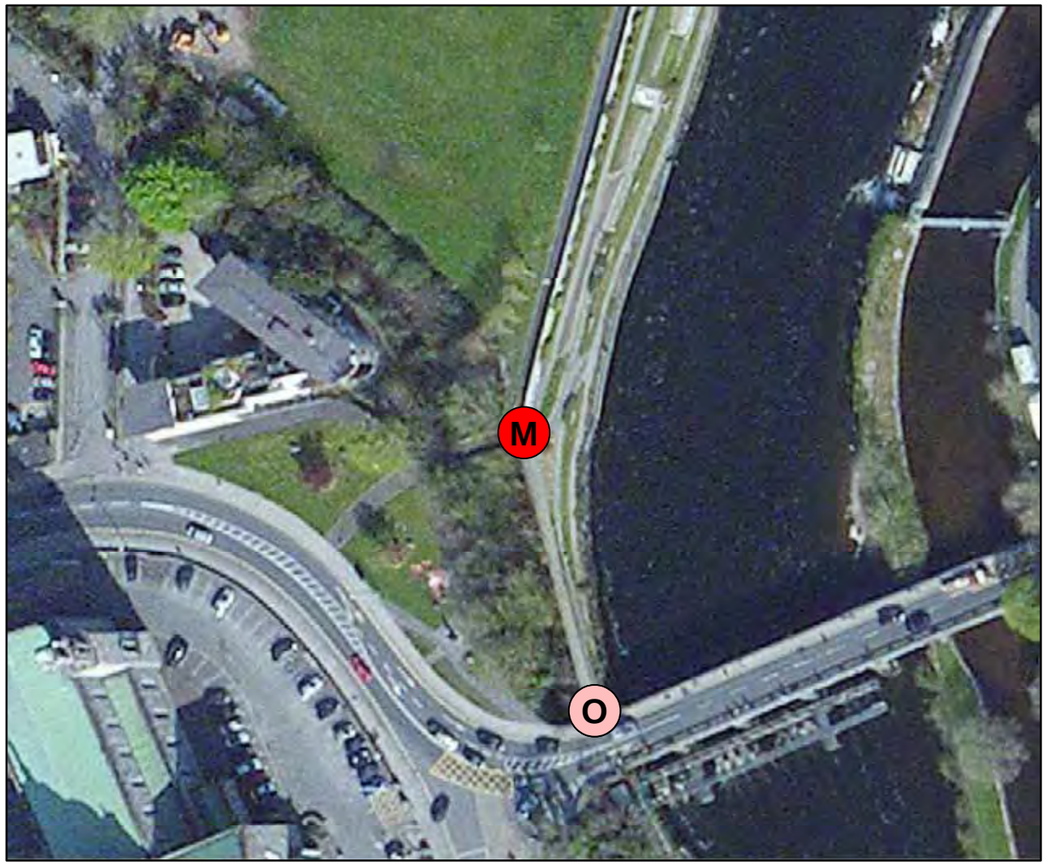
Species: Common Pipistrelle **Sex:** Male
Dates bats confirmed resident: 28th

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost M

GCTP Radiotracking
August 2014

ITM: 529520 725588
Location: Cathedral footbridge

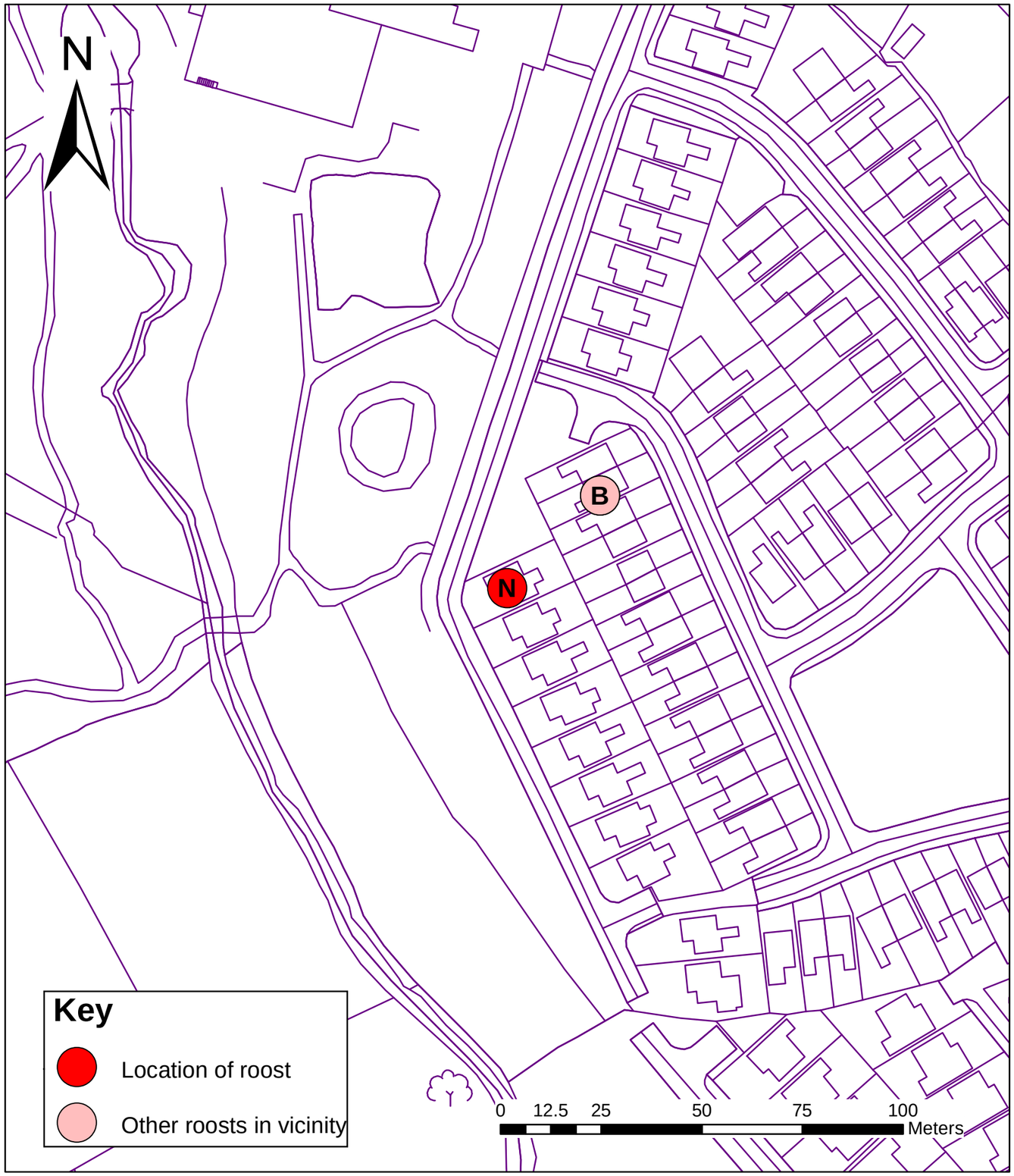
Species: Daubenton's Sex: Male
Dates bats confirmed resident: 28th

Sheet 13 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology



Roost N

GCTP Radiotracking
August 2014

ITM: 524591 724159
Location: Ard Na Coille. Residence behind Sport's centre

Species: Whiskered Sex: Male
Dates bats confirmed resident: 29th

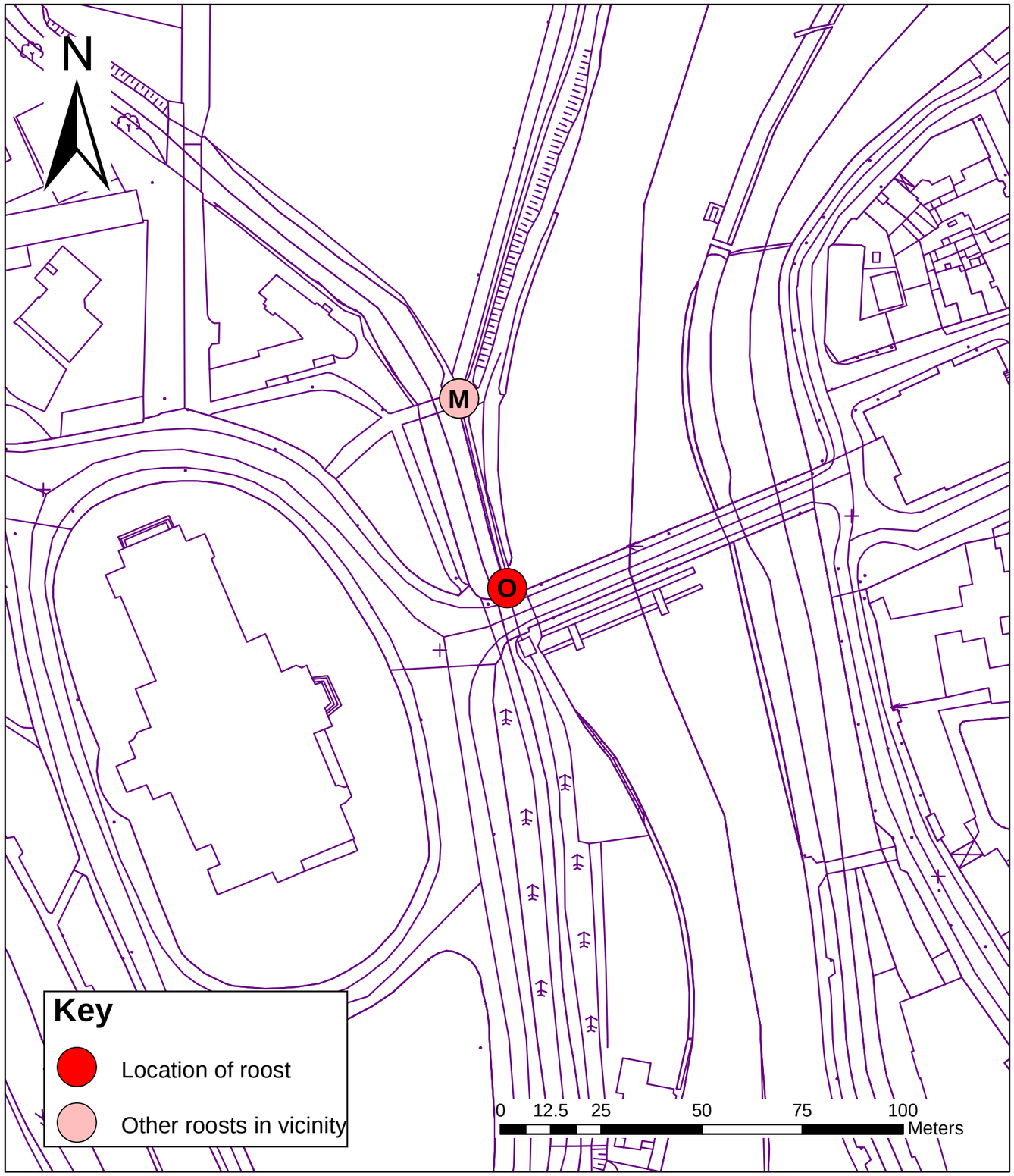
Note: Roost B backs on to Roost N. Although signal strength indicates separate roosts, would need to be between buildings to be certain.

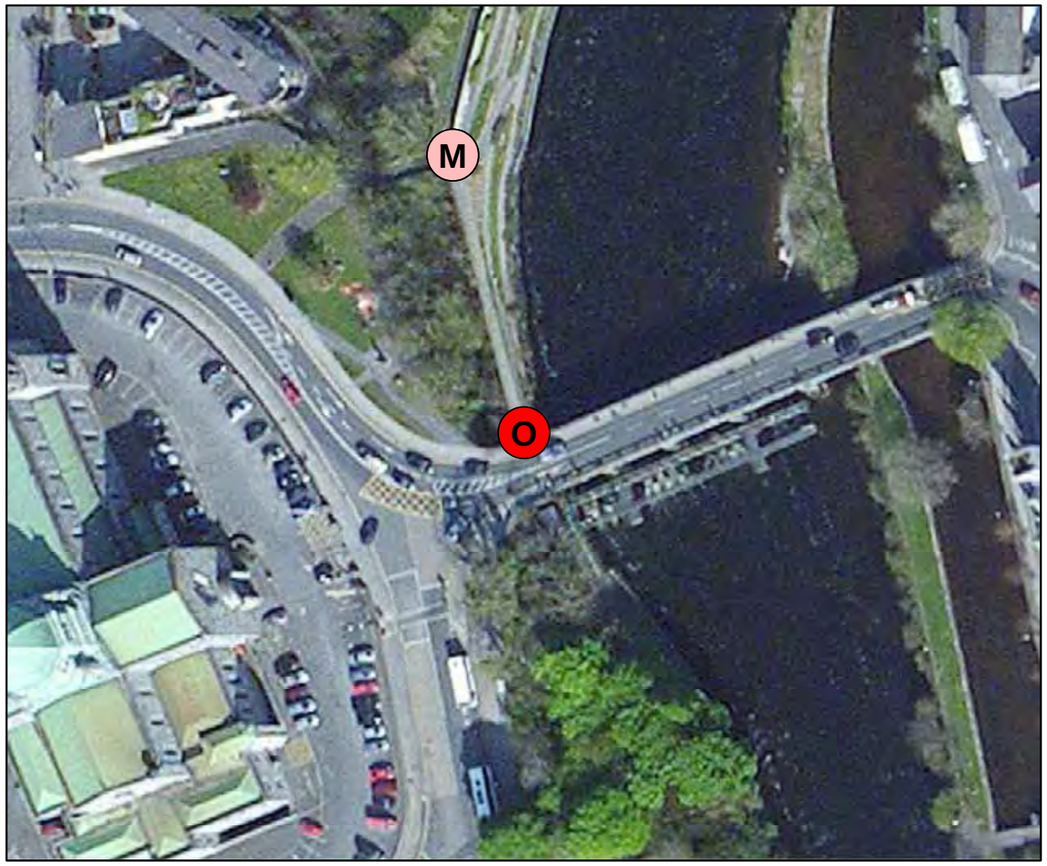
Sheet 14 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology





Roost O

GCTP Radiotracking
August 2014

ITM: 529532 725541
Location: Salmon Wier Bridge

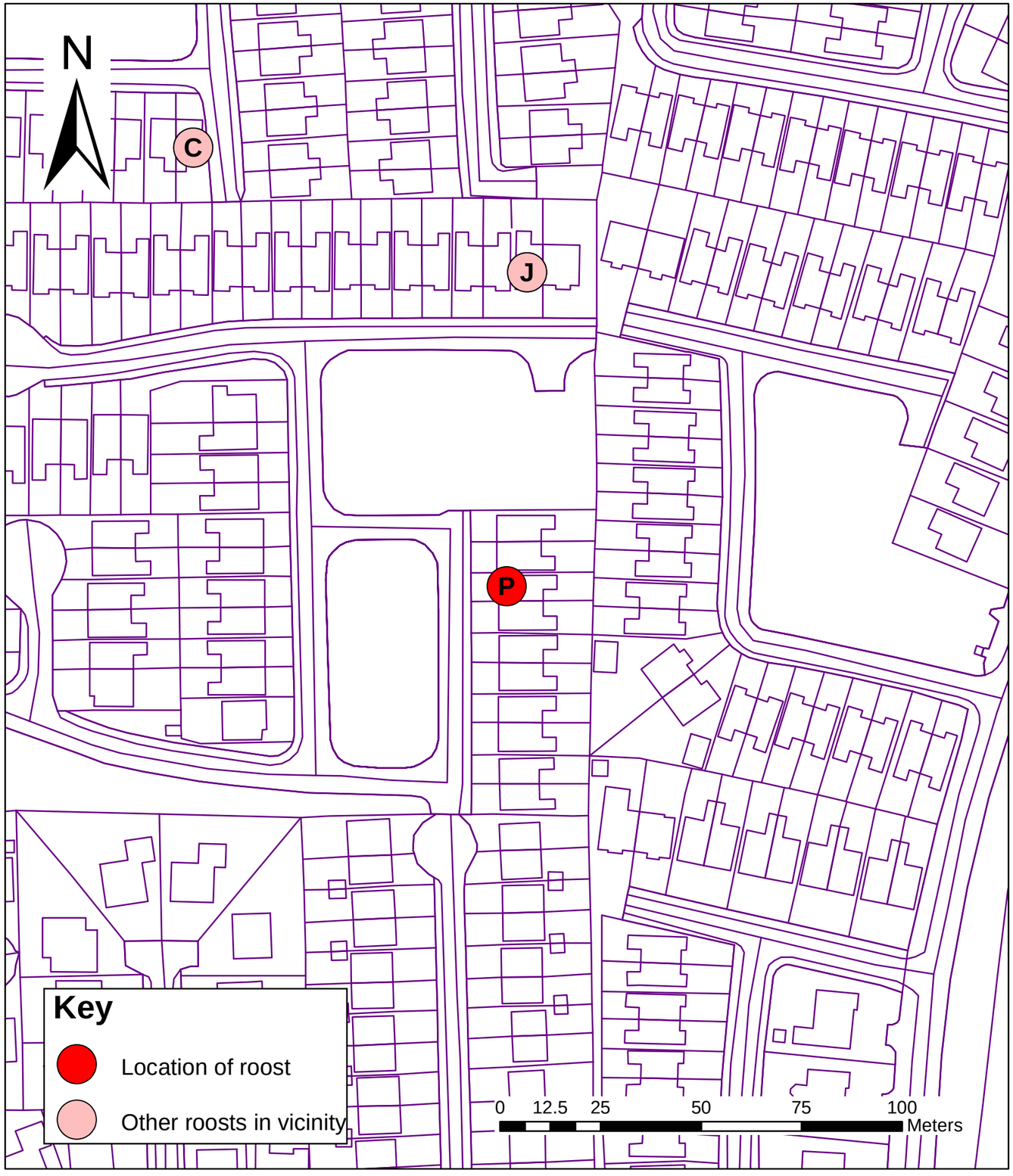
Species: Daubenton's Sex: Male
Dates bats confirmed resident: 29th

Sheet 15 of 16

GCTP: Roost Locations From Radiotracking

Figs 2A to 2P

Ecology and Geology



Roost P

GCTP Radiotracking
August 2014

ITM: 526434 725235
Location: Residence. Ballymoneen. 68 Sli Na Sruchan

Species: Common Pipistrelle Sex: Female
Dates bats confirmed resident: 29th

Sheet 16 of 16

Figures 3A-3I. Detailed Radiotracking: Individual Bats

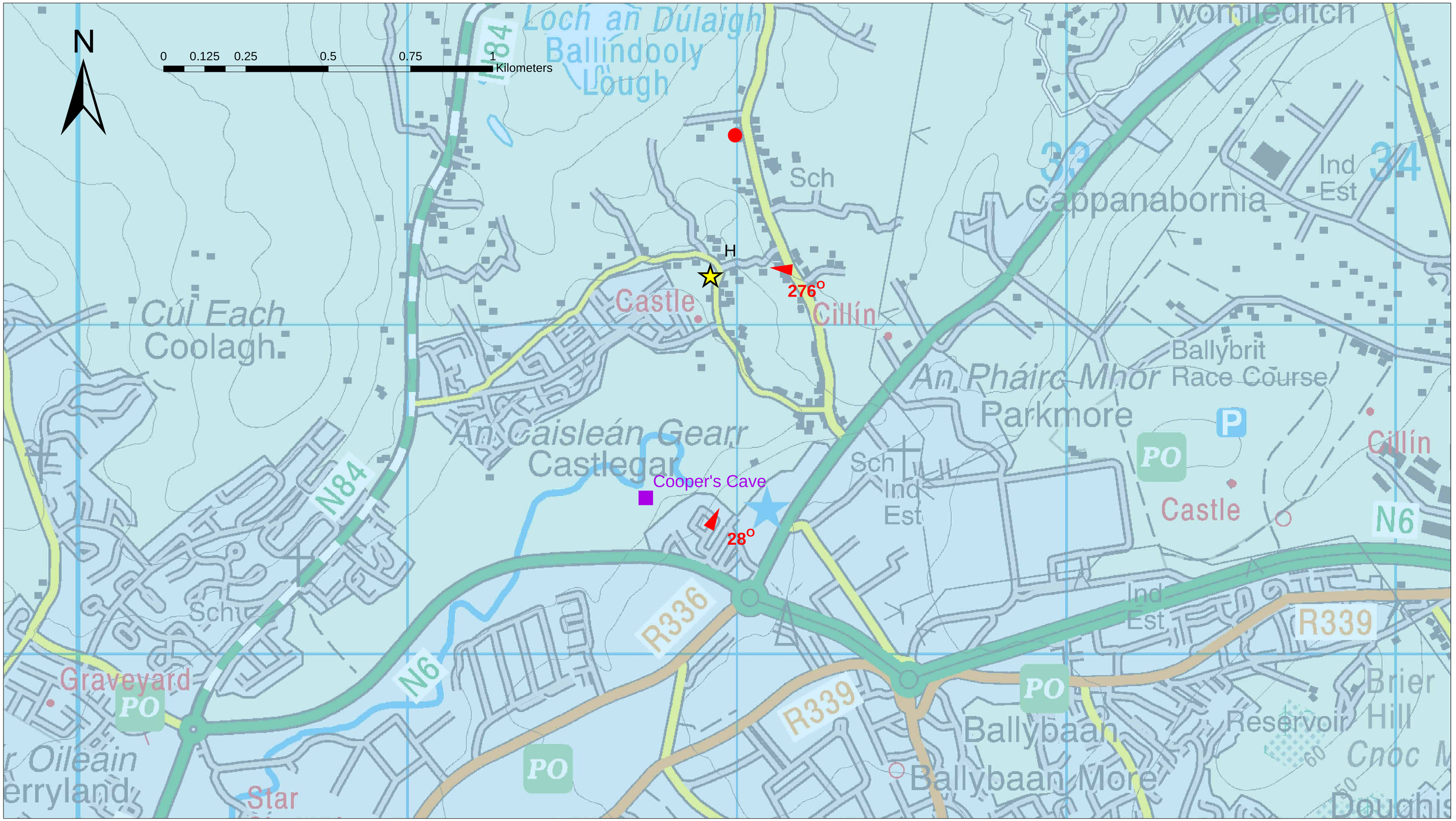


Figure 3A
Species: Brown Long-eared
Frequency: 173.395
Sex: Female Breeding Condition: Y

Trapping Location:
Cooper's Cave, ITM 531729 727476, Date 21/08/2014
Roosts:
H. ITM 531925 728152. Dates resident: 24th, 25th, 26th, 27th, 28th, 29th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

Figure 3B
Species: Daubenton's
Frequency: 173.459
Sex: Female Breeding Condition: N

Trapping Location:
Merlin Woods, ITM 533450 725600, Date 19/08/2014
Roosts:
D. ITM 526370 728692. Dates resident: 25th, 26th, 27th

Ecology and Geology

Key

- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Figures 3A-3I. Detailed Radiotracking: Individual Bats

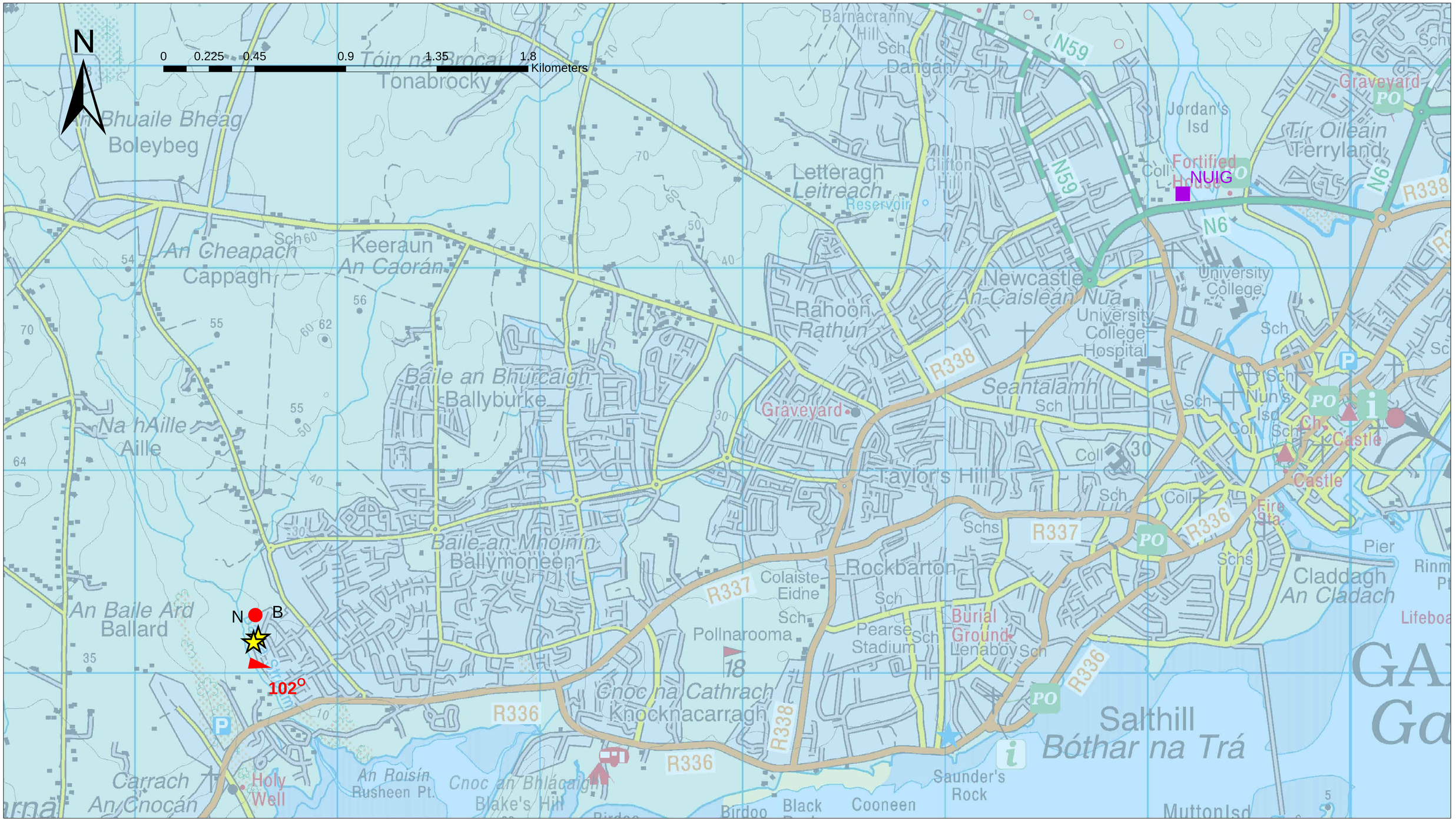


Figure 3C
Species: Whiskered
Frequency: 173.414
Sex: Male Breeding Condition: N

Trapping Location:
NUIG, ITM 529178 726369, Date 22/08/2014
Roosts:
B. ITM 524614 724182. Dates resident: 24th, 25th, 26th
N. ITM 524591 724159. Dates resident: 29th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

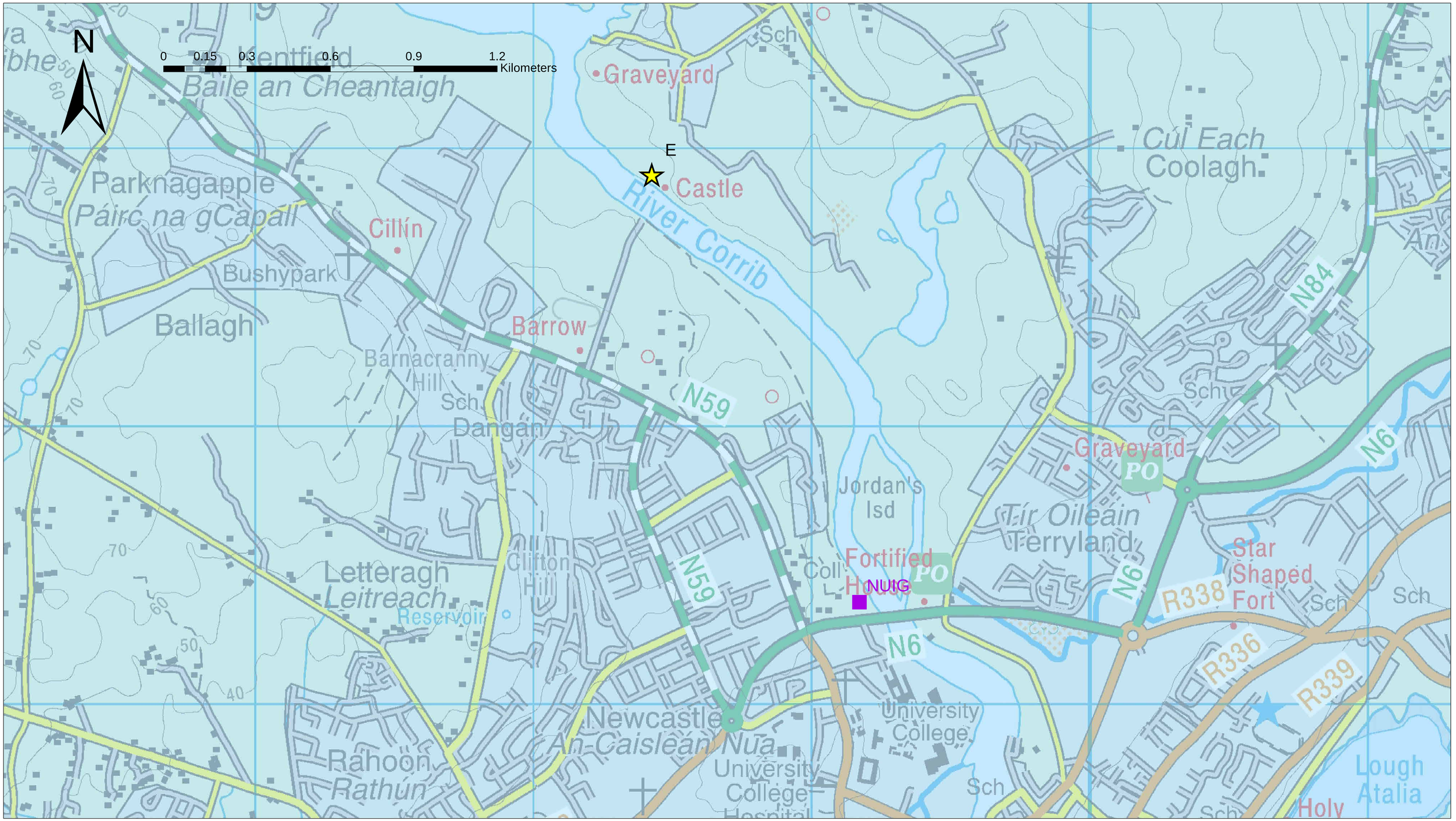


Figure 3D
Species: Daubenton's
Frequency: 173.252
Sex: Female Breeding Condition: N

Trapping Location:
NUIG, ITM 529178 726369, Date 22/08/2014
Roosts:
E. ITM 528431 727907. Dates resident: 24th, 25th, 26th, 27th, 28th, 29th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

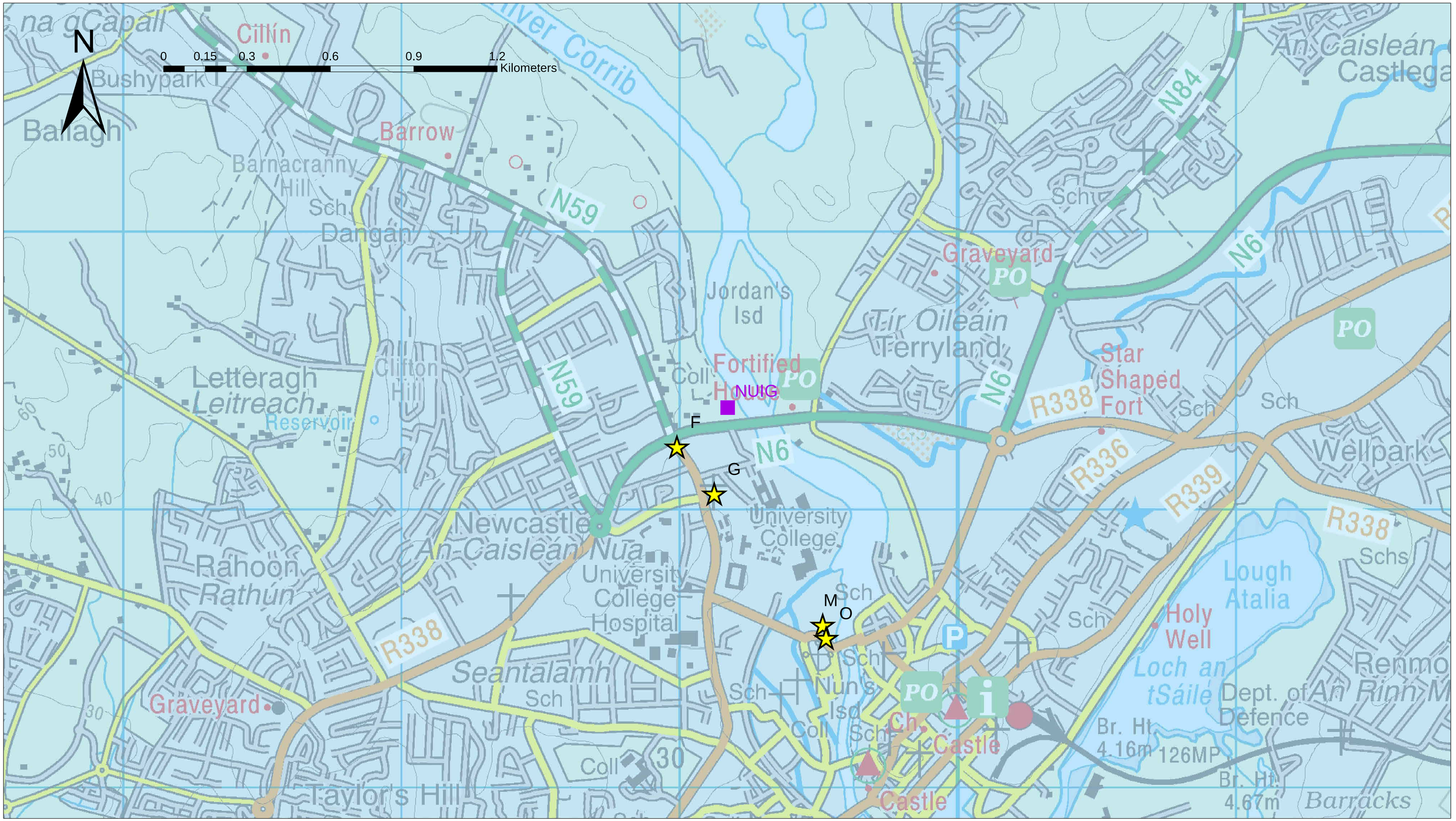


Figure 3E
Species: Daubenton's
Frequency: 173.297
Sex: Male Breeding Condition: N

Trapping Location:
NUIG, ITM 529178 726369, Date 22/08/2014
Roosts:
F. ITM 528996 726229. Dates resident: 24th
G. ITM 529130 726060. Dates resident: 25th
M. ITM 529520 725588. Dates resident: 28th
O. ITM 529532 725541. Dates resident: 29th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

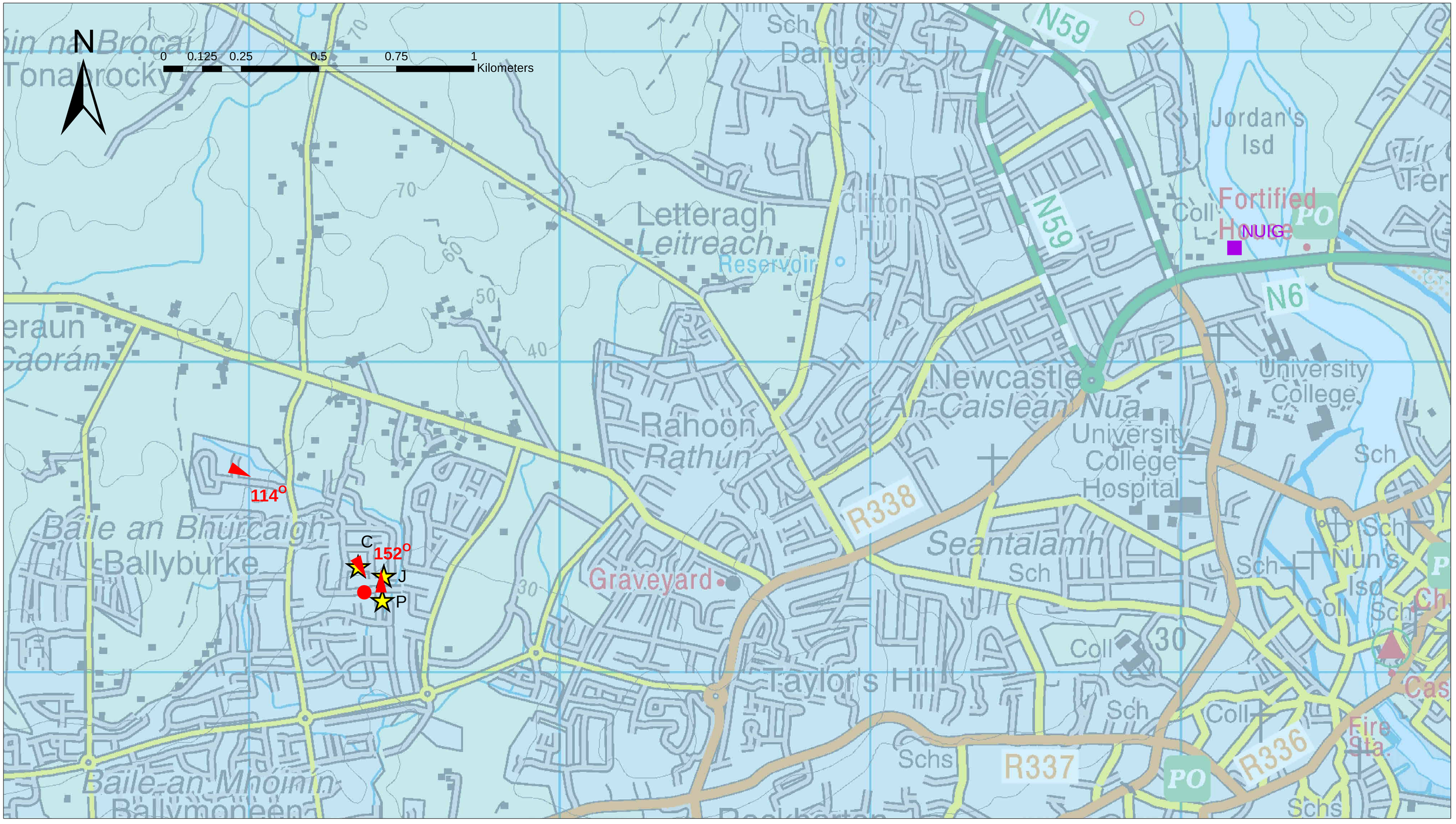


Figure 3F
Species: Common Pipistrelle
Frequency: 173.361
Sex: Femle Breeding Condition: N

Trapping Location:
NUIG, ITM 529178 726369, Date 22/08/2014
Roosts:
C. ITM 526356 725344. Dates resident: 24th, 25th
J. ITM 526439 725313. Dates resident: 26th, 27th
P. ITM 526434 725235. Dates resident: 29th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

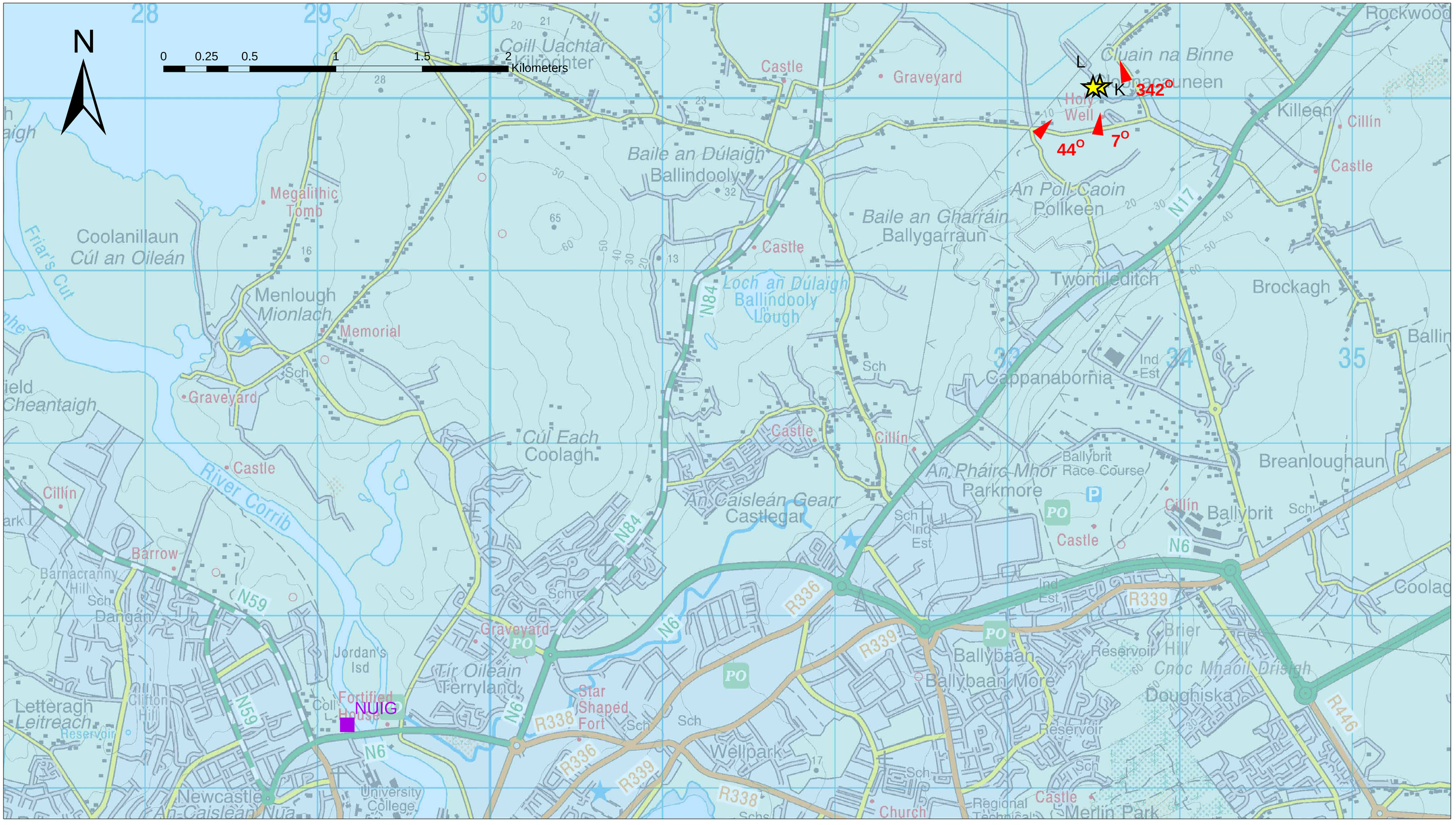


Figure 3G
Species: Common Pipistrelle
Frequency: 173.323
Sex: Male Breeding Condition: N

Trapping Location:
NUIG, ITM 529178 726369, Date 22/08/2014
Roosts:
K. ITM 533542 730077. Dates resident: 25th, 26th
L. ITM 533503 730071. Dates resident: 28th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

Figure 3H
Species: Leisler's
Frequency: 173.438
Sex: Male Breeding Condition: Y

Trapping Location:
Barna Woods, ITM 524400 723800, Date 20/08/2014
Roosts:
Roost not located. Foraging data only

Key

- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Figures 3A-3I. Detailed Radiotracking: Individual Bats

Figure 3I
Species: Leisler's
Frequency: 173.535
Sex: Male Breeding Condition: Y

Trapping Location:
Barna Woods, ITM 524400 723800, Date 20/08/2014
Roosts:
A. ITM 524485 725124. Dates resident: 24th, 25th, 28th
I. ITM 524391 725205. Dates resident: 26th, 27th

Key
- Fix with bearing
- Fix without bearing
- Tag Site
- Roost

Eckoella
Ecology and Geology

Appendix A: Weather in Galway 15-29th August 2014

The weather in August 2014 was broadly typical for Galway in summertime and did not pose a significant constraint to survey. Warm, humid, calm weather is good for flying invertebrates and hence good for bat foraging. Data highlighted in blue represents sub-optimal temperatures of less than 10ºC, wind speeds equivalent to Beaufort score of 5 or more (Fresh breeze), and/or significant rainfall. Trapping was not carried out in the wet and windy conditions of the 27th and 28th August. Two trapping nights were slightly cooler than optimum (21st and 23rd August). Daytime roost checks were not affected by the weather. The surveys started on 19th August; the data from 15th to 19th are included to show that good conditions for bats were present also prior to the start of survey.

	Weather during trapping						General weather in Oranmore near Galway during 24hr period						
Date	**Site**	**Temp ºC**	**Humidity**	**Wind speed (Bft)**	**Cloud**	**Rain**	**Temp Max C**	**Temp Avg C**	**Temp Min C**	**Humidity Avg**	**Wind Speed Max km/h**	**Wind Speed Avg km/h**	**Precipitation Sum cm**
15/08/2014							21	16	12	71	21	5	0
16/08/2014							17	15	14	80	27	6	0.03
17/08/2014							19	15	12	73	34	7	0.03
18/08/2014							18	14	11	73	27	6	0.05
19/08/2014	Merlin Woods	16	moderate	1to 2	4	0	18	14	10	71	24	4	0.1
20/08/2014	Barna Woods	13	81	1	4	Slight shower	18	13	9	73	19	3	0
21/08/2014	Cooper's Cave	cool, dropped below 11 during survey	75	2 to 3	overcast	0	19	14	12	76	26	5	0.05
22/08/2014	NUIG	12	70	2	0	0	18	14	11	71	27	5	0
23/08/2014	Sports fields	12 at start, dropped to 9	68	1 to 2	clearing		19	14	9	68	24	3	0
24/08/2014							16	13	9	87	32	6	0.2

Appendix A: Weather in Galway 15-29th August 2014

	Weather during trapping						General weather in Oranmore near Galway during 24hr period						
Date	**Site**	**Temp °C**	**Humidity**	**Wind speed (Bft)**	**Cloud**	**Rain**	**Temp Max C**	**Temp Avg C**	**Temp Min C**	**Humidity Avg**	**Wind Speed Max km/h**	**Wind Speed Avg km/h**	**Precipitation Sum cm**
25/08/2014							20	16	14	94	32	7	0.48
26/08/2014	Menlo Woods	15-16	High	1-2	4 to 8	0	18	16	15	89	31	7	0.03
27/08/2014							17	15	14	89	47	10	0.05
28/08/2014							19	15	11	86	43	8	1.27
29/08/2014							18	16	14	90	31	7	0.61

Data on General Weather during 24hr period produced under license from Weather Underground.

http://www.wunderground.com/personal-weather-station/dashboard?ID=ICOGALWA2#history/s20140805/e20140812/mweek

Weather Station ID: ICOGALWA2. Station Name: Oranmore
Latitude / Longitude: N 53 ° 16 ' 28 ", W 8 ° 55 ' 45 ", Elevation: 0. City: Oranmore, State: Co.Galway
Hardware: Davis VP2(24h FARS), Software: meteohub, Owner: Private

Annex A: Summary notes on the geology of Galway, and its potential for bats and roosts

Introduction

Underground sites can be extremely important roost sites for bats, offering in particular hibernation roosts for the winter and swarming roosts for social and mating behaviour in the Autumn. Locating underground sites in a limestone landscape can be challenging. These notes describe the geology of the area in order to narrow down the area of search for suitable features for bats in the limestone landscape around Galway.

Geological setting of Galway

The geology of Galway and surrounding area is shown in Figure 1. To the east and south of the city, including the Inishmor isles, the area is dominated by Lower Carboniferous (Tournaisian and Viséan) sediments comprising limestones, calcitic mudstones and sandstones. Devonian-aged sandstones, conglomerates and mudstones (Old Red Sandstone) crop out to the south-west of the area between Loughrea and the border with County Clare. High ground west of Galway (including Moycullen Bog and Oughterard District Bog NHAs, and extending north-west towards Connemara) is formed mainly of igneous rocks, comprising a core of Silurian and Devonian granites and appinites, with fringing areas of Lower Palaeozoic gabbros and diorites, and occasional Ordovician-aged volcanic rocks.

Geology of Galway City area

The bedrock geology of Galway City itself comprises three main lithologies:

i) Lower Palaeozoic gabbros and diorites, which occur in a roughly triangular-shaped central area extending from Dangan Heights/Galway Business Park southwards to Galway Bay (Cuan na Gaillimhe). The western side of the triangle runs via Shantallow (Seantalamn) to Salthill; the eastern side runs via Newcastle (An Caisleán Nu) and south of Townparks to Renmore Barracks (Dun Ui Mhaoiliosa)

ii) Lower Carboniferous (Viséan) limestones and calcitic mudstones, which occur east and north of the gabbros and diorites, and extend from Lough Corrib (Loch Coirib) eastwards beyond Claregalway (Baile Chláir) and Oranmore (Oran Mór)

iii) Siluro-Devonian granites and appinites, which occur west of the gabbros and diorites, and extend beyond Barna (Bearna) and Tonabrochy (Tóin na Brocai) to the highground of Moycullen Bogs NHA and further west.

The main lower Carboniferous limestones in and around Galway City are Viséan-aged (Upper Viséan, D_1-D_2 zones), and include strata now assigned to the Knockman Formation. Kinahan (1869, pp. 21-22) recorded quarries in the townlands of Angliham and Menlough on the south-east shore of Lough Corrib, three miles due

north of Galway town. These quarries were formerly worked for their bands of dark limestone known as 'Galway black marble' which was formerly highly sought after and exported. Kinahan (loc. cit.) also reported quarries in the vicinity of Terryland village which were worked for general building stones. All these quarries contained numerous limestone crags, and sections in excessive of 12m height were worked.

Characteristically, the majority of limestones in the Galway City area are horizontally-bedded or exhibit very shallow dips (less that 10°), only locally does the dip reach up to 20-25°.

Limestone features, and potential for bats and roosts

The limestones exhibit considerable lithological variation and include:

- massive, compact varieties;
- other types which are more susceptible to water solution and form caves and other karstic features (such as 'mushroom rocks' and irregular limestone pavements);
- other limestone types which are more siliceous ('flinty') and shatter, providing tight crevices and fissures in quarry faces.

Interbedded within the limestone sequences are calcareous shales and calcitic mudstones which are relatively impervious and act as boundary layers along which surface and subsurface water may migrate and form cavities. This varied lithology is regarded here to offer considerable potential for a wide variety of possible roost sites for bats.

Table 1 provides a list of limestone quarries and cave/karst features identified within the Galway City area and signs of bat presence noted.

A case-example indicating the potential that geological features may have for identifying areas of possible interest for bat and roost sites is provided by Cooper's Cave at Castlegar; at least two species of bat (Lesser Horseshoe *Rhinolophus hipposideros* and *Myotis* sp.) are now recorded to use Cooper's Cave despite the cave showing signs of extensive human disturbance (litter) and smoke damage from fires lit within it.

Figure 2 is schematic, but demonstrates the principle that extrapolation of the generally horizontally-bedded limestones from Castlegar (including the limestone unit in which Cooper's Cave occurs) to the northwest indicates that the same limestone strata may crop out along the flanks of Cnoc an Ghearrtha. Several other quarries (including Angliham Quarry and old quarries along Route N84, see Table 1) are likely to have directly worked these strata, or to have excavated down to the levels of these limestone units.

Field observation and aerial photo analysis confirms that limestone faces are exposed in these quarries, and these faces are likely to include the same limestone features found at Castlegar which readily form caves and fissures, and, if present,

these have considerable potential for use by bats. **Further investigation of these quarry sites to properly assess their potential use by bats is highly recommended, since the probability of further fissures and cave features within these geological beds is high.**

Conversely, limestone areas less likely to have roost features suitable for bats include the limestone pavement areas – these do not expose the type of limestone which is most likely to have fissures and caves.

Dr. Andy King, September 2014

References

Galway City Council, 2011-2017: SEA Environmental Report to Development Plan 2011-2017 (available at http://gis.galwaycity.ie/devplanflipbook/sea). 111pp.

Kinahan, G. H. 1869: Explanation to accompany Sheet 105 with that portion of Sheet 111 that lies on the North of Galway Bay of the Geological Survey of Ireland. Memoirs of the Geological Survey. Dublin & London. 63 pp.

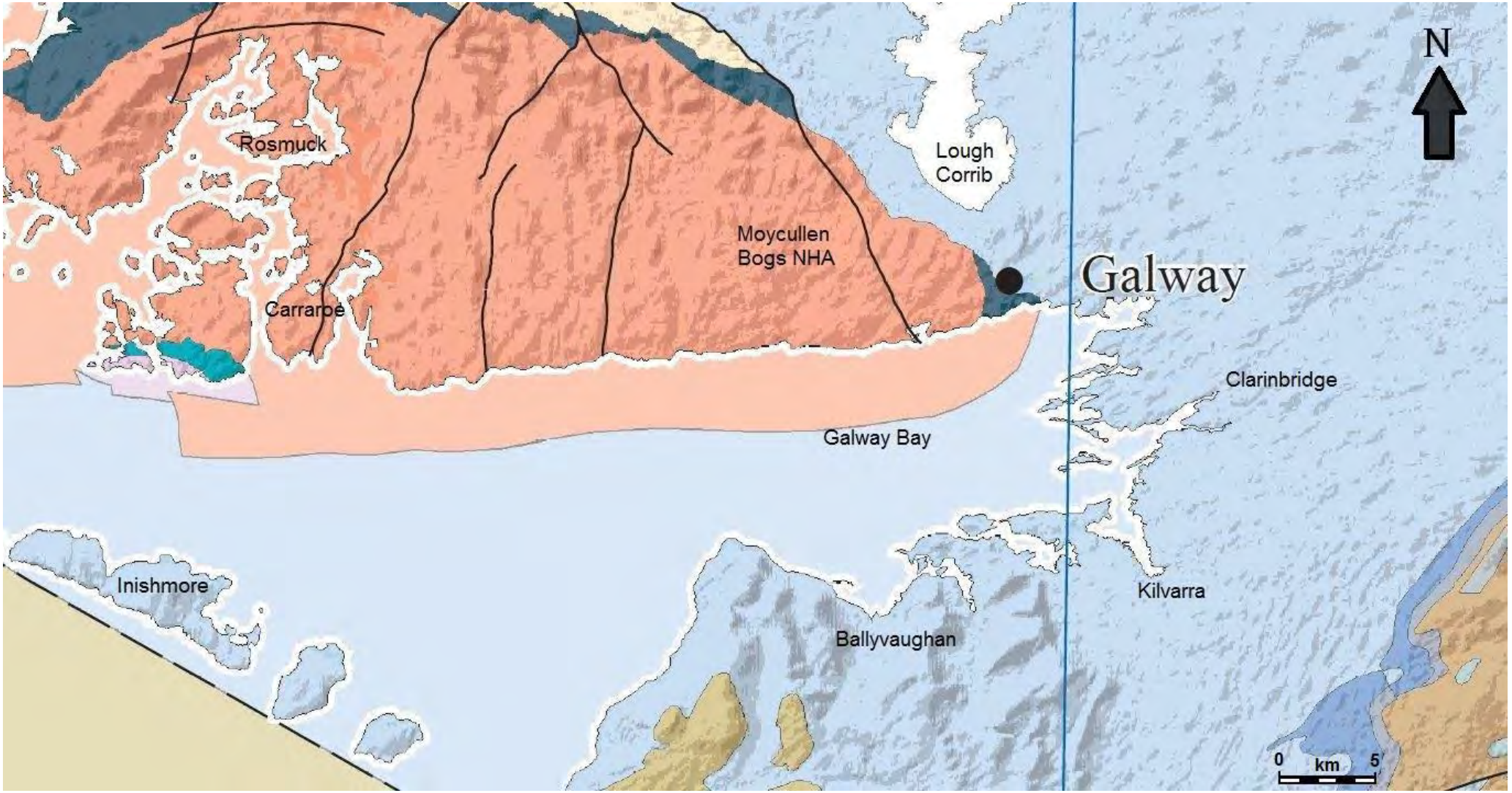
OS Maps, 1842: Galway Six Inch OS maps (available at http://www.galway.ie/en/Services/Library/1842OSMaps)

Location	Northing[1]	Easting	Status	Bat observations	Notes[1]
Cooper's Cave (Cooley's Cave), Castlegar	131761	227409	Cave	Lesser-horseshoe *Rhinolophus hipposideros* and *Myotis* sp. seen in cave (21 Aug 2014)	Limestones very shallowly dipping / horizontal. Smoke damage and litter, few cave decorations remaining
Newry's Cave, Merlin Park	134345	225287	Cave	Recent bat droppings found (28 Aug 2014), currently being analysed	County Geological Site, Galway 'black marble', Upper Viséan, brachiopod fossils, minor damage/disturbance , cave decorations present
Lackagh Quarry, Coolough	130473	228383	Active quarry	Not visited	Not visited
Roadstone Quarry, Tuam	132893	229198	Quarry in receivership	Not visited	Not visited. County Geological Site. Limestone aggregate quarry, Knockman Formation
Angliham Quarry, near Kilroghter	129222	230119	Disused quarry	Records of Lesser-horseshoe roosting at site, 2014 (SCA, pers. comm.)	Not visited. Galway 'black marble', Upper Viséan
Old quarry by N84, near Ballindooley	130978	228163	Disused quarry	Not visited	Not visited, access from Route N84 (locked gates)
Old quarry tips, Caireal Mór	131114	228002	Quarry tips	Not visited	Not visited, exposed quarry faces still remaining?
Old quarry tips, Ballygarruan	131026	228838	Quarry tips	Not visited	Not visited, exposed quarry faces still remaining?

Table 1. Limestone quarries and cave/karst features identified within the Galway City area (during period of survey, 14th – 30th August 2014)

([1]Notes based on field observations where sites visited, and literature searches: Kinahan, 1869; OS Maps, 1842; Galway City Council 2011-17)

[1] Irish Grid coordinates



Explanation of Bedrock Geology

- Lower Carboniferous (Visean) limestones and calcareous mudstones
- Lower Carboniferous (Tournaisian) limestones, sandstones and mudstones
- Devonian (Old Red Sandstone) sandstones, conglomerates and mudstones
- Siluro-Devonian granitic rocks and appinites
- Lower Palaeozoic gabbroic-dioritic rocks
- Ordovician volcanic rocks

Figure 1. Bedrock geology of Galway and environs

Onshore geology derived from Bedrock geology of Ireland (Geological Survey of Ireland, 2014), 1:500,000 Bedrock geology map of Ireland, 1:100,000 Bedrock Map Series; Offshore geology derived from EMOD net project map compiled by GSI and INFOMAR, with materials from the British Geological Survey, NERC 1982, 1986, 2009.

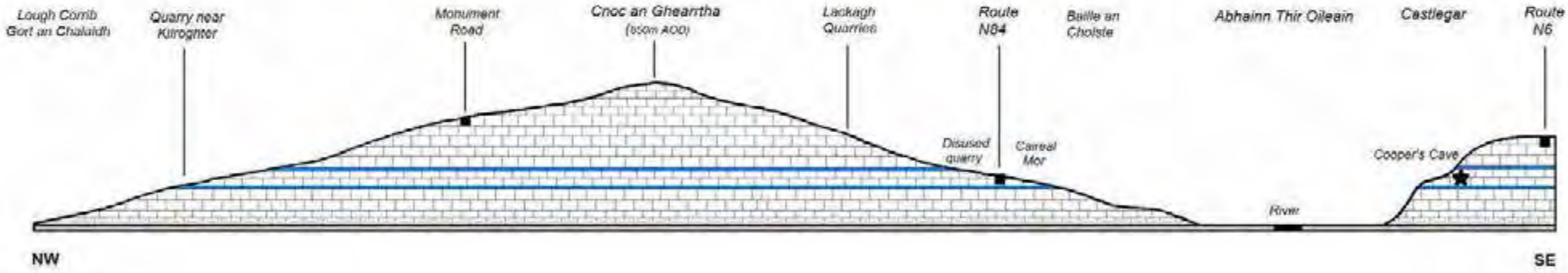


Figure 2. Diagrammatic NW-SE cross-section from Lough Corrib (Gort and Chalaidh) to Castlegar (Glenburren Park and Route N6), distance 4.6km, vertical scale exaggerated.

(Inset photographs; views NW to Baille an Choiste and hillside quarries (towards Cnoc an Ghearrtha) from Castlegar ridge, near Cooper's Cave)