Ecology and Protected Species Survey
Boston West Golf Course
Hubbert's Bridge
Lincolnshire

Issued to:
Smart Move Boston Ltd
Head Office
The County-hall
Market Place
Boston
PE21 6DY

NOVEMBER 2019

IEL Inspired Ecology Ltd

Malham, Washdyke Lane, Kirton Meeres, Boston, Lincolnshire PE20 1PW
T: 01205 723342
M: 07833 674500
E: enquiries@inspiredecology.co.uk
W: www.inspiredecology.co.uk
Company registration number: 8087266
VAT registration number: 994957340

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

Report to:	Smart Move Boston Ltd Head Office The County-hall Market Place Boston PE21 6DY	
Report title:	Ecology and Protected Species Survey Boston West Golf Course, Hubbert's Bridge, Lincolnshire	
Revision:	Final	
Original issue date:	November 2019	
Amended:	N/A	
Originated by:	Rachel McNally Assistant ecologist	**Date:** 7th November 2019
Reviewed by:	Andrew Malkinson Associate	**Date:** 22nd November 2019
Approved by:	Ian Nixon Director	**Date:** 22nd November 2019

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

Contents

Photographs

Tables

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

1 INTRODUCTION

Inspired Ecology Ltd has been commissioned by Paul Wilkinson of Smart Move Boston Ltd. to undertake to undertake an ecology and protected species survey of part of the former Boston West Golf Course, Hubbert's Bridge, Boston, Lincolnshire. The appraisal involves a Phase 1 Habitat survey, an assessment of ecological significance, management advice and the production of digital maps of the survey area. The survey is required in connection with proposals to construct holiday lodges on the site.

The site was surveyed on 29th October 2019 by Ian Nixon (registered to use Natural England Class Licences WML-CL08 to survey great crested newts, WML-CL19 and WML-CL20 to survey bats and WML-CL29 to survey barn owls; registration numbers 2015-16823-CLS-CLS, 2015-12336-CLS-CLS, 2015-12338-CLS-CLS and CL29/00110 respectively) and Tim Smith.

During the initial appraisal of the site, the protected species considered likely to occur on site were identified. These were:

- Great crested newts
- Bats
- Badger
- Common bird species
- Schedule 1 bird species

Certain protected species were scoped out of the survey; in particular, it was considered that white-clawed crayfish *Austropotamobius pallipes*, common dormouse *Muscardinus avellanarius*, and otter *Lutra lutra* were highly unlikely to occur on the site due to lack of suitable habitat.

There are no recent records of water vole *Arvicola amphibius* and the ponds on site have shallow banks unsuitable for burrowing into. The only ditch on site is the boundary ditch to the west which will not be affected by the proposed works. As a result water vole were scoped out of the survey.

There are single records of grass snake *Natrix helvetica* and slow-worm *Anguis fragilis* within

2km of the survey site, and the habitats on site provide some refugia for common reptile species. However, given the isolated nature of the site from areas of suitable habitat it is considered unlikely that a significant, well established population of common reptile species will be found on site.

A note was made of any species which are local or national Biodiversity Action Plan (BAP) species/species of principal importance.

This report details the methods used, describes the habitats and species found on the site, discusses the results and makes recommendations for future management. English names of higher plants are used throughout the text and are those used by Stace (2010). The site location and habitats present are provided as Figure 1, and a full plant list (including scientific names) is included as Appendix 1.

2 METHODS

2.1 Data search

The Lincolnshire Environmental Records Centre (LERC) was consulted and commissioned on 31st October 2019 to search for sites with statutory and non-statutory designation and records of protected species within 2km of the survey site. Records of protected species more than 20 years old are not referred to in this report but are included within Appendix 2.

2.2 Great crested newts

The site was assessed for its potential to support great crested newts *Triturus cristatus*. All habitats on the site were assessed for their potential to support amphibians as either breeding or terrestrial habitat. All potential refugia/habitat piles on site which were considered suitable for use as shelter for amphibians were identified. The ponds located on the survey site were accessed and assessed for their potential to support breeding great crested newts using the Habitat Suitability Index (HSI) (Oldham et al, 2000).

HSI is a quantitative measure of the habitat quality and evaluates the suitability of the water body and surrounding land to support great crested newts. The HSI is a number between 0 and 1 which is derived from an assessment of ten habitat variables known to influence the presence of newts. These variables include quality of the terrestrial habitat, water quality in the pond, presence of fish, and aquatic macrophyte cover. An HSI of 1 is optimal habitat (high probability of supporting great crested newts) and 0 is very poor quality with a minimal chance of

occurrence.

The Habitat Suitability Index for each of the ponds on the site was calculated following the survey.

2.3 Bats

2.3.1 Ground level roost assessment

A preliminary ground level roost assessment was carried out on all trees on the site, in accordance with Collins (2016). The trees were visually checked with the assistance of binoculars for potential roost features such as:

- Woodpecker holes
- Broken limbs, snag ends, cracks and splits in branches and rot holes
- Cankers with cavities
- Gaps between overlapping stems or branches
- Dense ivy, with stem diameters in excess of 50mm
- Flaking bark

Any trees with roost potential were then assigned a measure of potential suitability to determine the extent of future survey work needed. The categories of potential suitability and further survey effort required are as follows:

- Negligible – Negligible potential roosting features on the tree – no further survey work
- Low – A tree of sufficient size and age to contain potential roost features but with none seen from the ground, or features seen with only very limited roosting potential – no further surveys necessary
- Moderate – One or more potential roost features that could be used by bats on a regular basis – further survey work required (roost feature inspections or emergence/ re-entry surveys)
- High – One or more potential roost features that are obviously suitable for use by larger numbers of bats on a regular basis and for longer periods of time – further survey work required (roost feature inspections or emergence/ re-entry surveys)

There are no buildings on the survey site.

2.3.2 Assessment of commuting and foraging habitats

In accordance with Collins (2016), the survey site and adjacent areas were assessed for their potential suitability for commuting and foraging bats and categorised as follows;

- Negligible – Negligible habitat features on site or in surrounding area likely to be used by commuting or foraging bats
- Low – Habitat features that could be used by small numbers of commuting bats such as a gappy hedgerow or small numbers of foraging bats such as a patch of scrub, but that are isolated from other habitat features
- Moderate – Continuous habitat connected to the wider landscape such as lines of trees that could be used by commuting bats or trees, grassland or water features that could be used by foraging bats
- High – Continuous, high-quality habitat that is well connected to the wider landscape for use by commuting and foraging bats such as river valleys, woodland, grassland and parkland

2.4 Badger

The site was searched for signs of use by badger *Meles meles* including setts, latrines, dung pits, pathways, hairs, footprints, snuffle holes and scratch marks on trees.

2.5 Common bird species

The survey site was searched for signs of use by nesting birds, typically old nests and concentrations of faecal deposits associated with a breeding site. All bird species recorded on site were noted.

2.6 Habitats and plant species

An extended ecological assessment survey was undertaken, not only to identify the habitats present on the survey site, but also to include more detailed information on plant species on site and undertake a further appraisal of the area as habitat for legally protected species. The habitat types were classified as per JNCC guidelines, and target notes were made whenever a particular area or feature of interest was encountered. The results of the habitat survey have been digitised and are included as Figure 1. Target notes are presented in tabular form as Appendix 3. Plant species on site were assessed against the Vascular Plant Red Data List for Great Britain, and the site was assessed against the Local Wildlife Site (LWS) criteria for Lincolnshire.

2.7 Survey constraints and limitations

The information contained in this report was accurate at the time of the survey; however, it should be noted that the status of mobile species such as badgers, birds and bats can alter in a short period of time and any survey only represents a 'snapshot' of the site at one point in the season. There are no definitive guidelines relating to the longevity of an ecology report, however we recommend that the results are updated after 12 months if the proposed work has not commenced.

3 SITE DESCRIPTION

3.1 Location and grid reference

The site is located to the north of Hubbert's Bridge in Lincolnshire – central grid reference TF264440. The surveyed area comprises an area of a former golf course including fairways, bunkers, woodland and ponds.

3.2 Habitats

3.2.1 Woodland

All of the woodlands on the western half of the former golf course are broad-leaved plantations with a few conifers. The plantations all date from after the creation of the golf course from arable land. The scattered trees and small groups of trees on the golf course outside the main blocks of woodland date from the same time. All of the woodland and other tree plantings are from the same suite of trees and shrub species used at the time, with no one particular block of woodland being significantly different from any other.

The most common tree and shrub species are guelder-rose, Italian alder, silver birch, alder, ash, wild cherry, field maple, pedunculate oak, small-leaved lime, Norway maple, Scots pine, bird cherry, common whitebeam, dog-rose, aspen, ornamental dogwood, hawthorn, crack-willow, grey willow and white poplar. Less common are larch, hazel, elder, wayfaring-tree, spindle, dogwood, rowan, apple, sweet chestnut and goat willow. The ground flora of the woodland is poor, typically comprising common nettle, creeping thistle, colt's-foot, bramble, cleavers, wood avens, cock's-foot and false oat-grass. There are some fallen branches and a few piles of branches within the woodland. At the edges of the woodlands there are areas of rough grass including occasional common knapweed and wild teasel.

Photograph 1: View within woodland on site

Photograph 2: Further view within woodland on site

Photograph 3: Further view within woodland on site

Photograph 4: Further view within woodland on site

3.2.2 Bunkers

The former sandy bunkers are gradually colonising with plants, typically perennial rye-grass, daisy, annual meadow-grass, dandelion, white clover, prickly sow-thistle, willowherb species, common mouse-ear, groundsel, scentless mayweed, fat-hen and spear thistle. There is also sparse celery-leaved buttercup in these areas.

Photograph 5: Bunker on site

Photograph 6: Bunker and fairway on site

3.2.3 Fairways

The former fairways comprise areas of improved grassland which are species poor and grass dominated. Typical plants include perennial rye-grass, white clover, daisy and dandelion. There are some sparse creeping buttercup plants and sparse rosettes of common ragwort, spear thistle and prickly sow-thistle.

To the south of Pond 3 there is an area of unmown rough semi-improved neutral grassland with wild teasel, cock's-foot, creeping buttercup, false oat-grass, creeping thistle, spear thistle, timothy, upright hedge parsley, tall fescue, common knapweed, oxeye daisy, hogweed, Yorkshire-fog, common bent, common couch, bristly oxtongue, broad-leaved dock, red fescue and common ragwort.

The site is bordered by both tall and low hawthorn hedgerows.

Photograph 7: View of a fairway on site

Photograph 8: Further view of a fairway on site

Photograph 9: Further view of a fairway on site

Photograph 10: Further view of a fairway on site

3.2.4 Ponds

Pond 1 is the westernmost pond on site and is choked by common reed and bulrush.

Pond 2 has locally dominant common reed. Other marginal and emergent plants include yellow iris, bulrush, false fox-sedge, great willowherb, clustered dock and grey club-rush. Water plants include a water-lily species and mare's-tail. The pond is spanned by a bridge.

Pond 3 is the southernmost pond on site. There are some areas of open water amongst extensive and dense swamp vegetation, with common reed and bulrush dominant. There is also bittersweet, great willowherb, lesser bulrush, clustered dock, false fox-sedge. Grey willow, goat willow, white willow and crack-willow are located at the edge of the pond, as well as guelder-rose and ornamental dogwood. Plants in the open water are common duckweed, water-cress, mare's-tail, gypsywort, and a water-speedwell species.

Pond 4 is located to the north of Pond 2 and has a waterfall. Species present include bulrush, weeping willow, water lily species and common reed.

Pond 5 is a small pond towards the north of the survey site. Species present here include bulrush, rosebay willowherb, dogwood, hazel and common knapweed.

Pond 6 is a very small pod adjacent to the woodland at the north of the site. It is dominated by bulrush with rosebay willowherb, dogwood, hazel and common knapweed.

Photograph 11: View of vegetation in Pond 2

Photograph 12: View of vegetation in Pond 3

Photograph 13: View of Pond 3

Photograph 14: View of Pond 4

Photograph 15: Further view of Pond 4

Photograph 16: Further view of Pond 4

Photograph 17: View of Pond 5

Photograph 18: View of Pond 6

4 RESULTS

4.1 Data search

The LERC data search identified two non-statutory sites within 2km of the survey site;

- South Forty Foot Drain Local Wildlife Site (LWS)
- Boston West Golf Course Site of Nature Conservation Interest (SNCI)

The South Forty Foot Drain LWS is located to the south of the site and separated by the main A1121 road and it is considered unlikely that the proposed works would impact upon the nature conservation interests of this site.

Boston West Golf Course SNCI encompasses the retained nine-hole golf course and two fields currently in arable production to the north of the survey site. As there was no citation for this site provided and it has not been resurveyed against the Local Wildlife Site criteria which replaced SNCI it is difficult to understand why the arable fields were included. Aerial photography shows that the survey site was originally planted in 2000. The proposals aim to build sympathetically on this and management recommendations to further enhance the site are included in this report.

The following UK BAP species have been recorded within 2km of the site:

- brown hare *Lepus europaeus* in 2015
- west European hedgehog *Erinaceus europaeus* in 2018

Where applicable, the records of protected species are included within the relevant section of the report.

4.2 Great crested newts

There are no records of great crested newt *Triturus cristatus* in the area. HSI scores were calculated for each of the accessible ponds and waterbodies in the park, to assess their potential suitability for great crested newt.

HSI is a quantitative measure of the habitat quality and evaluates the suitability of the water body and surrounding land to support great crested newts. The HSI is a number between 0 and 1 which is derived from an assessment of ten habitat variables known to influence the presence of newts. These variables include quality of the terrestrial habitat, water quality in the pond, presence of fish, and aquatic macrophyte cover. An HSI of 1 is optimal habitat (high probability of supporting great crested newts) and 0 is very poor quality with a minimal chance of occurrence. The Habitat Suitability Indices for all of the accessible ponds and waterbodies were calculated following the surveys.

The HSI calculations for each of the three ponds are included below:

Table 1: HSI calculation for Pond 1

Suitability Index	Factor	Notes	Score
SI 1	Location	Zone A	1
SI 2	Pond area (m^2)	1,200	0.93
SI 3	Pond drying	Rarely	0.90
SI 4	Water quality	Good	1
SI 5	Shoreline shade	60%	1
SI 6	Fowl	Present	0.67
SI 7	Fish	Present	0.01
SI 8	No ponds/km^2**	3.822	0.95
SI 9	Terrestrial habitat	Poor	0.33
SI 10	Macrophytes	90%	0.9
		HSI Score -	**0.52 (below average suitability)**

There are 13 ponds within 1km of Pond 1, of which one is separated by the South Forty Foot Drain, a significant barrier to great crested newt dispersal. The HSI indicates that Pond 1 has below average suitability, and therefore has low potential to support breeding great crested newts.

Table 2: HSI calculation for Pond 2

Suitability Index	Factor	Notes	Score
SI 1	Location	Zone A	1
SI 2	Pond area (m^2)	1,950	0.81
SI 3	Pond drying	Never	0.90
SI 4	Water quality	Moderate	0.67
SI 5	Shoreline shade	20%	1
SI 6	Fowl	Minor	0.67
SI 7	Fish	Major	0.01
SI 8	No ponds/km^2**	3.822	0.95
SI 9	Terrestrial habitat	Poor	0.33
SI 10	Macrophytes	85%	0.95
		HSI Score -	**0.50 (below average suitability)**

There are 14 ponds within 1km of Pond 2, of which one is separated by the South Forty Foot Drain and two by a busy main road, both significant barriers to great crested newt dispersal. The HSI indicates that Pond 2 has below average suitability, and therefore has low potential to support breeding great crested newts.

Table 3: HSI calculation for Pond 3

Suitability Index	Factor	Notes	Score
SI 1	Location	Zone A	1
SI 2	Pond area (m^2)	6,900	0.8
SI 3	Pond drying	Never	0.9
SI 4	Water quality	Moderate	0.67
SI 5	Shoreline shade	40%	1
SI 6	Fowl	Minor	0.67
SI 7	Fish	Major	0.01
SI 8	No ponds/km^2**	3.503	0.98
SI 9	Terrestrial habitat	Poor	0.33
SI 10	Macrophytes	60%	0.9
		HSI Score -	**0.50 (below average suitability)**

There are 18 ponds within 1km of Pond 3, of which five are separated by the South Forty Foot Drain and two by a busy main road, both significant barriers to great crested newt dispersal. The HSI indicates that Pond 3 has below average suitability, and therefore has low potential to support breeding great crested newts.

Table 4: HSI calculation for Pond 4

Suitability Index	Factor	Notes	Score
SI 1	Location	Zone A	1
SI 2	Pond area (m^2)	1,600	0.85
SI 3	Pond drying	Never	0.9
SI 4	Water quality	Moderate	0.67
SI 5	Shoreline shade	40%	1
SI 6	Fowl	Minor	0.67
SI 7	Fish	Minor	0.33
SI 8	No ponds/km^2**	4.459	1
SI 9	Terrestrial habitat	Poor	0.33
SI 10	Macrophytes	50%	0.6
		HSI Score -	**0.68 (average suitability)**

There are 16 ponds within 1km of Pond 4, of which one is separated by the South Forty Foot Drain and one by a busy main road, both significant barriers to great crested newt dispersal. The HSI indicates that Pond 4 has average suitability, and therefore has moderate potential to support breeding great crested newts.

Table 5: HSI calculation for Pond 5

Suitability Index	Factor	Notes	Score
SI 1	Location	Zone A	1
SI 2	Pond area (m^2)	<50	0.05
SI 3	Pond drying	Dries annually	0.1
SI 4	Water quality	Moderate	0.67
SI 5	Shoreline shade	10%	1
SI 6	Fowl	Absent	1
SI 7	Fish	Absent	1
SI 8	No ponds/km^2**	5.100	1.00
SI 9	Terrestrial habitat	Poor	0.33
SI 10	Macrophytes	90%	0.9
		HSI Score -	**0.50 (below average suitability)**

There are 18 ponds within 1km of Pond 5, of which two are separated by the South Forty Foot Drain and two by a busy main road, both significant barriers to great crested newt dispersal. The HSI indicates that Pond 5 has below average suitability, and therefore has low potential to support breeding great crested newts.

Table 6: HSI calculation for Pond 6

Suitability Index	Factor	Notes	Score
SI 1	Location	Zone A	1
SI 2	Pond area (m^2)	<50	0.05
SI 3	Pond drying	Dries annually	0.1
SI 4	Water quality	Moderate	0.67
SI 5	Shoreline shade	0%	1
SI 6	Fowl	Absent	1
SI 7	Fish	Absent	1
SI 8	No ponds/km^2**	5.100	1.00
SI 9	Terrestrial habitat	Poor	0.33
SI 10	Macrophytes	70%	1
		HSI Score -	**0.595 (below average suitability)**

There are 18 ponds within 1km of Pond 6, of which two are separated by the South Forty Foot Drain and two by a busy main road, both significant barriers to great crested newt dispersal. The HSI indicates that Pond 6 has below average suitability, and therefore has low potential to support breeding great crested newts.

Overall, it is considered unlikely that this species occurs on site and the proposed work is therefore unlikely to result in a breach of the legislation which protects great crested newts and their habitats.

4.3 Bats

There are several records of bats within 2km of the survey site. Common pipistrelle *Pipistrellus pipistrellus* and Daubenton's bat *Myotis daubentonii* were recorded in the area in 2016, with records of noctule *Nyctalus noctula* and Myotis species *Myotis sp*. from 2015. Pipistrelle species *Pipistrellus sp.* were recorded in the area in 2014, with a single record for Nathusius's pipistrelle *Pipistrellus nathusii* from 2012.

4.3.1 Ground level roost assessment

There were no trees on site identified as suitable for roosting bats.

4.3.2 Assessment of commuting and foraging habitats

As there are a range of woodland and ponds on the survey site it would likely provide good foraging habitat for bat species due to it attracting a high invertebrate population, however the survey site is somewhat isolated, with few hedgerows or ditches to provide connectivity. It is

therefore likely that bats will forage across the site, however potential for commuting is limited by this lack of connecting features on site. This is also perhaps exacerbated by the lighting around the A1121 main road.

Within 500m of the survey site, there are a number of residential properties with mature gardens and arable fields and a small number of field boundary hedgerows and drains providing connectivity. The wider surrounding area is dominated by arable land with field boundaries of ditches and occasional hedgerows which provide some connectivity within the wider area.

The results of the assessment of the surrounding habitats appear in tabular form below:

Table 7: Assessment of surrounding habitats to support commuting and foraging bats

Feature	Description	Value for bats
Immediate area (<500m)	Residential properties, the retained nine-hole golf course, arable fields and the South Forty Foot drain. However, the well-lit A1121 main road would limit the species willing to commute across the site.	Moderate potential for foraging bats. Low potential for commuting bats
Wider surroundings (500m-3km)	Arable fields, with ditches and occasional hedgerows contribute to connectivity.	Moderate potential for foraging and commuting bats

4.4 Badger

Badger *Meles meles* have most recently been recorded within the area in 2016. No signs of badger were noted on site. No further work or mitigation is required in respect of this species, but as badger are a mobile species, it is recommended that vigilance is maintained for signs of badger activity. If badger presence is suspected at any time then it will be necessary to seek advice immediately by calling 07833 674500, to ensure legal compliance. To safeguard ground mammals, including badgers and hedgehogs, during the development phase, it is essential that no trenches or pipes are left uncovered overnight.

4.5 Birds

4.5.1 Common bird species

A number of common birds were seen on or flying over the site during the survey. These are listed below along with their current status as BAP species or Birds of Conservation Concern 4 (Eaton et al, 2015):

Table 8: Bird species seen on site

English name	Scientific name	BAP	BoCC
buzzard	*Buteo buteo*		Green
woodpigeon	*Columba palumbus*		Green
green woodpecker	*Picus viridis*		Green
kestrel	*Falco tinnunculus*		Amber
jay	*Garrulus glandarius*		Green
magpie	*Pica pica*		Green
carrion crow	*Corvus corone*		Green
great tit	*Parus major*		Green
starling	*Sturnus vulgaris*	Y	Red
blackbird	*Turdus merula*		Green
redwing	*Turdus iliacus*		Red
robin	*Erithacus rubecula*		Green
pied wagtail	*Motacilla alba*		Green

4.5.2 Schedule 1 bird species

Redwing are listed on Schedule 1 of The Wildlife and Countryside Act 1981 (and as amended), however they are a winter visitor and are unlikely to nest on the survey site.

There is a barn owl towers on the survey site with a further tower on the retained nine-hole golf course. Both towers are reported to have been successful with chicks having been raised.

4.6 Other notable species

Brown hare, a UK BAP species, were noted on site. Grey squirrel *Sciurus carolinensis* and red fox *Vulpes vulpes* were also noted.

4.7 Habitats and plant species

The habitats and plant species recorded on the site are common and widespread in the local area and in the country. All noteworthy habitats and ecological features are marked as target notes on the Phase 1 habitats map. A list of target notes is presented as Appendix 3.

The site is unlikely to meet the required criteria to qualify as a Local Wildlife Site and there are no species that are listed in the Vascular Plant Red Data List for Great Britain. No invasive plant species listed on Schedule 9 were recorded.

5 DISCUSSION AND RECOMMENDATIONS

5.1 Bats

5.1.1 Legal protection

In England, Scotland and Wales, all bats are strictly protected under the Wildlife and Countryside Act 1981 (and as amended); in England and Wales this legislation has been amended and strengthened by the Countryside and Rights of Way (CRoW) Act 2000. Bats are also protected by European legislation; the EC Habitats Directive is transposed into UK law by The Conservation of Habitats and Species Regulations 2017 – often referred to as 'The Habitat Regs'. Taken together, all this legislation makes it an offence to:

- Deliberately capture (or take), injure or kill a bat
- Intentionally or recklessly disturb a group of bats where the disturbance is likely to significantly affect the ability of the animals to survive, breed, or nurture their young or likely to significantly affect the local distribution or abundance of the species whether in a roost or not
- Damage or destroy the breeding or resting place of a bat
- Possess a bat (alive or dead) or any part of a bat
- Intentionally or recklessly obstruct access to a bat roost
- Sell (or offer for sale) or exchange bats (alive or dead) or parts of bats

A roost is defined as being ‘any structure or place that is used for shelter or protection’, and since bats regularly move roost site throughout the year, a roost retains such designation whether or not bats are present at the time.

5.1.2 Recommendations

As a positive conservation measure to enhance the site for bats, install at least 20 bat boxes should be installed onto the new buildings and trees on site. These should be placed on the northern and southern elevations. Examples of bat boxes which could be used are given as Appendix 4 and more information can be found at www.wildcareshop.co.uk.

Increases in artificial lighting have been linked to negative effects on our native wildlife, especially upon those species which are active at night. As such it is necessary to consider the lighting required as part of development and install lighting that will disturb nocturnal wildlife the least. It is considered that appropriate placement and types of lighting will minimise disturbance of wildlife on site.

Lighting on site should be kept to a minimum. External lighting should, wherever possible, be limited to the immediate surrounds of the buildings. If it is absolutely necessary to include some

external lighting around the lodges and paths, then these should be carefully designed to minimise disturbance to bats, by using down-lights rather than up-lights and using shields to limit light spill. Any external lighting (especially up-lights) used should emit minimal ultra-violet light, be narrow-spectrum (avoiding white and blue wavelengths) and should peak higher than 550nm. It should be remembered that artificial lighting disrupts and disturbs many animals, including birds and invertebrates, as well as bats.

The lighting scheme will be designed to ensure that dark unlit areas of the site are retained, particularly around the woodlands, ponds and boundaries of the site, where bats are likely to be foraging and commuting. This ensures that unlit corridors, for commuting bats and unlit foraging areas for bats are retained. Any lighting installed should be motion sensitive and set on a timer in order to avoid any more than short duration impacts on nocturnal wildlife such as bats. All newly installed bat and bird boxes will remain unlit. Further information regarding artificial lighting and wildlife is provided in Appendix 6.

5.2 Common bird species

5.2.1 Legal protection

All common wild birds are protected under The Wildlife and Countryside Act 1981 (and as amended). Under this legislation it is an offence to:

- Kill, injure or take any wild bird
- Take, damage or destroy the nest of any wild bird while it is in use or being built
- Take or destroy the egg of any wild bird

Certain rare breeding birds are listed on Schedule 1 of The Wildlife and Countryside Act 1981 (and as amended). Under this legislation they are afforded the same protection as common wild birds and are also protected against disturbance whilst building a nest or on or near a nest containing eggs/unfledged young.

5.2.2 Recommendations

The trees and grassland on site provide potential for nesting bird species. It is recommended that any vegetation clearance work should commence outside the active nesting season, which typically runs from March through to late August. If work commences during the bird breeding season, a search for nests will need to be carried out before work begins, and active nests should be protected until the young fledge.

A number of bird boxes were noted on trees within the woodlands on site, however the scheme of boxes is old and most need replacing. 70 nest boxes of various designs should therefore be

installed on trees within the woodland on site, to include 20 open fronted bird boxes, 20 25mm diameter hole nest boxes, 20 28mm diameter hole next boxes and 10 sparrow nest boxes. Details of nest boxes suitable for use by a range of common bird species can be obtained from Wildcare, Eastgate House, Moreton Road, Longborough, Gloucestershire GL56 0QJ (01451 833181), www.wildcareshop.co.uk, with examples provided in Appendix 5.

A kingfisher *Alcedo atthis*/sand martin *Riparia riparia* bank should also be created on site. This needs to provide a nearly vertical face to 1.5m above the normal water level for 5m with a depth of approximately 2m with half of the construction filled with a mix of 50:1 sand/soil to dry cement whilst the remaining half is filled with pipes, which are half filled with sand, 700mm long fitted behind a marine grade plywood front with entrance holes which is backfilled with sand/soil. Further details can be obtained from RSPB or Lincolnshire Wildlife Trust.

5.3 Habitats and biodiversity

It is advisable to diversify the woodland structure on site. This can be achieved in a number of ways. One in 20 trees in the larger areas of woodland could be coppiced to create a more diverse structure, and the felled materials can then be used to make hedgehog refuges. The refugia would likely also be utilised by other species, including invertebrates and amphibians.

In addition, larger areas of woodland could be underplanted with woodland shrubs to further diversify woodland. Suitable species include hazel *Corylus avellana*, hawthorn *Crataegus monogyna*, Midland hawthorn *Crataegus laevigata*, wild privet *Ligustrum vulgare*, dogwood *Cornus sanguinea*, red currant *Ribes rubrum*, black currant *Ribes nigrum*, dog-rose *Rosa canina*, field-rose *Rosa arvensis* and elder *Sambucus nigra*.

The woodland ground flora could be diversified by sowing a woodland plant seed mixture, such as Emorsgate EW1 Woodland Mixture and/or introducing plug plants of species such as primrose *Primula vulgaris*. Additionally, bulbs of species such as snowdrop *Galanthus nivalis* and wild daffodil *Narcissus pseudonarcissus*.

In order to provide suitable habitats on site to encourage high invertebrate activity, including declining pollinators, the grassed areas on the site should be seeded with appropriate wildflower mixes. Seeding of any amenity areas should use a flowering lawn mixture, such as Emorsgate Seeds EL1 mix (www.wildseed.co.uk), which is resistant to regular mowing. Any areas of longer grass could be seeded with a general wildflower mix such as Emorsgate EM1 mix (basic all-purpose meadow mix). It is recommended that any wildflower areas are cut once a year, in late summer/early autumn and the arisings removed after 7 days to enable the wildflowers to flourish and provide food sources for invertebrates. Details of how to adequately prepare the ground

prior to seeding as well as ongoing management can also be found on the Emorsgate website. Increasing the levels of invertebrate activity on site will also provide further foraging opportunities for insectivorous species.

The site could be improved for solitary bees and wasps, both of which are important pollinators, by creating one or more open earth, south facing sloping banks. This will provide hot and sunny spots on slopes for these invertebrates to nest in.

Where the ponds are proposed to be cleared out for fishing, some tall swamp vegetation should be retained in order to provide fish refuges. The grey club-rush and lesser bulrush should also be retained within the ponds, as these are uncommon in Lincolnshire (Gibbons, 1975).

6 SUMMARY

Part of the Boston West Golf Course at Hubbert's Bridge, Lincolnshire was surveyed in connection with plans to construct a series of holiday lodges on site.

No ecological constraints were found to be associated with plans to develop this land.

Some precautionary measures and ecological enhancements are required in order to ensure legal compliance and no net loss to biodiversity. These are as follows:

- Best practice in relation to bats and lighting
- Vigilance and best practice regarding badgers and other ground mammals
- Appropriate timing with regards to nesting birds
- Provision of bird nest boxes
- Provision of bat boxes

7 REFERENCES AND BIBLIOGRAPHY

Cheffings, C.M. & Farrell, L. (ed.), Dines, T.D., Jones, R.A., Leach, S.J., McKean, D.R., Pearman, D.A., Preston, C.D., Rumsey, F.J. and Taylor, I. 2005. *The Vascular Plant Red Data List for Great Britain. Species Status 7*: 1-116. Joint Nature Conservation Committee, Peterborough

Collins, J. (ed.) 2016. Bat Surveys for Professional Ecologists: Good Practice Guidelines (3rd edition). The Bat Conservation Trust, London

Collop, C. (revised Bouic, A.) 2015. *Lincolnshire Biodiversity Action Plan 2011-20*. 3rd edition. Greater Lincolnshire Nature Partnership, Horncastle.

Eaton, M., Aebischer, N., Brown, A., Hearn, R., Lock, L., Musgrove, A., Noble, D., Stroud, D. and Gregory, R. 2015. *Birds of Conservation Concern 4: the population status of birds in the United Kingdom, Channel Islands and Isle of Man*. British Birds. 108, pp708–746.

Gibbons, E. J. 1975. *The Flora of Lincolnshire*. Lincolnshire Naturalists' Union, Lincoln.

Oldham R.S., Keeble J., Swan M.J.S. & Jeffcote M. (2000). *Evaluating the suitability of habitat for the Great Crested Newt (Triturus cristatus)*. Herpetological Journal 10(4), 143-155.

Poole, J. and Fraser, J. (ed.) 2013. *Local Wildlife Site Guidelines for Greater Lincolnshire (3rd edition)*. Greater Lincolnshire Nature Partnership, Horncastle.

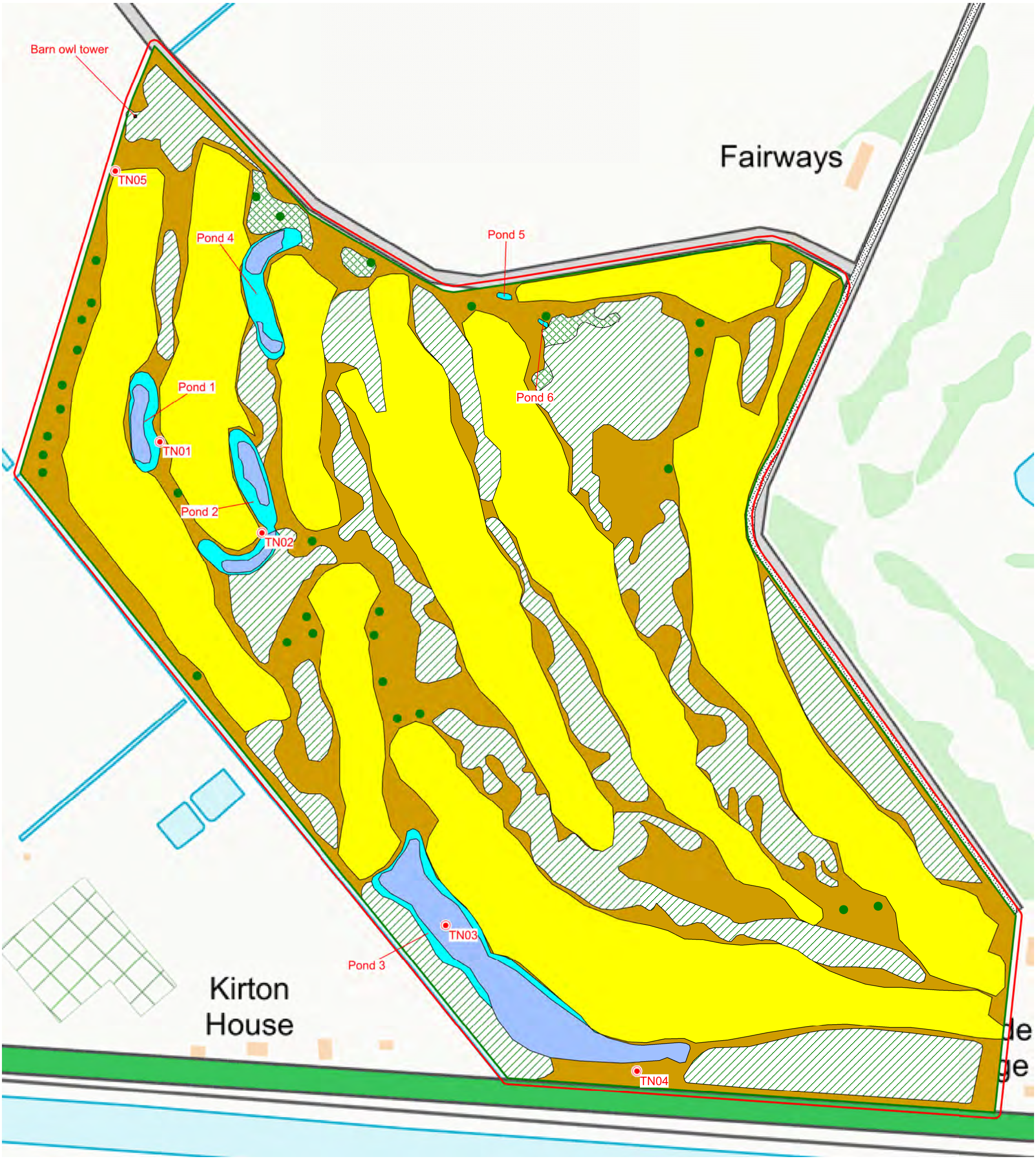
Stace, C. 2010. *New Flora of the British Isles*. 3rd Edition. CUP, Cambridge.

Stewart, A., Pearman, D. A., and Preston, C. D. 1994. *Scarce Plants in Britain.* JNCC, Peterborough.

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

FIGURE 1

Habitat Map



Key

- Tree
- Target note
- Approximate site boundary
- Hedge
- Broadleaf plantation
- Dense scrub
- Rough grassland
- Swamp
- Open water
- Amenity grassland
- Hard surface
- Building

0 — 100

Metres

Scale 1:2,500

N

Client:
Smart Move Boston Ltd
Head Office
The County-hall
Market Place
Boston
PE21 6DY

Project:
Boston West
Golf Course

Reference:
Figure 1

Title:
Habitat Map

IEL Inspired Ecology Ltd
Malham
Washdyke Lane
Kirton Meeres
BOSTON
Lincolnshire
PE20 1PW
01205 723342

21/11/2019

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

APPENDIX 1

Plant Species List

ECOLOGY AND PROTECTED SPECIES SURVEY
BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

ENGLISH NAME	SCIENTIFIC NAME (Stace 3rd)
alder	*Alnus glutinosa*
annual meadow-grass	*Poa annua*
apple	*Malus pumila*
ash	*Fraxinus excelsior*
bird cherry	*Prunus padus*
bittersweet	*Solanum dulcamara*
bramble	*Rubus fruticosus*
bristly oxtongue	*Helminthotheca echioides*
broad-leaved dock	*Rumex obtusifolius*
bulrush	*Typha latifolia*
celery-leaved buttercup	*Ranunculus sceleratus*
cleavers	*Galium aparine*
clustered dock	*Rumex conglomeratus*
cock's-foot	*Dactylis glomerata*
colt's-foot	*Tussilago farfara*
common bent	*Agrostis capillaris*
common couch	*Elytrigia repens*
common duckweed	*Lemna minor*
common knapweed	*Centaurea nigra*
common mouse-ear	*Cerastium fontanum*
common nettle	*Urtica dioica*
common ragwort	*Senecio jacobaea*
common reed	*Phragmites australis*
common whitebeam	*Sorbus aria agg.*
crack-willow	*Salix fragilis*
creeping buttercup	*Ranunculus repens*
creeping thistle	*Cirsium arvense*
daisy	*Bellis perennis*
dandelion	*Taraxacum sp.*
dogwood	*Cornus sanguinea*
elder	*Sambucus nigra*
false fox-sedge	*Carex otrubae*

false oat-grass	*Arrhenatherum elatius*
fat-hen	*Chenopodium album*
field maple	*Acer campestre*
goat willow	*Salix caprea*
great willowherb	*Epilobium hirsutum*
grey club-rush	*Schoenoplectus tabernaemontani*
grey willow	*Salix cinerea*
groundsel	*Senecio vulgaris*
guelder-rose	*Viburnum opulus*
gypsywort	*Lycopus europaeus*
hawthorn	*Crataegus monogyna*
hazel	*Corylus avellana*
hogweed	*Heracleum sphondylium*
Italian alder	*Alnus cordata*
larch	*Larix sp.*
lesser bulrush	*Typha angustifolia*
mare's-tail	*Hippuris vulgaris*
Norway maple	*Acer platanoides*
ornamental dogwood	*Cornus sp.*
oxeye daisy	*Leucanthemum vulgare*
pedunculate oak	*Quercus robur*
perennial rye-grass	*Lolium perenne*
prickly sow-thistle	*Sonchus asper*
red fescue	*Festuca rubra*
rosebay willowherb	*Chamerion angustifolium*
rowan	*Sorbus aucuparia*
scentless mayweed	*Tripleurospermum inodorum*
Scots pine	*Pinus sylvestris*
silver birch	*Betula pendula*
small-leaved lime	*Tilia cordata*
spear thistle	*Cirsium vulgare*
spindle	*Euonymus europaeus*
sweet chestnut	*Castanea sativa*
tall fescue	*Schedonorus arundinaceus*
timothy	*Phleum pratense*
upright hedge parsley	*Torilis japonica*
water-lily species	*Nymphaea sp.*
water-speedwell species	*Veronica sp.*
water-cress	*Nasturtium officinale*

wayfaring-tree	*Viburnum lantana*
weeping willow	*Salix x sepulcralis*
white clover	*Trifolium repens*
white poplar	*Populus alba*
white willow	*Salix alba*
wild cherry	*Prunus avium*
wild teasel	*Dipsacus fullonum*
willowherb species	*Epilobium sp.*
wood avens	*Geum urbanum*
yellow iris	*Iris pseudacorus*
Yorkshire-fog	*Holcus lanatus*
aspen	*Populus tremula*
dog-rose	*Rosa canina*

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

APPENDIX 2

Data search

LERC Search Summary Report

Grid Reference: TF 264 440
Buffer: 2km

Date of publication: 31/10/2019
Expires: 31/10/2020

Achieving more for nature

GLNP
GREATER LINCOLNSHIRE NATURE PARTNERSHIP

Report Details

Produced for	Alex Scurrah-Price, Inspired Ecology Ltd
Search area	

Terms and conditions

1. The data and reports provided by LERC are only to be used for the specific purpose they were produced.
2. The data and any copyright remains the property of GLNP, its licensors and/or the data providers (as applicable), and the data products and services remain the copyright of GLNP.
3. Permission to use the data and reports provided by LERC expires 12 months following supply.

For full terms and conditions see https://search.glnp.org.uk/terms-and-conditions

This report summarises a search of statutory sites, non-statutory sites, other sites, habitats and species within the specified area; where no information is returned for a section, it is excluded from this summary report.

About the Lincolnshire Environmental Records Centre

The Lincolnshire Environmental Records Centre (LERC) collates wildlife and geological information for Greater Lincolnshire from various sources and makes it available for various uses. This data is crucial to aid conservation management of sites, to help organisations prioritise action, and to understand the distribution of species and trends over time. For more information on LERC or to request a data search, visit the website at https://glnp.org.uk/partnership/lerc/

an ALERC accredited LERC
Association of Local Environmental Records Centres

Lincolnshire Environmental Records Centre is an ALERC accredited LRC, meeting the standard level criteria.
For more information on acceditation, see the ALERC website at http://www.alerc.org.uk/alerc-accreditation.html

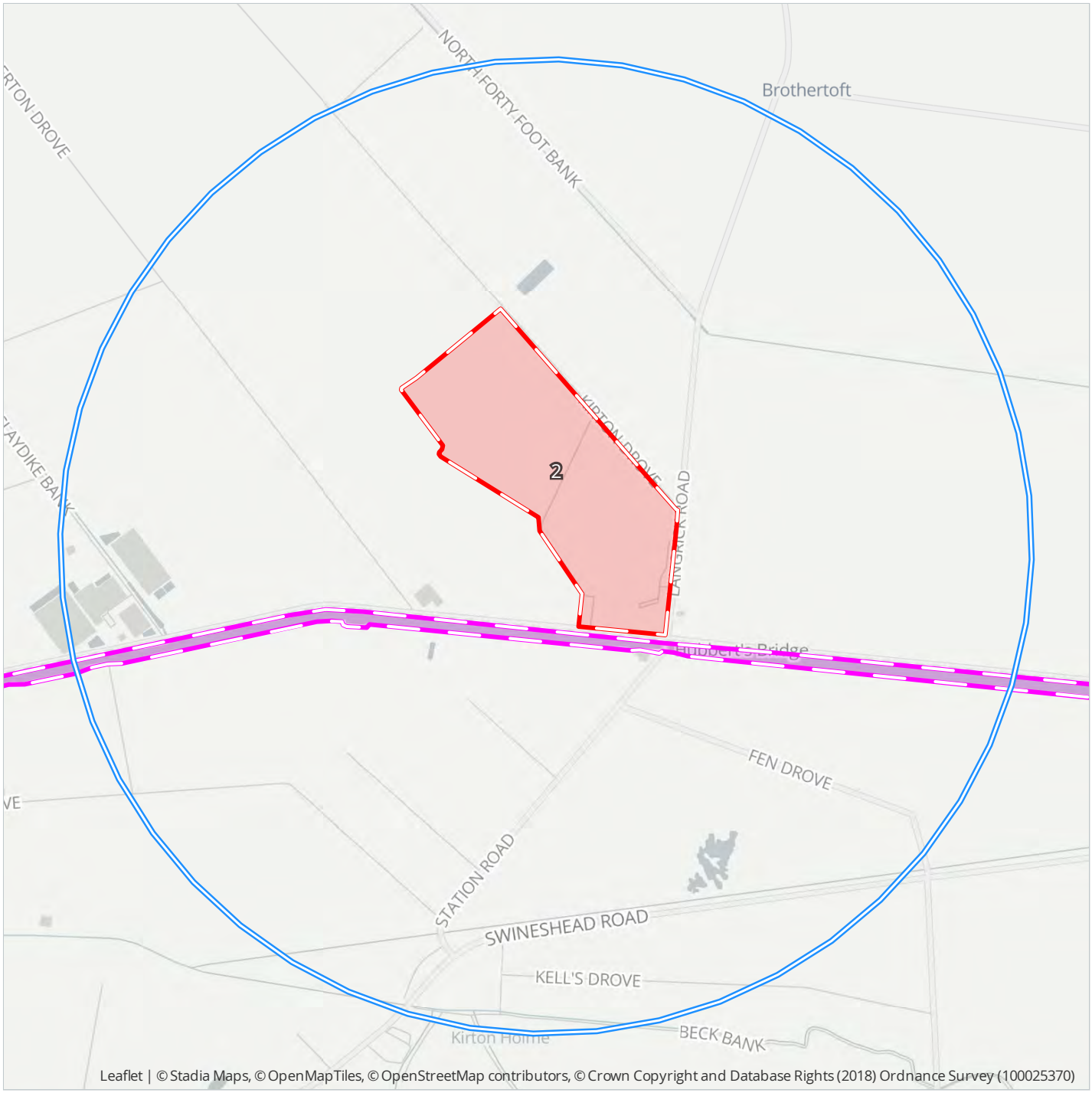
Non-statutory sites

The GLNP works directly with local authorities to coordinate the Local Sites system in Greater Lincolnshire. Sites are selected by the Nature Partnership, based on recommendations made by its expert working groups known as the LWS Panel and LGS Panel. The Register of Local Sites is then submitted for inclusion within local authority planning policy.

These sites are recognition of wildlife or geological value and are a testament to the land management that is already being undertaken on them. Identifying these sites helps local authorities meet their obligations under legislation and government guidance, including reporting on the number of sites in positive management for Single Data List Indicator 160-00.

Code	Designation	Status	Name
1	LWS	Selected	South Forty Foot Drain
2	SNCI	Notified	Boston West Golf Course

Non-statutory sites within the search area



Space restrictions on the map may result in some sites not being labelled. Please refer to the site citations for details.

Local Wildlife Site

Site of Nature Conservation Interest

Search area

Species

Lincolnshire Environmental Records Centre holds records on the following species within or overlapping the search area. Data shown is as held by LERC; past records of presence of a species does not guarantee continued occurrence and absence of records does not imply absence of a species, merely that no records are held. Confidential data, zero abundance records, data at poorly defined geographic resolutions and data pending validation and/or verification are also excluded from this report. A number of different datasets have been consulted to produce this report - a summary of attribution statements is available at https://glnp.org.uk/admin/resources/species-attribution.pdf.

Amphibian (2 taxa)

Common Frog, *Rana temporaria*	6	1989 - 2009	Protected
Common Toad, *Bufo bufo*	2	1995 - 2009	Protected, Priority

Bird (46 taxa)

Barn Owl, *Tyto alba*	11	1998 - 2011	Protected, Local Priority
Bewick's Swan, *Cygnus columbianus subsp. bewickii*	1	2008 - 2008	Protected, Priority
Black Swan, *Cygnus atratus*	1	2002 - 2002	Non-native
Brambling, *Fringilla montifringilla*	1	2009 - 2009	Protected
Bullfinch, *Pyrrhula pyrrhula*	1	2009 - 2009	Local Priority
Canada Goose, *Branta canadensis*	5	1998 - 2005	Non-native
Collared Dove, *Streptopelia decaocto*	121	1977 - 2014	Non-native
Cuckoo, *Cuculus canorus*	1	1999 - 1999	Priority
Curlew, *Numenius arquata*	1	2000 - 2000	Priority, Local Priority
Fieldfare, *Turdus pilaris*	4	1999 - 2015	Protected
Gadwall, *Anas strepera*	3	1999 - 2000	Non-native
Goldeneye, *Bucephala clangula*	6	1998 - 2005	Protected
Great Northern Diver, *Gavia immer*	1	2014 - 2014	Protected
Green Sandpiper, *Tringa ochropus*	2	2004 - 2006	Protected
Greenshank, *Tringa nebularia*	1	2002 - 2002	Protected
Grey Partridge, *Perdix perdix*	5	1998 - 2010	Priority, Local Priority, Non-native
Greylag Goose, *Anser anser*	8	2000 - 2014	Protected
Hobby, *Falco subbuteo*	9	1999 - 2012	Protected
House Sparrow, *Passer domesticus*	76	1977 - 2014	Priority, Local Priority
Kingfisher, *Alcedo atthis*	4	1998 - 2007	Protected
Lapwing, *Vanellus vanellus*	14	1998 - 2011	Priority, Local Priority
Linnet, *Linaria cannabina*	3	2009 - 2011	Local Priority
Little Owl, *Athene noctua*	5	1999 - 2008	Non-native
Marsh Harrier, *Circus aeruginosus*	4	2000 - 2010	Protected
Merlin, *Falco columbarius*	5	1998 - 2009	Protected
Mute Swan, *Cygnus olor*	26	1999 - 2011	Non-native
Peregrine, *Falco peregrinus*	1	2011 - 2011	Protected
Pheasant, *Phasianus colchicus*	51	2005 - 2015	Non-native
Pink-footed Goose, *Anser brachyrhynchus*	17	1998 - 2012	Non-native

Bird (46 taxa)			
Pochard, *Aythya ferina*	3	2001 - 2003	Non-native
Red-legged Partridge, *Alectoris rufa*	6	2009 - 2014	Non-native
Redshank, *Tringa totanus*	11	1998 - 2005	Local Priority
Redwing, *Turdus iliacus*	3	2000 - 2015	Protected
Reed Bunting, *Emberiza schoeniclus*	2	2011 - 2011	Priority, Local Priority
Ring-necked Parakeet, *Psittacula krameri*	2	2002 - 2002	Non-native
Rock Dove, *Columba livia*	4	2007 - 2014	Non-native
Skylark, *Alauda arvensis*	5	2005 - 2011	Local Priority
Song Thrush, *Turdus philomelos*	13	1999 - 2013	Local Priority
Spotted Flycatcher, *Muscicapa striata*	3	2008 - 2015	Priority
Starling, *Sturnus vulgaris*	82	1977 - 2014	Local Priority
Swift, *Apus apus*	12	1998 - 2013	Local Priority
Tree Sparrow, *Passer montanus*	113	2005 - 2011	Priority, Local Priority
Turtle Dove, *Streptopelia turtur*	4	1999 - 2008	Priority, Local Priority
Whimbrel, *Numenius phaeopus*	2	1998 - 2000	Protected
Yellow Wagtail, *Motacilla flava*	6	2001 - 2011	Local Priority
Yellowhammer, *Emberiza citrinella*	1	2010 - 2010	Priority, Local Priority

Bony Fish (Actinopterygii) (3 taxa)			
Common Carp, *Cyprinus carpio*	1	2007 - 2007	Non-native
European Eel, *Anguilla anguilla*	57	1977 - 2012	Priority, Local Priority
Spined Loach, *Cobitis taenia*	3	2012 - 2012	Priority, Local Priority

Conifer (3 taxa)			
Corsican Pine, *Pinus nigra*	1	2014 - 2014	Non-native
Leyland Cypress, *Cupressus macrocarpa x Xanthocyparis nootkatensis = X Cuprocyparis leylandi*	2	2014 - 2014	Non-native
Norway Spruce, *Picea abies*	1	2014 - 2014	Non-native

Crustacean (2 taxa)			
Crangonyx pseudogracilis, *Crangonyx pseudogracilis*	2	2007 - 2007	Non-native
Gammarus tigrinus, *Gammarus tigrinus*	3	2015 - 2015	Non-native

Fern (1 taxa)			
Water Fern, *Azolla filiculoides*	1	2016 - 2016	Non-native

Flatworm (Turbellaria) (1 taxa)			
Planaria torva, *Planaria torva*	1	2007 - 2007	Non-native

Flowering Plant (67 taxa)			
Apple, *Malus pumila*	1	2011 - 2011	Non-native
Barren Brome, *Bromus sterilis*	3	2009 - 2014	Non-native
Black-bindweed, *Fallopia convolvulus*	1	2009 - 2009	Non-native
Black-grass, *Alopecurus myosuroides*	3	1998 - 2014	Non-native
Bluebell, *Hyacinthoides non-scripta x hispanica = H. x massartiana*	1	2014 - 2014	Non-native
Bristly Oxtongue, *Picris echioides*	3	2009 - 2014	Non-native
Broad Bean, *Vicia faba*	1	2014 - 2014	Non-native
Bunch-flowered Daffodil, *Narcissus tazetta*	1	2014 - 2014	Non-native
Butterfly-bush, *Buddleja davidii*	1	2009 - 2009	Non-native
Canadian Fleabane, *Conyza canadensis*	1	1998 - 1998	Non-native
Charlock, *Sinapis arvensis*	4	1998 - 2014	Non-native
Cherry Plum, *Prunus cerasifera*	1	2014 - 2014	Non-native
Common Field-speedwell, *Veronica persica*	5	1998 - 2014	Non-native
Common Fumitory, *Fumaria officinalis subsp. officinalis*	1	2014 - 2014	Non-native
Common Fumitory, *Fumaria officinalis*	1	2009 - 2009	Non-native
Common Mallow, *Malva sylvestris*	6	1998 - 2014	Non-native
Common Poppy, *Papaver rhoeas*	3	1998 - 2014	Non-native
Cornus sanguinea subsp. australis, *Cornus sanguinea subsp. australis*	1	2014 - 2014	Non-native
Cotton Thistle, *Onopordum acanthium*	1	1998 - 1998	Non-native
Cut-leaved Crane's-bill, *Geranium dissectum*	5	1998 - 2014	Non-native
Cut-leaved Dead-nettle, *Lamium hybridum*	2	1998 - 2009	Non-native
Dwarf Mallow, *Malva neglecta*	1	1998 - 1998	Non-native
Equal-leaved Knotgrass, *Polygonum arenastrum*	1	1998 - 1998	Non-native
Field Forget-me-not, *Myosotis arvensis*	1	1998 - 1998	Non-native
Field Penny-cress, *Thlaspi arvense*	1	2014 - 2014	Non-native
Garden Grape-hyacinth, *Muscari armeniacum*	1	2014 - 2014	Non-native
Greater Burdock, *Arctium lappa*	1	1998 - 1998	Non-native
Greater Periwinkle, *Vinca major*	1	2014 - 2014	Non-native
Green Field-speedwell, *Veronica agrestis*	1	2009 - 2009	Non-native
Ground-elder, *Aegopodium podagraria*	1	1998 - 1998	Non-native
Hedge Mustard, *Sisymbrium officinale*	4	1998 - 2014	Non-native
Hoary Cress, *Lepidium draba*	1	2014 - 2014	Non-native
Horse-chestnut, *Aesculus hippocastanum*	3	1998 - 2014	Non-native
Horse-radish, *Armoracia rusticana*	3	1998 - 2011	Non-native
Hybrid Black-poplar, *Populus nigra x deltoides = P. x canadensis*	1	1998 - 1998	Non-native
Italian Rye-grass, *Lolium multiflorum*	1	1998 - 1998	Non-native
Ivy-Leaved Speedwell, *Veronica hederifolia subsp. hederifolia*	2	2014 - 2014	Non-native
Long Smooth-headed Poppy, *Papaver dubium*	1	1998 - 1998	Non-native
Mugwort, *Artemisia vulgaris*	5	1998 - 2014	Non-native

Flowering Plant (67 taxa)			
Nonesuch Daffodil, *Narcissus poeticus x pseudonarcissus = N. x incomparabilis*	1	2014 - 2014	Non-native
Oil-seed Rape, *Brassica napus subsp. oleifera*	2	2014 - 2014	Non-native
Osier, *Salix viminalis*	1	1998 - 1998	Non-native
Pineappleweed, *Matricaria discoidea*	3	2009 - 2014	Non-native
Populus nigra 'Italica', *Populus nigra 'Italica'*	2	2014 - 2014	Non-native
Prickly Lettuce, *Lactuca serriola*	1	1998 - 1998	Non-native
Primrose-peerless, *Narcissus tazetta x poeticus = N. x medioluteus*	2	2014 - 2014	Non-native
Red Dead-nettle, *Lamium purpureum*	4	1998 - 2014	Non-native
Russian Comfrey, *Symphytum officinale x asperum = S. x uplandicum*	1	2014 - 2014	Non-native
Scentless Mayweed, *Tripleurospermum inodorum*	3	2009 - 2014	Non-native
Shepherd's-purse, *Capsella bursa-pastoris*	5	1998 - 2014	Non-native
Small Nettle, *Urtica urens*	4	1998 - 2014	Non-native
Snowberry, *Symphoricarpos albus*	1	2009 - 2009	Non-native
Snowdrop, *Galanthus nivalis*	3	2014 - 2014	Non-native
Spanish Daffodil, *Narcissus pseudonarcissus subsp. major*	2	2014 - 2014	Non-native
Sun Spurge, *Euphorbia helioscopia*	2	1998 - 2009	Non-native
Swine-cress, *Lepidium coronopus*	4	1998 - 2014	Non-native
Sycamore, *Acer pseudoplatanus*	4	2009 - 2014	Non-native
Turnip, *Brassica rapa*	1	1998 - 1998	Non-native
Wall Barley, *Hordeum murinum*	3	1998 - 2010	Non-native
Wall Cotoneaster, *Cotoneaster horizontalis*	1	2014 - 2014	Non-native
Weld, *Reseda luteola*	1	1998 - 1998	Non-native
White Campion, *Silene latifolia*	2	1998 - 2011	Non-native
White Dead-nettle, *Lamium album*	5	2009 - 2014	Non-native
White Willow, *Salix alba*	2	2009 - 2011	Non-native
Wild Plum, *Prunus domestica*	4	1998 - 2014	Non-native
Wild-oat, *Avena fatua*	2	2009 - 2014	Non-native
Yellow Archangel, *Lamium galeobdolon subsp. argentatum*	1	2009 - 2009	Non-native

Insect - Moth (1 taxa)			
Cinnabar, *Tyria jacobaeae*	1	2007 - 2007	Priority

Mollusc (6 taxa)			
Atlantic Rangia, *Rangia cuneata*	3	2015 - 2015	Non-native
Bladder snails, *Physa*	2	2007 - 2007	Non-native
Bladder snails, *Physa fontinalis*	1	2007 - 2007	Non-native
False Dark Mussel, *Mytilopsis leucophaeata*	3	2015 - 2015	Non-native
Jenkins' Spire Snail, *Potamopyrgus antipodarum*	6	1980 - 2015	Non-native
Physella acuta, *Physella acuta*	1	2015 - 2015	Non-native

Reptile (2 taxa)			
Grass Snake, *Natrix helvetica*	1	2009 - 2009	Protected, Priority
Slow-worm, *Anguis fragilis*	1	2009 - 2009	Protected, Priority

Terrestrial Mammal (10 taxa)			
American Mink, *Neovison vison*	1	1990 - 1990	Non-native
Brown Hare, *Lepus europaeus*	13	1977 - 2015	Priority
Chinese Muntjac, *Muntiacus reevesi*	1	2009 - 2009	Non-native
Eastern Grey Squirrel, *Sciurus carolinensis*	6	2009 - 2017	Non-native
Eurasian Badger, *Meles meles*	8	2007 - 2016	Protected
European Otter, *Lutra lutra*	2	2010 - 2010	Protected, Priority
European Rabbit, *Oryctolagus cuniculus*	10	1977 - 2015	Non-native
European Water Vole, *Arvicola amphibius*	3	1977 - 1996	Protected, Priority, Local Priority
Harvest Mouse, *Micromys minutus*	1	1972 - 1972	Priority
West European Hedgehog, *Erinaceus europaeus*	18	1977 - 2018	Priority

Terrestrial Mammal (bat) (7 taxa)			
Bats, *Chiroptera*	12	1977 - 2016	Protected, Priority, Local Priority
Common Pipistrelle, *Pipistrellus pipistrellus sensu stricto*	6	2001 - 2016	Protected, Local Priority
Daubenton's Bat, *Myotis daubentonii*	5	2000 - 2016	Protected, Local Priority
Nathusius's Pipistrelle, *Pipistrellus nathusii*	1	2012 - 2012	Protected, Local Priority
Noctule Bat, *Nyctalus noctula*	3	2000 - 2015	Protected, Priority, Local Priority
Pipistrelle Bat species, *Pipistrellus*	4	1982 - 2014	Protected, Priority, Local Priority
Unidentified Bat, *Myotis*	4	2012 - 2015	Protected, Priority, Local Priority

Greater Lincolnshire Nature Partnership
Banovallum House
Manor House Street
Horncastle
Lincolnshire
LN9 5HF

Tel: 01507 528398
Email: info@glnp.org.uk
Web: www.glnp.org.uk

Achieving more for nature

GLNP
GREATER LINCOLNSHIRE
NATURE PARTNERSHIP

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

APPENDIX 3

Target notes

ECOLOGY AND PROTECTED SPECIES SURVEY
BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

TARGET NOTES

Label	Note
TN001	Pond 1. Choked by common reed and bulrush. Phase 1 code for swamp vegetation is F1; Phase 1 code for standing eutrophic water is G1.1
TN002	Pond 2. Spanned by bridge. Dragonflies. Phase 1 code for swamp vegetation is F1; Phase 1 code for standing eutrophic water is G1.1 Locally dominant common reed. Other marginal and emergent plants are yellow iris, bulrush, false fox-sedge, great willowherb, clustered dock, grey club-rush. Water plants here are a water-lily species and mare's-tail. The Flora of Lincolnshire describes grey club-rush as an uncommon plant in the county.
TN003	Pond 3. Some areas of open water amongst extensive and dense swamp vegetation, with common reed and bulrush dominant; also bittersweet, great willowherb, lesser bulrush, clustered dock, false fox-sedge. Willows (grey, goat, white, crack-) at edge of pond and also guelder-rose and ornamental dogwood. Plants in the open water are common duckweed, water-cress, mare's-tail, gypsywort, a water-speedwell species. Dragonflies. The Flora of Lincolnshire describes lesser bulrush as an uncommon plant in the county. Phase 1 code for swamp vegetation is F1; Phase 1 code for standing eutrophic water is G1.1
TN004	Rough grassland between Pond 3 and edge of site. Area of unmown rough grassland with wild teasel, cock's-foot, creeping buttercup, false oat-grass, creeping thistle, spear thistle, timothy, upright hedge parsley, tall fescue, common knapweed, oxeye daisy, hogweed, Yorkshire-fog, common bent, common couch, bristly oxtongue, broad-leaved dock, red fescue, common ragwort. Phase 1 code is B2.2 for semi-improved neutral grassland.
TN005	Tall hedge on boundary near owl tower, hawthorn dominated. Phase 1 code is J2.1.2 for intact species poor hedge.

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

APPENDIX 4

Bat box examples

Schwegler 1FF Flat Bat Box

Chillon Woodstone Bat Box

Schwegler 1FD Triple Front Panel Bat Box 55

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

APPENDIX 5

Bird box examples

Examples of bird boxes with, from left to right:
a 25mm diameter entrance hole, open fronted and a 28mm diameter entrance hole

ECOLOGY AND PROTECTED SPECIES SURVEY BOSTON WEST GOLF COURSE, HUBBERT'S BRIDGE, LINCOLNSHIRE

APPENDIX 6

Artificial lighting and wildlife

Bat Conservation Trust

Institution of Lighting Professionals

Guidance Note 08/18

Bats and artificial lighting in the UK

Bats and the Built Environment series

Common pipistrelle bat © Hugh Clark / www.bats.org.uk

Institution of Lighting Professionals
Regent House
Regent Place
Rugby
Warwickshire
CV21 2PN

Tel: (01788) 576492
Email: info@theilp.org.uk

Website: www.theilp.org.uk

Registered Charity Number 268547

Bat Conservation Trust
Quadrant House
250 Kennington Lane
London
SE11 5RD

Tel: 0345 1300 228
Email: enquiries@bats.org.uk

Website: www.bats.org.uk

Registered charity in England and Wales (1012361) and in Scotland (SC040116)

Contents

This document is aimed at lighting professionals, lighting designers, planning officers, developers, bat workers/ecologists and anyone specifying lighting. It is intended to raise awareness of the impacts of artificial lighting on bats, and mitigation is suggested for various scenarios. However it is not meant to replace site-specific ecological and lighting assessments.

This is a working document and as such the information contained has been updated in line with advances in our knowledge both into the impact on bats and also to reflect the advances in technology available in the lighting industry at the time of publication.

The information provided here is believed to be correct. However, no responsibility can be accepted by the Bat Conservation Trust, the Institution of Lighting Professionals or any of their partners or officers for any consequences of errors or omissions, nor responsibility for loss occasioned to any person acting or refraining from action as a result of information and no claims for compensation for damage or negligence will be accepted.

The use of proprietary and commercial trade names in this guidance does not necessarily imply endorsement of the product or relevant companies by the authors or publishers.

Acknowledgements

James Miles (Chair) – Kingfisher Lighting Ltd

Jo Ferguson (Chapter 1) – Bat Conservation Trust

Nick Smith (Chapter 2) – Nick Smith Associates Ltd

Harry Fox (Chapter 3) – Clarkson and Woods Ecological Consultants Ltd

The authors are grateful to the following people for their consultation during the preparation of this document:

Bonnie Brooks – Illume Design Ltd

Larry Burrows – Somerset County Council

Jan Collins – Bat Conservation Trust

Alison Fure – Furesfen Ecological Consultancy

Gregor Neeve – Natural England

Karen Renshaw – Bath and North East Somerset Council

Carol Williams – Bat Conservation Trust

Allan Howard – WSP

Charles Potterton (Illustrations) – Potterton Associates Ltd

Glossary of technical terms

Terms used in this document or that may be used by the lighting industry

Arc tube	A tube, normally ceramic or quartz, enclosed by the outer glass envelope of a high-intensity discharge lamp (HID) that contains the arc stream.
Asymmetric beams	Lamp is off-centre in a reflector more steeply curved at one end.
Calculation Plane	An even grid of points denoting the anticipated or modelled intensity (candelas) or illuminance (lux) levels at a given point.
Candela	The intensity of a light source in a specific direction. Unit of luminous intensity.
CMS – Central Management System	Is a specially developed software and service package that can efficiently handle all tasks of data collection and facility management. It allows users to remotely monitor and control lighting and apply dimming and/or switching controls.
Colour Rendering Index (CRI)	A scale from 0 to 100 percent indicating how accurate a given light source is at rendering colour when compared to a reference light source. The higher the number, the better a light source is at revealing the actual colours present at a surface or object.
Contrast	The relationship between the luminance of an object and its background. The higher the contrast the more likely it is an object can be seen.
Cowl	Physical light spill control accessory.
Diffuse	Term describing dispersed light distribution referring to the scattering of light.
Efficacy	A measure of light output against energy consumption measured in lumens per watt.
Glare	The sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort, or loss in visual performance and visibility.
Hood	Physical light spill control accessory.
Illuminance	Illuminance is the quantity of light, or luminous flux, falling on a unit area of a surface. It is sometimes designated by the symbol E. The unit is the lux (lx). Luminance refers to the light given off from a source while illuminance refers to the amount of light hitting a surface.
Lamp	Light source.
Light cone	The angle at which the beam falls off to 50% of peak intensity.
Light pollution	The spillage of light into areas where it is not required. Also known as obtrusive light.
Light spill	The light that falls outside the light cone.
Light trespass (nuisance)	Light that impacts on a surface outside of the area designed to be lit by a lighting installation. The correct legal term is nuisance.
Louvres	Physical light spill control accessory.

Lumen	The unit of light power emitted from a light source
Luminaire	Lighting enclosure, lantern, or unit designed to distribute light from a lamp or lamps.
Luminance	The physical measurement of the stimulus that produces the sensation of brightness measured by the luminous intensity reflected in a given direction. The unit is the candela per square metre (cd/m^2). Luminance refers to the light given off from a source while illuminance refers to the amount of light hitting a surface.
Lux (LX)	This is 'illuminance' or the quantity of light (luminous flux), falling on a unit area of a surface in the environment. It is sometimes designated by the symbol E.
Maintenance factor	A correction applied to a lighting calculation to allow for the build-up of dirt on a luminaire and the deprecation of the lumen output of a lamp over time. 1=100% output, 0.9=90% etc.
Optic	The components of a luminaire such as reflectors, refractors, and protectors which make up the directional light control section.
Photocell	A unit which senses light to control luminaires.
Reflector	A device used to reflect light in a given direction.
Refractor	A device used to redirect the light output from a lamp when the light passes through it. It is usually made from prismatic glass or plastic.
Shield	Physical light spill control accessory.
Sky glow	The brightening of the night sky caused by artificial lighting.
Symmetric beams	Lamp mounted in the centre of the reflector.
Voltage	The difference in electrical potential between two points of an electrical circuit.
Watt (W)	The unit for measuring electrical power.
Upward Light Output Ratio ULOR (%)	The proportion of direct light transmitted from the luminaire above 90° in the vertical plane

Chart of example lux levels for reference

Lighting conditions	Lux level	Lighting conditions	Lux level
British summer sunshine	50,000	Typical side road lighting	5
Overcast sky	5,000	Minimum security lighting	2
Well-lit office	500	Twilight	1
Minimum for easy reading	300	Clear full moon	0.25 to <1
Passageway or outside working area	50	Typical moonlight/cloudy sky	0.1
Good main road lighting	5-20	Typical starlight	0.001
Sunset	10	Poor starlight	0.0001

Source: IPCCTV specialists use-IP Ltd

1. Bats

General ecology

Bats are the only true flying mammals. Like us, they are warm-blooded, give birth to live young and produce milk for suckling. In Britain there are 18 species, all of which are small (most weigh less than a £1 coin) and eat insects.

Bats have developed a highly sophisticated echolocation system that allows them to avoid obstacles and catch these insects. When they're flying, bats produce a stream of high-pitched calls and listen to the echoes to produce a sound picture of their surroundings.

Some bats specialise in catching large insects such as beetles or moths but others eat large numbers of very small insects, such as gnats, midges and mosquitoes. Bats gather to feed wherever there are lots of insects, so the best places for them include traditional pasture, woodland, hedgerows, marshes, ponds and slow moving rivers.

During the winter there are relatively few insects available, so bats hibernate. They seek out appropriate sheltered roosts, let their body temperature drop to close to that of their surroundings and slow their heart rate to only a few beats per minute. This greatly reduces their energy requirements so that their food reserves last as long as possible.

During the spring and summer period female bats gather together into maternity colonies for a few weeks to give birth and rear their young (called pups). Usually only one pup is born each year. Bats may gather together from a large area to form these maternity roosts in warm and dry environments, so impacts at the summer breeding site can affect the whole colony of bats from a wide surrounding area.

Both winter and summer roosts have specific conditions that bats require at those times of the year and that is why bats are so faithful to their roosts. They are also an unusually long-lived mammal with a slow reproductive rate for their size, meaning that they return year after year to roosts. If roosts are damaged or disturbed it takes a very long time for a population to recover.

For information on populations see http://www.bats.org.uk

Legal protection of bats

Due to the decline in bat numbers over the last century and the importance of specific roost requirements in their life cycle, all species of bat and their roost sites (whether bats are present at the time or not) are fully protected under international and domestic legislation. The international protection (the EC Habitats Directive) has been transposed into national laws by means of the Conservation of Habitats and Species Regulations 2017 (England and Wales), the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (Scotland) and the Conservation (Natural Habitats, etc) Regulations (Northern Ireland) 1995 (as amended). Commonly the regulations are referred to as the Habitats Regulations. This makes it illegal to kill, injure, capture, or cause disturbance that affects populations of bats, obstruct access to bat roosts, or damage or destroy bat roosts. Individual bats are protected from 'intentional' or 'reckless' disturbance under the Wildlife and Countryside Act 1981 (as amended).

Lighting in the vicinity of a bat roost causing disturbance and potential abandonment of the roost could constitute an offence both to a population and to individuals (Garland and Markham, 2007). It is therefore important that the use of an area by bats is thoroughly assessed before artificial lighting is changed or added in the vicinity of a roost or where bats may commute or forage.

Natural England, Natural Resources Wales, Scottish Natural Heritage or Northern Ireland Environment Agency will need to

see that any impacts have been fully assessed and appropriate mitigation considered within any mitigation licence applications in relation to bats. Similarly these bodies will be statutory consultees in planning applications where impacts on Special Areas of Conservation (SACs), including those designated for bat conservation, are considered possible.

Local authorities also have a duty to ensure impacts upon legally protected species are avoided, and impacts upon bats are a material consideration in any planning permission. Furthermore, local authorities typically have specific planning policies ensuring that impacts upon wildlife, including bats, are avoided within development.

Impacts from artificial lighting

Studies have estimated that in 2016 more than 80% of the world population and more than 99% of the U.S. and European population live under light-polluted skies. Worldwide this is up from 66% in 2001, or an increase of more than 14% (Cinzano et al 2001); 'light-polluted skies' are defined as being about 10% higher than normal night sky brightness levels (Fabio et al 2016).

This means that only about a fifth of England now has 'pristine night skies' – that is skies 'completely free from light pollution' (CPRE 2016). Concerns about the impacts of this have been expressed for a long time, both in reference to human and ecosystem health (Gaston et al 2015).

For bats, artificial lighting is thought to increase the chances of predation, and therefore bats may modify their behaviour to respond to this threat (Speakman et al 1991, Jones et al 1994). Many avian predators will hunt bats which may be one reason why bats avoid flying in the day.

When we refer to artificial lighting we are referring to a number of different characteristics and types (see 'Artificial lighting' section below), all of which have varying impacts. For example, different types of luminaire emit a different spectrum of light. The spectrum of light runs from short wave (ultraviolet) to long wave (infrared), and can vary in intensity (potentially causing glare) and illuminance (measured in lux). Definitions of technical terms can be found in the glossary.

Roosting and commuting

Illuminating a bat roost can cause disturbance (Downs et al 2003) and this may result in the bats deserting the roost or even becoming entombed within it (Packman et al 2015). Light falling on a roost access point will at least delay bats from emerging and this shortens the amount of time available to them for foraging (Boldogh et al 2007). As the main peak of nocturnal insect abundance occurs at and soon after dusk, a delay in emergence means this vital time for feeding is missed. This has been shown to have direct impacts on bats' reproductive ecology, such as slower growth rates and starvation of young (Duverge et al 2000).

In addition, the associated flightpath to and from the access point is just as valuable and vulnerable as the roost itself. Severing a key flightpath some distance from the roost could cause desertion in its own right.

Foraging

In addition to causing disturbance to bats at the roost, artificial lighting can also affect the feeding behaviour of bats. There are two aspects to this. One is the attraction that light from certain types of light sources has to a range of insects; the other is the presence of lit conditions posing a barrier to movement.

Many night-flying species of insect are attracted to light, especially those light sources that emit an ultraviolet component or have a high blue spectral content. This is particularly a problem if it is a single light source in a dark area. As well as moths (Wakefield et al 2015), a range of other insects can be attracted to light such as craneflies, midges and lacewings (Bruce-White et al 2011).

Studies have shown that noctule, Leisler's bat, serotine and pipistrelle bats can congregate around white mercury street lights (Rydell J et al 1993, Blake et al 1994) and white metal halide lamps (Stone et al 2015b) feeding on the insects attracted to the light, but this behaviour is not true for all bat species. The slower-flying broad winged species such as long-eared bats, Myotis species (which include Brandt's bat, whiskered, Daubenton's bat, Natterer's bat and Bechstein's bat), barbastelle, and greater and lesser horseshoe bats generally avoid all street lights (Stone et al 2009, 2012, 2015a). Consequently, bat species less tolerant of light are put at a competitive disadvantage and are less able to forage successfully and efficiently. This can have a significant impact upon fitness and breeding success.

The spectral impacts of light break down further still; when presented with lights with a range of colour types, it has been shown that Plecotus and Myotis species (slow flying) avoided white and green light lit areas, but Pipistrellus species (fast flying) were significantly more abundant feeding at these lights (Spoelstra et al 2015, 2017). However, both groups were equally abundant in the red light areas compared to the dark control, which may provide options for lighting when considering mitigation (see 'Mitigation' section below).

In addition it is thought that insects are attracted to lit areas from beyond the immediately illuminated habitat. This is thought to result in adjacent habitats supporting reduced numbers of insects, a 'vacuum effect'; population declines have been shown further afield, suggesting both direct and indirect impacts at play (Langevelde et al 2018). This is a further impact on the ability of the light-avoiding bats to be able to feed. It is noticeable that most of Britain's rarest bats are among those species listed as avoiding artificial light, so artificial lighting has potentially devastating conservation consequences for these species (Rowse et al 2016).

Drinking

The effects of artificial lighting on drinking resources for bats has been recorded to be stronger than on foraging. White light has been shown to stop slower-flying species drinking at cattle troughs, and even for faster-flying species drinking behaviour was reduced, however foraging behaviour increased as above (Russo et al 2017).

Commuting

When considering how bats move through the landscape, artificial lighting has been shown to be particularly harmful if used along river corridors, near woodland edges and near hedgerows. In mainland Europe, in areas where there are foraging or 'commuting' bats, stretches of road are left unlit or lighting is designed in such a way as to avoid bat colonies being cut off from their foraging grounds.

Studies have shown that continuous lighting in the landscape, such as along roads or waterways, creates barriers which many bat species cannot cross, especially the slower-flying species (Fure, A. 2012), even at very low light levels. Lesser horseshoe bats have been shown to move their flight paths which link their roosts and foraging grounds to avoid artificial light installed on their usual commuting route. Significant impacts have been recorded from as low as 3.6 lux (Stone et al 2012). Furthermore, the average light level on hedgerows most regularly used by this species has been recorded at 0.45 lux (Stone et al 2009).

Even bat species that have been shown to opportunistically forage in lit conditions (see above) have subsequently been recorded being impacted by artificial lighting. In our cities, for example, common pipistrelles – the UK's most numerous species – have been recorded avoiding gaps that are well lit, thereby creating a barrier effect (Hale et al 2015).

Migrating

Green light has been shown to not only impact upon foraging bats (see above) but also bats migrating through Europe.

Nathusius' and soprano pipistrelles have been shown to be attracted to green light from a distance further than their echolocation calls reach, indicating they are attracted to the light rather than insects (Voigt et al 2017). This demonstrates positive light attraction for this species meaning limiting UV is only part of the solution and indicates impacts from artificial light at night that aren't yet fully understood for migrating bats. This is especially true given that the most recent studies in this area suggest that red light also causes positive light responses for both of these bat species when they are migrating over and above warm-white light (Voigt et al 2018).

Summary

In summary, these impacts both alone and in combination are likely to have significant impacts for slower-flying, rarer species, and even for fast-flying species, potentially affecting reproductive, foraging and roosting opportunities. On a population and ecosystem level, impacts may affect the overall genetic pool of bat species and their prey species.

Consequently, if bats are suspected as being present on site ecological advice should be sought – and potentially survey data collected – in advance of any lighting design or fixing of scheme layout.

2. Artificial lighting

Types of lights used in exterior lighting applications

1. **Low-pressure sodium lamps (SOX)** (orange lamps seen along roadsides). Light is emitted predominantly at one wavelength, contains no ultraviolet (UV) light, and has a low attraction to insects. The lamps tend to be large which makes it more difficult to focus the light from these lamps. These are in the gradual process of being removed or replaced, in part due to their poor colour rendition, and will not be available past 2019
2. **High-pressure sodium lamps (SON)** (brighter pinkish-yellow lamps). Commonly used as road lighting. Light is emitted over a moderate band of long wavelengths giving little, if any, UV component, except for the version of the lamp used in horticulture. Insects are attracted to the brighter light. The lamp is of medium size and the light can be more easily directed than low pressure sodium. This lamp is still used for some main road lighting but this is being reduced; these lamps are expected to be phased out in the future.
3. **Mercury lamps (MBF)** (bluish-white lamps). These emit light over a moderate spectrum, including a larger component of UV light to which insects are particularly sensitive. Insects are attracted in large numbers along with high densities of certain tolerant bat species (Rydell & Racey 1993). They ceased to be available in the EU in 2015 and are rare now.
4. **White SON**. This is a reddish white light source. It is based on high-pressure sodium technology and has the same UV component as SON. This source is no longer used and is not available now.
5. **Metal halide.** A small lamp and therefore more easy to focus light and make directional. Emits a small UV content. The light source is available in three forms a) quartz arc tube (HQI); b) ceramic arc tube (CDM-T) and c) CosmoPolis which is the newest of the ceramic forms. Still used by some for some exterior lighting applications.
6. **Light emitting diodes (LEDs)**. This is the light source of choice for most local authorities. The light emitted is more directional and normally controlled by lenses or sometimes reflectors. The light is produced in a narrow beam. It is an instant light source. LED is available in a number of colour temperatures. Older installations tend to use 'cool white' (blueish colour) at >5700° Kelvin. More recently, 4000°K has become more commonly used. 'Warm white' (more yellow/orange colour) at around 3000°K and as low as 2700°K can now be used with little reduction in lumen output. LED typically features no UV component and research indicates that while lower UV components attract fewer invertebrates, warmer colour temperatures with peak wavelengths greater than 550nm (~3000°K) cause less impacts on bats (Stone, 2012, 2015a, 2015b).
7. **Tungsten halogen**. Is not used in new lighting schemes but may be encountered as security light on a private household.
8. **Compact fluorescent.** Mostly in use in residential street lighting. It produces a white light; variants are available with

Light source spectral ranges	
High pressure sodium	~390 to 800 nanometres (nm)
Tungsten Halogen	~400 to 800 nm
Metal Halide	~400 to 800 nm
LEDs	~410 to 750 nm
Compact fluorescent	~410 to 820 nm

UV spectral ranges	
UVA	315 to 400 nanometres (nm)
UVb	280 to 315 nm
UVc	100 to 280 nm

minimal UV output. It can be used at a low wattage and therefore on a low output to achieve low levels of illuminance (measured in lux).

Legal requirements for lighting

It is important to remember that there is no legislation requiring an area or road to be lit.

The building regulations for domestic buildings specify that 150 watts is the maximum for exterior lighting of buildings but this does not apply to private individuals who install their own lighting.

There are a number of British Standards that relate to various components of lighting – BS5489 for road lighting, BS12164 for outdoor workplaces, BS12193 for sports lighting – and there are also guidelines that relate to crime prevention, prevention of vehicular accidents and amenity use.

BS5266-1:2011 relates to the design of emergency lighting and specifies that the minimum lighting level within an escape route from a building is 1 lux. While this represents an increase in lighting, because of the nature and infrequent use of emergency lighting (as most systems are non-maintained – off unless an emergency occurs) this should not pose an issue to bats.

Lighting and the planning system

Many county councils and less often district and borough councils set out standards in local guidance policy documents.

When a developer is assessing the need for lighting it would be beneficial to ask the local authority for their lighting policy document as this should incorporate all of the above. It is likely that local planning authorities will have policies outlining lighting standards for new roads or in public areas. However, local authorities also have a duty to ensure impacts upon legally protected species are avoided.

Roads, cycleways and footpaths to be adopted by a council highway authority may require some form of lighting. Some local authorities may only use columns and may not permit bollard lighting along footpaths or cycleways, or have certain illuminance standards to meet, therefore it is advisable to seek further specific information for your location. In addition to lighting on the application site the ecologist may also need to assess the effects of proposed illumination on habitat beyond the site boundary; for example, along roads and paths where proposed lighting connects to existing street lighting to cover access to the development and beyond. Surveys for lighting and bat activity to cover these areas may be required outside the proposed development's red line boundary.

Consequently, a judgement on the sensitivity of the particular bat feature or habitat on site and the perceived public need for lighting in proximity to it would need to be made. This would be done through collaborative discussion between the project ecologist, lighting professional and local authority (potentially involving one or more of the planning officer, ecology officer, highways officer or council lighting professional). This team can decide whether, where bat features or habitats are particularly important or sensitive, it may be appropriate to avoid, redesign or limit lighting accordingly. Such reasoned compromise decisions between protected species and public lighting, where it is justified to deviate from policy standards, are becoming increasingly accepted by local authorities. In addition, any unavoidable residual lighting may require further mitigation (alternative habitat creation, artificial barriers to lighting etc) over and above that for direct habitat loss. See 'Mitigation' section below for further information.

Domestic lighting needs no planning permission and depends on direct advice on the effects of lighting on bats being given to the householder. Lighting associated with new development or a

listed building does require planning permission.

When dealing with applications for the addition of artificial lighting planning officers or developers should ensure a lighting assessment is done alongside an ecological assessment. Full details on this process can be found in Mitigation section below.

Planning conditions requiring the detail of any domestic amenity and security lighting are regularly applied, as are those relating to the post-development monitoring of light levels against any modelled or baseline levels. This usually includes light trespass through windows in proximity to important bat habitat or roost features.

3. Mitigation of artificial lighting impacts on bats

This section provides a simple process which should be followed where the impact on bats is being considered as part of a proposed lighting scheme. It contains techniques which can be used on all sites, whether a small domestic project or larger mixed-use, commercial or infrastructure development. It also provides best-practice advice for the design of the lighting scheme for both lighting professionals and other users who may be less familiar with the terminology and theory.

The stepwise process and key follow-up actions are outlined in the flowchart overleaf, and are followed throughout the chapter.

The questions within this flow chart should be asked as early as possible, so that necessary bat survey information can be gathered in advance of any lighting design or fixing of overall scheme design.

Effective mitigation of lighting impacts on bats depends on close collaboration from the outset between multiple disciplines within a project. Depending on the specific challenges this will almost certainly involve ecologists working alongside architects and/or engineers; however, lighting professionals and landscape architects should be approached when recommended by your ecologist. This should be done as early in your project as possible in order to ensure mitigation is as effective as it can be and to minimise delays and unforeseen costs.

Step 1: Determine whether bats could be present on site

If your site has the potential to support bats or you are at all unsure, it is highly recommended that an ecologist is appointed to advise further and conduct surveys, if necessary. This information should be collected as early as possible in the design process, and certainly before lighting is designed, so as to avoid the need for costly revisions.

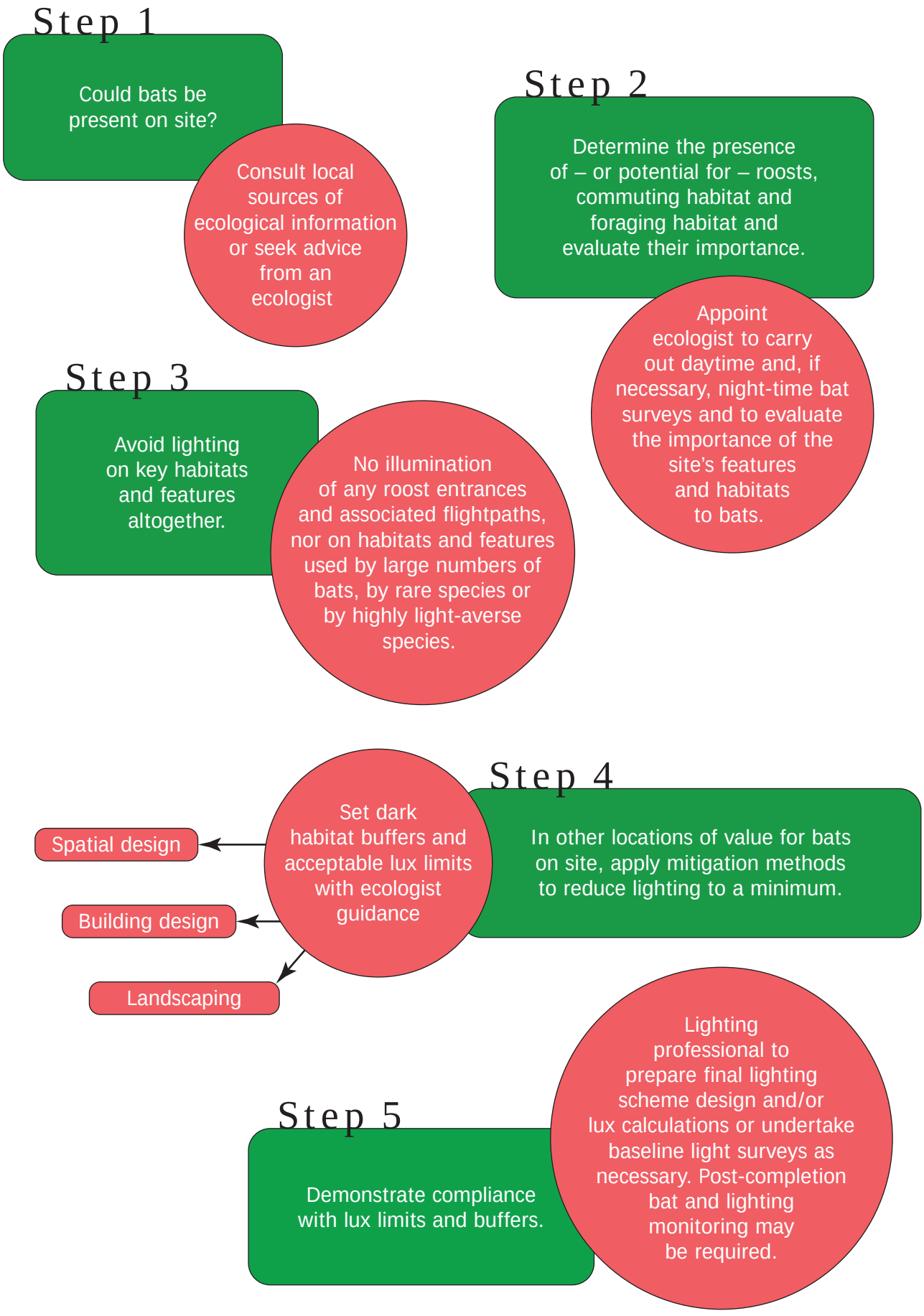
If any of the following habitats occur on site, and are adjacent to or connected with any of these habitats on or off site, it is possible that newly proposed lighting may impact local bat populations:

- Woodland or mature trees
- Hedgerows and scrub
- Ponds and lakes
- Ditches, streams, canals and rivers
- Infrequently managed grassland
- Buildings – pre 1970s or in disrepair

If you are unsure about whether bats may be impacted by your project, and an ecologist has not yet been consulted, sources of information on the presence of bats within the vicinity of your site include the following.

- Local environmental records centres (LERC) – Will provide third-party records of protected and notable species for a fee. Search http://www.alerc.org.uk/ for more information.
- National Biodiversity Network Atlas – Provides a resource of third-party ecological records searchable online at https://nbnatlas.org. Typically this is less complete than LERC data. Please note: Some datasets are only accessible on a non-commercial basis, while most can be used for any purpose, as long as the original source is credited.
- Local authority planning portals – Most local planning authorities have a searchable online facility detailing recent planning applications. These may have been accompanied by ecological survey reports containing information on bat roosts and habitats.
- Defra's MAGIC map – Provides an online searchable GIS database including details of recent European protected species licences and details of any protected sites designated for bat conservation.

The professional directory at the website of the Chartered Institute of Ecology and Environmental Management (www.cieem.net) will provide details of ecologists in your area with the relevant


Step 1
Could bats be present on site?
Consult local sources of ecological information or seek advice from an ecologist
Step 2
Determine the presence of – or potential for – roosts, commuting habitat and foraging habitat and evaluate their importance.
Appoint ecologist to carry out daytime and, if necessary, night-time bat surveys and to evaluate the importance of the site's features and habitats to bats.
Step 3
Avoid lighting on key habitats and features altogether.
No illumination of any roost entrances and associated flightpaths, nor on habitats and features used by large numbers of bats, by rare species or by highly light-averse species.
Step 4
Set dark habitat buffers and acceptable lux limits with ecologist guidance
Spatial design
Building design
Landscaping
In other locations of value for bats on site, apply mitigation methods to reduce lighting to a minimum.
Step 5
Demonstrate compliance with lux limits and buffers.
Lighting professional to prepare final lighting scheme design and/or lux calculations or undertake baseline light surveys as necessary. Post-completion bat and lighting monitoring may be required.

skills/experience. The early involvement of a professional ecologist can minimise the likelihood of delays at the planning stage (if applicable) and ensure your project is compliant with conservation and planning legislation and policy.

It should be noted that the measures discussed in this document relate only to the specific impacts of lighting upon bat habitat features on or adjacent to the site. If loss or damage to roosting, foraging or commuting habitat is likely to be caused by other aspects of the development, separate ecological advice will be necessary in order to avoid, mitigate or compensate for this legally and according to the ecologist's evaluation.

Step 2: Determine the presence of – or potential for – roosts, commuting habitat and foraging habitat and evaluate their importance

Your ecologist will visit the site in order to record the habitats and features present and evaluate their potential importance to bats, and the likelihood that bats could be affected by lighting both on and immediately off site. This may also include daytime building and tree inspections. On the basis of these inspections further evening surveys may be recommended, either to determine the presence of roosts within buildings and/or trees or to assess the use of the habitats by bats by means of a walked survey. Such surveys may be undertaken at different times during the active season (ideally May to September) and should also involve the use of automated bat detectors left on site for a period of several days. The surveys should be carried out observing the recommendations within the Bat Conservation Trust's Bat Surveys for Professional Ecologists: Good Practice Guidelines (Collins, 2016).

The resulting report will detail the relative conservation importance of each habitat feature to bats (including built structures, if suitable). The ecologist's evaluation of the individual features will depend on the specific combination of contributing factors about the site, including:

- The conservation status of species recorded or likely to be present
- Geographic location
- Type of bat activity likely (breeding, hibernating, night roosting, foraging etc)
- Habitat quality
- Habitat connectivity off-site
- The presence of nearby bat populations or protected sites for bats (usually identified in a desk study)

The evaluation of ecological importance for each feature is most commonly expressed on a geographic scale from Site level to International level, or alternatively in terms of that feature's role in maintaining the 'favourable conservation status' of the population of bats using it.

The ecologist should set out where any key bat roost features and/or habitat areas (ie flightpath habitat and broader areas of foraging habitat) lie on a plan of the site or as an ecological constraints and opportunities plan (ECOP) together with their relative importance. The ECOP and report can then be used to help guide the design of the lighting strategy as well as the wider project.

Step 3: Avoid lighting on key habitats and features altogether

As has been described in 'Artificial lighting', above, there is no legal duty requiring any place to be lit. British Standards and other policy documents allow for deviation from their own guidance where there are significant ecological/environmental reasons for doing so. It is acknowledged that in certain situations lighting is critical in maintaining safety, such as some industrial sites with 24-hour operation. However in the public realm, while lighting can increase the perception of safety and security, measureable benefits can be subjective. Consequently, lighting design should be flexible and be able to fully take into account the presence of protected species

and the obligation to avoid impacts on them.

Sources of lighting which can disturb bats are not limited to roadside or external security lighting, but can also include light spill via windows, permanent but sporadically operated lighting such as sports floodlighting, and in some cases car headlights. Additionally, glare (extremely high contrast between a source of light and the surrounding darkness – linked to the intensity of a luminaire) may affect bats over a greater distance than the target area directly illuminated by a luminaire and must also be considered on your site.

It is important that a competent lighting professional is involved in the design of proposals as soon as potential impacts (including from glare) are identified by the ecologist in order to avoid planning difficulties or late-stage design revision. Your lighting professional will be able to make recommendations about placement of luminaires tailored to your specific project.

Where highways lighting schemes are to be designed by the local planning authority (LPA) post-planning, an ecology officer should be consulted on the presence of important bat constraints which may impact the design and illuminance in order for the scheme to remain legally compliant with wildlife legislation.

Where adverse impacts upon the 'favourable conservation status' of the bat population using the feature or habitat would be significant, an absence of artificial illumination and glare, acting upon both the feature and an appropriately-sized buffer zone is likely to be the only acceptable solution. Your ecologist will be best placed to set the size of such a buffer zone but it should be sufficient to ensure that illumination and glare is avoided and so the input of a lighting professional may be required. Further information on demonstrating an absence of illumination via lux/illuminance contour plans is provided in Step 5.

Because different species vary in their response to light disturbance (as discussed in section 1 'Bats'), your ecologist will be able to provide advice tailored to the specific conditions on your project, however examples of where the no-lighting approach should be taken in particular include:

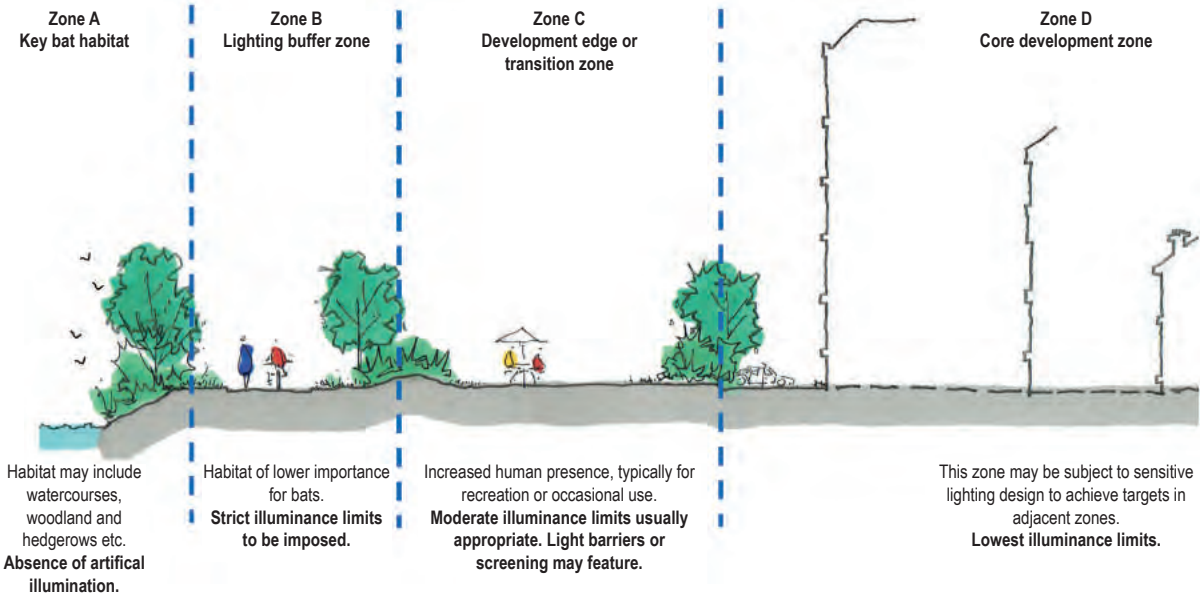
- Roosting and swarming sites for all species and their associated flightpath/commuting habitat.
- Foraging or commuting habitat for highly light-averse species (greater and lesser horseshoe bats, some Myotis bats, barbastelle bats and all long-eared bats).
- Foraging or commuting habitat used by large numbers of bats as assessed through survey.
- Foraging or commuting habitat for particularly rare species (grey long-eared bat, barbastelle, small Myotis, Bechstein's bat and horseshoe bats).
- Any habitat otherwise assessed by your ecologist as being of importance to maintaining the 'favourable conservation status' of the bat population using it.

Completely avoiding any lighting conflicts in the first place is advantageous because not only would proposals be automatically compliant with the relevant wildlife legislation and planning policy, but they could avoid costly and time-consuming additional surveys, mitigation and post-development monitoring. Furthermore, local planning authorities are likely to favour applications where steps have been taken to avoid such conflicts.

Step 4: Apply mitigation methods to reduce lighting to agreed limits in other sensitive locations – lighting design considerations

Where bat habitats and features are considered to be of lower importance or sensitivity to illumination, the need to provide lighting may outweigh the needs of bats. Consequently, a balance between a reduced lighting level appropriate to the

Example of illuminance limit zonation



ecological importance of each feature and species, and the lighting objectives for that area will need to be achieved.

It is important to reiterate the legal protection from disturbance that bats receive under the Wildlife and Countryside Act 1981, as amended. Where the risk of offences originating from lighting is sufficiently high, it may be best to apply the avoidance approach in Step 3.

Advice from an ecologist and lighting professional will be essential in finding the right approach for your site according to their evaluation. The following are techniques which have been successfully used on projects and are often used in combination for best results.

Dark buffers, illuminance limits and zonation

Dark buffer zones can be used as a good way to separate habitats or features from lighting by forming a dark perimeter around them. Buffer zones rely on ensuring light levels (levels of illuminance measured in lux) within a certain distance of a feature do not exceed certain defined limits. The buffer zone can be further subdivided in to zones of increasing illuminance limit radiating away from the feature. Examples of this application are given in the figure above.

Your ecologist (in collaboration with a lighting professional) can help determine the most appropriate buffer widths and illuminance limits according to the value of that habitat to bats (as informed by species and numbers of bats, as well as the type of use).

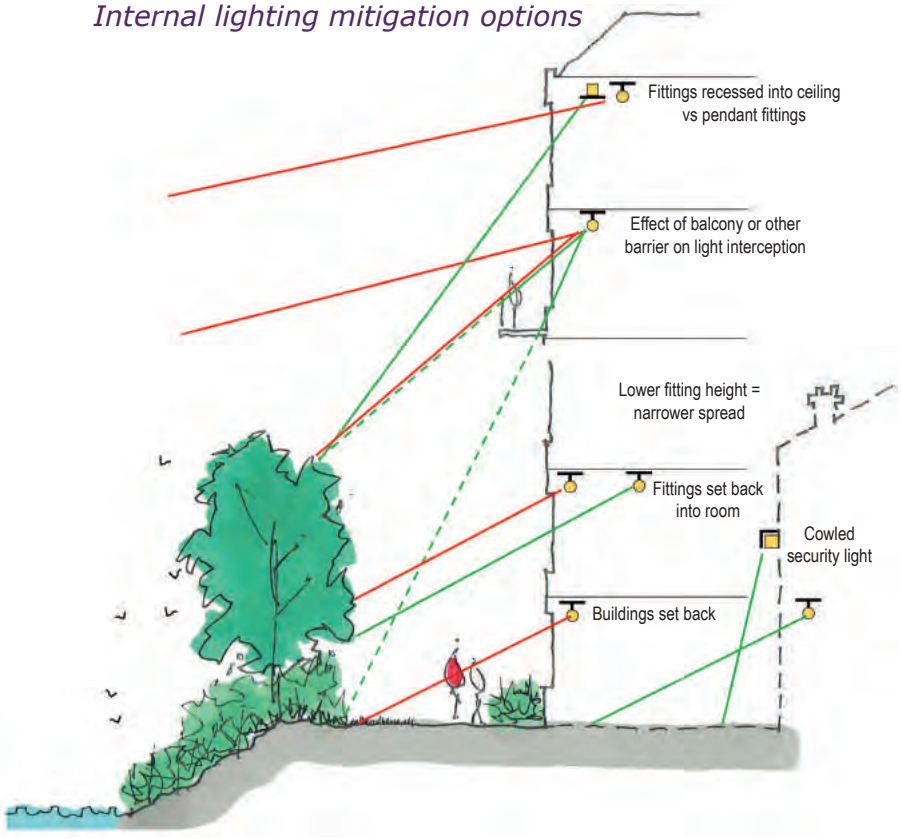
Appropriate luminaire specifications

Luminaires come in a myriad of different styles, applications and specifications which a lighting professional can help to select. The following should be considered when choosing luminaires.

- All luminaires should lack UV elements when manufactured. Metal halide, fluorescent sources should not be used.
- LED luminaires should be used where possible due to their sharp cut-off, lower intensity, good colour rendition and dimming capability.
- A warm white spectrum (ideally <2700Kelvin) should be adopted to reduce blue light component.
- Luminaires should feature peak wavelengths higher than 550nm to avoid the component of light most disturbing to bats (Stone, 2012).
- Internal luminaires can be recessed where installed in proximity to windows to reduce glare and light spill. (See figure overleaf.)
- The use of specialist bollard or low-level downward directional luminaires to

retain darkness above can be considered. However, this often comes at a cost of unacceptable glare, poor illumination efficiency, a high upward light component and poor facial recognition, and their use should only be as directed by the lighting professional.
- Column heights should be carefully considered to minimise light spill.
- Only luminaires with an upward light ratio of 0% and with good optical control should be used – See ILP Guidance for the Reduction of Obtrusive Light.
- Luminaires should always be mounted on the horizontal, ie no upward tilt.
- Any external security lighting should be set on motion-sensors and short (1min) timers.
- As a last resort, accessories such as baffles, hoods or louvres can be used to reduce light spill and direct it only to where it is needed.

Internal lighting mitigation options



Sensitive site configuration

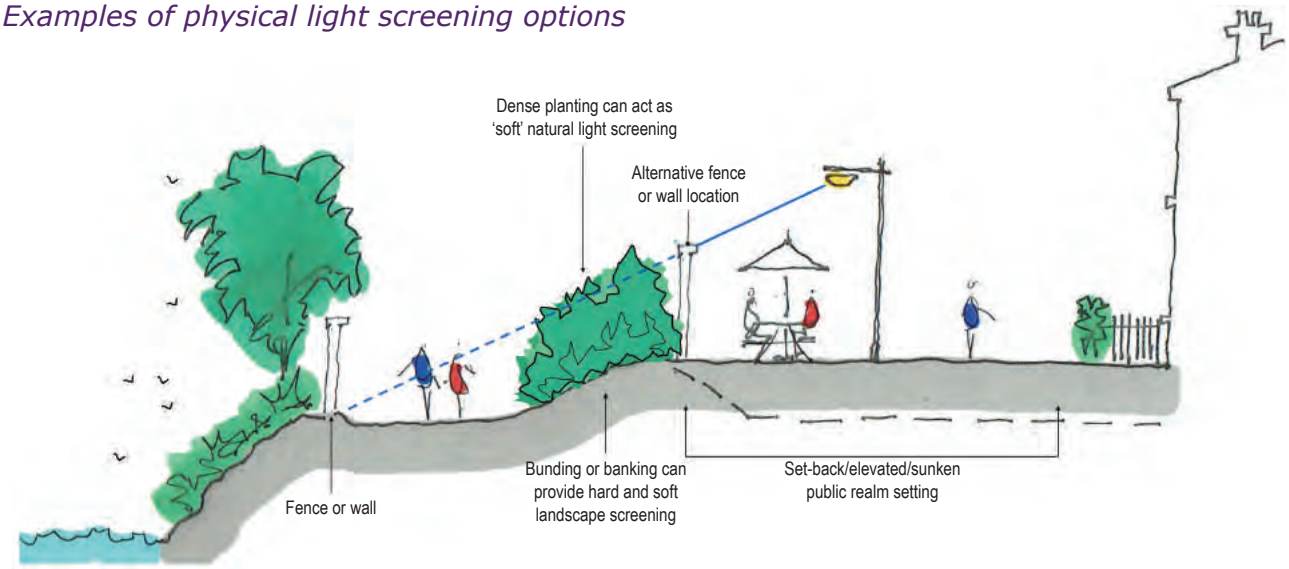
The location, orientation and height of newly built structures and hard standing can have a considerable impact on light spill (see figure above for examples of good internal lighting design). Small changes in terms of the placement of footpaths, open space and the number and size of windows can all achieve a good outcome in terms of minimising light spill on to key habitats and features.
- It may be possible to include key habitats and features into unlit public open space such as parks and gardens.
- Buildings, walls and hard landscaping may be sited and designed so as to block light spill from reaching habitats and features.
- Taller buildings may be best located toward the centre of the site or sufficiently set back from key habitats to minimise light spill.
- Street lights can be located so that the rear shields are adjacent to habitats or optics selected that stop back light thereby directing light into the task area where needed.

Screening

Light spill can be successfully screened through soft landscaping and the installation of walls, fences and bunding (see figure overleaf for example of physical light-screening options). In order to ensure that fencing makes a long-term contribution, it is recommended that it is supported on concrete or metal posts. Fencing can also be over planted with hedgerow species or climbing plants to soften its appearance and provide a vegetated feature which bats can use for navigation or foraging.

The planting of substantial landscape features integrated to the wider network of green corridors such as hedgerows, woodland and scrub is encouraged by

Examples of physical light screening options



planning policy and would make a long-term positive contribution to the overall bat habitat connectivity and light attenuation. A landscape architect can be appointed to collaborate with your ecologist on maximising these natural light screening opportunities.

It should be noted that newly planted vegetation (trees, shrubs and scrub) is unlikely to adequately contribute to light attenuation on key habitats for a number of years until it is well established. Sufficient maintenance to achieve this is also likely to be required. Consequently, this approach is best suited to the planting of 'instant hedgerows' or other similarly dense or mature planting, including translocated vegetation. In some cases, it is appropriate to install temporary fencing or other barrier to provide the desired physical screening effects until the vegetation is determined to be sufficiently established.

Given the fact that planting may be removed, die back, or be inadequately replaced over time it should never be relied on as the sole means of attenuating light spill.

Glazing treatments

Glazing should be restricted or redesigned wherever the ecologist and lighting professional determine there is a likely significant effect upon key bat habitat and features. Where windows and glass facades etc cannot be avoided, low transmission glazing treatments may be a suitable option in achieving reduced illuminance targets.

Products available include retrofit window films and factory-tinted glazing. 'Smart glass', which can be set to automatically obscure on a timer during the hours of darkness, and automatic blinds can also be used but their longevity depends on regular maintenance and successful routine operation by the occupant, and should not be solely relied upon.

Depending on the height of the building and windows, and therefore predicted light spill, such glazing treatments may not be required on all storeys. This effect can be more accurately determined by a lighting professional.

Creation of alternative valuable bat habitat on site

The provision of new, additional or alternative bat flightpaths, commuting habitat or foraging habitat could result in appropriate compensation for any such habitat being lost to the development. Your ecologist will be able to suggest and design such alternative habitats although particular consideration as to its connectivity to other features, the species to be used, the lag time required for a habitat to sufficiently establish, and the provision for its ongoing protection and maintenance should be given.

Dimming and part-night lighting

Depending on the pattern of bat activity across the key features identified on site by your ecologist, it may be appropriate for an element of on-site lighting to be controlled either diurnally, seasonally or according to human activity. A control management system can be used to dim (typically to 25% or less) or turn off groups of lights when not in use.

It should be noted that these systems depend on regular maintenance and a long-term commitment for them to be successful. Additionally, part-night lighting should be designed with input from an ecologist as they may still produce unacceptably high light levels when active or dimmed. Part-night lighting is not usually appropriate where lights are undimmed during key bat activity times as derived from bat survey data. Research has indicated that impacts upon commuting bats are still prevalent where lighting is dimmed during the middle of the night at a time when illumination for human use is less necessary (Azam et al, 2015). Thus this approach should not always be seen as a solution unless backed up by robust ecological survey and assessment of nightly bat activity.

Step 5: Demonstrate compliance with illuminance limits and buffers

Design and pre-planning phase

It may be necessary to demonstrate that the proposed lighting will comply with any agreed light-limitation or screening measures set as a result of your ecologist's recommendations and evaluation. This is especially likely to be requested if planning permission is required.

A horizontal illuminance contour plan can be prepared by a suitably experienced and competent lighting professional (member of the Chartered Institution of Building Services Engineers (CIBSE), Society of Light and Lighting (SLL), Institution of Lighting Professionals (ILP) or similar to ensure competency) using an appropriate software package to model the extent of light spill from the proposed and, possibly, existing luminaires. The various buffer zone widths and illuminance limits which may have been agreed can then be overlaid to determine if any further mitigation is necessary. In some circumstances, a vertical illuminance contour plot may be necessary to demonstrate the light in sensitive areas such as entrances to roosts.

Such calculations and documentation would need to be prepared in advance of submission for planning permission to enable the LPA ecologist to fully assess impacts and compliance.

Because illuminance contour plots and plans may need to be understood and examined by non-lighting professionals such as architects and local planning authority ecologists, the following should be observed when producing or assessing illuminance contour plans to ensure the correct information is displayed.

- A horizontal calculation plane representing ground level should always be used.
- Vertical calculation planes should be used wherever appropriate, for example along the site-facing aspects of a hedgerow or façade of buildings containing roosts to show the illumination directly upon the vertical faces of the feature. Vertical planes can also show a cross-sectional view within open space. Vertical planes will enable a visualisation of the effects of illumination at the various heights at which different bat species fly.
- Models should include light from all luminaires and each should be set to the maximum output anticipated to be used in normal operation on site (ie no dimming where dimming is not anticipated during normal operation).
- A calculation showing output of luminaires to be expected at 'day 1' of operation should be included, where the luminaire and/or scheme Maintenance Factor is set to zero.

- Where dimming, PIR or variable illuminance states are to be used, an individual set of calculation results should accompany each of these states.
- The contours (and/or coloured numbers) for 0.2, 0.5, 1, 5, and 10 lux must be clearly shown as well as appropriate contours for values above these.
- Each contour plan should be accompanied by a table showing their minimum and maximum lux values.
- Where buildings are proposed in proximity to key features or habitats, plots should also model the contribution of light spill through nearby windows, making assumptions as to internal luminaire specification and transmissivity of windows. It should be assumed that blinds or curtains are absent or fully open although low-transmittance glazing treatments may be appropriate. Assumptions will need to be made as to the internal luminaire specification and levels of illuminance likely to occur on 'day 1' of operation. These assumptions should be clearly stated and guided by the building/room type and discussions between architect, client and lighting professional. It is acknowledged that in many circumstances, only a 'best effort' can be made in terms of accuracy of these calculations.
- Modelled plots should not include any light attenuation factor from new or existing planting due to the lag time between planting and establishment and the risk of damage, removal or failure of vegetation. This may result in difficulties in the long term achievement of the screening effect and hamper any post-construction compliance surveys.
- The illuminance contour plots should be accompanied by an explanatory note from the lighting professional to list where, in their opinion, sources of glare acting upon the key habitats and features may occur and what has been done/can be done to reduce their impacts.

N.B. It is acknowledged that, especially for vertical calculation planes, very low levels of light (<0.5 lux) may occur even at considerable distances from the source if there is little intervening attenuation. It is therefore very difficult to demonstrate 'complete darkness' or a 'complete absence of illumination' on vertical planes where some form of lighting is proposed on site despite efforts to reduce them as far as possible and where horizontal plane illuminance levels are zero. Consequently, where 'complete darkness' on a feature or buffer is required, it may be appropriate to consider this to be where illuminance is below 0.2 lux on the horizontal plane and below 0.4 lux on the vertical plane. These figures are still lower than what may be expected on a moonlit night and are in line with research findings for the illuminance found at hedgerows used by lesser horseshoe bats, a species well known for its light averse behaviour (Stone, 2012).

Baseline and post-completion light monitoring surveys

Baseline, pre-development lighting surveys may be useful where existing on- or off-site lighting is suspected to be acting on key habitats and features and so may prevent the agreed or modelled illuminance limits being achieved. This data can then be used to help isolate which luminaires might need to be removed, where screening should be implemented or establish a new illuminance limit reduced below existing levels. For example, where baseline surveys establish that on- and off-site lighting illuminates potential key habitat, improvements could be made by installing a tall perimeter fence adjacent to the habitat and alterations to the siting and specification of new lighting to avoid further illumination. Further information and techniques to deal with modeling pre-development lighting can be found in ILP publication PLG04 *Lighting Impact Assessments* due to be published late 2018.

Baseline lighting surveys must be carried out by a suitably qualified competent person. As a minimum, readings should be

taken at ground level on the horizontal plane (to give illuminance hitting the ground), and in at least one direction on the vertical plane at, for example, 1.5m or 2m above ground (to replicate the likely location of bats using the feature or site). The orientation should be perpendicular to the dominant light sources or perpendicular to the surface/edge of the feature in question (such as a wall or hedgerow) in order to produce a 'worst case' reading. Further measurements at other orientations may prove beneficial in capturing influence of all luminaires in proximity to the feature or principal directions of flight used by bats. This should be discussed with the ecologist.

Baseline measurements should be taken systematically across the site or features in question. That is, they will need to be repeated at intervals to sample across the site or feature, either in a grid or linear transect as appropriate. The lighting professional will be able to recommend the most appropriate grid spacing.

Measurements should always be taken in the absence of moonlight, either on nights of a new moon or heavy cloud to avoid artificially raising the baseline. As an alternative, moonlight can be measured at a place where no artificial light is likely to affect the reading.

As all proposed illuminance level contours will be produced from modelled luminaires at 100% output, baseline measurements need to be taken with all lights on and undimmed, with blinds or screens over windows removed. Cowls and other fittings on luminaires can remain in place.

Where possible, measurements should be taken during the spring and summer when vegetation is mostly in leaf, in order to accurately represent the baseline during the principal active season for bats and to avoid artificially raising the baseline.

The topography of the immediate surrounding landscape should be considered in order to determine the potential for increased or decreased light spill beyond the site.

Post-construction/operational phase compliance-checking

Post-completion lighting surveys are often required where planning permission has been obtained on the condition that the proposed lighting levels are checked to confirm they are in fact achieved on site and that the lighting specification (including luminaire heights, design and presence of shielding etc) is as proposed.

All lighting surveys should be conducted by a suitably qualified competent person and should be conducted using the same measurement criteria and lighting states used in the preparation of the illuminance contour plots and/or baseline surveys as discussed above. It may be necessary to conduct multiple repeats over different illumination states or other conditions specific to the project.

Results should always be reported to the LPA as per any such planning condition. A report should be prepared in order to provide an assessment of compliance by the lighting professional and a discussion of any remedial measures which are likely to be required in order to achieve compliance. Any limitations or notable conditions such as deviation from the desired lighting state or use of blinds/barriers should be clearly reported. Ongoing monitoring schedules can also be set, especially where compliance is contingent on automated lighting and dimming systems or on physical screening solutions.

4. References

Azam, C., Kerbiriou, C., Vernet, A., Julien, J.F., Bas, Y., Plichard, L., Maratrat, J., Le Viol, I. (2015). Is part-night lighting an effective measure to limit the impacts of artificial lighting on bats? Global Change Biology 21:4333–4341.

Bat Conservation Trust. (2009). Bats and lighting in the UK- bats and the built environment series www.bats.org.uk

Blake, D., Hutson, A.M., Racey, P.A., Rydell, J., Speakman, J.R. (1994). Use of lamplit roads by foraging bats in southern England. J. Zool. 234, 453–462.

Bruce-White, C. and Shardlow, M. (2011). A Review of the Impact of Artificial Light on Invertebrates. Buglife.

Boldogh, S., D. Dobrosi & P. Samu 2007. The effects of the illumination of buildings on house-dwelling bats and its conservation consequences. Acta Chiropterologica 9, 527–534.

Campaign to Protect Rural England. (2016). Night Blight: Mapping England's light pollution and dark skies.

Cinzano, P., Falchi, F. and Elvidge, C. D. (2001). The first World Atlas of the artificial night sky brightness. Monthly notices of the Royal astronomical society. 328, pp. 689-707.

Downs, N. C. et al (2003) The effects of illuminating the roost entrance on the emergence behaviour of Pipistrellus pygmaeus. Biological Conservation 111, 247-252

Duvergé, P. L., G. Jones, J. Rydell & R. D. Ransome (2000). The functional significance of emergence timing in bats. Ecography 23, 32-40.

Fabio Falchi, Pierantonio Cinzano, Dan Duriscoe, Christopher C. M. Kyba, Christopher D. Elvidge, Kimberly Baugh, Boris A. Portnov, Nataliya A. Rybnikova and Riccardo Furgoni. (2016). The new world atlas of artificial night sky brightness. Sci. Adv. 2016; 2 : e1600377

Fure, A (2012) Bats and Lighting – six years on. The London Naturalist No. 85

Garland L & Markham, S. (2007) Is important bat foraging and commuting habitat legally protected? (self published)

Gaston KJ, Visser ME, Hölker F. (2015) The biological impacts of artificial light at night: the research challenge. Philosophical Transactions of the Royal Society B: Biological Sciences. 2015;370(1667):20140133. doi:10.1098/rstb.2014.0133.

Institution of Lighting Engineers (2011) Guidance Notes for the Reduction of Obstructive Light

James D. Hale, Alison J. Fairbrass, Thomas J. Matthews, Gemma Davies, Jon P. Sadler. (2015) The ecological impact of city lighting scenarios: exploring gap crossing thresholds for urban bats. Global Change Biology, 2015; DOI: 10.1111/gcb.12884

Jones, G., Rydell, J. (1994). Foraging strategy and predation risk as factors influencing emergence time in echolocating bats. Philos. T. R. Soc. B. 346, 445–455.

Frank van Langevelde, Marijke Braamburg-Annegarn, Martinus E. Huigens, Rob Groendijk, Olivier Poitevin, Jurriën R. van Deijk, Willem N. Ellis, Roy H.A. van Grunsven, Rob de Vos, Rutger A. Vos, Markus Franzén and Michiel F. WallisDeVries (2017) Declines in moth populations stress the need for conserving dark nights. Global Change Biology DOI: 10.1111/gcb.14008

Mitchell-Jones, A. J. (2004) Bat Mitigation Guidelines. English Nature

Packman, C., Zeale, M., Harris, S. & Jones, G. (2015). Management of bats in churches – a pilot. English Heritage Research Project: 6199.

Rich, C., Longcore, T. (2006). Ecological consequences of artificial night lighting. Washington, DC, USA. Island Press.

Rowse, E. G., D. Lewanzik, E. L. Stone, S. Harris, and G. Jones (2016). Dark Matters : The Effects of Artificial Lighting on Bats. In: Bats in the Anthropocene: conservation of bats in a changing world (C. C. Voigt and T. Kingston, Eds.).

Russo, D., Cistrone, L., Libralato, N., Korine, C., Jones, G. and Ancillotto, L. (2017), Adverse effects of artificial illumination on bat drinking activity. Anim Conserv. doi:10.1111/acv.12340

Rydell J & Racey, P A (1993) Street lamps and the feeding ecology of insectivorous bats. Recent Advances in Bat Biology Zool Soc Lond Symposium abstracts.

Speakman, J. R. (1991). Why do insectivorous bats in Britain not fly in daylight more frequently? Funct. Ecol. 5, 518-524.

Spoelstra, K., van Grunsven, R.H.A., Donners, M., et al (2015). Experimental illumination of natural habitat—an experimental set-up to assess the direct and indirect ecological consequences of artificial light of different spectral composition. Philos. T. R. Soc. B. 370, 20140129. http://dx.doi.org/10.1098/rstb.2014.0129.

Spoelstra K, van Grunsven RHA, Ramakers JJC, Ferguson KB, Raap T, Donners M, Veenendaal M, Visser ME. (2017) Response of bats to light with different spectra: light-shy and agile bat presence is affected by white and green, but not red light. Proc. R. Soc. B 284: 20170075. http://dx.doi.org/10.1098/rspb.2017.0075

Stone, E.L., Jones, G., Harris, S. (2009). Street lighting disturbs commuting bats. Curr. Biol. 19, 1123–1127.

Stone, E.L., Jones, G., Harris, S. (2012). Conserving energy at a cost to biodiversity? Impacts of LED lighting on bats. Glob. Change Biol. 18, 2458–2465.

Stone, E.L., Harris, S., Jones, G. (2015a). Impacts of artificial lighting on bats: A review of challenges and solutions. Mammal. Biol. 80, 213-219.

Stone, E.L., Wakefield, A., Harris, S., Jones, G. (2015b). The impacts of new street light technologies: experimentally testing the effects on bats of changing from low-pressure sodium to white metal halide. Philos. T. R. Soc. B. 370, 20140127.

Voigt CC, Roeleke M, Marggraf L, Pētersons G, Voigt-Heucke SL (2017) Migratory bats respond to artificial green light with positive phototaxis. PLoS ONE 12(5): e0177748.

Voigt CC, Rehnig K, Lindecke O, Pētersons G. (2018) Migratory bats are attracted by red light but not by warm-white light: Implications for the protection of nocturnal migrants. Ecology and Evolution.

Wakefield, A., Stone, E.L., Jones, G., Harris, S. (2015). Light-emitting diode street lights reduce last-ditch evasive manoeuvres by moths to bat echolocation calls. R. Soc. Open Sci. 2, 150291. http://dx.doi.org/10.1098/rsos.150291.