

M. DELACEY & SONS (HOLDINGS) LIMITED

YR HEN LAETHDY, ABERFAN

PRELIMINARY ECOLOGICAL APPRAISAL

JANUARY 2023



soltysbrewster
E C O L O G Y

4 Stangate House,
Stanwell Road,
Penarth,
Vale of Glamorgan,
United Kingdom.
CF64 2AA

Telephone:- 033 00 13 00 12
e-mail:- enquiry@soltysbrewster.co.uk
Web Site:- www.soltysbrewster.com

M. DELACEY & SONS (HOLDINGS) LIMITED

YR HEN LAETHDY, ABERFAN

PRELIMINARY ECOLOGICAL APPRAISAL

DOCUMENT REF: E22108301/DOC 01 – 23 JANUARY 2023

Issue	Revision	Stage	Date	Prepared by	Approved by	Signed
1	-	Draft for review	28 February 2022	Daniel Jones (Senior Ecologist)	Dr M Watts (Director)	
2	Text changes following updated site layout plan	For submission	11 July 2022	Daniel Jones (Senior Ecologist)		
3	Minor text revisions to sections 5.9 and 5.10. Updated site layout plan.	For submission	23 January 2023	Daniel Jones (Senior Ecologist)		

CONTENTS

Summary

1.0 Introduction

2.0 Methodology

Desk study

Extended Phase 1 Habitat Survey

Survey Limitations

3.0 Results

Desk study

Extended Phase 1 Habitat Survey

Fauna

4.0 Policies and Plans

5.0 Conclusions and Recommendations

References

Appendices

Appendix I Proposed Site Layout

Appendix II SEWBRc Desk Study Records

Appendix III Extended Phase 1 Habitat Survey Plan & Target Notes

Appendix IV Bats and Artificial Lighting in the UK Guidance Note

Appendix V Reptile Hibernacula Design

SUMMARY

Soltys Brewster Ecology (SBE) were commissioned by M. Delacey & Sons (Holdings) Limited to undertake a preliminary appraisal of an area of land at Yr Hen Laethdy (Kinsley Terrace) in Aberfan, Merthyr Tydfil. The site is proposed for the development of 14no. residential units. The site has received prior planning permission for the development of up to 8no. dwellings and attached garages. A new planning application is required for the change in site layout. An updated desk study and Extended Phase 1 Habitat Survey was undertaken at the application site in February 2022 to identify any ecological constraints or opportunities associated with the proposal.

Desk based consultation confirmed that the application site does not hold any designation for nature conservation. The southern section of Aberfan West Site of Importance for Nature Conservation (SINC) is located approx. 65m west of the site. However, given the small extent of the proposals and residential development separating the sites, no significant impacts to the qualifying features of the SINC are considered likely.

The desk study returned a list of records for protected fauna and flora within 1km of the application site. This included multiple records of foraging/commuting bats within the surrounding area as well as records of protected and priority listed bird species, hedgehog and common amphibians and reptiles within the 1km search buffer.

An Extended Phase 1 Habitat survey undertaken in February 2022 identified a limited range of habitats present at the application site including poor semi-improved grassland, dense/continuous scrub, scattered broad-leaved trees, running water and bare ground. The habitats at the site were considered likely to support locally foraging/commuting bat species, nesting birds and, to a lesser extent, common reptiles.

The proposed development design indicates that a 3m wooded/scrub buffer will be maintained along the eastern boundary. In addition, the design of site lighting should aim to reduce artificial light spill onto this boundary to further minimise impacts to habitat connectivity for foraging and commuting bats. Vegetation removal (i.e., tree and scrub removal) will be subject to seasonal constraints and should be undertaken via a directional two-staged process to minimise risks to nesting birds and reptiles that may be present. Other mitigation measures include the appropriate treatment /removal of invasive plant species and pollution prevention measures to minimise surface water run-off into the adjacent watercourse.

Other mitigation and enhancement design measures at the application site include the inclusion of bat and bird boxes onto new units (2no. bat boxes, 2no. bird boxes), the use of native species or those with a known biodiversity benefit within the soft landscape plan, creation of a reptile hibernaculum and the design of any external fences to include a 130x130mm gap to allowed continued connectivity for Hedgehog and other small mammals throughout the development.

1.0 INTRODUCTION

- 1.1 Soltys Brewster Ecology (SBE) were commissioned by M. Delacey & Sons (Holdings) Limited to undertake an ecological appraisal of an area of land at Yr Hen Laethdy, Aberfan. The site is proposed for the development of 8no. residential units (proposed layout plan included in Appendix I). To inform a planning application a survey to establish the ecological baseline conditions and identify any ecological constraints or opportunities associated with the proposal is required.
- 1.2 The application site, approx. 0.25ha in size, is located to the east of Yr Hen Laethdy (Kingsley Terrace) road in Aberfan, Merthyr Tydfil. The site is allocated for housing as part of the current Merthyr Tydfil County Borough Council Local Development Plan (Policy: SW3-31) and has received prior planning permission. Planning for the development of up to 8no. dwellings and attached garages was approved in January 2018 (Planning Ref: P/17/0245), with the subsequent discharge of planning condition 4 (ecological buffer zone) approved in February 2019 (Planning Ref: P/18/0400). A new planning application is required for the change in site layout.
- 1.3 Previous ecological survey work was undertaken at the application site in 2011 by Barry Stewart and Associates to inform the previous planning application. The survey identified that the site mainly comprises of scattered scrub, disturbed ground and ruderal vegetation.
- 1.4 The current report presents the findings of an ecological desk study and Extended Phase 1 Habitat survey undertaken at the application site in February 2022. The current report describes the current ecological conditions as well as identifying any potential ecological constraints/opportunities associated with residential development at the site.

2.0 METHODOLOGY

- 2.1 In order to establish the baseline ecological conditions at the application site, a combination of desk-based consultation and Extended Phase 1 Habitat survey were undertaken in February 2022.

Desk study

- 2.2 The desk study involved consultation with the South East Wales Biodiversity Record Centre (SEWBRc) and Merthyr Tydfil County Borough Council (MTCBC) to identify any records of rare, protected or notable flora and fauna within 1km of the application site. The search criteria also included information relating to the location and citation details (where available) for any sites designated for their nature conservation interest such as Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs) or locally designated Sites of Importance for Nature Conservation (SINCs).
- 2.3 The desk study also included a review of previous ecological survey work undertaken at the application site by Barry Stewart and Associates between July and October 2011.

Extended Phase 1 Habitat Survey

- 2.4 The fieldwork was undertaken on 23rd February 2022 by a suitably experienced ecologist¹ and followed standard Phase 1 Habitat Survey protocol (JNCC, 2010) as amended by the Institute of Environmental Assessment (1995). All habitats within and immediately adjacent to the site boundary were classified and mapped as accurately as possible. Habitats considered to have potential to support rare, protected or otherwise notable species of flora and fauna were noted, as were any direct signs of these species (e.g. Eurasian Badger *Meles meles* setts and dung-pits). Incidental observations of birds on or flying over the site were also recorded and any incidence of invasive weed species (e.g. Japanese Knotweed *Fallopia japonica*) noted.
- 2.5 A map of habitats was drawn up and target notes were used to identify features of ecological interest. Where possible, habitats were cross-referenced to any relevant important UK or Wales priority habitats as identified under Section 7 of the Environment Act (Wales) 2016.
- 2.6 During the field survey any trees at the application site were assessed for their potential to support roosting bats and were categorised in relation to the bat roosting features (BCT, 2016). The categories are as follows:
- **Known or confirmed roost**

¹ Associate member of the Chartered Institute of Ecology & Environmental Management (CIEEM)

- **High** - A tree with one or more potential roost sites that are obviously suitable for use by larger numbers of bats on a more regular basis and potentially for longer periods of time due to their size, shelter, protection, conditions and surrounding habitat.
- **Moderate** – A tree with one or more potential roost sites that could be used by bats due to their size, shelter, protection, conditions and surrounding habitat but unlikely to support a roost of high conservation status.
- **Low** – A tree or structure with one or more potential roost sites that could be used by individual bats opportunistically. Or: A tree of sufficient size & age to contain PRFs (Potential Roost Features) but with none seen from the ground or features seen with only very limited roosting potential.
- **Negligible** – Negligible habitat features on site likely to be used by roosting bat

Survey Limitations

2.7 The Extended Phase 1 survey was conducted in February 2022 and whilst habitat characterisation was possible, much of the ground flora was not yet in flower and was instead identified vegetatively where possible. As such a full assessment of the ground-flora species associated with the grassland and scrub habitats was not possible at the time of writing although this was not considered to affect the broad habitat categorisation and subsequent mapping and the overall recommendations included within the current appraisal.

3.0 RESULTS

Desk Study

SEWBRc Records

- 3.1 Consultation with SEWBRc and MTCBC confirmed that the application site holds no designation for nature conservation. The southern section of Aberfan West Site of Importance for Nature Conservation (SINC) is located approx. 65m west of the application site. The locally designated nature site supports a mosaic of habitats including broad-leaved semi-natural woodland, species-rich neutral grassland and scrub and bracken communities². Although located in close proximity, the application site and SINC are separated by Yr Hen Laethdy/Kinsley Terrace Road and existing residential development. Based on the small extent of the development proposals the scheme is considered unlikely to have any negative impact on the qualifying features of the SINC and is given no further consideration in this report. Other locally designated sites located within 1km of the application site include Afon Taf, Tarren y Gigran, St Tydfil Forest and Mynydd y Capel Common SINC. Given the physical separation between these sites and extent of the development proposals they were not considered of ecological relevance.
- 3.2 No international or national statutory designated sites (e.g., SACs or SSSIs) are located within 1km of the application site. Summary plans to illustrate the SEWBRc records are included in Appendix II.
- 3.3 The data search returned a list of protected species records within 1km of the application site. This included a small number of bat roost records within 300m of the site, including roosting Common and Soprano Pipistrelle *Pipistrellus pipistrellus/pygmaeus* and Daubenton's Bat *Myotis daubentonii*. There were also multiple records of foraging and commuting Common, Soprano and Nathusius's Pipistrelle *P. nathusii*, Noctule *Nyctalus noctula*, Brown Long-Eared Bat *Plecotus auritus* and unidentified *Myotis* bats within 1km of the site, largely associated with the habitats along the River Taff/Afon Taf.
- 3.4 Other priority mammal records of ecological relevance to the application site include 6no. sightings of Hedgehog *Erinaceus europaeus*.
- 3.5 The desk study included records of common reptiles and amphibians within 1km of the application site with multiple records of Common Toad *Bufo bufo*, Common Frog *Rana temporaria*, Common Lizard *Zootoca vivipara* and Slow Worm *Anguis fragilis*.

² Merthyr Tydfil County Borough Council (2018) Background Paper: Review of Sites of Importance for Nature Conservation. June 2018.

- 3.6 Records of protected bird species listed under Schedule 1 of the Wildlife and Countryside Act (1981) (as amended) recorded within 1km of the site such include Red Kite *Milvus milvus*, Osprey *Pandion haliaetus*, Fieldfare *Turdus pilaris* and Kingfisher *Alcedo atthis*. Other Section 7 priority listed bird species recorded within 1km of the site include Cuckoo *Cuculus canorus*, Herring Gull *Larus argentatus*, Linnet *Linaria cannabina*, Bullfinch *Pyrrhula pyrrhula*, Dunnock *Prunella modularis*, House Sparrow *Passer domesticus*, Song Thrush *Turdus philomelos* and Starling *Sturnus vulgaris*. Based on the habitats present at the site not all of these records (e.g. birds of prey sightings) were considered of ecological relevance to the proposal.
- 3.7 The desk study results included various of records of invasive plant species, as listed under Schedule 9 of the Wildlife and Countryside Act (1981) (as amended), within the 1km search radius. This included multiple records of Japanese Knotweed as well as Himalayan Balsam *Impatiens glandulifera* and Himalayan Cotoneaster *Cotoneaster simonsii*.

Previous survey work

- 3.8 Previous ecological survey work was undertaken at the application site in 2011 by Barry Stewart and Associates. The walkover survey identified that the site mainly comprises of disturbed ground containing a mosaic of scattered scrub and ruderal vegetation. The eastern boundary of the site is bordered by a small ditch and narrow corridor of dense scrub. Song Thrush *Turdus philomelos*, a priority listed bird species in Wales, was recorded at the site as well as Himalayan Cotoneaster, an invasive plant species as described in paragraph 3.7.

Extended Phase 1 Habitat Survey

- 3.9 The distribution and extent of habitats recorded in February 2022 at the application site are illustrated on the Extended Phase 1 Habitat Plan with accompanying target notes in Appendix III. The application site supports a limited range of habitats including poor semi-improved grassland, dense/continuous scrub, scattered broad-leaved trees, running water and bare ground. Habitat conditions were found to be generally consistent with those recorded during the 2011 survey.

Poor semi-improved grassland

- 3.10 The application site supports small areas of species-poor semi-improved grassland along the road verge to Yr Hen Laethdy/Kingsley Terrace (See Plate 1 and cover image). The grassland mainly comprises of tussocky Cock's Foot *Dactylis glomerata* with scattered stands of Alder *Alnus glutinosa* saplings. The grassland sward also contains Yorkshire Fog *Holcus lanatus*, Bent grasses *Agrostis* sp., Fescue grasses *Festuca* sp., Crested Dog's Tail *Cynosurus cristatus*, Creeping Buttercup *Ranunculus repens*, Dock *Rumex* sp., Dandelion *Taraxacum officinale*, Ribwort Plantain *Plantago lanceolata* and unidentified feather and bank-haircap mosses. The habitat also contains some areas of disturbed/bare ground from tracking vehicles and incidences of fly-tipping and burning.

Plate 1: Poor semi-improved grassland (south of footpath).



Dense/continuous scrub

- 3.11 The majority of the application site and road verge comprises of dense/continuous scrub. This includes area of thick Bramble scrub interspersed with stands of Alder, Rose *Rosa sp.* and Hawthorn *Crataegus monogyna*. Along the eastern site boundary and small stream bank, the areas of dense scrub contain taller stands of Hawthorn, Dogwood *Cornus sanguinea*, Blackthorn *Prunus spinosa*, Holly *Ilex aquifolium* and Willow *Salix sp.* as well as a line of broad-leaved trees (as described below in 3.12), forming a species-rich scrub corridor (Plate 2).

Scattered broad-leaved trees

- 3.12 The application site contains a line of broad-leaved trees along the eastern boundary (Plate 2) including stands of Alder, Birch *Betula sp.*, Hazel *Corylus avellana*, Sycamore *Acer pseudoplatanus* and Ash *Fraxinus excelsior*.

Plate 2: Dense/continuous scrub with line of broad-leaves trees along eastern boundary.



Running water/ditch

- 3.13 A small stream is located along the application site's eastern boundary (Plate 3). The stream is approx. 1m wide and contains a small volume of running water (approx. 40cm deep) with a muddy and rocky substrate. There is none/limited aquatic and marginal vegetation present within the watercourse with only Duckweed *Lemna sp.* present within slower flowing sections of the channel. The stream appears to be of poor water quality and contains large amounts of plastic litter.

Plate 3: Small stream along eastern site boundary (south of footpath).



Invasive species

- 3.14 The survey found dead stems indicative of Japanese Knotweed along the stream banks located outside of the site boundary (target note 2). The species is listed as an invasive plant species under Schedule 9 of the Wildlife and Countryside Act (1981) (as amended). Himalayan Cotoneaster, which was previously noted within the site boundary in 2011, was not recorded during the current survey. However, given the extent of bramble scrub the presence of the species and other invasive non-native species (INNS) within the site boundary cannot be precluded.

Fauna

3.15 In the course of the survey, a search of field signs for protected or notable species was undertaken and the potential of the habitats to support these species considered. In the context of this report, these species meet any of the following criteria:

- Species protected by British or international law;
- Priority species included on Section 7 (Environment Act, Wales);
- Nationally rare or nationally scarce species;
- Species of Conservation Concern (e.g. JNCC Red List, RSPB/BTO Red or Amber Lists);

The following were considered of ecological relevance to the site:

Bats

3.16 The habitats at the application site were considered likely to support a small number of locally foraging and commuting bats. The tree and scrub corridor along the eastern boundary is well connected to other linear habitat features in the surrounding area of suitability for bats. The dense scrub and trees along this boundary contribute to a section of a continuous woodland corridor which connects to habitats along the River Taff to the north, and along the A470 carriageway to the south. In addition, the data search returned multiple records of foraging and commuting bats in the surrounding area including Common and Soprano Pipistrelle and Noctule and light sensitive species such as Brown Long-Eared bat and Myotis bats.

3.17 The application site does not contain any mature trees or other trees/structures supporting potential bat roost features.

Birds

3.18 A small number of birds were recorded at the application site or within the immediate surroundings during the survey. This included House Sparrow, Great Tit *Parus major*, Blue Tit *Cyanistes caeruleus*, Blackbird *Turdus merula*, Woodpigeon *Columba palumbus*, Magpie *Pica pica* and Jackdaw *Corvus monedula*. Of these species, House Sparrow is listed as a priority bird species under Section 7 of the Environment Act (Wales) 2016. The assemblage of species recorded at the site comprised of common and widespread species was considered typical of the scrub and tree habitats present within the surrounding area (i.e., urban setting). The dense scrub and tree habitats at the application site were considered likely to support nesting birds.

Reptiles

3.19 The habitats present at the application site were considered to be of low suitability to support common reptiles. Whilst the areas of tussocky poor semi-improved grassland and dense scrub margins provide suitable shelter and foraging opportunities for reptiles (e.g. Slow-Worm), the site is relatively small (approx. 0.17ha), disconnected from local record reptile sightings and likely subject to regular disturbance by members of the

public (e.g., dog walkers, fly-tipping, burning and tracking vehicles). As such the presence of anything other than individual/low numbers of common reptiles such as Slow-Worm is considered unlikely.

Other

- 3.20 The grassland and scrub habitats at the application site were considered likely to support suitable foraging resources for Hedgehog. The data search returned multiple records of the species within 1km of the site.

4.0 POLICIES AND PLANS

- 4.1 The following local and national planning policy relating to nature conservation and biodiversity are considered of relevance to the site.

Planning Policy Wales (2021)

- 4.2 This document set out the land use planning policies of the Welsh Government with Chapter 6 dealing with Distinctive and Natural Places which covers Biodiversity and Ecological Networks. The advice contained within PPW is supplemented for some subjects by Technical Advice Notes (TAN's), with TAN 5 addressing Nature Conservation & Planning.
- 4.3 TAN 5 identifies a number of key principles, which the town and country planning system in Wales should consider. Those relevant are detailed below:
- Work to achieve nature conservation objectives through a partnership between local planning authorities, Natural Resources Wales (NRW), voluntary organisations, developers, landowners and other key stakeholders;
 - Integrate nature conservation into all planning decisions looking for development to deliver social, economic and environmental objectives together over time;
 - Ensure that the UK's international obligations for site, species and habitat protection are fully met in all planning decisions;
 - Look for development to provide a net benefit for biodiversity conservation with no significant loss of habitats or populations of species, locally or nationally;
 - Promoting approaches to development which create new opportunities to enhance biodiversity, prevent biodiversity losses, or compensate for losses where damage is unavoidable. Minimising or reversing the fragmentation of habitats and improving habitat connectivity through the promotion of wildlife corridors;
 - Local planning authorities should seek to protect trees, groups of trees and areas of woodland where they have natural heritage value or contribute to the character or amenity of a particular locality;
 - The presence of a species protected under European or UK legislation is a material consideration when a local planning authority is considering a development proposal which, if carried out, would be likely to result in disturbance or harm to the species or its habitat.

Environment (Wales) Act, 2016

- 4.4 Part 1 of the Environment Act Wales' came into force in May 2016 and sets out the approach to planning and managing natural resources at a national and local level with a general purpose linked to statutory 'principles of sustainable management of natural resources' defined within the Act.

Section 6 - Biodiversity and resilience of ecosystems duty

- 4.5 Section 6 of the Act places a duty on public authorities to 'seek to maintain and enhance biodiversity' so far as it is consistent with the proper exercise of those functions. In so doing, public authorities must also seek to 'promote the resilience of ecosystems'.

Section 7 - Biodiversity lists and duty to take steps to maintain and enhance biodiversity

- 4.6 This section lists living organisms and types of habitat in Wales which are considered of key significance to maintaining and enhancing biodiversity in relation to Wales. The Welsh Ministers are required to take all reasonable steps to maintain and enhance the living organisms and types of habitat included in any list published under this section, and encourage others to take such steps.

Local Planning Policy

Merthyr Tydfil County Borough Council Replacement Local Development Plan (2016 - 2031)

- 4.7 The Merthyr Tydfil CBC Replacement Local Development Plan (LDP) was adopted in January 2020. The LDP sets out the current land use policies and proposals to control development in the county borough up to 2031. Policies within the LDP relating to biodiversity, and considered of relevance to the application site, are listed below.

Policy EnW1: Nature Conservation and Ecosystem Resilience

Development proposals will be required to promote the resilience of ecosystems. In particular, proposals will be required to maintain and enhance biodiversity interests unless it can be demonstrated that:

1. The need for the development clearly outweighs the biodiversity value of the site; and
2. The impacts of the development can be satisfactorily mitigated and acceptably managed through future management regimes.

Policy EnW2: Internationally and Nationally Protected Sites and Species

Development proposals likely to affect protected species will only be permitted where it is demonstrated that:

1. The population size, range, distribution and long-term prospects of the species will not be significantly adversely impacted;
2. There is no suitable alternative to the proposed development;
3. The benefits of the development clearly outweigh the adverse impacts on the protected species; and
4. Appropriate, avoidance, minimisation, mitigation, compensation and enhancement measures are provided.

Policy EnW3: Regionally Important Geological Sites, Sites of Importance for Nature Conservation, Local Nature Reserves and Priority Habitats and Species

Development proposals likely to have an adverse impact on Regionally Important Geological Sites, Sites of Importance for Nature Conservation, Local Nature Reserves, or Priority Habitats and Species will only be permitted where it can be demonstrated that:

1. The need for the development clearly outweighs the conservation value of the site;
2. Adverse impacts on nature conservation features or geological features can be avoided;
3. Appropriate and proportionate mitigation and compensation measures can be provided; and
4. The development maintains and where possible enhances biodiversity and geodiversity interests.

5.0 CONCLUSIONS AND RECOMMENDATIONS

- 5.1 The combination of desk study and Extended Phase 1 Habitat survey identified a limited range of habitats at the application site. This included poor semi-improved grassland, dense/continuous scrub, scattered broad-leaved trees, running water and bare ground – none of which would identify as priority habitat in Wales or meet local wildlife site criteria. The habitats at the site were considered suitable to support locally foraging and commuting bats, nesting birds and, to a lesser extent, common reptiles. The proposed layout plan (Appendix I) indicates that a 3m woodland/scrub buffer will be retained along the eastern boundary with development focused within areas of poor semi-improved grassland and bramble scrub (considered to be of low ecological importance). The following avoidance, mitigation and enhancement measures are considered appropriate to the current application.

Bats

- 5.2 The tree and scrub corridor located along the eastern boundary was considered likely to support small numbers of locally foraging and commuting bats. The proposed layout plan (Appendix I) indicates that this scrub corridor will be retained with a 3m ecology buffer zone between the rear of garden curtilages and the small watercourse. The retention of this corridor will minimise any negative impacts to habitat connectivity and fragmentation for bats. The design of a 3m ecology buffer was given prior approval as part of the previous planning application (Planning Ref: P/18/0400). The layout plan also includes new planting along the new retaining wall which will both provide a landscape buffer and strengthen this wooded corridor post-development.
- 5.3 In addition, the design of any site lighting as part of the development should aim to reduce artificial light spill onto this corridor as far as practicable to further minimise any habitat fragmentation impacts to foraging/commuting bats. This could include fitting down-lighters to security lighting at the rear of properties or the placement of light fittings away from windows on the rear elevation. See lighting guidance note produced by BCT & ILP (2018) for advice on how to mitigate for impacts of artificial lighting on bats (extract included in Appendix IV). Enhancement measures relating to bats include installing bat boxes onto new residential units (2no. boxes will be installed on units 6 and 8).

Birds

- 5.4 The habitats at the application site were considered likely to support tree and scrub nesting bird species. Under the Wildlife and Countryside Act (1981) (as amended) all wild birds and their nests are protected against damage or destruction whilst in use or being built. Given the high likelihood of nesting birds being present, any future vegetation clearance (i.e., tree and scrub removal) at the application site would be subject to seasonal constraints and should be undertaken over the winter period outside of the nesting bird season (clearance possible between September – February). If this is not possible an ecologist should be present to inspect

habitats prior to removal to confirm the absence of nesting birds. Timing of vegetation clearance would also need to consider common reptiles (see 5.5 – 5.6) and a co-ordinated approach regarding nesting birds and reptiles would be required. For example, clearance of vegetation above ground (e.g., to a height of 150mm) could be undertaken over winter with directional clearance to ground level between April and October (see 5.5 – 5.6). In addition to avoidance and mitigation measures above, the final development design will also include the provision of bird boxes as a localised biodiversity enhancement. 2no. boxes (House Sparrow terraces) will be installed on units 1 and 3.

Reptiles

- 5.5 The habitats at the application site were considered of low suitability to support common reptiles. As discussed in paragraph 3.19; whilst habitat features at the site (tussocky grasses and scrub margin) provide suitable shelter and foraging opportunities, evidence suggests the site is subject to regular human disturbance with signs of dog walkers, tracking vehicles, fly-tipping and burning which could discourage reptiles from the area. Therefore, the presence of anything other than individual/small numbers of common reptiles at the application site is considered unlikely. On this basis, further reptile presence/absence surveys have not been recommended.
- 5.6 All common UK reptiles are protected against intentional killing and injuring under Section 9(1) of the Wildlife and Countryside Act (1981) (as amended). Based on the above (i.e., assumed presence of low numbers of common reptiles) it is recommended that a sensitive approach is taken to any future vegetation clearance at the site on a precautionary basis to minimise any risks to reptiles that may be present. Vegetation clearance should be undertaken via a directional two-stage process where an initial cut to 100-150mm is undertaken with the use of hand tools (strimmers or brush-cutters), followed by a second cut to ground level after a minimum period of 48hrs. Arisings should be removed immediately following each cut. Works should be undertaken via a directional process, working west to east, to encourage any reptiles or other animals present to move towards retained habitats – this directional clearance would need to be implemented during the period when reptiles are active, typically April to October. Any larger root systems or the earth mound (target note 1) that require removal should be undertaken outside of the reptile hibernation period (typically October – March) under the supervision of an ecologist via a supervised destructive search.
- 5.7 As an enhancement measures to improve habitat suitability at the site for reptiles (and amphibians) in the long-term, a reptile hibernaculum will be created within the retained ecology buffer. The hibernacula will be approx. 1.5m x 1.5m in size and comprise of dead wood, rocks and other rubble and will be covered with turf (see Appendix V for design guidance).

Invasive species

- 5.8 The current survey found dead stems indicative of Japanese Knotweed along the stream banks located outside of the site boundary. Given the time of year the current survey was undertaken, the presence of knotweed and other INNS within the site boundary cannot be precluded. The species is listed under Schedule 9 of the Wildlife and Countryside Act (1981) (as amended) meaning it is an offence to plant or otherwise cause these species to grow in the wild. The development proposals should seek to manage the spread of invasive species at the site either through appropriate treatment (e.g. chemical treatment) or removal and disposal. The development proposals should also implement appropriate pollution prevention measures to minimise any surface water run-off into the adjacent watercourse during construction activities.

Enhancements

- 5.9 Other enhancement measures to provide localised biodiversity benefits, and to ensure compliance with local planning policy EnW1, include the use of native plant species or those with a known biodiversity benefit within the final landscape plans. The layout plan produced for the previous application included the use of Hawthorn, Blackthorn and Dogwood shrub – species already known to be present along the scrub corridor. As shown on the External Boundary Details Plan³, the final development design will also include a 130x130mm gap at the bottom of garden fences to provide continued connectivity for Hedgehog and other small mammals throughout the development, based on the Hedgehog Street principles by the People's Trust for Endangered Species⁴.

Avoidance, mitigation and enhancements

- 5.10 The avoidance, mitigation and enhancements are summarised below:

Avoidance

- Retention of tree/scrub corridor along eastern boundary (3m ecology buffer);
- Vegetation clearance (tree and scrub removal) to avoid nesting bird season and be undertaken over the winter period (between September – February);

Mitigation

- Design of site lighting to minimise artificial light spill onto retained eastern boundary for foraging/commuting bats;
- Sensitive approach to vegetation clearance to minimise any risks to reptiles that may be present (vegetation to be cleared via a directional two-stage process between April and October);
- Control measures for invasive species and pollution/surface water run-off;
- External boundary fencing to include 130x130mm gap to provide continued connectivity for hedgehog and other small mammals through the development;

³ LeTrucco Desgin (2022) *Kingsley Terrace, M. Tydfil – Boundary Details*. Drawing Number: LT2203.04.02. June 2022.

⁴ <https://www.hedgehogstreet.org/>

Enhancements

- Landscape plan to include native tree and shrub species or those with a known biodiversity benefit;
- Creation of reptile hibernaculum within ecology buffer; and
- Inclusion of 2no. bat boxes and 2no. bird boxes onto new residential units. Including:
 - 2no. Integrated Fixed Bird Box (<https://www.birdbrickhouses.co.uk/brick-nesting-boxes/nesting-boxes/>)
 - 2no. Integrated Built in Bat Boxes - Ibstock Type B (<https://www.nhbs.com/ibstock-enclosed-bat-box-b>)

REFERENCES

Barry Stewart and Associates Ecological Consultants (2011) *Land at Kingsley Terrace, Aberfan, Merthyr Tydfil – Ecology Inspection*. Dated: 11th September 2011.

Bat Conservation Trust (2016) *Bat Surveys – Good Practice Guidelines*. Bat Conservation Trust, London.

Bat Conservation Trust & Institution of Lighting Professionals (2018) *Bats and artificial lighting in the UK. Guidance Note 08/18*. Bat Conservation Trust, London.

Institute for Environmental Assessment (1995) *Guidelines for Baseline Ecological Assessment*. E & FN Spon, Hong Kong.

Joint Nature Conservation Committee (JNCC) (2010) *Handbook for Phase I Habitat Survey. A technique for environmental audit*. JNCC, Peterborough.

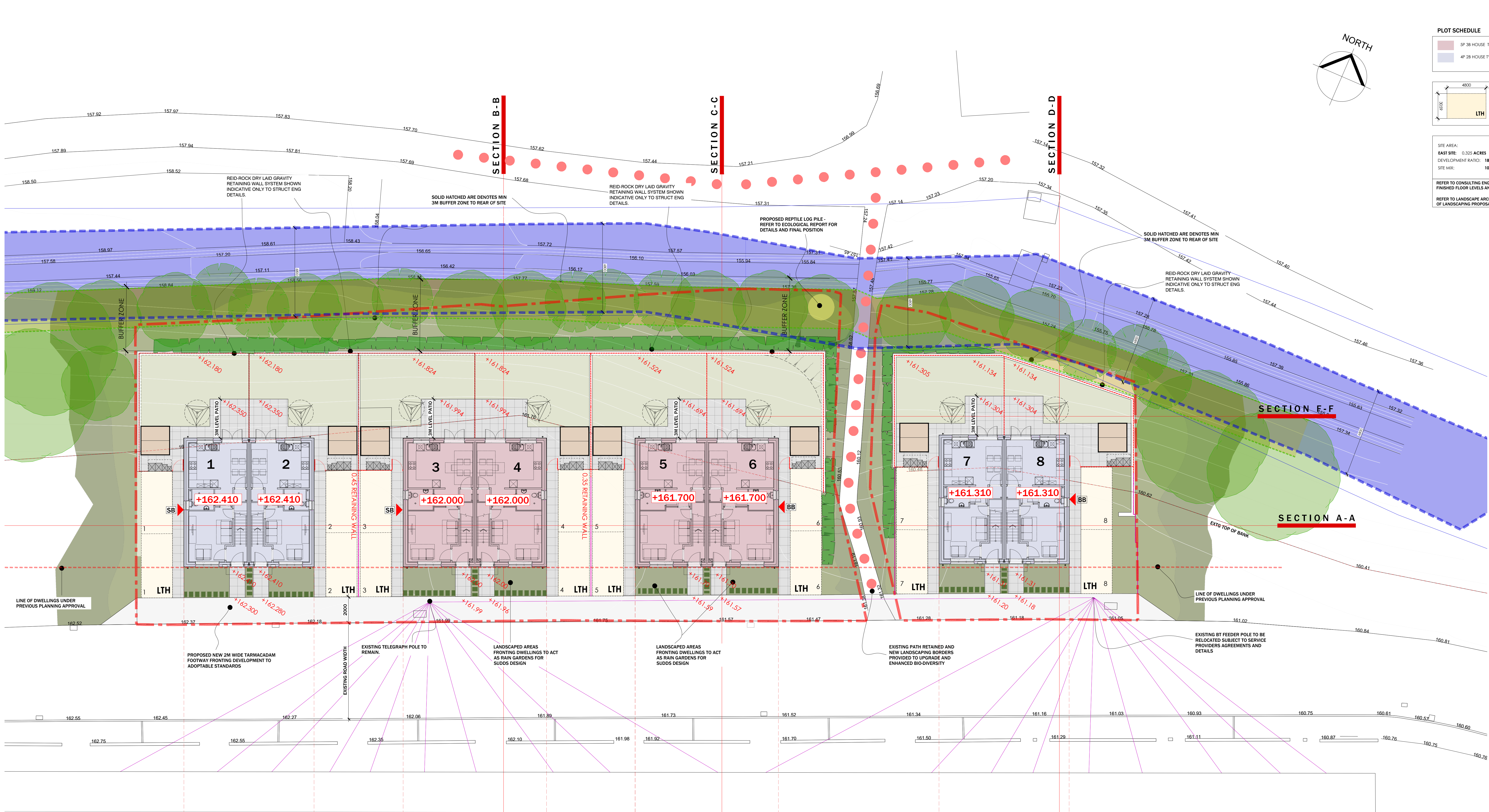
Merthyr Tydfil County Borough Council (MTCBC) (2018) Background Paper: Review of Sites of Importance for Nature Conservation. June 2018.

MTCBC (2020) Replacement Local Development Plan (2016 – 2031): Written Statement. January 2020.

Welsh Assembly Government (2009) Technical Advice Note 5: Nature Conservation and Planning.

Welsh Assembly Government (2021) Planning Policy Wales Edition 11. February 2021.

APPENDIX I PROPOSED LAYOUT PLAN



PROPOSED SITE LAYOUT
0 1.25 2.5 3.75 5.0 6.25m
SCALE 1:125



STREET ELEVATION

PLOT SCHEDULE

SP 38 HOUSE TYPE [92M ²]	4
4P 28 HOUSE TYPE [83M ²]	4

Site Area: 0.325 ACRES **West Site:** 0.10 ACRES
Development Ratio: 18 UNITS PER ACRE
Site Mix: 100% AFFORDABLE DGR.

REFER TO CONSULTING ENGINEERING DRAWINGS FOR PLOT FINISHED FLOOR LEVELS AND DETAILS OF RETAINING WALLS. REFER TO LANDSCAPE ARCHITECT'S DRAWINGS FOR DETAILS OF LANDSCAPING PROPOSALS.

KEY SCHEDULE
REFER TO BOUNDARY TREATMENTS & BOUNDARY IDENTIFICATION DRAWINGS FOR FURTHER DETAIL.

---	SITE APPLICATION BOUNDARY
---	DENOTES 1800MM HIGH TREATED BOARD CORDED FENCE.
---	DENOTES 900MM HIGH GALVANIZED FLAT TOP RAILINGS.
---	DENOTES RED ROCK DRY LAID GRAVITY RETAINING WALL SYSTEM. REFER TO ENGINEERS DRAWINGS FOR R-WALL DETAILS. 1.2M HIGH TIMBER FENCE ON TOP.
---	DENOTES NEW 2M WIDE FOOTWAY PARALLEL TO MAIN ROAD AND WITHIN CURTLAGES OF SITE OWNERSHIP TO ADAPTABLE STANDARDS. REFER TO STRUCTURAL ENGINEER'S DETAILS AND DRAWINGS.
---	DENOTES AREA OF 400 X 400MM P.C. CONCRETE PAVING SLABS TO FORM PATIO AREAS AND 1000 X 2000MM MIN. FOOTPATHS TO TO CURTLAGES OF HOUSES AND WORKMANSHIP.
---	DENOTES AREAS OF 2.4 X 4.8M PARKING BAYS IN TOBERMORE PERMEABLE PAVING SYSTEM - BUFF COLOUR
---	DENOTES AREAS OF LANDSCAPE WITHIN CURTLAGES OF DWELLINGS AND ADJOINING AREAS. INCORPORATING SUEBENATIVE SHRUB SPECIES AND RAINWATER GARDENS TO ASSIST SUDDS AS PER SEPARATE LANDSCAPING DRAWINGS BY OTHERS. REFER TO SCHEME SPEC FOR FURTHER DETAILS & WORKMANSHIP.
---	DENOTES AREAS OF TURF GRASS TO REAR GARDENS. REFER TO SCHEME SPECIFICATION FOR FURTHER DETAILS AND WORKMANSHIP.
---	DENOTES AREAS OF MIN 3M BUFFER ZONE TO EXISTING STREAM AND EMBANKMENT
---	DENOTES 6M EASEMENT TO EXISTING WATER MAIN
---	DENOTES 1.8M HIGH, 200MM WIDE TOWER CLOSE BOARDED GATE WITH A SECURITY LOCK IN COMPLIANCE WITH BS6858. NOTE GATE TO BE SIMILAR HEIGHT TO ADJACENT WALL/GATE IF APPLICABLE.
---	DENOTES NEW NATIVE PLANTING TO PLOT PERIMETERS WITH PUBLIC FOOTPATH TO SOFTEN BOUNDARIES
---	DENOTES AREA OF 0.9M HIGH PRIVE OR BOX HEDGE BOUNDARY. PLANT TO BE PLANTED 50M MAX. REFER TO LANDSCAPING ARCHITECT'S DRAWINGS FOR FURTHER DETAILS.
---	DENOTES EXISTING TREES AND TREE WELLS (REFER TO LANDSCAPE ARCHITECTS DRAWINGS FOR TYPES AND SCHEDULES)
---	DENOTES ROUTE OF EXISTING FOOTPATH
---	DENOTES 2.0M DIAMETER ROTARY DRIVE SET IN CONCRETE. PROVIDING 6M MIN. OF LINE FOR 2 BED DWELLINGS, 8M MIN. FOR 3 BED DWELLINGS.
---	DENOTES 0.8 X 0.8M CONCRETE HARVESTING SPACE FOR BLACK BAGS
---	DENOTES 1NO. 0.8 X 0.8M SPACE FOR GARDEN WASTE COLLECTION (CLEAR BAG)
---	DENOTES 1NO. 50 X 400MM SPACE FOR RECYCLING COLLECTION (CLEAR BAG)
---	DENOTES 1NO. FOOD CADDY
---	DENOTES ROBUST TREATED TIMBER FRAMED SHED WITH 1NO. 2NO. SHEETED OR SIMILAR TYPE STEEL FRAMED BEEHIVE RACK, BOTH BOLTED TO 100MM THICK CONCRETE BASE. PROVIDING SPACE FOR 1NO. 2NO. BICYCLES AND 1NO. GARDEN STORE SPACE. PERMANENT LOCK TO BE PROVIDED TO SHED DOOR, CONFORMING TO BS 3621:2004.
---	DENOTES POSITION OF ISTOCK OR SIMILAR SWIFT BOX IN SMOOTH RED. TO BE INSTALLED AT MIN. 5M FROM EXTERNAL GROUND LEVEL. REFER TO ECOLOGISTS REPORT.
---	DENOTES POSITION OF ISTOCK BAT BRICK (TYPE A) OR SIMILAR. REFER TO INDIVIDUAL ELEVATIONS FOR EXACT LOCATION. REFER TO ECOLOGISTS REPORT.

PLOT NO.	DWELLING TYPE	GIA (M ²)	GIA (FT ²)	GARDEN AREA (M ²)
BLOCK 1				
1	4P 28 HOUSE TYPE	81.56	877.91	43.8
2	4P 28 HOUSE TYPE	81.56	877.91	43.8
BLOCK 2				
3	SP 38 HOUSE TYPE	81.56	877.91	52.4
4	SP 38 HOUSE TYPE	81.56	877.91	51.7
BLOCK 3				
5	SP 38 HOUSE TYPE	90.94	978.87	51.6
6	SP 38 HOUSE TYPE	90.94	978.87	51.8
BLOCK 4				
7	4P 28 HOUSE TYPE	81.56	877.91	39.4
8	4P 28 HOUSE TYPE	81.56	877.91	54.6

Revisions

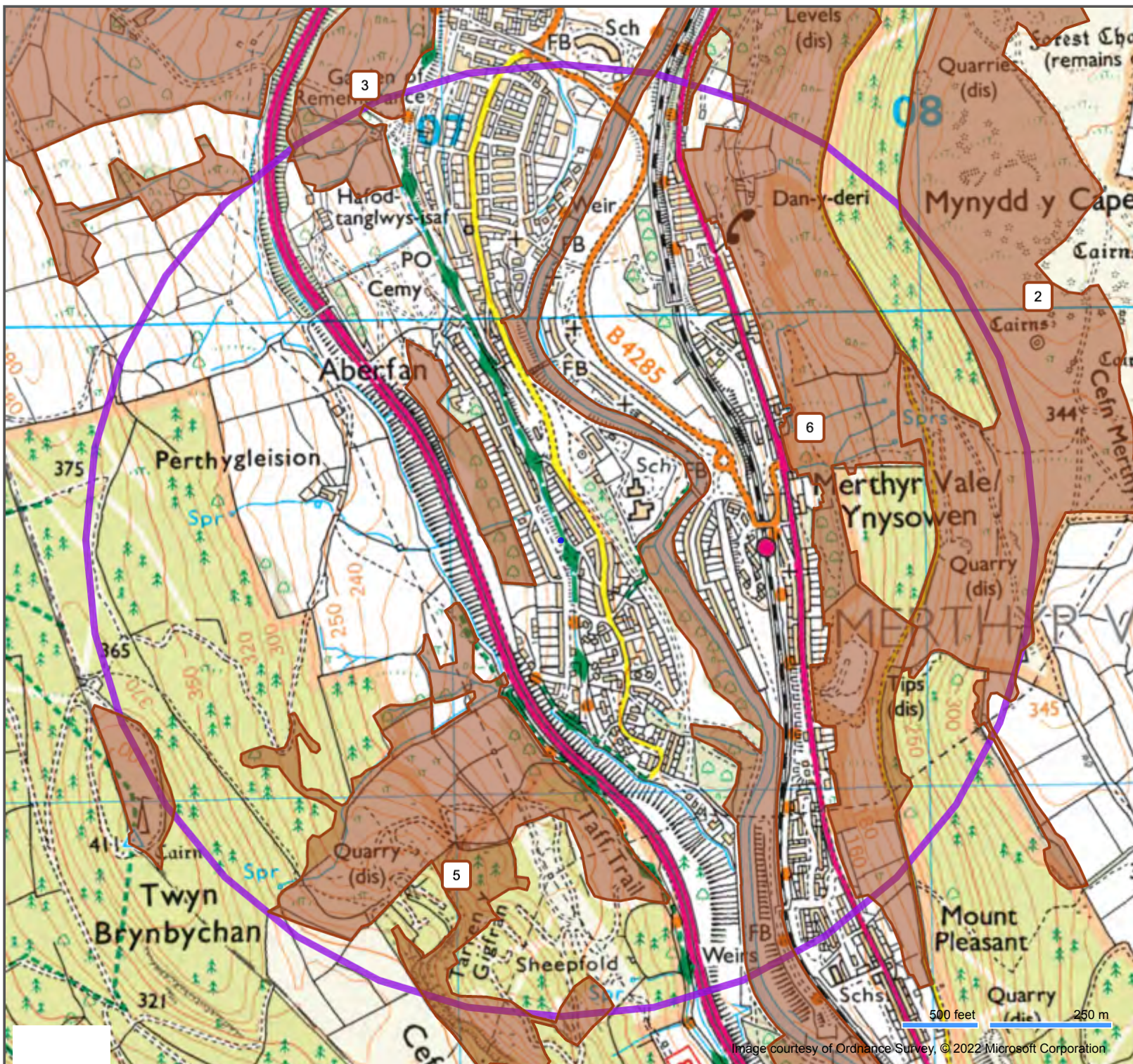
Rev.	Date	Description	Scale	Revision
REV. A	JUNE 22	DESIGN FROM MEETING DISCUSSIONS. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.	1:125 @ A0	H
REV. B	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. C	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. D	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. E	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. F	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. G	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. H	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. I	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. J	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. K	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. L	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. M	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. N	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. O	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. P	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. Q	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. R	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. S	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. T	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. U	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. V	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. W	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. X	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. Y	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		
REV. Z	JUNE 22	SCHEMATIC DESIGN POLY REVISIONS TO B1. STREET ELEVATIONS UPDATED TO MATCH REVISED ELEVATIONS.		

Client: MDL / Werthyn Valley Homes
Job Title: Kingsley Terrace, M Tydfil
Drawing Title: Proposed Site Layout
Scale: 1:125 @ A0
Revision: H
Date: June 22
Checked: KML

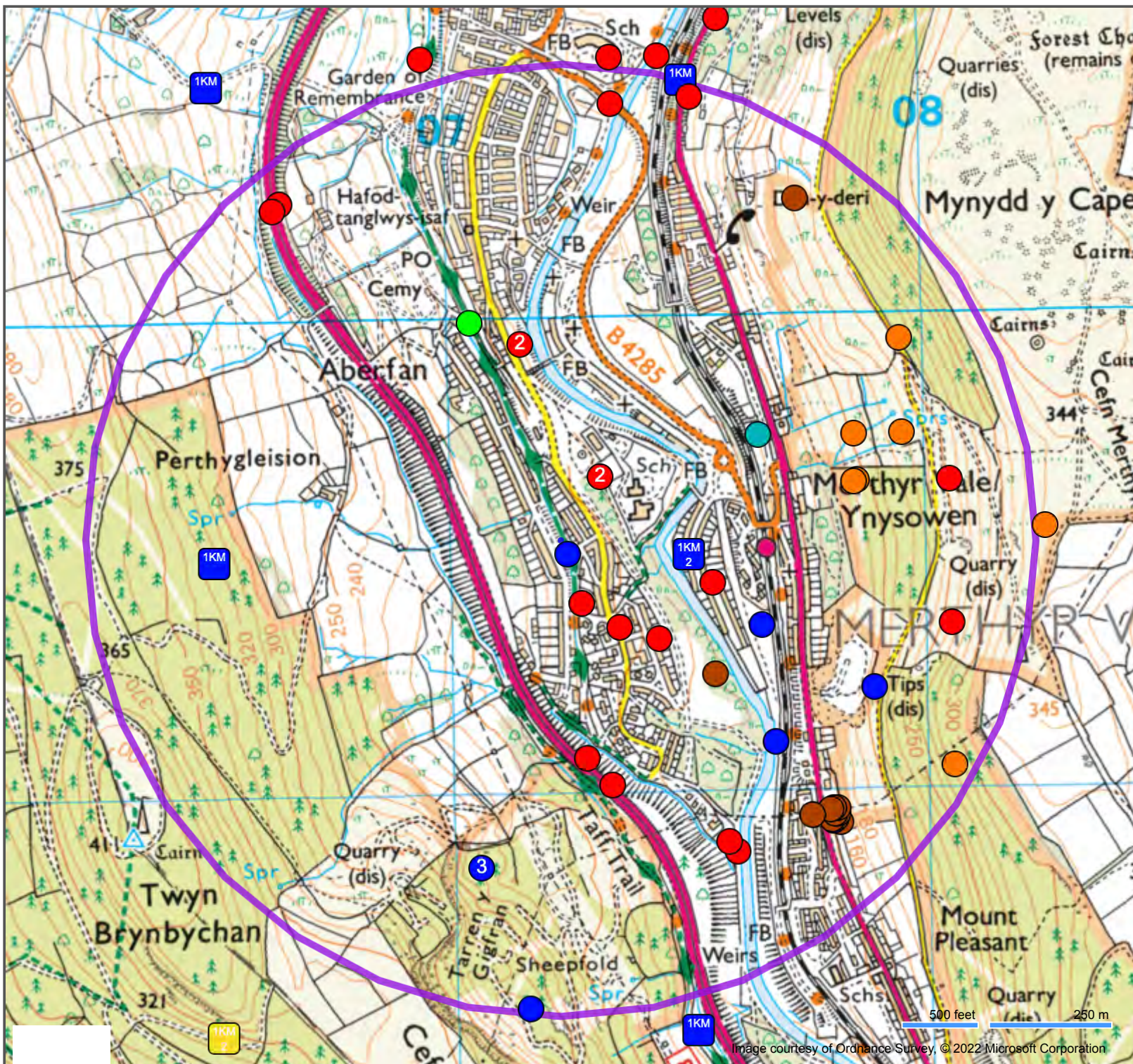
Drawing Purpose: PLANNING

Client: MDL / Werthyn Valley Homes
Job Title: Kingsley Terrace, M Tydfil
Drawing Title: Proposed Site Layout
Scale: 1:125 @ A0
Revision: H
Date: June 22
Checked: KML

APPENDIX II SWEBR_eC DESK STUDY RECORDS



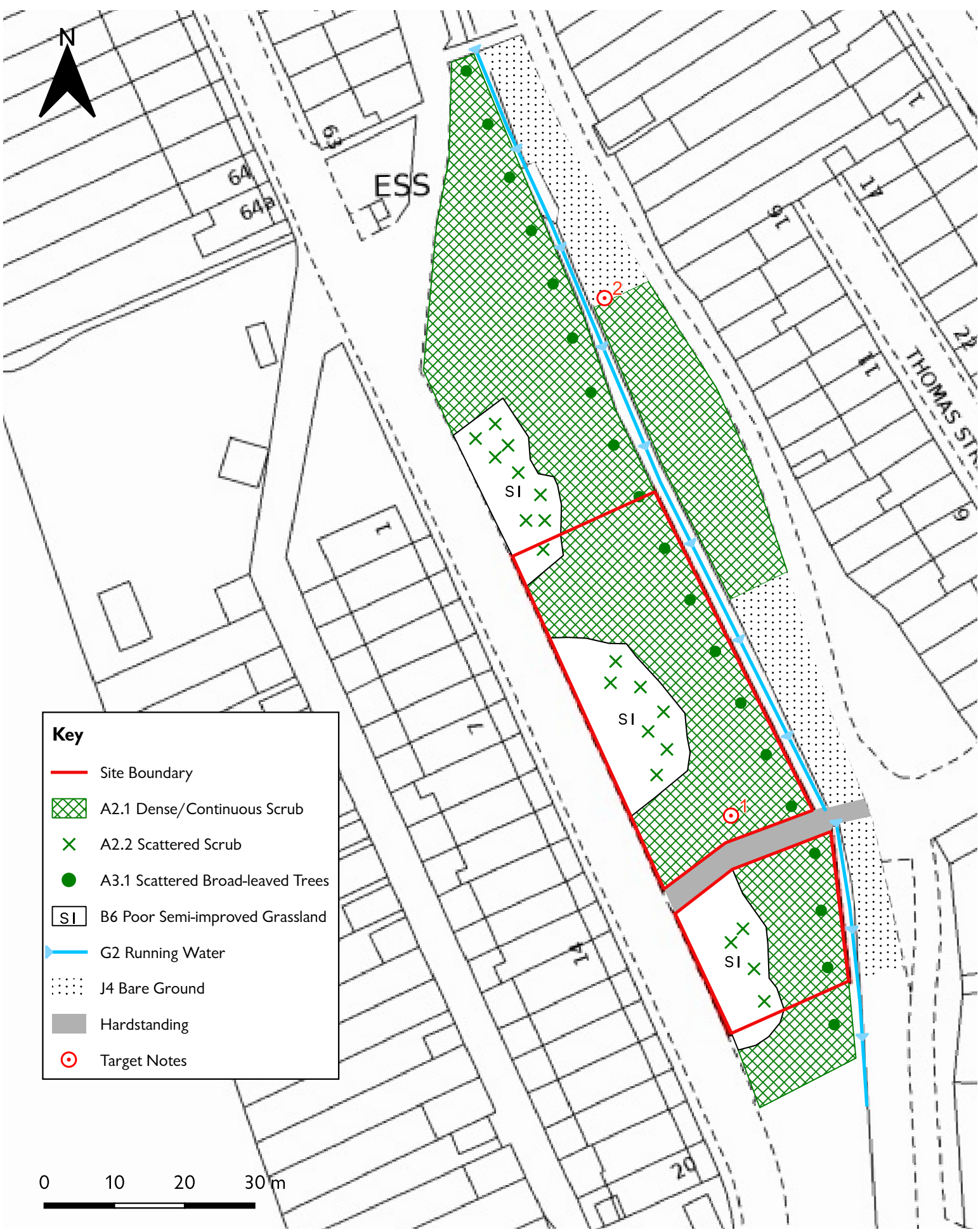
- Key**
- Search Location
 - Search Buffer (1000m)
- Adopted SINC**
- 1: Afon Taf
 - 2: Mynydd y Capel Common
 - 3: West of Aberfan
 - 4: Mynydd Merthyr
 - 5: Tarran y Gigfran, St Tydfil Forest
 - 6: Merthyr Vale



- Key**
- Search Location
 - Search Buffer (1000m)
 - Bees, Wasps, Ants and Sawflies
 - Birds
 - Butterflies and Moths
 - Fish
 - Mammals
 - Plants
 - Reptiles and Amphibians

APPENDIX III EXTENDED PHASE 1 HABITAT SURVEY PLAN & TARGET NOTES

Target Note	Description/Comment
Birds seen/ heard: House Sparrow, Blackbird, Great Tit, Blue Tit, Jackdaw, Magpie and Woodpigeon.	
1	Earth mound/spoil colonised by bramble scrub and ruderal vegetation. Potential reptile hibernacula.
2	Dead stems indicative of Japanese Knotweed. Located along stream banks next to cleared area of bare ground. 
Additional site photographs	Poor semi-improved grassland sward.  



Key

- Site Boundary
- A2.1 Dense/Continuous Scrub
- A2.2 Scattered Scrub
- A3.1 Scattered Broad-leaved Trees
- SI B6 Poor Semi-improved Grassland
- G2 Running Water
- J4 Bare Ground
- Hardstanding
- Target Notes

M. Delacey & Sons (Holdings) Limited Yr Hen Laethdy (Kingsley Terrace), Aberfan		Extended Phase 1 Habitat Survey		PRELIMINARY PLANNING DESIGN TENDER CONSTRUCTION	
E22108301/DR01		DJ MW 23 February 2022		soltysbrewster E C O L O G Y 4 Stangate House Stanwell Road Penarth Vale of Glamorgan CF64 2AA Tel: 033 00 13 00 12 Email: enquiry@soltysbrewster.co.uk	

Soltys Brewster Ecology is the trading name of Soltys Brewster Ecology Ltd. Registered Offices:- 4 Stangate House, Stanwell Road, Penarth, Vale of Glamorgan. CF64 2AA. Registration No. 5779051.
 Dimensions should not be scaled from this drawing, only figured dimensions are to be used. All discrepancies or queries regarding this drawing should be referred to Soltys Brewster Ecology Ltd. Soltys Brewster Ecology Ltd accept no liability for any expense, loss or damage of whatever nature and however arising from variation made to this drawing or in the execution of the work to which it relates which has not been referred to them and their approval obtained.

APPENDIX IV BATS AND ARTIFICIAL LIGHTING IN THE UK GUIDANCE NOTE

The following is an extract from the **Bat Conservation Trust and Institution of Lighting Professionals (2018)** guidance note on **Bats and Artificial lighting in the UK**. Section 3 contains advice on how to mitigate for the impacts of artificial lighting on bats. Full citation:

Bat Conservation Trust & Institution of Lighting Professionals (2018) *Bats and artificial lighting in the UK. Guidance Note 08/18*. Bat Conservation Trust, London.

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

In other locations of value for bats on site, apply mitigation methods to reduce lighting to a minimum.

Spatial design

Building design

Landscaping

Set dark habitat buffers and acceptable lux limits with ecologist guidance

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:

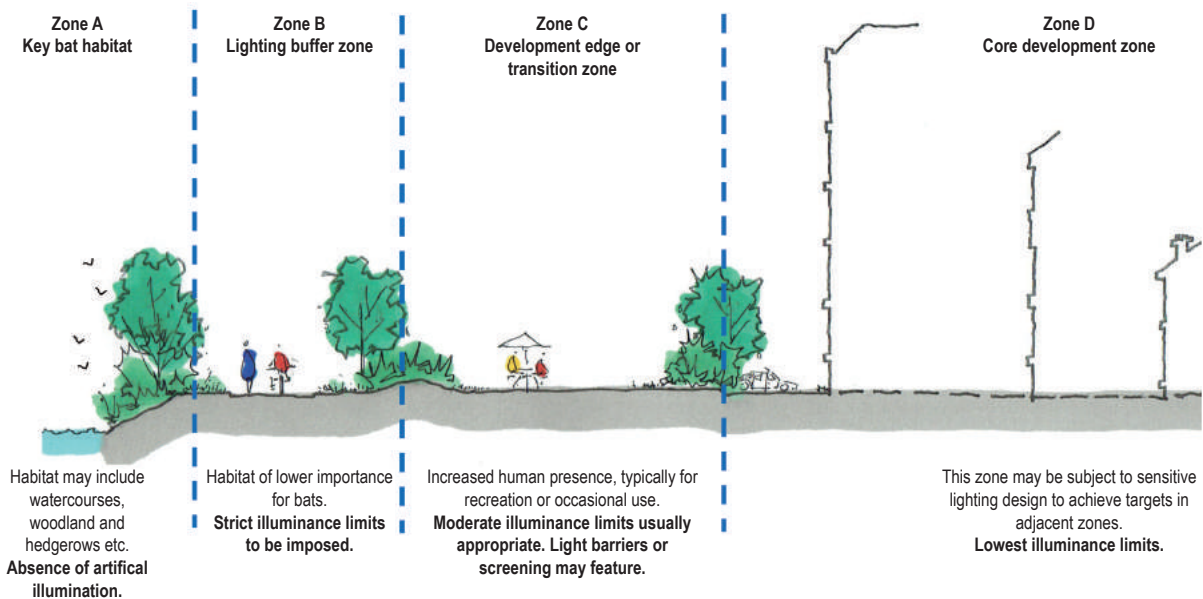
- Roosting and swarming sites for all species and their associated flightpath/commuting habitat.
- Foraging or commuting habitat for highly light-averse species (greater and lesser horseshoe bats, some *Myotis* bats, barbastelle bats and all long-eared bats).
- Foraging or commuting habitat used by large 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 into 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

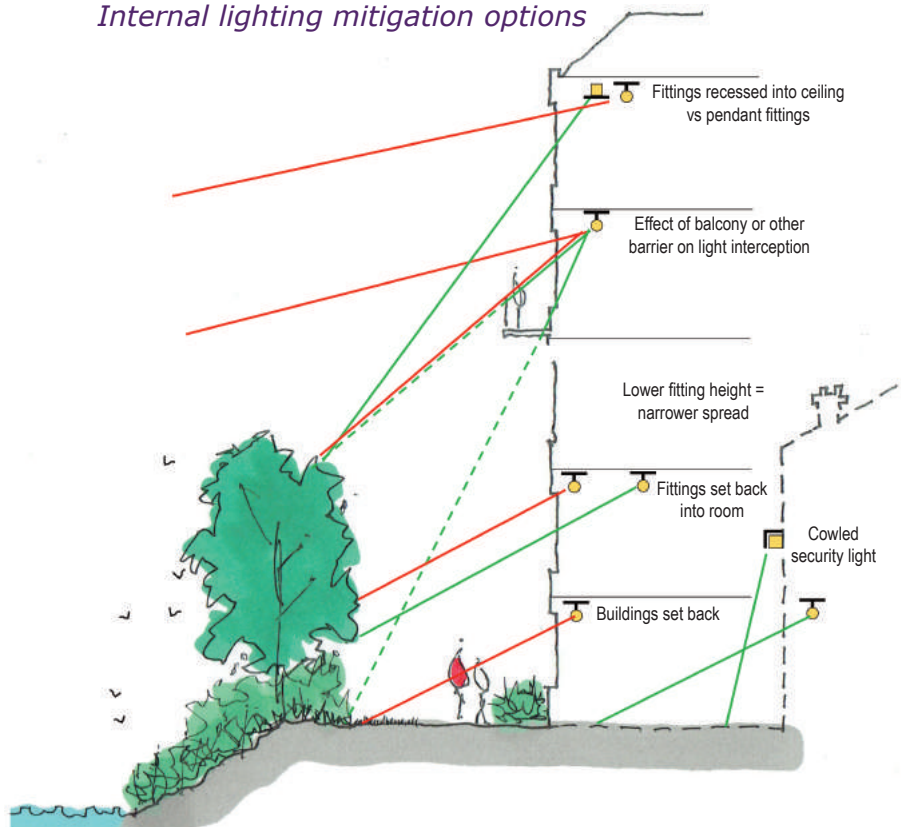
Luminaires come in a myriad of different styles, applications and specifications which a lighting professional can help to select. The following should be considered when choosing luminaires.

- 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



- 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.

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.

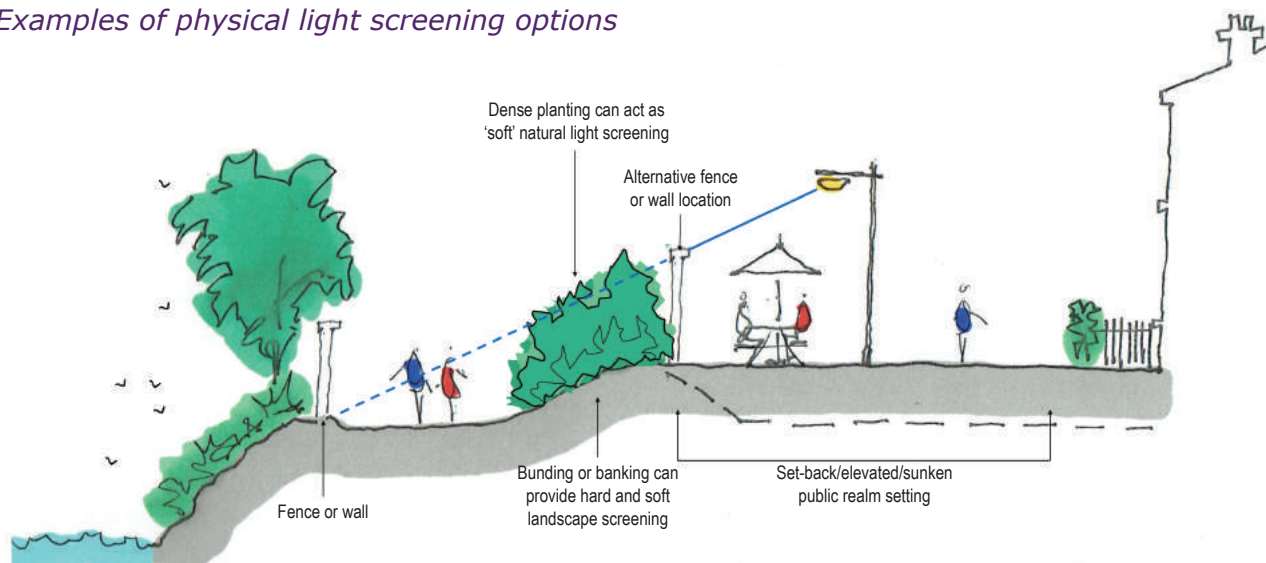
- It may be possible to include key habitats and features into unlit public open space such as parks and gardens.
- Buildings, walls and hard landscaping may be sited and designed so as to block light spill from reaching habitats and features.

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 one.

- 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

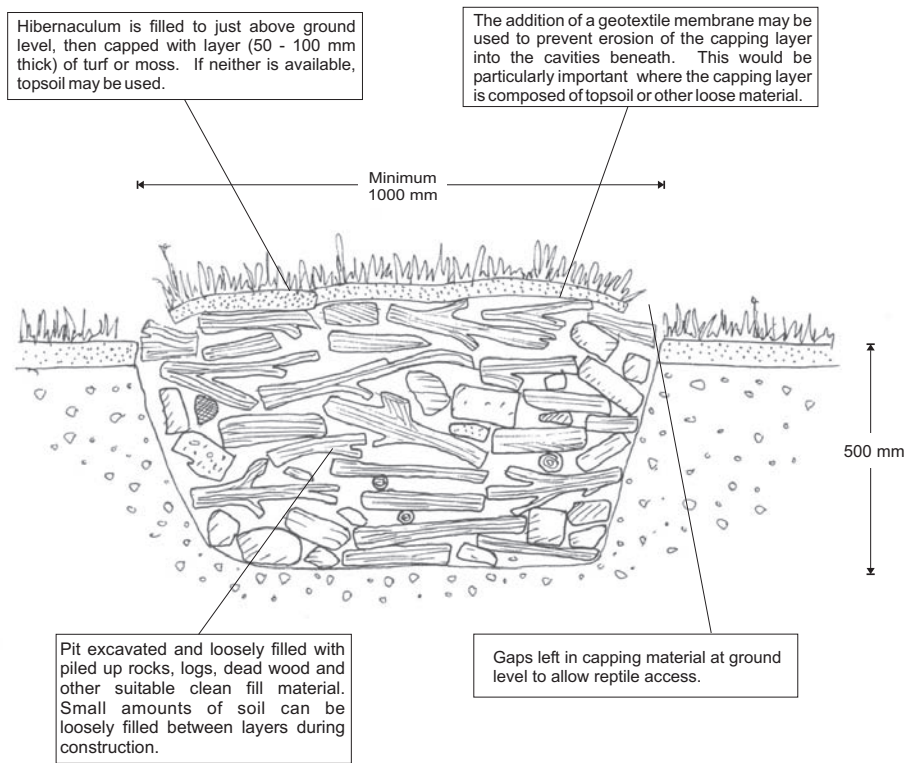
- Azam, C., Kerbiriou, C., Vernet, A., Julien, J.F., Bas, Y., Plichard, L., Maratrat, J., Le Viol, I. (2015). Is part-night lighting an effective measure to limit the impacts of artificial lighting on bats? *Global Change Biology* 21:4333–4341.
- Bat Conservation Trust. (2009). Bats and lighting in the 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
- Duverg , 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, H lker 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, Jurri n R. van Deijk, Willem N. Ellis, Roy H.A. van Grunsven, Rob de Vos, Rutger A. Vos, Markus Franz n 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>.

APPENDIX V REPTILE HIBERNACULA DESIGN

Hibernaculum on free-draining ground

Where ground conditions allow, the hibernaculum should be incorporated into a shallow pit. This design is more likely to remain frost-free, and will be less obtrusive and thus unlikely to be subject to interference.



Hibernaculum on impermeable ground

Where ground conditions are impermeable, then an 'above-ground' or mounded design should be utilised in order to prevent the hibernaculum from flooding. This design should also be used if it is not possible to excavate a pit for any other reason.

