A417 Missing Link
TR010056

6.2 Environmental Statement

Chapter 8 Biodiversity

Planning Act 2008

APFP Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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A417 Missing Link

Development Consent Order 202[x]

6.2 Environmental Statement

Chapter 8 Biodiversity

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8 Biodiversity

8.1 Introduction

8.1.1 This chapter provides an assessment of the potential impacts and effects on biodiversity from the construction and operation of the A417 Missing Link (the scheme), following the methodology set out in Design Manual for Roads and Bridges (DMRB) *LA 108 Biodiversity*[1].

8.1.2 This chapter details the methodology followed for the assessment, summarises the regulatory and policy framework related to biodiversity and describes the existing environment in the area surrounding the scheme. Following this, the design, mitigation and residual effects of the scheme are discussed, along with the limitations of the assessment.

8.2 Competent expert evidence

8.2.1 The biodiversity lead is a Chartered Environmentalist of the Society for the Environment (SocEnv), and a Full member of the Chartered Institute of Ecology and Environmental Management (CIEEM). They have the French equivalent of a BSc (Hons) in Ecosystems Biology, an MSc in Integrated Environmental Studies and an MPhil in Marine Biology and 15 years' experience working as a professional ecologist. Full details of relevant project experience and survey licences held are provided in ES Appendix 1.2 Competent expert evidence (Document Reference 6.4).

8.2.2 The biodiversity chapter technical reviewer is a Chartered Ecologist (CEcol) and Full member of the Chartered Institute of Ecology and Environmental Management (MCIEEM). They have a First-Class BSc (Hons) degree in Zoology from the University of Sheffield (2004). They have worked as a professional ecologist since 2005, with particular focus on the assessment and mitigation of the ecological impacts of development across a wide range of sectors. Full details of relevant project experience are provided in ES Appendix 1.2 Competent expert evidence (Document Reference 6.4).

8.3 Legislative and policy framework

8.3.1 A framework of national and local legislation and planning policy guidance exists to protect and conserve wildlife and habitats.

Legislation

8.3.2 The following relevant legislation exists to protect habitats and species of nature conservation importance:

- The Conservation of Habitats and Species Regulations 2017 (the 'Habitat Regulations 2017').
- The Ramsar Convention on Wetlands 1971.
- Wildlife and Countryside Act (WCA) 1981.
- Natural Environment and Rural Communities (NERC) Act 2006.
- Countryside and Rights of Way Act 2000.
- The Hedgerows Regulations 1997.
- Protection of Badgers Act 1992.
- The Eels (England and Wales) Regulations 2009.
- Salmon and Freshwater Fisheries Act 1975.

- The Water Environment (Water Framework Directive) (WFD) (England and Wales) Regulations 2017.

8.3.3 These pieces of legislation include a number of offences relating to protected species, and requirements for licences to allow construction works to proceed that would otherwise result in an offence. In addition, the Habitats Regulations 2017 set out the requirement for the consideration of the potential effects of a project on European designated sites.

8.3.4 The legislation and policy relating to specific species are further detailed within the ecological baseline reports, provided within the Biodiversity appendices (ES Appendices 8.1 to 8.24 (Document Reference 6.4)).

National policy

8.3.5 As discussed in ES Chapter 1 Introduction (Document Reference 6.2), the primary basis for deciding whether or not to grant a Development Consent Order (DCO) is the *National Policy Statement for National Networks*, (NPSNN, 2014[2]), which sets out policies to guide how DCO applications will be decided and how the effects of national networks infrastructure should be considered. Table 8-1 identifies the *NPSNN* policies relevant to biodiversity and then specifies where in the Environmental Statement (ES) chapter information is provided to address the policy.

Table 8-1 Relevant NPSNN policies for biodiversity assessment

Relevant NPSNN paragraph reference	Requirement of the NPSNN	Where in this ES chapter is information provided to address this policy
4.22 and 4.25	NPSNN describes the need under the Habitats Regulations 2017 to consider whether the scheme could have a significant effect on the objectives of a European site and the procedure to be followed.	A Habitats Regulations Assessment (HRA) has been undertaken, comprising the screening of likely significant effects on European protected sites and a statement to inform appropriate assessment. The HRA is presented in the Habitat Regulations Assessment: Screening Report and Habitats Regulations Assessment: Statement to Inform an Appropriate Assessment (both Document Reference 6.5).
5.22, 5.26 - 5.32, 5.34 and 5.35	NPSNN section 5: Biodiversity and ecological conservation, describes the process of Environmental Impact Assessment (EIA) and the need to assess any likely significant effects on all of the following: internationally, nationally and locally designated sites of importance for the conservation of biodiversity, protected species and habitats (including irreplaceable habitat of ancient woodland and veteran trees) and other species identified as being of principal importance for the conservation of biodiversity and the full range of potential impacts on ecosystems.	The assessment of effects on all biodiversity receptors is provided in section 8.10 Assessment of likely significant effects. As identified in section 8.10, the assessment of certain effects also relies upon information from ES Chapter 5 Air quality. ES Chapter 12 Population and human health and ES Chapter 13 Road drainage and the water environment (all Document Reference 6.2).

Relevant NPSNN paragraph reference	Requirement of the NPSNN	Where in this ES chapter is information provided to address this policy
5.23	NSPNN gives guidance on the principles that should be applied in the EIA and design development, including avoiding adverse impacts on sites, species and habitats (outlined in 5.22); providing appropriate mitigation measures as an integral part of a development and taking advantage of opportunities to conserve and enhance biodiversity features in and around development.	Section 8.9 Design, mitigation and enhancement measures outlines the design, mitigation and enhancement measures incorporated in the scheme.
5.29	Where a proposed development on land within or outside a Site of Special Scientific Interest (SSSI) is likely to have an adverse effect on an SSSI (either individually or in combination with other developments), development consent should not normally be granted. Where an adverse effect on the site's notified special interest features is likely, an exception should be made only where the benefits of the development at this site clearly outweigh both the impacts that it is likely to have on the features of the site that make it of special scientific interest, and any broader impacts on the national network of SSSIs.	The assessment on the Crickley Hill and Barrow Wake SSSI is included in section 8.10 Assessment of likely significant effects.
5.33	Development proposals potentially provide many opportunities for building in beneficial biodiversity or geological features as part of good design. When considering proposals, the Secretary of State should consider whether the applicant has maximised such opportunities in and around developments. The Secretary of State may use requirements or planning obligations where appropriate in order to ensure that such beneficial features are delivered.	Embedded design mitigation is included in full in ES Chapter 2, The project (Document Reference 6.2) and summarised in Section 8.9.5
5.36	Applicants should include appropriate mitigation measures as an integral part of their proposed development, including identifying where and how these will be secured.	Refer to Section 8.9, Design, mitigation and enhancement measures. Embedded design mitigation is included within ES Chapter 2, The project (Document Reference 6.2).
5.37	The Secretary of State should consider what appropriate requirements should be attached to any consent and/or in any planning obligations entered into in order to ensure that mitigation measures are delivered.	Mitigation measures are identified in the Register of Environmental Actions and Commitments (REAC), contained within ES Appendix 2.1 EMP, and Annex D LEMP (Document Reference 6.4).
5.38	The Secretary of State will need to take account of what mitigation measures may have been agreed between the applicant and Natural England and/or the MMO, and whether Natural England and/or or the MMO has granted or refused, or intends to grant or refuse, any relevant licences, including protected species mitigation licences.	Refer to Section 8.4.17 regarding Stakeholder engagement.

8.3.6 Particular attention has been made to the planning policy and strategy documents listed below that are applicable to assessing the impacts to the ecological resources:

- *NPSNN*, (2014).
- *National Planning Policy Fra*mework (NPPF), (2019).
- *National Planning Practice Guidance* (PPG) (2019).
- *UK-Post 2010 Biodiversity Framework* (replaced the previous UK Biodiversity Action Plan (BAP)).
- *Biodiversity 2020: A strategy for England's wildlife and ecosystem services, Natural England*, (2011).
- *A Green Future: Our 25 Year Plan to Improve the Environment* (Department for Environment, Food & Rural Affairs (Defra) (2018).
- *A Nature Recovery Network to create a Wilder Future*, The Wildlife Trusts (2018).

8.3.7 The Government's detailed policy on environmental mitigations for development is set out in section 5 Biodiversity and ecological conservation of the NPSNN:

"Biodiversity is the variety of life in all its forms and encompasses all species of plants and animals and the complex ecosystems of which they are a part. Government policy for the natural environment is set out in the Natural Environment White Paper (NEWP). The NEWP sets out a vision of moving progressively from net biodiversity loss to net gain, by supporting healthy, well-functioning ecosystems and establishing more coherent ecological networks that are more resilient to current and future pressures."

8.3.8 Biodiversity policy within the UK has been revised through the publication of the *UK Post-2010 Biodiversity Framework*[3] which supersedes the UK BAP and covers the period from 2011 to 2020. A total of 65 Priority Habitats and 1,150 Priority Species have been identified as the most in need of protection.

8.3.9 However, the UK list of priority species remains an important reference source and has been used to draw up statutory lists of priority species in England as required under section 41 of the NERC Act 2006. A total of 56 Habitats of Principal Importance and 943 Species of Principal Importance (HPI and SPI respectively) found in England are included in the section 41 of the NERC Act 2006 list. These habitats and species were identified as requiring action in the UK BAP and continue to be regarded as conservation policies in the subsequent UK post-2010 Biodiversity Framework.

Local policy and guidance

8.3.10 Consideration has been given to the following policies and guidance relating to biodiversity:

- *Cotswold District Local Plan 2001 – 2011* (adopted 2006) with particular focus on key policy 9 Biodiversity, geology and geomorphology[4].
- *Cotswold AONB Management Plan 2018-2023*[5] **–** Policy CE7: Biodiversity.
- *Gloucester City Plan* (Sustainability Appraisal Summary (2012).
- *Gloucester City Plan Sustainability Appraisal* (2013).
- *Gloucestershire Highways Biodiversity Guidance* (Version 3.1, December 2019).
- *Gloucester, Cheltenham and Tewksbury Joint Core Strategy 2011 – 2031*.

- *Gloucester, Cheltenham and Tewksbury Sustainability (Integrated) Appraisal* (SA).
- *Gloucester, Cheltenham and Tewksbury Strategic Environmental Assessment (SEA) Adoption Statement* 2017.
- *Gloucestershire Tree Strategy* (2020) Gloucestershire Local Nature Partnership.

Guidance and standards

8.3.11 A range of standards and guidance documents are available for biodiversity, but the principal assessment sources include:

- DMRB *LA 108 Biodiversity* (March 2020)[6], DMRB *LA 104 Environmental assessment and monitoring*[7], and DMRB *LA 115 Habitats Regulations assessment*[8].
- *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater Coastal and Marine (*2018) CIEEM[9].
- *Ancient woodland, ancient trees and veteran trees: protecting them from development* (2018) Natural England[10].

8.3.12 Guidance for specific species, groups and other ecological features is discussed in individual relevant sections or is provided in the ecological baseline reports (ES Appendices 8.1 to 8.24 (Document Reference 6.4)).

8.4 Assessment methodology

8.4.1 ES Appendix 4.5 Changes to scope and methodology (Document Reference 6.4) outlines the changes in scope and methodology since the submission of the Scoping Report in May 2019[11].

Assessment of biodiversity value and significance criteria

8.4.2 This assessment methodology is based on that set out in DMRB *LA 104 Environmental assessment and monitoring* and *LA 108 Biodiversity*. *LA 108* sets out a process for the establishment of the relative importance of the biodiversity resources including sites, habitats, species populations and assemblages of species, characterisation of predicted scheme impacts before and after mitigation and the subsequent assessment of significance of effects.

8.4.3 The assessment methodology for ecological resources is supplemented where appropriate with guidance from the CIEEM *Guidelines for Ecological Impact Assessment in the UK and Ireland*[9].

8.4.4 The assessment process has also relied on professional judgement by individuals with relevant expertise, recognising scheme specific circumstances and decisions have been made through consultation with stakeholders including Natural England.

Valuation of resources

8.4.5 The importance of resources including sites, habitats, species populations and assemblages of species is assessed in accordance with DMRB LA 108 as summarised in Table 8-2.

8.4.6 The valuation of bat roosts has been informed by guidance on valuing bats in ecological impact assessment by Wray et al[12]. The valuation of roosts considers

the distribution and relative rarity of the bat species based on its UK population size and the type of bat roost present. The guidance provides a framework for assigning roosts to geographic importance categories that are consistent with the values defined in DMRB *LA 108* as summarised in Table 8-2.

Table 8-2 Biodiversity resource importance

Importance	Typical biodiversity resources
International or European importance	
Sites	Sites including: 1) European sites: • Sites of Community Importance (SCIs). • Special Protection Areas (SPAs). • Potential SPAs (pSPAs). • Special Areas of Conservation (SACs). • Canditate or possible SACs (cSAC or pSACs) • Wetland of international importance (Ramsar site) 2) Biogenic Reserves, World Heritage Sites (where recognised specifically for their biodiversity value) and Biosphere reserves. 3) Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such.
Habitats	N/A
Species	Resident, or regularly occurring, populations of species which may be considered at an International or European level[13] where: • he loss of these populations would adversely affect the conservation status or distribution of the species at this geographic scale; or • the population forms a critical part of a wider population at this scale; or • the species is at a critical phase of its life cycle at an international or European scale. Bat roosts as defined in Wray et al[12]: • SACs designated for Annex II bat species (greater horseshoe (*Rhinolophus ferrumequinum)* and lesser horseshoe (*Rhinolophus hipposideros*), barbastelle (*Barbastellus barbastella*), Bechstein's (*Myotis Bechsteinii*)).
UK or National (England)	
Sites	Sites including: 1) Sites of Special Scientific Interest (SSSIs) 2) National Nature Reserves (NNRs) 3) National Parks 4) Marine Protected Areas (MPAs) including Marine Conservation Zones (MCZs) 5) areas which meet the criteria, but which are not themselves designated.
Habitat	Habitats including: 1) Areas of UK BAP priority habitats 2) Habitats included in the relevant statutory list of priority species and habitats; and 3) Areas of irreplaceable habitats including: • Ancient woodland • Ancient or veteran trees 4) areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such.

Importance	Typical biodiversity resources
Species	Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: 1) the loss of these populations would adversely affect the conservation status or distribution of the species at this scale; or 2) the population forms a critical part of a wider population at this scale; or 3) the species is at a critical phase of its life cycle at a UK or national scale Bat roosts as defined in Wray et al.[12]: • maternity sites for rarest species (greater horseshoe, Bechstein's, Alcathoe (*Myotis alcathoe*), greater mouse-eared (*Myotis myotis*), barbastelle, grey long-eared (*Plecotus austriacus*));
Regional (South-West England)	
Sites	Designated sites (non-statutory) including heritage coasts.
Habitats	Areas of habitats identified (including for restoration) in regional plans or strategies (where applicable)
Species	Species including: 1) Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: • the loss of these populations would adversely affect the conservation status or distribution of the species at a regional scale; or • the population forms a critical part of a wider regional population; or • the species is at a critical phase of its life cycle at a regional scale 2) Species identified in regional plans or strategies. Bat roosts as defined in Wray et al.[12]: • mating sites for rarer species (lesser horseshoe, whiskered (*Myotis mystacinus*), Brandt's (*Myotis brandtii*), Daubenton's (*Myotis daubentonii*), Natterer's (*Myotis nattereri*), Leisler's (*Nyctalus leisleri*), noctule (*Nyctalus noctula*), Nathusius' pipistrelle (*Pipistrellus nathusii*), serotine (*Eptesicus serotinus*)) and rarest species (greater horseshoe, Bechstein's, Alcathoe, greater mouse-eared, barbastelle, grey long-eared) including well used swarming sites • maternity sites (rarer species as above) • hibernation sites (rarest species as above) • significant hibernation sites for rarer/rarest species (as above) or all species assemblages
County (Gloucestershire)	
Sites	Wildlife/ nature conservation sites designated at a county level (or equivalent) level including: 1) Local Wildlife Sites(LWS) (and potential Local Wildlife Sites (pLWS) 2) Local Nature Conservation Sites (LNCS) 3) Local Nature Reserves (LNRs) 4) Sites of Importance for Nature Conservation (SINCs). 5) County Wildlife Sites (CWSs)
Habitats	Areas of habitat identified in the county of equivalent authority plans or strategies (where applicable)
Species	Species including

Importance	Typical biodiversity resources
	1) Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: • the loss of these populations would adversely affect the conservation status or distribution of the species across the County; or • the population forms a critical part of a wider population; or • the species is at a critical phase of its life cycle 2) Species identified in a county or equivalent authority area plans or strategies Bat roosts as defined in Wray et al.[12]: • maternity sites for common species (common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle (*Pipistrellus pygmaeus*), brown long-eared (*Plecotus auritus*)) • small numbers of hibernating bats for common species (as above) and rarer species (lesser horseshoe, whiskered, Brandt's, Daubenton's, Natterer's, Leisler's, noctule, Nathusius' pipistrelle, serotine) • feeding perches for rarer species (as above) and rarest species (greater horseshoe, Bechstein's, Alcathoe, greater mouse-eared, barbastelle, grey long-eared) • individual bats for rarer/rarest species (as above) • small numbers of non-breeding bats for rarer/rarest species (as above)
Local	
Sites	Wildlife/ nature conservation sites designated at a local level including sites including: 1) Local Wildlife Sites (LWS) 2) Local Nature Conservation Sites (LNCS) 3) Local Nature Reserves (LNRs) 4) Sites of Importance for Nature Conservation (SINCs) 5) Sites of Local Nature Conservation Importance (SLNCIs)
Habitats	Areas of habitat considered to appreciably enrich the habitat resource within, the locl context including features of importance for migration, dispersal, or genetic exchange.
Species	Populations/communities of species considered to appreciably enrich the habitat resource within the local context including features of importance for migration, dispersal or genetic exchange. Bat roosts as defined in Wray et al.[12]: • feeding perches for common species (common pipistrelle, soprano pipistrelle, brown long-eared) • individual bats for common species (as above) • small numbers of non-breeding bats for common species (as above) • mating sites for common species (as above)

Table taken from Table 3.9 of DMRB *LA 108* 'Biodiversity Resource Importance'

Characterisation of impacts

8.4.7 The potential impacts from the scheme on biodiversity resources of at least local importance are described and characterised in detail in accordance with Table 3.11 in DMRB *LA 108* as shown in Table 8-3.

Table 8-3 Level of impact and typical description

Level of impact		Typical description
Major	Adverse	1 Permanent/irreversible damage to a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact negatively affect the integrity or key characteristics of the resource.
	Beneficial	1 Permanent addition of, improvement to, or restoration of a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact positively affects the integrity or key characteristics of the resource.
Moderate	Adverse	1 Temporary/reversible damage to a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact negatively affects the integrity or key characteristics of the resource.
	Beneficial	1 Temporary addition of, improvement to, or restoration of a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact positively affects the integrity or key characteristics of the resource.
Minor	Adverse	1 Permanent/irreversible damage to a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
	Beneficial	1 Permanent addition of, improvement to, or restoration of a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
Negligible	Adverse	1 Temporary/reversible damage to a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
	Beneficial	1 Temporary addition of, improvement to, or restoration of a biodiversity resource; and 2 the extent, magnitude, frequency, and/or timing of an impact does not affect the integrity or key characteristics of the resource.
No change		No observable impact, either positive or negative.

Table taken from DMRB *LA 108* (Table 3.11 Level of impact and typical descriptions).

8.4.8 In accordance with DMRB *LA 108*, the level of impact on biodiversity features is also informed by CIEEM's *Guidelines for Ecological Impact Assessment in the UK and Ireland*[9].

8.4.9 The assessment of the impact of nitrogen deposition on designated habitats is completed using the outputs from the air quality modelling within ES Chapter 5 Air quality (Document Reference 6.2), and in accordance with DMRB *LA 105 Air quality*. The process is set out within the flow chart in Figure 2.98 of DMRB *LA 105*. The presumption is that the air quality attribute for all designated habitats considered within this assessment is set to restore. Therefore, if a change in nitrogen deposition predicted to a designated habitat is more than 1% of the lower critical load for the habitat being assessed, Table 21 in the Natural England's nitrogen deposition dose response report[14] is used to determine the lowest change in nitrogen deposition that would lead to loss of one species (i.e. a reduction in species richness). For habitat types not included in Table 21 of the Natural England report, the habitat with the lowest change in nitrogen deposition likely to result in the loss of one species (excluding sand dune habitats) is used, which is 0.4kg N/ha/yr.

8.4.10 Where the change in nitrogen deposition arising from the scheme upon designated habitats is predicted to be greater than 1% of lower critical load and greater than 0.4kg N/ha/yr, further assessment of the likely impact on the designated habitat is undertaken. This includes consideration of mitigation measures where feasible, in order to assess the significance of any residual effects.

8.4.11 Changes in nitrogen deposition of less than 1% of the lower critical load for the habitat being assessed are considered to result in imperceptible impacts to ecological receptors in accordance with this widely used environmental benchmark[15].

8.4.12 If the predicted increase in nitrogen deposition is greater than 1% of critical load, but less than the reference figure in Table 21 of the Natural England report, or 0.4kg N/ha/yr where the habitat type is not included within this report, then the impact of the change is not considered to result in a significant effect upon the designated habitat, in accordance with Figure 2.98 of DMRB *LA 105*.

Assessment of significance of effects

8.4.13 Environmental assessment and design of the scheme incorporates mitigation measures using a hierarchical system described in DMRB LA 104 as follows:

1. Avoidance and prevention: design and mitigation measures to prevent the effect (e.g. alternative design options or avoidance of environmentally sensitive sites).
2. Reduction/mitigation: where avoidance is not possible, then mitigation is used to lessen the magnitude or significance of effects.
3. Remediation/compensation: where it is not possible to avoid or reduce a significant adverse effect, these are measures to offset the effect.

8.4.14 In accordance with DMRB *LA 104* and *LA 108*, the importance of the biodiversity resource and the level of impact is used to determine the significance of an effect after avoidance and mitigation measures have been taken into account (the residual effect). Residual effects are categorised as Neutral, Slight, Moderate, Large, or Very Large as shown in Table 8-4. A significant residual effect is considered to be any effect within the Moderate, Large or Very Large categories.

8.4.15 As described in DMRB *LD 118 Biodiversity design*[16], where the use of the hierarchical system within DMRB *LA 104* does not resolve all identified adverse residual effects, compensation measures shall be developed. Such compensation measures are not considered within the assessment of the significance of the adverse effect for which the compensation has been developed. However, where compensation measures result in beneficial effects, these are reported as separate effects following the assessment methodology described throughout this section (8.4 Assessment methodology).

Table 8-4 Significance matrix

Resource importance	Level of Impact					
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
	International or European importance	Neutral	Slight	Moderate or large	Large or very large	Very large
	UK or National importance	Neutral	Slight	Slight or moderate	Moderate or large	Large or very large
	Regional importance	Neutral	Neutral or slight	Slight	Moderate	Moderate or large
	County or equivalent authority importance	Neutral	Neutral or slight	Neutral or slight	Slight	Slight or moderate
	Local importance	Neutral	Neutral	Neutral or slight	Neutral or slight	Slight

Table taken from DMRB *LA 108* (Table 3.13 Significance matrix)

8.4.16 The assessment of the significance of effects is also informed by guidance as provided within CIEEM's *Guidelines for Ecological Impact Assessment in the UK and Ireland*[9] and the professional judgement of ecologists experienced in the assessment of ecological impacts of major linear infrastructure schemes in the UK.

Stakeholder engagement

8.4.17 Ecologists have been involved in discussion, Technical Working Groups (TWGs) and other collaborative meetings with the Gloucestershire Wildlife Trust (GWT), the National Trust (NT), the Environment Agency (EA), Natural England (NE), the Woodland Trust and the Cotswolds Conservation Board (CCB)[17]. TWG and collaborative meetings discussed the shared scheme vision and more detailed design with regard to the multi-functional crossings, infrastructure crossings and ecological networks. Further details on the consultation relating to biodiversity is provided in the Statements of Common Ground (see Statement of Commonality (Document Reference 7.3), submitted with the DCO Application.

8.5 Assessment assumptions and limitations

8.5.1 The findings presented in this chapter represent those available at the time of writing and data collected to date. Every effort has been made to ensure that the findings of the study present as accurate an interpretation as possible of the status of flora and fauna within the study area.

8.5.2 Ecological surveys are limited by factors that affect the presence of plants and animals, such as the time of year, migration patterns and behaviour. Surveys undertaken were largely conducted at the optimal survey periods and using standard methodologies accepted by Natural England and other statutory bodies.

8.5.3 Field survey limitations are stated within the individual technical reports accompanying this ES chapter (see ES Appendices 8.1-8.24 (Document Reference 6.4)).

8.5.4 Where 'reasonable worst-case' valuations are necessary they have been made based on the information available. This has included consideration of any available field or desk study data (including aerial photography), a comparison with similar habitat areas occurring in the wider local area, and a qualitative

consideration against any factors that indicate suitability for the particular habitat or species in question. The degree of precaution built into the assessment is linked to the level of confidence in the existing data upon which the assessment is based. The majority of ecological surveys considered to be required have been completed but with some exceptions as described below.

8.5.5 Access to Emma's Grove woodland, situated to the east of Air Balloon roundabout, was not available in the relevant survey period to allow ground level trees assessments for bat roosts or a woodland National Vegetation Classification (NVC) to be undertaken. Due to the mature nature of the woodland, it is assumed that Emma's Grove provides suitable bat roosting habitat. Access outside of the optimal period for NVC survey has allowed a broad habitat assessment to be undertaken of the woodland. Emma's Grove includes some botanical ancient woodland indicator species. However, research of historical mapping does not show woodland at this location prior to 1600AD which is the date from which a continuously wooded area is considered ancient. The woodland first appears on the Ordnance Survey 25 inch first edition map, produced between 1844-1888. Adjacent ancient woodland is noted on Taylor's earlier maps of 1777 and 1800. For this assessment it is therefore considered that Emma's Grove is not ancient woodland. Veteran trees within or adjacent to Emma's Grove are assessed as separate irreplaceable habitat features.

8.5.6 Several *Myotis* day roosts were recorded in trees across the scheme. The species of the *Myotis* bat found in trees (through tree climbing and emergence surveys) could not be determined at the time of survey. According to Wray et al.[12], roosts of small numbers of non-breeding bats for rarer and rarest species are of county importance. The rarer and rarest species encompass all *Myotis* species found in the UK. Therefore, the two *Myotis* sp. day roosts are thus assigned county importance on a precautionary basis.

8.5.7 The scheme includes the demolition of several buildings and felling of a small number of trees around Grove Farm. A preliminary assessment of bat roosting potential was undertaken as part of the original bat surveys in 2018/2019. Due to the extent of the scheme at the time, several buildings and trees with low and moderate bat roosting potential were not subjected to further survey as they were to be retained at the time and not within the study area which would have required a higher survey effort. A small number of trees with moderate to high bat roosting potential located along Cowley Lane, which will be lost to the construction of the Cowley overbridge. These trees were not subject to the full extent of survey effort because they were to be retained at the time of survey and were not within a study area that would have required a higher survey effort.

8.5.8 Presence/absence surveys would be undertaken prior to demolition/ felling of the above features to inform any specific Natural England licensing requirements should roosting bats are present. Based on the preliminary assessment of roosting potential, these buildings and trees are unlikely to support roosts of different species or any greater conservation importance than are to be impacted elsewhere within the scheme. Therefore, the assessment of effects and principles of mitigation related to roost loss that are reported within this assessment would be relevant should roosts be found in pre-demolition or pre-felling surveys of these buildings and trees. There is no reasonable likelihood that such surveys would identify impacts to bat roosts that would result in additional significant residual effects.

8.5.9 Access restrictions during badger bait marking surveys in March and April 2019, due to farming practices such as lambing, meant that some areas within 500 metre buffers of main badger setts identified for further survey were not accessible within the bait marking survey period. In the case of one main sett, 50% of the area within 500m was not accessible for bait marking surveys. However, these areas were previously accessible during the walkover surveys undertaken in September and October 2018 and January and February 2019. It is considered that sufficient area and habitat features were accessible to determine the badger territories affected by the scheme.

8.5.10 Due to the absence of baseline fish data from the upper reaches of the tributary of Norman's Brook, assumptions about migratory fish species and resident communities of fish present within the scheme and the ZoI have been made based on habitat assessments and review of desk study data provided by the Environment Agency.

8.5.11 [redacted]

8.5.12 With regard to the impact assessment of changes in air quality upon designated habitats, the Air Pollution Information System (APIS) website[18] does not include a critical load for ancient woodland or veteran trees. The recommended values within nutrient nitrogen critical load ranges for use in air pollution impact assessments for broadleaved deciduous, coniferous and mixed woodland is 10-20kg N/ha/yr. This value has been used to inform the assessment for ancient woodland and veteran trees present within 200m of the ARN.

Limits of deviation (LoD)

8.5.13 The assessment has taken into account the maximum lateral and vertical LoD outlined within ES Chapter 2 The project (Document Reference 6.2).

8.5.14 For biodiversity, the worst-case scenario has been considered as the assessment takes account of the full extent of the scheme within the DCO Boundary. This scenario has identified and reported the effect that the maximum lateral and vertical LoD would realistically give rise to. This has, for example, taken into account the potential for the scheme to be brought into closer proximity to ecological features. Notwithstanding any potential deviation, all biodiversity mitigation measures described in section 8.9 Design, mitigation and enhancement measures would still be deliverable within the maximum LoD and would still fulfil their intended function.

8.6 Study area and survey methodology

8.6.1 The study area varied for different sites designations, species habitat types and species/species groups. The maximum extent of the study areas was determined by best practice guidance, the predicted Zone of Influence (ZoI) of the scheme and consultation with statutory bodies.

8.6.2 The maximum ZoI for internationally, nationally and locally designated sites including ancient woodland and veteran trees relating to potential air quality impacts is established at 200m from the Affected Road Network (ARN) within the limits of the Traffic Model, as detailed in the Combined Modelling and Appraisal (ComMA) Report (Document Reference 7.6) and in accordance with *DMRB LA105 Air quality*. Further details are provided within ES Chapter 5 Air quality (Document Reference 6.2).

8.6.3 Table 8-5 provides a summary of the desk study and field study area distances applied for each type of biodiversity resource relevant to the scheme. Specific guidance used to inform this distance and survey methodology are included in the relevant paragraphs below. Where there are any deviations from guidance, these are described and justified within the assessment and ecological baseline reports (ES Appendices 8.1 to 8.24 (Document Reference 6.4)).

8.6.4 The ecological baseline of the scheme and surrounding area was surveyed primarily over three years between 2017 and 2019, in which time several route options were considered, with the preferred route (option 30) being determined and announced in March 2019 (see ES Chapter 3 Assessment of alternatives (Document Reference 6.2)). Additional surveys for bats, invertebrates (both aquatic and terrestrial) and tufaceous[19] vegetation were conducted in spring and autumn 2020.

8.6.5 The study area for each survey was based upon the latest iteration of the scheme boundary at the stage the surveys commenced. Therefore, references to scheme boundary in Table 8-5 relate to the boundary at the time of survey which is stated in Table 8-6. Specific study areas for each survey type are shown in the relevant ecological baseline reports (ES Appendices 8.1 to 8.24 (Document Reference 6.4)). As part of the survey planning process, any design changes between draft to final scheme boundary were reviewed to determine whether they resulted in gaps in survey data that could be of relevance to the sufficiency of the assessment. Where this was considered to be the case, additional surveys were undertaken as described below. Where this was not possible the limitations are described above in section 8.5.

Table 8-5 Summary of the study area distances for each type of biodiversity resource relevant to the scheme

Biodiversity resource or survey type	Study area
Desk study	
Internationally designated nature conservation sites, including SAC, SPA and Ramsar Sites	18.6 miles (30km) from scheme boundary for sites designated for bats Any site with a component SSSI that has an Impact Risk Zone that extends into the scheme boundary 200 metre of the (ARN) for sites sensitive to nitrogen deposition (assessed for air quality impacts only)
Nationally and locally designated nature conservation sites, including NNR, SSSI, LNRs, priority habitats, LWS, ancient woodland, ancient and veteran trees and Royal Society for	Any SSSI that has an Impact Risk Zone that extends into the scheme boundary 1.2 miles (2km) from scheme boundary for other sites

Biodiversity resource or survey type	Study area
the Protection of Birds (RSPB) Reserves.	200m of the (ARN) for sites sensitive to nitrogen deposition (assessed for air quality impacts only)
Records of protected species and notable species from Gloucestershire Centre for Environmental Records (GCER).	1.2 miles (2km) from scheme boundary
Field survey	
Extended Phase 1 habitat survey	The Extended Phase 1 habitat survey was conducted up to 0.3 miles (500m) from the scheme boundary. Additional areas added to the scheme boundary after the initial Phase 1 habitat survey were updated where possible during subsequent field surveys in 2019. These areas are included within the Phase 1 habitat map in ES Figure 8.3 Phase 1 habitat survey (Document Reference 6.3). In limited areas where the scheme boundary was extended in 2020, only the immediate works area is included on the Phase 1 habitat survey map, e.g. drainage works at the western, northern and southern extent of the scheme. In such areas, additional Phase 1 mapping of a buffer of several hundred metres of land outside of the scheme boundary was not considered necessary to inform the assessment, as proposed works are small-scale and do not have potential to impact a wider area.
River Habitat Survey	Watercourses which were within the scheme boundary or wider catchment likely to be impacted by the works were considered, and the River Habitat Survey was ultimately undertaken along 500m lengths of two watercourses: tributary of Norman's Brook (upstream and downstream of the A417), and Horsbere Brook.
Assessment of habitat suitable for migratory and resident populations of fish such as salmonid species, European eel (*Anguilla anguilla*), lamprey species and shad species.	Fish habitat assessments were completed in six reaches located in the tributary of Norman's Brook (within scheme boundary), Horsbere Brook, and tributaries of the River Churn and River Frome (where indirect effects could occur).
Tufaceous vegetation	Four hydrological features where potential for tufaceous vegetation had been identified following a review of the Water Features Survey Report (ES Appendix 13.11 Water features survey, Document Reference 6.4) were assessed. These included sites that were within the scheme boundary or were hydrologically connected.
Hedgerow survey	All hedgerows within 50m of the scheme boundary.
Woodland survey - National Vegetation Classification	Woodland sites within 200m of the scheme boundary were scoped in for NVC surveys if they had the potential to support protected or notable plant species, were designated for their botanical interest, and/or were listed on the Ancient Woodland Inventory (AWI). This distance was used to account for potential air quality impacts which have potential to have adverse impacts within 200m of the air pollution source in accordance with *DMRB LA 105 Air quality.*
Botanical Survey - National Vegetation Classification	Grassland sites of potential conservation importance selected based on the Phase 1 habitat Map within the scheme boundary or hydrologically connected sites.
Bat surveys – ground level tree assessments (GLTAs)	Trees within 100m of the scheme options at the time of survey (which includes all those within the scheme boundary) were surveyed from ground level in summer 2018.

Biodiversity resource or survey type	Study area
Bat surveys – aerial tree climbing	Following the GLTA results, aerial tree climbing surveys were conducted on all trees with high bat roosting potential within 100m of the scheme boundary, and all trees with moderate potential within 20m of the scheme boundary.
Bat surveys – internal building inspections	Internal inspections were conducted on all high potential buildings within 100m of the scheme boundary, all buildings with moderate potential to support roosting bats within 20m of the scheme boundary, and all buildings with low potential to support roosting bats which would be directly impacted.
Bat surveys – dusk emergence and dawn re-entry surveys	Moderate and high potential buildings and trees, and low potential buildings within the scheme boundary were included in emergence and re-entry surveys. Buildings and trees with moderate and high suitability within 20m and 100m of the scheme boundary, respectively, were also subject to emergence and re-entry surveys.
Bat surveys – hibernation surveys	Any caves or other underground features which could provide suitable hibernation conditions within 100m of the scheme boundary. The study area was extended beyond the 100m buffer where highly suitable features had been highlighted, including caves around Birdlip and deep rock fissures along Crickley Hill.
Bat surveys – activity transects and automated detector surveys	Seven transects designed to cover suitable bat foraging and commuting habitat within 250m of the scheme boundary. Three static detectors were deployed for each transect route.
Bat surveys – crossing points	Seven bat crossing point locations along the scheme alignment.
Bat surveys – bat trapping and radio-tracking	In woodlands/tree-dominated habitats within or adjacent to the scheme boundary.
Badgers – surveys to identify and classify badger setts including activity level, followed by badger bait marking of main setts.	Surveys were conducted within a 500m area of the scheme boundary.
Wintering and breeding bird survey transects	One pre-determined transect route designed to cover all of the habitats suitable for breeding birds present within 250m of the scheme boundary with particular focus upon those areas that were likely to be directly affected by the scheme.
Barn owl (*Tyto alba)* surveys	Stage 1 (On-site scoping) and Stage 2 (Investigative Field Survey) were combined into one walkover undertaken within 0.9 miles (1.5 kilometres) of the scheme boundary. Stage 3 (Nest Verification Surveys) was completed within 500m of the scheme boundary.
Dormouse (*Muscardinus avellanarius)*	Suitable habitat within 250m of two scheme options (route options 12 and 30[20]) which includes suitable habitat within 250m of the scheme boundary.
Great crested newt (*Triturus cristatus)* surveys, including Habitat Suitability Index (HSI) assessments, environmental DNA (eDNA) surveys and population size class estimate surveys.	All ponds and other potentially suitable waterbodies identified within 500m of two scheme options (route options 12 and 30) were assessed for their suitability to support great crested newts using the standardised Habitat Suitability Index (HSI) methodology[21]. Further eDNA surveys were undertaken of ponds within 500m of the scheme boundary. Population size class estimate surveys were undertaken on ponds testing positively for great crested newt eDNA within 250m of the scheme boundary.

Biodiversity resource or survey type	Study area
Reptiles	A habitat suitability assessment, presence/likely absence surveys and population assessment surveys were conducted within 100m of the scheme boundary.
Otter (*Lutra lutra)*	Following the Extended Phase 1 habitat survey, three watercourses within 250m of the scheme boundary were identified as having potential to support otters: Upper Frome, Norman's Brook and its tributaries and Horsbere Brook. A fourth watercourse; Coldwell Bottom, a tributary of the River Churn, was assessed for its suitability for otters in July 2019. This was added following consultation with the Environment Agency regarding the potential suitability of this watercourse, in particular with regard to otters moving between catchments. This watercourse, which is often dry and very shallow, was surveyed once. A minimum survey extent of 1.2 miles (2km) was covered for each watercourse.
Water vole (*Arvicola amphibius)*	Watercourses wholly or partially within 250m of the scheme boundary were surveyed for water vole, including habitat suitability and presence/absence. The section of the tributary of Norman's Brook to the south of the A417 falls within 250m of the scheme boundary and was surveyed along its entire length until the point at which it is culverted under the A417. Only 90m of the River Frome Upper Tributaries falls within 250m of the scheme boundary, but surveys were continued for a minimum of 200m upstream and 200m downstream where access was available and habitat was suitable.
White-clawed crayfish (*Austropotamobius pallipes)*	Within scheme boundary (tributary of Norman's Brook) and where indirect effects could occur (River Frome Upper Tributaries)
Terrestrial invertebrates excluding Roman snails (*Helix pomatia)*	Suitable terrestrial invertebrate habitats, including broadleaved woodland, open grassland with veteran trees and calcareous grassland (as identified within the Extended Phase 1 habitat survey) within or adjacent to the scheme boundary (within 0.3 miles (500m)).
Roman snail	Suitable habitats within the scheme boundary.
Aquatic invertebrate assessment through kick sampling and manual searching.	Within scheme boundary (tributary of Norman's Brook) and where indirect effects could occur (River Frome and River Churn - Upper Tributaries).

8.6.6 A desk study was carried out, followed by field studies. Definition of the desk and field study areas follows DMRB *LD 118 Biodiversity design*, DMRB *LA 115 Habitats Regulations assessment* (January 2020) and other available sources of survey good practice guidance referenced below and in ES Appendices 8.1 to 8.24 (Document Reference 6.4).

Desk study methodology

8.6.7 A desk study was undertaken in 2017 to collate and review records of statutory and non-statutory sites designated for biological reasons, protected and notable species and notable habitats within 1.2 miles (2 kilometres) of the scheme options considered at the time. This search area was extended to 18.6 miles (30 kilometres) for SACs where bats are a qualifying species. This desk study was updated in December 2019 to account for any additional protected and notable species and notable habitat records. In 2020 the desk study was extended to

include internationally designated sites which are hydrologically connected to watercourses potentially affected by the scheme, and to include internationally designated sites that fall within 200m of the Affected Road Network (ARN). The following organisations and resources were consulted to compile the desk study:

- Multi-Agency Geographic Information for the Countryside (MAGIC) (Defra).
- Gloucestershire Centre for Environmental Records (GCER) in February 2017 and December 2019.
- Additional habitat and protected and notable species data were provided by the National Trust (NT) and Gloucestershire Wildlife Trust (GWT) for records around Crickley Hill and Barrow Wake SSSI (comprising Crickley Hill and Barrow Wake Nature Reserve).
- National Trust report (2015): Nature Conservation Evaluation, Crickley Hill, Gloucestershire.
- Additional winter records of horseshoe bats for the past ten years at Birdlip cave and Cranham mine were provided by Dr Roger Ransome in December 2019, along with ring data of ringed bats caught during the bat trapping surveys (2019-2020).
- National Trust report by Dr K. Alexander (2019): Crickley Hill baseline saproxylic invertebrate survey.
- Woodland Trust, for records of veteran trees.
- Environment Agency freshwater fish and aquatic invertebrate records.

8.6.8 In 2006, an Assessment of an earlier iteration of the scheme which covered the options considered at the time was undertaken and results reported in the A417 Cowley to Brockworth Bypass Improvement Scheme - Stage 2 Ecology and Nature Conservation Report[22]. Key findings of this report formed part of the desk study and they are considered within this chapter.

Field survey methodology

8.6.9 The field survey methods are summarised within Table 8-6 and additional details, including limitations and figures, are provided in the baseline reports in ES Appendix 8.1 to 8.25 (Document Reference 6.4).

Table 8-6 Summary of field survey methods used for each type of biodiversity resource relevant to the scheme

Biodiversity survey	Field survey methods	Dates of survey	Reference/ Appendix
Extended Phase 1 habitat survey	Habitats within the study area were mapped, and potential for protected and notable species established following the standard JNCC methodology[23].	May and June 2017, and various months in 2019, 2020 and 2021	ES Appendix 8.1 (Document Reference 6.4), and the 2017 Preliminary Ecological Appraisal report[24].
River Habitat Survey	The physical structure and quality of watercourses within the study area were assessed following published standards for River Habitat Surveys[25].	October 2019 and January 2020	ES Appendix 8.23 (Document Reference 6.4) ES Figures 8.6-8.12 (Document Reference 6.3)

Biodiversity survey	Field survey methods	Dates of survey	Reference/ Appendix
Fish habitat assessment	Fish habitat assessment consisted of mapping fish habitat according to habitat types adapted from the EA *Fisheries Technical Manual 4 - Restoration of riverine salmon habitats*[26] and *Monitoring the River, Brook and Sea Lamprey*[27].	October 2019 and January 2020	ES Appendix 8.23 (Document Reference 6.4)
Tufaceous vegetation	In the absence of a standard methodology for this type of assessment, the methodology used to assess tufaceous vegetation was based on professional judgement informed by the research work undertaken by Farr, Graham and Stratford in 2014[28].	March 2020	ES Appendix 8.24 and ES Appendix 13.11 (Document Reference 6.4) ES Figure 8.29 (Document Reference 6.3)
Hedgerow	Hedgerows within the study area were surveyed in accordance with methodology laid out in the *Hedgerow Survey Handbook 2007*[29], and *The Hedgerows Regulations 1997*[30].	June 2019	ES Appendix 8.2 (Document Reference 6.4).
National vegetation classification (NVC)	NVC surveys were undertaken for woodland and grassland following best practice guidelines and standard methodology[31] [32]. Plant species are named in accordance with guidance, except for the naming of NVC communities, which are based on detailed descriptions of vegetation communities provided by Rodwell[33].	May (woodland) July and August (grassland) 2019	ES Appendix 8.3 and ES Appendix 8.4 (Document Reference 6.4)
Bats	The following surveys were undertaken: ground level tree assessments, aerial tree climbing surveys, internal and external inspections, dusk emergence and dawn re-entry surveys, hibernation surveys, bat activity transect surveys, automated detector surveys, bat crossing point surveys, bat trapping and radio-tracking surveys, The surveys were undertaken with consideration of current best practice[34] [35] and in accordance with the conditions of Natural England licences 2019-40186-SCI-SCI (for the bat trapping and radio-tracking work in July and September 2019) and 2020-46090-SCI-SCI-1 (for the bat trapping and radio-tracking work in May 2020).	Appropriate survey seasons 2018 to 2020 GLTA of trees in Emma's Grove - March 2021.	ES Appendix 8.5 (confidential), ES Appendix 8.6, ES Appendix 8.7 and ES Appendix 8.8 (confidential) (Document Reference 6.4) ES Figures 8.4 and 8.22-8.28 (Document Reference 6.3)
Badger	Badger walkover surveys and badger bait marking surveys were conducted in accordance with best practice guidelines[36] [37] [38] [39] to assess presence of badger setts, activity status and territory ranges.	Walkover: September and October 2018, January, February 2019. Bait marking: March and April 2019 Walkover of Emma's Grove and adjacent fields: 2021	ES Appendix 8.9 (confidential) (Document Reference 6.4)

Biodiversity survey	Field survey methods	Dates of survey	Reference/ Appendix
Breeding birds	Breeding bird surveys were conducted in accordance with the Common Bird Census [40]. Species and behaviour were recorded using the standard British Trust for Ornithology (BTO) codes.	April to June 2019	ES Appendix 8.10 (Document Reference 6.4)
Wintering birds	Wintering bird surveys were conducted following the same transect route as the breeding bird surveys. Species and behaviour were recorded using the standard British Trust for Ornithology (BTO) codes.	October 2018 to February 2019	ES Appendix 8.11 (Document Reference 6.4)
Barn owl	Stage 1, Stage 2 and Stage 3 barn owl surveys were carried out using best practice guidance from Shawyer 2011[41] to identify Potential Nest Site (PNS); Occupied Breeding Site (OBS); Active Roost Site (ARS); and/or Temporary Roost Site (TRS).	March to August 2019	ES Appendix 8.12 (confidential) and ES Appendix 8.13 (confidential) (Document Reference 6.4) ES Figures 8.15-8.19 (Document Reference 6.3)
Hazel dormouse	A minimum of 50 artificial nest tubes were deployed in suitable and connected habitat at each site between May and August 2018 and checked between July and August 2018, and April and September 2019 to achieve, and in many cases exceed a minimum score of 20 points for each site, following good practice guidance[42] The scoring system allocates a number of points to each survey visit undertaken at a site, which varies according to how optimal the month of survey is for finding signs of dormice (e.g. 20 points could be achieved by fewer checks in more optimal survey months, or more checks in less optimal months).	2017 (habitat suitability) April 2018 to September 2019 presence/likely absence	ES Appendix 8.14 (Document Reference 6.4)
Great crested newt	Waterbodies within the study area were subject to Habitat Suitability Index (HSI) assessments, (eDNA) surveys where suitable and, with subsequent population size class estimate surveys conducted where required, in accordance with standard best practice[43] [44]. Due to an extension in the DCO Boundary for potential drainage works at Bentham Lane at the west of the scheme in 2019, a further three waterbodies fell within the study area that were not included within the original assessment. Desk study data for records of great crested newts has been obtained for these ponds and a great crested newt survey report submitted with a planning application detailing results of population surveys in 2019. The great crested newt report associated with these records is available on the Tewksbury Borough Council website[45].	HSI 2017 -2019 Additional ponds scoped in in 2020 eDNA - May 2018 and June 2019. Additional ponds April and May 2021. Population survey May 2019	ES Appendix 8.15 (Document Reference 6.4)

Biodiversity survey	Field survey methods	Dates of survey	Reference/ Appendix
	Furthermore, due to a change to the area required for drainage works at the north of the scheme in 2020, a further three waterbodies at National Star College Golf Course became included within the 500m study area from the DCO Boundary. These waterbodies were assessed for habitat suitability for great crested newts in September 2020 and subject to eDNA survey in April and May 2021.		
Reptiles	A habitat suitability assessment was completed for the study area, with subsequent survey visits to determine presence/absence (seven surveys) and population size (20 surveys) and importance (as required), in accordance with best practice guidelines[46]. Eighteen sites were identified as requiring further presence/ absence surveys, though one of these (at Crickley Hill) was subject to monitoring was undertaken by South Gloucester Amphibian and Reptile Group (SGARG) and not duplicated to avoid excessive disturbance to reptiles. An additional ten specific adder sites were set up in targeted areas within existing reptile survey sites.	2017 (habitat suitability) June – October 2018 and March to September 2019 (presence absence and population)	ES Appendix 8.16 (Document Reference 6.4)
Otter	Watercourses within the study area that were identified during the Extended Phase 1 habitat survey as having potential to support otter were surveyed for otter in accordance with best practice guidelines[47] [48] [49].	2018 and 2019	ES Appendix 8.17 (Document Reference 6.4).
Water vole	Habitat suitability assessments and presence/absence surveys for water vole were conducted within the study area in accordance with published guidance[50] [51].	August 2018 and May 2019	ES Appendix 8.18 (Document Reference 6.4).
White-clawed crayfish	Detailed habitat assessments and presence/absence surveys for white-clawed crayfish were undertaken within the study area, comprising hand searches and baited trapping surveys. The survey methodology followed the protocol outlined in the JNCC CSM Guidance for Freshwater Fauna[52], which is based on the method in LIFE in UK Rivers Project[53].	October 2018	ES Appendix 8.19 (Document Reference 6.4).
Terrestrial invertebrate	Suitable habitats were surveyed three times through visual searching, sweep netting, beating vegetation, grubbing and moth trapping. Species requiring further identification were collected and identified under microscope.	June to August 2019, May to June 2020	ES Appendix 8.20 (Document Reference 6.4).
Roman snail	A habitat suitability assessment was undertaken of habitats within the study area, with subsequent nocturnal torchlight surveys undertaken for habitats identified as being of high or moderate potential to support Roman snail.	October 2019	ES Appendix 8.21 (Document Reference 6.4) Es Figure 8.13-8.14 (Document Reference 6.3)

Biodiversity survey	Field survey methods	Dates of survey	Reference/ Appendix
Aquatic invertebrate	Invertebrate kick sampling was undertaken within the tributary of Norman's Brook, the River Frome and the River Churn. Under laboratory conditions, specific biological indices were calculated to analyse the invertebrate community data[54] [55] [56] [57]. The River Invertebrate Classification Tool[58] was used to generate WFD statuses for each site.	Autumn 2019, spring and autumn 2020	ES Appendix 8.22 (Document Reference 6.4) ES Figures 8.20-8.21 (Document Reference 6.3)
Other section 41 Species of Principal Importance (SPI)	Dedicated surveys were not undertaken for the remaining SPIs. However, desk study records, incidental sightings and knowledge of the presence of suitable habitat gathered during other surveys, has informed professional judgement as to the likelihood of other SPI species occurring within the scheme boundary.	N/A	N/A

8.7 Baseline conditions

8.7.1 Desk study data for each habitat and protected species is summarised within each relevant sub-heading, which is followed by the field survey results. These baseline studies are used to identify biodiversity resources within the study area and to establish their value in accordance with *DMRB LA 108.*

Statutory Designated sites

8.7.2 Statutory designated sites within the study area are summarised in Table 8-7. ES Figure 8.1 Statutory designated sites (Document Reference 6.3) shows the location of these sites in relation to the scheme.

8.7.3 There are three internationally designated sites within the study area of the scheme, which are of international importance. These are:

- Cotswold Beechwoods SAC
- Wye Valley and Forest of Dean Bat Sites SAC
- North Meadow and Clattinger Farm SAC

8.7.4 There are four nationally designated sites within the study area of the scheme, which are of national importance. These are:

- Crickley Hill and Barrow Wake SSSI
- Bushley Muzzard Brimpsfield SSSI
- Cotswold Commons and Beechwoods SSSI
- Leckhampton Hill and Charlton Kings Common SSSI

8.7.5 All measurements of distances of designated sites, habitats and protect species have been calculated from the DCO Boundary.

Table 8-7 Statutory designated sites within the study area

Site	Reasons for designation	Distance from the DCO Boundary
Statutory sites of international importance		
Cotswold Beechwoods SAC	Cotswolds Beechwoods SAC is 82% broadleaved deciduous woodland and represents the most westerly block of (*Asperulo-Fagetum)* beech forests in the UK. The woodland has a species-rich flora with rare plants, including red helleborine (*Cephalanthera rubra)*, stinking hellebore (*Helleborus foetidus)*, narrow-lipped helleborine (*Epipactis leptochila)* and wood barley (*Hordelymus europaeus)*. The woods are structurally varied with some areas of remnant beech coppice and blocks of high forest. There is also a rich mollusc fauna here.	291m west
Wye Valley and Forest of Dean Bat Sites SAC	The Wye Valley and Forest of Dean Bat Sites SAC contains the greatest concentration of lesser horseshoe bat in the UK, with 26% of the national population present. The importance of the site lies in the excellent breeding population and most sites on the complex are maternity roosts. There is also a population of greater horseshoe bats present and the site contains the main maternity roost for bats in the area. The bats are believed to hibernate in many of the disused mines in the area.	13.7 miles (22km) west
North Meadow and Clattinger Farm SAC	The 104.88ha site in the Thames Valley represents an exceptional survival of the traditional patterns of management of lowland hay meadows which are an Annex 1 habitat and the primary reason for selection of the site. The site also contains a very high proportion (>90%) of the surviving UK population of fritillary (*Fritillaria Meleagris)* a species characteristic of damp lowland meadows and now rare throughout its range.	12.4 miles (20km) south east - within study area for air quality impacts only
Statutory sites of national importance		
Crickley Hill and Barrow Wake SSSI (comprising Crickley Hill and Barrow Wake Nature Reserve)	Within the Cotswolds AONB, the Crickley Hill and Barrow Wake SSSI comprises two sites: Crickley Hill and Barrow Wake Nature Reserve. Crickley Hill is co-owned and managed by Gloucestershire Wildlife Trust and the National Trust and Barrow Wake is owned by Gloucestershire Wildlife Trust and co-managed with the National Trust. The site contains a range of habitats characteristic of the Cotswold limestone, including species-rich grassland, scrub and semi-natural woodland, together with nationally important rock exposures. Several types of grassland are present and feature many calcicole herbs including clustered bellflower (*Campanula glomerate)* and chalk milkwort (*Polygala calcarean)* and several orchids, with the notable musk orchid (*Herminium monorchis)* locally frequent. The diversity of vegetation provides habitat for a variety of invertebrates including the marsh fritillary (*Eurodryas aurinia)*, the notable Cistus Forester moth (*Adscita Geryon)* and the very local snail (*Abide secale)*.	Partly within
Bushley Muzzard, Brimpsfield SSSI	The Bushley Muzzard, Brimpsfield SSSI is one of a small number of marshes in the Cotswolds and is of particular importance for its species richness and uncommon plant species. Dominant plant species are jointed rush (*Juncus articulates)*, hard rush (*Juncus inflexus)* and Yorkshire fog (*Holcus lanatus)*. There are eight species of sedge present, including the scarce yellow sedge (*Carex lepidocarpa)*. There are also a number of orchid species including early marsh orchid (*Dactylorhiza incarnate)* and hybrid marsh orchids (*D. fuchsii x incarnata)* and (*D. fuchsii x pratermissa)*. Unimproved calcareous permanent pasture surrounds the marsh areas.	218m west

Site	Reasons for designation	Distance from the DCO Boundary
Cotswold Commons and Beechwoods SSSI (part of Cotswold Beechwoods SAC)	The importance of the Cotswold Commons and Beechwoods SSSI lies in the ancient beech woodlands which are among the most diverse and species-rich of their type. The canopy is dominated by beech (*Fagus sylvatica)* with an understory of holly (*Ilex aquifolium)* and yew (*Taxus bacata)*. The field layer consists mainly of bramble (*Rubus fruticosus)*, dog's mercury (*Mercurialis perennis)* and ivy (*Hedera helix)*. A number of nationally rare plants also occur, including fingered sedge (*Carex digitate)*, wood barley and stinking hellebore. There are also areas of wet woodland, mixed conifer and broadleaved plantation and hazel (*Corylus avellana)* coppice as well as unimproved calcareous pastures. Several nationally rare terrestrial snails are present in the ancient woodland sites including (*Ena montana)* and (*Phenocolimax major)*. Some disused limestone mines within the notified area are used as winter roosts by several bat species. The majority of the SSSI falls within the boundary of the SAC designation, with additional areas of the SSSI extending beyond the SAC boundary.	291m west
Leckhampton Hill and Charlton Kings Common SSSI	A range of habitats are present including unimproved calcareous grassland, scrub, woodland, scree slopes and cliff faces. The most important and extensive feature is the calcareous grassland. This mainly consists of a tall ungrazed sward dominated by tor-grass (*Brachypodium pinnatum*) and upright brome (*Bromus erectus*) with meadow oat-grass (*Avenula pratensis)*, sweet vernal-grass (*Anthoxanthum odoratum)*, and quaking grass (*Briza media)*. Herb species present include salad burnet (*Sanguisorba minor)*, common rock-rose (*Helianthemum nummularium*) and common bird's-foot-trefoil (*Lotus corniculatus)*. There is extensive scrub development over parts of the site. Two principal types of scrub could be distinguished: mixed broadleaf scrub dominated by hawthorn (*Crataegus monogyna)* with blackthorn (*Prunus spinosa)* and wild rose *Rosa sp*.; and gorse scrub consisting of gorse (*Ulex europaeus)* with occasional pockets of ash (*Fraxinus excelsior)* regeneration.	0.7 miles (1.2km) north-east

Non-statutory designated Sites

8.7.6 There are 14 non-statutory sites and four potential non-statutory sites within the 1.2 mile (2 kilometre) study area. These are Local Wildlife Reserves (LWR), Local Wildlife Sites (LWS)[59], Conservation Road Verges (CRV), and potential LWS (pLWS). The non-statutory sites are summarised in

Table 8-8. ES Figure 8.2 Non-Statutory designated sites (Document reference 6.3) shows the location of these sites in relation to the scheme.

8.7.7 These non-statutory sites have been designated by the local planning authorities and are protected through local planning policies as they support important habitats and/or species of nature conservation value within the county.

8.7.8 Non-statutory sites are of county importance except for sites that fall into more than one designation category, in which case the highest value category applies. Crickley Hill County Park and LWR, and Barrow Wake LWR are components of Crickley Hill and Barrow Wake SSSI and are therefore of national importance. Sites that include ancient woodland are valued as national importance, as per the section on irreplaceable habitat below.

Table 8-8 Non-statutory designated sites within a 1.2 mile (2 kilometre)

Site	Reasons for designation	Distance from DCO Boundary in meters (m) and miles /kilometres (km)
Non-statutory sites of national importance		
Barrow Wake Gloucestershire Wildlife Trust Reserve LWR	A site containing herb-rich calcareous grassland where five species of orchid have been recorded.	Adjacent/partly within DCO Boundary
Crickley Hill Country Park Gloucestershire Wildlife Trust Reserve LWR	A large heterogeneous area of species-rich calcareous grassland of varying slope and aspect, scrub and semi-natural woodland.	Adjacent/within DCO Boundary
Ullen Wood LWS	Ancient semi-natural broadleaved woodland sites larger than two hectares. This woodland is split into compartments under different ownership. Much of the woodland is managed under a coppice cycle.	Adjacent to DCO Boundary
Cowley and Wards Woods LWS	Ancient semi-natural broadleaved woodland sites larger than 2ha.	148m east
Hawcote Hill Wood LWS	Ancient semi-natural broadleaved woodland sites larger than 2ha.	252m west
Poston, Syde and Ostrich Woods LWS	Ancient semi-natural broadleaved woodland sites larger than 2ha.	556m south-west
Park Wood (Brimpsfield) LWS	Ancient semi-natural broadleaved woodland sites larger than 2ha.	615m south
Hartley Wood LWS	Ancient semi-natural broadleaved woodland sites larger than 2ha.	1 mile (1.7km) north-east
Hazel Hanger Wood LWS	Ancient semi-natural broadleaved woodland sites larger than 2ha.	1 mile (1.7km) south-west
Non-statutory sites of county importance		
Haroldstone Fields (Crickley Hill) Potential LWS	An area north of the A417 comprising a mosaic of neutral and calcareous grassland.	Adjacent/partly within DCO Boundary
Bentham, Dog Lane Fields Potential LWS	A site containing rough grassland, tall herbs, scrub, ponds, wetland and dead/veteran trees.	Adjacent to DCO Boundary
River Frome Mainstream and Tributaries LWS	Structural diversity with significant botanical and animal interest with a variety of bankside, emergent and aquatic vegetation. Riparian mammals are present and white-clawed crayfish are present within the wider catchment.	Adjacent to DCO Boundary
Coldwell Bottom LWS	Contains calcareous semi-natural grassland.	281m east
Birdlip (Hawcote Hill) Former Conservation Road Verge	This is a former road verge of conservation importance. The narrow banked verge supported priority habitats mixed hedgerows and lowland calcareous grassland along about 0.2 miles (250m), both sides of a minor road. Flora includes field scabious (*Knautia arvensis),* wild	468m south-west

Site	Reasons for designation	Distance from DCO Boundary in meters (m) and miles /kilometres (km)
	basil (*Clinopodium vulgare),* salad burnet (*Sanguisorba minor),* common restharrow (*Ononis repens)* and greater knapweed (*Centaurea scabiosa).* Meadow crane's-bill (*Geranium pratense)* were also abundant. This verge was removed from the CRV register in 2020 following a survey by the Wildlife Trust in July 2019 which showed it to be now species poor with no evidence of common restharrow of greater knapweed. It is however still of some conservation interest[60].	
Little Bittomes LWS	A site of invertebrate interest.	722m west
Witcombe Reservoirs LWS	Contains lakes, reservoirs and gravel pits of importance, all of which are larger than 0.25ha.	0.6 miles (1km) west
Gorveridge Banks LWS	Contains unimproved and semi-natural grassland.	0.7 miles (1.1km) south-west
Stonehill Valley LWS	Contains unimproved and semi-natural grassland.	0.9 miles (1.4km) south-west
Orchard Meadow Potential LWS	An area of damp neutral grassland.	0.9 miles (1.4km) south-west
Ostrich Bank Potential LWS	An area of herb rich calcareous grassland and scrubby calcareous grassland.	1.1 miles (1.8km) south

Irreplaceable Habitat - Ancient woodland and veteran trees

Ancient woodland

8.7.9 There are nine ancient woodland sites listed on the AWI as shown in Table 8-9. The majority are also LWS as shown in Table 8-8. Ancient woodland is considered to be any area that has been continuously wooded since 1600 AD[10]. Ancient woodlands are considered to be irreplaceable habitat and are of national importance, irrespective of whether they are listed on Natural England's AWI. However, Witcombe and Buckle Wood is a component part of the Cotswold Beechwood SAC and SSSI and therefore is of international importance.

Table 8-9 Ancient woodland sites within 1.2 mile (2 kilometre)

Ancient woodland Site	Reasons for designation	Distance from DCO Boundary
National importance		
Ullen Wood AWI site	Ancient semi-natural broadleaved woodland sites larger than two hectares. This woodland is split into compartments under different ownership. Much of the woodland is managed under a coppice cycle.	Adjacent to DCO Boundary
Cowley and Wards Woods AWI site	Ancient semi-natural broadleaved woodland sites larger than 2ha.	148m east
Hawcote Hill Wood AWI site	Ancient semi-natural broadleaved woodland sites larger than 2ha.	252m west

Ancient woodland Site	Reasons for designation	Distance from DCO Boundary
Poston, Syde and Ostrich Woods AWI site	Ancient semi-natural broadleaved woodland sites larger than 2ha.	556m south-west
Park Wood (Brimpsfield) AWI site	Ancient semi-natural broadleaved woodland sites larger than 2ha.	615m south
Hartley Wood AWI site	Ancient semi-natural broadleaved woodland sites larger than 2ha.	1 mile (1.7km) north-east
Hazel Hanger Wood AWI site	Ancient semi-natural broadleaved woodland sites larger than 2ha.	1 mile (1.7km) south-west
Witcombe and Buckle Wood AWI site	Ancient semi-natural broadleaved beech woodland sites larger than 2ha.	291m west
Eddington Wood AWI site	Ancient replanted semi-natural broadleaved woodland	0.93 miles (1.5km) south-west

Ullen Wood

8.7.10 Ullen Wood is split into ten different compartments which are privately owned. The woodland composition is generally ash and beech with evidence of past management such as areas of coppice with-standards that have not been managed for many years and older trees have been historically coppiced or low-pollarded. Fallen dead wood and tree stumps are frequent. The ground flora includes abundant bluebells (*Hyacynhoides non-scripta*) throughout much of the woodland and many other ancient woodland indicator species including dog's mercury (*Mercurialis perennis)*, woodruff (*Galium odoratum)* wood spurge (*Euphorbia amygdaloides*), sanicle (*Sanicula europaea)* and ramsons (*Alium ursinium)*. The bryophyte community is not very diverse but some species such as fox-tail feather-moss (*Thamnobryum alopecurums*) were dominant on the woodland floor in several compartments. Less abundant epiphytes included lateral Cryphaea (*Cryphaea heteromalla),* Straw Bristle-moss (*Orthotrichum stramineum*), Elegant Bristle-moss (*O. pulchellum*), Shaw's Bristle-moss (*Lewinskya striata*).

8.7.11 Many of the compartments are managed for conservation with evidence of hazel coppicing, thinning (and removal of ash with ash dieback) deer fencing and other biodiversity enhancements such as pond creation. Two separate areas of the woodland adjoin the scheme boundary, and neither of these areas appear to be under current woodland management.

Veteran trees

8.7.12 As defined in the Natural England and Forestry Commission Standing advice[10], ancient and veteran trees can be individual trees or groups of trees within habitat such as wood pasture. Ancient trees are exceptionally valuable and include attributes such as great age, size, conditions and biodiversity value as a result of significant wood decay and ageing. All ancient trees are veteran but not all veteran trees are ancient. A veteran tree may not be very old but has decay features such as branch death and hollowing that contribute to its biodiversity value. Ancient and veteran trees are both irreplaceable habitat features that are each of national importance and afforded the same level of policy protection.

8.7.13 There are 21 broadleaved veteran trees within or adjacent to the scheme (one of these is considered ancient) as shown in Table 8-10 and on ES Figure 7.9 Retained vegetation (Document Reference 6.3). Trees have been identified as veteran or ancient either in the arboricultural survey or by the Woodland Trust. The arboricultural report is included as ES Appendix 7.6 Arboricultural Impact Assessment (Document Reference 6.4).

Table 8-10 Ancient and veteran trees within or adjacent to the DCO Boundary

Tree Reference	Species	Grid Reference	Within or adjacent to the DCO Boundary	Veteran status	Location within the scheme
Arboricultural Survey					
T17	Ash	395191 213519	Within	Veteran	Cowley Wood road
T19	Ash	394606 213601	Within	Veteran	A417 near Nettleton Bottom and Birdlip Quarry
T57	Sycamore – pollard	394366 214532	Within	Veteran	Stockwell Farm (within construction footprint)
T67 (duplicate of 143988 below)	Ash	394661 215041	Within	Veteran	East of Shab Hill
T109	Beech	393801 215090	Adjacent	Veteran	Shab Hill Crescent Woodland
T157	Ash	393618 216361	Within	Veteran	North of Crickley Hill entrance
T159	Ash	393632 216392	Adjacent	Veteran	North of Crickley Hill entrance
T172	Beech	393405 216114	Adjacent	Veteran	Air Balloon Cottages
T174	Beech	392985 215893	Within	Veteran	Cold Slad Lane
T190	Oak	392468 215646	Within	Veteran	Flyup 417 Bike Park
T205	Sycamore	392208 215833	Within	Veteran	Dog Lane, (north side)
T126	Beech	393509 216067	Within	Veteran	Adjacent to Emma's Grove (within construction footprint)
T127	Beech	393579 216116	Within	Veteran	Adjacent to Emma's Grove (within construction footprint)
Woodland Trust					
141310	Ash pollard	394380 213740	Adjacent	Veteran	Opposite Golden Hart public house
141309	Ash	394328 213747	Partially Within	Ancient	Opposite Golden Hart public house
143975	Ash	394669 215039	Within	Veteran	East of Shab Hill
143988 (duplicate	Ash pollard (ancient)	394663 215043	Within	Veteran	East of Shab Hill

Tree Reference	Species	Grid Reference	Within or adjacent to the DCO Boundary	Veteran status	Location within the scheme
of T67 above)					
155073	Orchard apple	393468 216101	Within	Veteran	Air Balloon public house
196380	Beech	394538 214492	Within	Veteran	Stockwell Farm hedgerow
196757	Field maple	393508 215871	Within	Veteran	Emma's Grove
196854	Ash	393516 215906	Within	Veteran	Emma's Grove
196857	Ash	393499 215889	Within	Veteran	Emma's Grove

Notable plant and fungi species

8.7.14 Notable plant species records were returned from data searches with Gloucestershire Centre for Environmental Records. The updated 2019 data search returned records of seven plant species within the study area of the scheme. These records include bee orchid (*Ophrys apifera)* and pyramidal orchid (*Anacamptis pyramidalis)* at a property in Brockworth, 0.8 miles (1.3 kilometres) west of the scheme. Musk orchid and white helleborine (*Cephalanthera damasonium)* which are UK priority species and listed on the Red List[61] for vascular plants as vulnerable in Great Britain and autumn gentian classified as near threatened on the Red List[61] were all recorded at Barrow Wake SSSI and LWS. White helleborine was also recorded during an invertebrate survey within woodland at Birdlip Quarry in 2019. These areas are not within the scheme boundary.

8.7.15 The Nature Conservation Evaluation report of Crickley Hill produced by the National Trust[62] provides records of further notable plants present within Crickley Hill SSSI including hound's tongue (*Cynoglossum officinale)* listed as near threatened on the GB Red List and located approximately 235m north of the scheme.

8.7.16 Crickley Hill SSSI and LWR is also noted for its diversity of fungi, lichen and bryophytes. Records from GCER also include 25 species of bryophytes. Data records up to 2008 record 482 separate species of fungus at Crickley Hill and the National Trust reports[62] 579 species up to the end of 2012, with the vast majority being from the Scrubbs woodland area at Crickley Hill indicating a long continuity of deadwood habitat. Records from 1997 include the GB Red List species Devil's bolete (*Boletus satanus)* listed as vulnerable, Contrary Webcap (*Cortinarious varius)* and Flea's ear fungus (*Chlorencoelia versiformis)* which is a GB Red List endangered priority species located approximately 100m from the scheme.

8.7.17 The species richness of the fungi and the notable plants recorded at Crickley Hill and Barrow Wake SSSI underline the biodiversity value of the habitats within the SSSI which is valued of national importance in paragraph 8.7.4.

Invasive plant species

8.7.18 Records of invasive species listed on Schedule 9 of the WCA 1981 were returned from the 2019 data search. Giant hogweed (*Heracleum mantegazzianum)* was recorded at Hill Farm on Leckhampton Hill in 2017, approximately 1.1 miles (1.7 kilometres) north-east of the scheme and montbretia (*Crocosmia pottsii x aurea* = *C. x crocosmiiflora*) was recorded at National Star College - Cotswold Block Outdoor centre, approximately 0.2 miles (271m) north of the scheme, in 2017. Invasive species, cherry laurel (*Prunus laurocerasus*) and cotoneaster spp' are present within the woodland adjacent to the tributary of Norman's Brook. These species are likely present where land was formally private gardens.

Habitats

8.7.19 The desk study identified five HPI within the study area. These are lowland mixed deciduous woodland, lowland calcareous grassland, lowland meadow all of which occur within the DCO Boundary. Traditional orchard and wood pasture and parkland are also present within 1.2 miles (2 kilometres) of the scheme.

8.7.20 A total of 23 different habitat types were recorded during the Extended Phase 1 habitat survey in 2017. Of these, the scheme passes predominantly though arable land, improved grassland and poor semi-improved grassland, but also through areas of unimproved and semi-improved calcareous grassland, broadleaved woodland (both semi-natural and plantation), coniferous woodland plantation, scrub, scattered trees and tree lines, and species-rich hedgerows.

8.7.21 All habitats surveyed are described and valued below using information from the Extended Phase 1 habitat survey, as indicated on ES Figure 8.3 Phase 1 habitat survey (Document Reference 6.3) with associated Target Notes included in Appendix 8.1 Phase 1 habitat survey target notes (Document Reference 6.4), hedgerow surveys and NVC botanical surveys.

8.7.22 Full results of the hedgerow survey can be found in ES Appendix 8.2 Hedgerow technical report (Document Reference 6.4).

8.7.23 Full results of NVC surveys including figures and explanations of NVC communities, can be found in ES Appendix 8.4 Botanical assessment (Document Reference 6.4) and ES Appendix 8.3 NVC woodland survey report (Document Reference 6.4).

<u>Semi-natural broadleaved woodland</u>

8.7.24 There are a number of areas of semi-natural broadleaved woodland within the study area, ranging from small woodlands such as Emma's Grove immediately to the east of the Existing A417 and by the Air Balloon roundabout, to large areas of continuous woodland, such as Witcombe Wood (which forms part of the Cotswolds Beechwoods SAC/SSSI) to the west of the Existing A417, south of Birdlip. A number of the woodlands within the study area are considered to be ancient semi-natural woodland including Hawcote Copse, Witcombe Wood and Ullen Wood as shown in

Table 8-8. Additionally, Emma's Grove, although historical mapping shows this woodland not to be ancient, is notable for supporting a number of ancient woodland indicator species including herb Paris (*Paris quadrifolia*), wild garlic (*Allium ursinum*), pignut (*Conopodium majus*), woodruff (*Galium odoratum*), bluebell (*Hyacinthoides non-scripta*) and dog's mercury (*Mercurialis perennis*).

8.7.25 The majority of the woodlands are dominated by canopy trees, with less developed understorey, except around the woodland margins. Species present include ash, beech, pedunculate oak (*Quercus robur)*, sycamore (*Acer pseudoplatanus)*, silver birch (*Betula pendula*), hazel, elder (*Sambucus nigra)*, hawthorn, blackthorn, field maple (*Acer campestre)*, wayfaring tree (*Viburnum lantana)*, horse chestnut (*Aesculus hippocastanum)*, hornbeam (*Carpinus betulus),* wild privet (*Ligustrum vulgare)* and yew. A linear belt of mature woodland including mature beech is found on the southern verge of the A417 between Brockworth and Crickley Hill.

8.7.26 NVC surveys to identify woodland plant communities assigned eight separate plant communities to the 25 land parcels surveyed, comprising mainly of beech and ash NVC communities.

8.7.27 Semi-natural broadleaved woodland is lowland mixed deciduous woodland HPI and the area of this habitat within the study area is therefore of national importance.

Plantation woodland – broadleaved

8.7.28 Broadleaved plantation woodland is present within a number of areas throughout the Extended Phase 1 study area. There is an extensive areaof plantation broadleaved woodland to the west of the of the scheme and south of the Existing A417, comprising ash, wild cherry (*Prunus avium*), pedunculate oak, field maple and lime (*Tilia* species). Broadleaved plantation woodland is also present along the existing highways verge in a number of locations at the southern end of the scheme. These are generally composed of a standard highway mix of species including hawthorn, hazel, whitebeam (*Sorbus aria*), guelder rose (*Viburnum opulus)*, wayfaring tree, hawthorn, dogwood (*Cornus sanguinia)* and field maple.

8.7.29 Due to the extensive and mature nature of these woodlands, broadleaved plantation woodland within the study area is of county importance.

Plantation woodland - mixed

8.7.30 There are several areas of mixed plantation woodland, of less than 5ha in size, largely to the east of the study area between arable fields and often planted as shelter for game birds. The largest block of mixed plantation woodland is present within the Clay Hill plantation to the east of Shab Hill, comprising a mix of ash, beech, guelder rose, hazel, hawthorn, blackthorn, lime, wild privet, dogwood, Norway spruce (*Picea abies)*, cedar *sp.*, and Scot's pine (*Pinus sylvestris)*.

8.7.31 Plantation mixed broadleaved woodland within the study area is of local importance.

Plantation woodland - coniferous

8.7.32 There are smaller areas of coniferous plantation woodland, generally less than 2ha and often of linear nature, which again are often planted as shelter for game

birds. Species include western red cedar (*Thuja plicata)*, European larch (*Larix decidua)* and spruce (*Picea)* species.

8.7.33 Plantation coniferous woodland within the study area is of less than local value.

Scattered broadleaved trees

8.7.34 Scattered mature broadleaved trees are present in the study area, as field trees, or those associated with defunct field boundaries. A number of these trees support significant cavities which could support protected species such as bats and barn owl and provide both standing and fallen deadwood habitat. Species present include ash, large leaved lime (*Tilia platyphyllos)*, horse chestnut and pedunculate oak.

8.7.35 Scattered trees within or adjacent to the DCO Boundary are recorded within ES Appendix 7.6 Arboricultural impact assessment (Document Reference 6.4).

8.7.36 Scattered trees that are not ancient or veteran trees, part of wood pasture or within hedgerows (all of which are biodiversity resources evaluated separately within this assessment) are of local importance.

Scrub

8.7.37 Areas of dense and scattered scrub are widespread, particularly to the west of Barrow Wake SSSI where scrub is encroaching on areas of calcareous grassland. Such areas are generally being colonised by hawthorn, blackthorn, bramble (*Rubus fruticosus agg)*, traveller's joy (*Clematis vitalba)*, hogweed (*Heracleum mantegazzianum)* and various ruderal herbs including common nettle (*Urtica dioica)* and willowherbs (*Epilobium sp.*). The steep slopes at Barrow Wake SSSI are locally being encroached by scrub and scrub encroachment is also present in a number of the less intensively managed fields throughout the study area.

8.7.38 Scrub habitat comprises common species such as hawthorn and blackthorn and is of less than local importance.

Unimproved calcareous grassland

8.7.39 Areas of unimproved calcareous grassland are present within Crickley Hill and Barrow Wake SSSI (comprising Crickley Hill and Barrow Wake Local Nature Reserve) which includes species-rich grasslands dominated by calcareous species including tor-grass (*Brachypodium pinnatum),* upright brome (*Bromus erectus)*, salad burnett (*Sanguisorba minor)*, yellow wort (*Blackstonia perfoliate)*, small scabious (*Scabiosa columbaria*), clustered bellflower (*Campanula glomerate)*, chalk milkwort (*Polygala calcarean),* carline thistle (*Carlina vulgaris)*, common rock rose (*Helianthemum nummularium),* ladies bedstraw (*Galium verum)* and burnet saxifrage (*Pimpinella saxifrage)*.

8.7.40 Orchid species are frequent including early-purple orchid (*Orchis mascula*) and bee orchid, and the musk orchid which is nationally scarce[63], a Red List species and priority species, is locally frequent. A strong-hold population of musk orchid is present within the grassland to the east of the Barrow Wake car-park. In 2015 over 500 musk orchids were recorded within the SSSI[64]. The areas of unimproved grassland are all located within the boundaries of the SSSI.

8.7.41 Unimproved calcareous grassland is a HPI and a qualifying feature of the SSSI which is valued as of national importance as per paragraph 8.7.4.

Semi-improved calcareous grassland

8.7.42 Semi-improved calcareous grassland is present within a number of areas in the study area including the Barrow Wake unit of the Barrow Wake and Crickley Hill SSSI. These areas are species-rich but less diverse than the unimproved grasslands. Upright brome is locally abundant in these areas, along with a mix of herbs typical of calcareous grassland habitats including ladies' bedstraw, yellow wort, common rock-rose and salad burnet. Common spotted orchid (*Dactylorhiza fuchsia)* and pyramidal orchid was recorded in a number of areas supporting this habitat. Locally frequent ant hills were present indicating lack of recent management of these areas of grassland.

8.7.43 Areas of the existing highways verge are locally species-rich with occasional calcareous indicators and a number of orchids including scattered common spotted and pyramidal orchids. One road verge at Hawcote Hill in Birdlip 0.3 miles (482 metres) south of the scheme is a conservation road verge designated as a LWS for its calcareous grassland species.

8.7.44 NVC surveys to classify calcareous grassland (CG) communities were undertaken at Shab Hill, Crickley Hill, Air Balloon area and Bushley Muzzard. At Shab Hill, calcareous grassland in poor condition was recorded only as small relict patches of NVC community CG4 (Tor-grass (*Brachypodium pinnatum)* grassland) *or* CG4c or in mosaic with mesotrophic (neutral) grassland on a south facing slope. The remainder of the grassland was characterised by coarse, species-poor neutral grassland communities.

8.7.45 The survey of an area of National Trust land at Crickley Hill directly north of the A417 and Air Balloon cottages recorded no calcareous grassland.

8.7.46 Surveys of land west of Air Balloon roundabout were undertaken in two fields. Both were classified as calcareous grassland, but neither in optimal condition due to overgrazing by horses in one field and lack of management in the field adjacent to the Air Balloon public house.

8.7.47 Bushley Muzzard SSSI grassland habitats include calcareous grassland assessed as NVC community CG4 and GC4c on a bank at the north of the SSSI area. All vegetation is regarded to be in good condition maintained by grazing of livestock.

8.7.48 Semi-improved calcareous grasslands not within the SSSI are of county importance. Those that fall within the SSSI form part of the biodiversity resource valued at national importance in paragraph 8.7.4.

Semi-improved neutral grassland

8.7.49 Semi-improved neutral grassland is only present in small isolated areas of the study area to the north of Birdlip and Shab Hill as grazed and ungrazed grassland. A small area was recorded also at the eastern extent of Crickley Hill where it is present with scattered trees.

8.7.50 At Shab Hill, grassland within the valley was characterised by coarse, species-poor neutral grassland (mesotrophic (MG)) communities assessed as MG1e, (False oat grass (*Arrhenatherum elatius*) community) MG9b (Yorkshire fog

(*Holcus lanatus)* and tufted hair grass (*Deschampsia cespitosa)*) grasslands and other areas of neutral grassland that were not referable to any NVC community. Small relic patches of calcareous grassland in poor condition was recorded only as NVC community GC4 or CG4c or in mosaic with mesotrophic (neutral) grassland on a south facing slope.

8.7.51 A field north of Shab Hill was surveyed due to the species-rich nature of the grassland with a high cover of forbs and species such as bee orchids, common spotted orchids and yellow rattle *(Rhinanthus minor),* noted during other species surveys. This field was assessed to be neutral grassland of NVC community MG5a (crested dog's-tail (*Cynosurus cristatus)* and common knapweed (*Centaurea nigra))*, although is described as an atypical example. It has maintained good floristic condition of high botanical value due to sympathetic agricultural management and exhibits characteristics of a hay meadow.

8.7.52 The survey of an area of National Trust land at Crickley Hill directly north of the A417 and Air Balloon cottages recorded two different neutral grassland communities MG1aii and a much smaller area of MG5a grassland with a shorter and more diverse sward and again, an atypical example. This stand was variable and of moderate botanical value due to degradation at the edges by trampling and false oat grass indicating a coarsening of the sward. It supported a number of meadow ant hills indicative of older grasslands. This area is no longer within the DCO Boundary due to a change in the scheme design.

8.7.53 Neutral, species rich grassland of high botanical value (MG5a NVC community) recorded to the north of Shab Hill is considered to be lowland meadow priority habitat of national importance.

8.7.54 Other areas of neutral semi-improved grassland within the study area are of local importance.

Semi-improved species-poor neutral grassland

8.7.55 Areas of semi-improved species-poor grassland are frequent throughout the study area, especially to the south of the A417 between Brockworth and Air Balloon roundabout and in meadows to the south of Ullen Wood. These areas include low intensity grazed pasture, hay meadows and highways verges. These grasslands are typically dominated by grasses including false oat grass, sweet vernal (*Anthoxanthum odoratum)*, red fescue (*festuca rubra)*, Yorkshire fog and cock's-foot (*Dactylis glomerate)*, together with scattered herbs including field wood rush (*Luzula campestris)*, common sorrel (*Rumex acetosa)*, cuckoo flower (*Cardamine pratensis)*, lesser celandine (*Ficaria verna)*, meadow vetchling (*Lathyrus pratensis)*, ribwort plantain (*Plantago lanceolate)*, selfheal (*Prunella vulgaris)*, barren strawberry (*Potentilla sterilis*), creeping thistle (*Cirsium arvense)*, and crosswort (*Galium cruciate)*. Whilst these areas of grassland are generally of low diversity, small areas are locally herb-rich.

8.7.56 Semi-improved species-poor neutral grassland within the study area is of local importance.

Improved grassland

8.7.57 A number of large fields of agriculturally improved grassland are present across the study area mainly to the east of the Existing A417.These grasslands have a

low diversity being typically dominated by perennial rye-grass (*Lolium perenne)*. These areas of grassland are largely sheep grazed pastures.

8.7.58 Improved grassland within the study area is of less than local importance.

Marshy grassland

8.7.59 Marshy grassland is rare within the study area due to the free draining nature of the local geology. A small number of areas of marshy grassland are present, notably within Bushley Muzzard, Brimpsfield SSSI where narrow areas of marshy grassland are present along spring lines with jointed rush, hard rush and eight species of sedge, including the scarce yellow sedge. There are a number of orchid species including early marsh orchid (*Dactylorhiza incarnate)* and hybrid marsh orchids (*Dactylorhiza fuchsii x incarnata)* and (*Dactylorhiza fuchsii x pratermissa)*. A second area of marshy grassland is present south of Shab Hill Farm with cuckoo flower, soft rush, common spotted orchid, willow herb, marsh thistle (*Cirsium palustre)* and lesser celandine.

8.7.60 Bushley Muzzard SSSI grassland habitats include species-rich fen meadow assessed as NVC community M22b over a spring. All vegetation is regarded to be in good condition maintained by grazing of livestock.

8.7.61 Marshy grassland at Bushley Muzzard is a qualifying feature of the SSSI which is valued as national importance in paragraph 8.7.4.

8.7.62 Other areas of marshy grassland within the study area are of local importance due to the floristic diversity they provide in arable settings.

Arable

8.7.63 A large proportion of the study area is arable land (cereal crops) which is predominantly to the east of the Existing A417 from the Air Balloon roundabout to Nettleton Bottom. Although some botanically diverse field margins were identified during the Extended Phase 1 habitat survey in the wider study area, none are within the DCO Boundary and as such, no further surveys for notable arable weeds were considered to be required.

8.7.64 Arable land within the study area is of less than local importance.

Hedgerows

8.7.65 Hedgerows are present throughout the study area, with the land to the west of Barrow Wake SSSI typically comprising more enclosed field systems and the area to the east of the A417 being more open and subject to more intensive agricultural management.

8.7.66 Thirty-four hedgerows or hedgerows with trees were recorded within the study area as shown in ES Figure 8.3 Phase 1 habitat survey (Document Reference 6.3).

8.7.67 The hedgerows are generally dominated by hawthorn and blackthorn, with field maple and occasional standard trees including ash and pedunculate oak. Twelve hedgerows were found to be species-rich, ten hedgerows were species-poor intact, nine species-poor defunct and three hedgerows were not accessible to allow for a detailed survey. Additional species within the species-rich hedges include species such as hazel, wild privet, wayfaring tree, dog rose (*Rosa*

canina), and elder. The hedgerows range from heavily managed and regularly cut, to unmanaged.

8.7.68 The ground flora recorded fell into two broad categories of hedgerow with woodland ground flora such as lords and ladies (*Arum maculatum)* and wood avens (*Geum urbanum)* more commonly found in hedgerows to the west of the Existing A417, and hedgerow with species-poor grassland ground flora found more commonly adjacent to intensely managed agricultural fields.

8.7.69 Hedgerows are often associated with defunct dry-stone walls, where these features have been taken over by shrub and tree species. Some areas to the east of the A417 support intact drystone walls.

8.7.70 Hedgerows providing important habitat linkages to streams and woodland are numerous throughout the study area and likely to contribute to landscape connectivity for wildlife movement and dispersal.

8.7.71 Thirty-one of the thirty-four hedgerows were accessible for further survey to assess for their importance under The Hedgerows Regulations 1997. Of these, thirteen were assessed as be important hedgerows. Ten of these qualified as important predominantly due to their species-rich composition rather than additional landscape criteria.

8.7.72 Intact hedgerows conforming with the priority habitat description[65], i.e. over 20m long, less than 5m wide and where gaps are less than 20m wide, are of national importance as are all hedgerows assessed as important hedgerows covered by the Hedgerows Regulations 1997 and qualifying as priority habitats.

8.7.73 All other hedgerows within the study area are of local importance.

8.7.74 Further details on the methodology, limitations and results can be found in ES Appendix 8.2 Hedgerow technical report (Document Reference 6.4).

Tall ruderal

8.7.75 Tall ruderal habitat characterised by the presence of species such as common nettle and great willow-herb (*Chamaenerion angustifolium*) was recorded adjacent to a woodland plantation on Cowley Lane. This area may be a fallow area of previously arable land.

8.7.76 Ruderal habitat within the study area is less than local importance.

Standing water

8.7.77 A total of 29 ponds were identified as part of the 2017 Preliminary Ecological Appraisal[24] from OS mapping within the study area along with numerous springs and wells. The majority of ponds and springs which were accessible were found to be dry at the time of survey in May and June 2017. These ponds could be wet at different times of the year. A number of ponds with standing water were identified with aquatic and emergent species including species such as mint (*Mentha aquatica)*, soft rush (*Juncus effuses)*, floating sweetgrass (*Glyceria fluitans)* and meadowsweet (*Filipedula ulmaria)*.

8.7.78 Additional ponds have been identified since the 2017 Preliminary Ecological Appraisal within 500m of the scheme at Bentham and within the National Star College land due to an increase in the study area.

8.7.79 The ponds at Bentham are described in a third party report[66] from 2013. This describes ponds on the east of Bentham Road as shallow irregularly shaped field ponds up to one metre deep with aquatic and marginal plants, good water quality and invertebrates present, and to the west of Bentham Road is a large pond approximately 450m^2 in area stocked with fish, including aquatic and marginal plants and good water quality.

8.7.80 At National Star College, one pond within the DCO Boundary is a small depression of less than 10m^2 at the end of a culvert within a golf course which had no standing water at the time of survey, although the presence of emergent species include bull rush (*Typha angustifolia*) indicates that it is wet at times. Two further waterbodies fall outside of the DCO Boundary. Firstly, a large fishing lake, currently stocked with fish and approximately 2,500m^2 in area is situated adjacent to the golf course within a wooded setting. The pond has good water quality with macrophytes and marginal vegetation. The second pond is approximately 150m^2 in area and located approximately 10m from the lake. It appears to be spring fed with clear water and very little emergent vegetation. The pond is shaded due to its woodland setting.

8.7.81 Freshwater ponds within the study area do not meet the criteria for priority habitat[67] on the basis of flora/habitat type. Any fauna of conservation importance that ponds support, such as great crested newt, are valued separately in the subsequent sections.

8.7.82 Freshwater ponds are of local importance due to the relative rarity of waterbodies in the area.

Running water

8.7.83 The limestone geology of the area means that wet ditches and streams are sparse. There are a number of spring lines which were dry at the time of survey and appear to only be seasonally wet. A tributary of Norman's Brook is located within the woodland along the westbound A417 running from the Air Balloon roundabout towards Gloucester. This watercourse is modified in several places with small structures. It is spring fed and is heavily shaded by woodland throughout the length of the scheme. The stream is culverted in several places through the woodland and eventually continues under and to the north of the Existing A417.

8.7.84 A small tributary of the River Frome is located around Brimpsfield Park at the southern extent of the scheme, associated with a number of ponds along the tributary. These small tributaries run adjacent to Bushley Muzzard SSSI and are poached in places by cattle.

8.7.85 Based on River Habitat Survey data, the tributary of Norman's Brook upstream of the Existing A417, is classified as "Severely Modified", driven by the presence of weirs, culverts and the artificial bed and bank materials associated with them. Despite its modified state, the natural features within the river corridor and high habitat diversity indicated that this section of the tributary of Norman's Brook is of "High" habitat quality, when compared to similar rivers in the River Habitat Survey database. The overall habitat quality score is driven by high sub-scores for vegetation structure, number of flow types and the variety of substrates present. The watercourse runs through a broadleaved woodland. Channel vegetation classes included emergent reeds/sedges/rushes/grasses/horsetails and liverworts/mosses/lichens.

8.7.86 Likewise, Norman's Brook downstream of the Existing A417, is classified as "Severely Modified", driven by the presence of channel realignment, culverts, bridges and the artificial bed and bank materials associated with them. This section of Norman's Brook is less diverse and is of "Low" habitat quality, when compared to similar rivers in the River Habitat Survey database. The overall low habitat quality score is driven by the absence of natural channel and bank features, and due to the low diversity of substrate types recorded. The watercourse runs through an urban area adjacent to housing and a minor road. Channel vegetation classes included liverworts/mosses/lichens, emergent broadleaved herbs and emergent rushes/sedges/rushes/grasses/horsetails.

8.7.87 Based River Habitat Survey data, the surveyed reach of Horsbere Brook, is classified as "Severely Modified", due to channel realignment and culverts. This section of Horsbere Brook is of "Low" habitat quality, when compared to similar rivers in the River Habitat Survey database. The overall low habitat quality score is driven by the absence of natural bank features, and the low diversity in substrate type and in-channel plants recorded. The watercourse is characterised by a realigned and culverted channel flowing through irrigated land. Channel vegetation was limited to liverworts. Four of the spot-checks and the sections in between were within a culverted section of the watercourse. The open section of watercourse runs adjacent to improved grassland and broadleaved woodland. The only channel vegetation classes recorded was liverworts/mosses/lichens.

8.7.88 Based on the results of the River Habitat Surveys and the qualifying criteria for UK BAP headwater stream priority habitat[68], which are not met, running water is of local importance.

8.7.89 The locations and results of the River Habitat Survey are detailed in ES Appendix 8.23 River habitat survey and fish habitat assessment report (Document Reference 6.4) and ES Figures 8.6 to 8.12 (Document Reference 6.3).

Tufaceous vegetation

8.7.90 Of the four features that were assessed and characterised, only feature G231 located along a tributary of Norman's Brook is considered to support qualifying vegetation of the Annex 1 habitat H7220 Petrifying springs with tufa formation (*Cratoneurion*). The undisturbed nature of this feature appears to have contributed to the accumulation of a substantial stream crust with loose overlying oncoids and ooids (small sedimentary grains), but its vegetation is quite a poorly developed example of the *M37 (Palustriella commutata - Festuca rubra)* spring community. A condition assessment of this feature indicates that it is in unfavourable condition, largely because the stream crust is not vegetated sufficiently.

8.7.91 The most extensive and/or best developed examples of the M37 (*Palustriella commutata - Festuca rubra*) spring community are concentrated in upland, lime-rich parts of northern England, Wales and Scotland and are designated as SACs due to the presence of the Annex 1 habitat H7220 Petrifying springs with tufa formation (*Cratoneurion*). The area of Annex 1 habitat at G231 is not comparable to the SACs in terms of extent or quality of this habitat. Based on the condition assessment and the geographical location of feature G231, this feature is therefore of regional importance.

8.7.92 The other sites either did not support tufa-forming vegetation, or they supported a small extent that does not qualify as the Annex 1 habitat H7220 Petrifying springs with tufa formation. These sites are of local importance.

8.7.93 Further details on the methodology and limitations can be found in ES Appendix 8.24 Assessment of tufaceous vegetation (Document Reference 6.4).

Bats

Desk study

8.7.94 There is one SAC designated for bats which is located within 18.6 miles (30 kilometres) of the scheme; the Wye Valley and Forest of Dean bat sites SAC, designated for its key lesser horseshoe and greater horseshoe bat populations. Several other designated sites from local to national level also contain habitats that could support numerous bat species and are located within 1.2 miles (2 kilometres) of the scheme, including the Cotswold Beechwoods SAC, Crickley Hill and Barrow Wake SSSI, and Bushley Muzzard SSSI.

8.7.95 A large number of bat records were returned from Gloucestershire Centre for Environmental Records (GCER). At least 16 species of bat have been recorded within 6.2 miles (10 kilometres) of the scheme. The data search results showed the importance of the area for lesser horseshoe bats, with lesser horseshoe records representing the highest number of records and included three maternity roosts (the closest of which is at Cowley Manor 1.1 miles (1.8 kilometres) north-east of the scheme). Other relevant records included:

- Two records of lesser horseshoe recorded within Birdlip Quarry car park adjacent to the scheme.
- Greater horseshoe hibernation roost 1.2 miles (1.95 kilometres) north of the scheme at Greenway Hotel, Shurdington.
- Barbastelle and Bechstein's bat records 3.4 miles (5.5 kilometres) north-west of the scheme in Lineover Wood SSSI.

8.7.96 The 2006 Stage 2 assessment[22] identified four bat roosts within buildings including the Air Balloon public house (pipistrelle); Barrow Wake House (brown long-eared bat); Crickley Hill Farmhouse (brown long-eared bat); and Pinewood (pipistrelle species). Two of these buildings are within the DCO Boundary, namely Pinewood and the Air Balloon public house.

8.7.97 Bat surveys have been undertaken by a third party as part of planning application 18/01259/FUL (Tewkesbury Borough Council) for the conversion of Haroldstone House, Crickley Hill. The buildings covered by this application are 160m and 170m from the scheme and so are well outside of the 100m survey buffer for building assessments. However, the ecological assessment for this proposed development has identified the presence of a lesser horseshoe maternity colony using these two buildings. Surveys in 2018 identified a maximum count of 41 lesser horseshoe bats using the two buildings. The surveys also identified day roosts for greater horseshoe, common pipistrelle, Natterer's and brown long-eared bat. No evidence of hibernating bats was recorded in the buildings.

Tree surveys

8.7.98 The tree surveys confirmed the presence of seven roosts in trees within the DCO Boundary (see Table 8-11). This includes four day roosts for common pipistrelle

of local importance, one Natterer's day roost identified during radiotracking of county importance, and two day roosts for *Myotis* species. The *Myotis* species are unknown as no droppings were found during climb and inspect surveys and it was not possible to positively identify bats to species level from the acoustic data. As explained in paragraph 8.5.6, these two *Myotis* day roosts have also been evaluated as being of county importance. Tree roost numbers used below are shown on ES Figure 8.4 Combined Bat survey results CONFIDENTIAL (Document Reference 6.3).

Table 8-11 Confirmed tree roosts within the DCO Boundary

Tree number	Approx. nearest chainage	Tree species	Species present	Roost type	Roost location
BAT ID 246245	3+200.000 (Shab Hill crescent)	Beech	Natterer's	Day	Trunk cavity 6m high on north side
T163	0+625.000 (Crickley Hill Farm)	Sycamore	Common pipistrelle	Day	6m high, ivy covered limb, north facing
T63	0+725.000 (Crickley Hill Farm)	Sycamore	Common pipistrelle	Day	7m high, Ivy covered limb
T63	0+725.000 (Crickley Hill Farm)	Sycamore	Myotis sp.	Day	7m high, Ivy covered limb
T33	1+025.000 (Crickley Hill Farm)	Ash	Common pipistrelle	Day	6m high branch cavity
T235	1+075.000	Pine sp.	Common pipistrelle	Day	Woodpecker hole 5m north-west facing
T239	1+375.000 (Cold Slad)	Dead	Myotis sp.	Day	Loose bark, 4m high, east facing

8.7.99 One common pipistrelle day roost of local importance and two *Myotis* sp. day roost were found within 50m of the DCO Boundary (see Table 8-12)

8.7.100 As above since the species of *Myotis* could not be determined at the time of survey, the two *Myotis* sp. roosts were evaluated as being of county importance.

8.7.101 An additional five tree roosts were identified during radio-tracking within 50m of the DCO Boundary, namely: one Bechstein's day roost, two barbastelle day roosts and two Natterer's day roosts all being of county importance.

8.7.102 Tree surveys within Emma's Grove woodland have not been fully carried out due to access constraints as explained in section 8.5 Assessment assumptions and limitations, but it considered, due to the mature nature of the woodland, that Emma's Grove provides suitable bat roosting habitat.

Table 8-12 Confirmed tree roosts within 50m of DCO Boundary

Tree roost radio-tracking ID	Approx. nearest chainage	Tree species	Species present	Roost type	Distance from scheme (metres)
T229	1+775.000 (Crickley Hill)	Beech - Dead	Common pipistrelle	Day	8
Bat ID 239873	2+400.000	Unconfirmed	Bechstein's	Day	11
T24	4+650.000	Oak	*Myotis* sp.	Day	19
Bat ID 239870	1+100.000	Horse chestnut tree	Barbastelle	Day	23
T193	1+750.000 (Crickley Hill)	Ash	*Myotis* sp.	Day	29
Bat ID 240308	2+250.000	Ash tree	Natterer's	Day	34
Bat ID 239870	1+150.000	Ash tree	Barbastelle	Day	40
Bat ID 240308	2+300.000	Oak	Natterer's	Day	45

8.7.103 Full results including the ground level tree assessments, tree climbing inspections and dusk and/or dawn surveys of trees can be found in ES Appendix 8.5 Bat roost surveys technical report CONFIDENTIAL (Document Reference 6.4).

Building surveys

8.7.104 A total of 128 separate buildings were identified within 100m of the scheme options being considered during the scoping surveys which were undertaken between 2018 and 2019. Building roost IDs used below are shown on ES Figure 8.4 Combined Bat survey results CONFIDENTIAL (Document Reference 6.3).

8.7.105 The external building assessments identified six confirmed roosts, 26 buildings with high bat roost potential, 36 buildings with moderate bat roost potential, 33 buildings with low bat roost potential and 20 buildings with negligible bat roost potential. Access was not permitted to a single building that was within 100m of the scheme: Building 17, Crickley Hill Farmhouse. Six additional buildings were also not subject to any assessment due to access issues, however all these buildings were outside of the option 30 survey buffer and therefore not considered further.

8.7.106 The surveys (emergence and re-entry and inspections combined) along the route options at the time of survey confirmed the presence of 44 roosts in 28 different buildings. Out of these roosts, 40 (in 26 separate buildings) are within 100m of the scheme, comprising:

- 1 common pipistrelle maternity roost (county importance)
- 20 common pipistrelle day roosts (local importance)
- 6 *Myotis* species day roosts (county importance)
- 2 brown long-eared day roosts (local importance)
- 1 long-eared bat transitional roost (local importance)
- 4 lesser horseshoe day roosts (county importance)

- 2 lesser horseshoe night roosts (county importance)
- 3 serotine roosts (type unconfirmed) (precautionary county importance due to unconfirmed roost status)
- 1 bat roost (species and type unconfirmed) (precautionary county importance due to unconfirmed roost status)

8.7.107 Eight of the 39 roosts are within the scheme boundary as shown in Table 8-13.

Table 8-13 Bat roosts confirmed in buildings within the DCO Boundary

Building roost ID	Approx. nearest chainage	Approx. location	Species	Roost type
28	1+475.000	Grove Farm	Lesser horseshoe	Day
			Brown long-eared	Day
31	1+700.000	Woodside House	Common pipistrelle	Day
5b	0+125.000	Dog Lane	Common pipistrelle	Day
91b	3+250.000	Shab Hill Crescent	Lesser horseshoe	Night
33a	1+825.000	Crickley Ridge	Lesser horseshoe	Day
21	1+375.000	Cold Slad	Common pipistrelle	Day
			Myotis sp.	Day

8.7.108 Another four roosts (in addition to the 40 roosts described above) were also identified in buildings within 50m of the scheme boundary through radio-tracking (see bold roost IDs in Table 8-14):

- Two lesser horseshoe day roosts (county importance)
- One barbastelle day roost (county importance)
- One lesser horseshoe maternity roost (regional importance)

Table 8-14 Confirmed roosts in buildings within 50m of the DCO Boundary

Building roost ID	Approx. nearest chainage	Approx. location	Species	Roost type	Distance from scheme (metres)
19a	1+425.000	Cold Slad	Common pipistrelle	Day	3
23	1+350.000	Cold Slad	Common pipistrelle	Day	7
20	1+425.000	Cold Slad	Common pipistrelle	Maternity	7
			Myotis sp.	Day	7
91a	3+275.000	Shab Hill	Lesser horseshoe	Night	7
			Common pipistrelle	Day	7
16b	0+675.000	Crickley Hill Farm	Common pipistrelle	Day	8

Building roost ID	Approx. nearest chainage	Approx. location	Species	Roost type	Distance from scheme (metres)
45	3+000.000	Birdlip radio station	Common pipistrelle	Day	8
Bat ID 239824	0+675.000	Crickley Hill Farm	Lesser horseshoe	Day	8
8a	0+550.000	Dog Lane	Common pipistrelle	Day	9
			Long-eared sp.	Day	9
			Serotine	Unconfirmed	9
Bat ID 239870	1+090.000	Haroldstone House Cottages*	Barbastelle	Day	9
Bat ID 239824	1+075.000	Haroldstone House Cottages*	Lesser horseshoe	Day	10
Bat ID 239827	1+050.000	Haroldstone House Cottages*	Lesser horseshoe	Maternity roost	10
91	3+250.000	Shab Hill	Common pipistrelle	Day	10
			Long-eared sp.	Transitional	10
60	4+975.000	Birdlip Quarry	Common pipistrelle	Day	10
15	0+700.000	Crickley Hill Farm	Common pipistrelle	Day	11
44	3+025.000	Birdlip radio station	Common pipistrelle	Day	12
32	1+875.000	Crickley Ridge	*Myotis* sp.	Day	20
			Common pipistrelle	Day	20
			Brown long-eared	Day	20
33	1+900.000	Crickley Ridge	Common pipistrelle	Day	21
			Serotine	Unconfirmed	21
60b	5+000.000	Birdlip Quarry	Lesser horseshoe	Day	29
			Serotine	Day	29
8b	0+550.000	Dog Lane	Common pipistrelle	Day	30
9	0+550.000	Dog Lane	Common pipistrelle	Day	33
			Myotis sp	Day	33
38	1+900.000	Shab Hill	Common pipistrelle	Day	36
41	1+875.000	Shab Hill	Unconfirmed	Unconfirmed	43

* Haroldstone House cottages are a pair of cottages also identified in the desk study as being used in 2018 as lesser horseshoe maternity roost, and as day roosts of greater horseshoe, common pipistrelle, Natterer's and brown long-eared bats.

Bold highlighted Bat IDs - Additional roosts identified through radio-tracking.

8.7.109 Table 8-15 shows confirmed roosts in buildings between 50 metres and 100 metres of the DCO Boundary.

Table 8-15 Confirmed roosts in buildings between 50m and 100m of the DCO Boundary

Building roost ID	Approx. nearest chainage	Approx. location	Species	Roost type	Distance from the scheme (metres)
66	3+750.000	Hawcote Hill	*Myotis* sp	Day	79
			Common pipistrelle	Day	79
68	3+750.000	Hawcote Hill	Common pipistrelle	Day	89
			Myotis sp	Day	89
80*	4+000.000	Stockwell	Common pipistrelle	Maternity	106

* Although building 80 is over 100m away from the scheme, it is relevant in terms of context for the impact assessment and associated mitigation.

8.7.110 Full results including internal and external inspections and dusk and/or dawn surveys of buildings can be found in ES Appendix 8.5 Bat roost surveys technical report CONFIDENTIAL (Document Reference 6.4).

Hibernation surveys

8.7.111 Results confirmed lesser horseshoe bats hibernating in Crickley Hill rock fissures (numbers not known) approximately 110m north of the DCO Boundary and indicated the likely presence of a serotine hibernation roost at this location. Lesser horseshoe bats were also confirmed hibernating within the Birdlip Royal George Cave (maximum count of 13 lesser horseshoes, with more bats likely to be present in inaccessible areas), approximately 300m south-west of the DCO Boundary. The Royal George Cave is also likely to be used as a hibernation roost by *Myotis* species based on the large proportion of calls (including social calls) recorded by the static detector deployed inside the cave. The location of these hibernation roosts can be found on ES Figure 8.4 Combined Bat survey results CONFIDENTIAL (Document Reference 6.3).

8.7.112 According to Wray et al[12]. and based on the relatively low number of individual bats using these hibernation sites, these roosts were assigned a county importance.

8.7.113 Full results can be found in ES Appendix 8.5 Bat roost surveys technical report CONFIDENTIAL (Document Reference 6.4).

Bat activity transect surveys and automated detector surveys

8.7.114 Bat activity surveys have confirmed the presence of at least 11 species of bat within and around the scheme boundary: common pipistrelle, soprano pipistrelle Nathusius' pipistrelle, serotine, barbastelle, *Myotis* species, noctule, Leisler's, long-eared species., greater horseshoe and lesser horseshoe.

8.7.115 The majority of bats recorded both during transects and static surveys were common pipistrelle, with high activity levels recorded across the majority of the site for this species. Key areas of activity identified during the transect surveys included along the convergence of a number of linear features along the track to the north-east of Birdlip Radio station, with the second highest levels of activity south of Crickley Hill along the lane to Cold Slad.

8.7.116 Transect and static surveys confirmed the presence of Annex II bat species including lesser horseshoe, greater horseshoe and barbastelle, as well as potential for Bechstein's due to the recording of *Myotis* species and availability of suitable habitat for this species. Of these species, lesser horseshoe was the most frequently recorded across the scheme, with moderate to high levels of activity recorded at a number of static locations including 1A and 1B (Birdlip Quarry area), 2B (Stockwell), 3C (Ullen Wood), 4B and 4Ca (Crickley Hill Farm/Flyup 417 Bike Park), 6B (between Hawcote Hill and Stockwell), 7A and 7B (Crickley Hill). Activity for the other Annex II species was generally low; however, percentile activity levels for greater horseshoe were in the moderate band for sites 4B, 4Ca (Crickley Hill Farm area) and 6B (between Hawcote Hill and Stockwell).

8.7.117 Full results including static detector locations and bat activity maps can be found in ES Appendix 8.6 Bat activity survey report (Document Reference 6.4).

Bat crossing point surveys

8.7.118 A summary of the bat crossing point findings can be found in Table 8-16.The locations of crossing point surveys are shown on ES Figures 8.22 – 8.28 (Document Reference 6.3).

Table 8-16 Bat crossing point survey results summary

Crossing point survey location	Chainage	Description and location	Total bats crossing using feature
1	4+725.000	A narrow unlit lane with an avenue of trees. Bordered on all sides by agricultural fields which are used for grazing livestock. Located north of Birdlip Quarry.	120
2	4+025.000	Narrow, unlit lane bordered by a dry-stone wall and semi-mature trees. To the south is a large farm known as Stockwell Farm.	98
3	3+600.000	Mature hedgerow between arable fields used for grazing- Located c.200m east of CP1. To the north-east is a belt of woodland.	31
4	3+940.000	Semi-circular belt of mature broadleaved woodland between fields. Located *c.*200m north of CP3. To the west of the site is an area of woodland known as Cally Hill plantation woodland.	60
5	2+925.000	Mature conifer treeline *c.*12m tall, between fields. To the south of the site is Cally Hill plantation woodland.	112
6	2+825.000	Section of hedgerow and scrub which is connected to a small area of woodland. The hedgerow splits two grass fields and is surrounded on all aspects by agricultural fields. To the east is Ullen Wood.	54
7	2+800.000	Pocket of semi-mature woodland - Triangular shaped and comprises of young broadleaved woodland, connected to CP5 and CP6. The western terminal end of the woodland is connected to Ullen Wood.	131

8.7.119 The number of commuting bats observed by surveyors at each survey location and the overall levels of bat activity varied considerably according to the nature of the feature being surveyed and the quality of the commuting and foraging habitat for bats in the immediate surroundings.

8.7.120 Common pipistrelle bats were observed at every crossing point location and were the most recorded species at all survey locations. Generally, the flight height for this species fluctuated; however, a correlation between flight height and the height of the vegetation along the feature was observed at some crossing point locations. For instance, CP5 and CP7 recorded the highest number of safe bat passes and both CP5 and CP7 comprise mature trees which were above five metres in height. Whereas at CP1 almost all bat passes were recorded at an unsafe flight height, and at this location the avenue of trees along the feature were immature and less than 5m tall.

8.7.121 CP5, CP6 and CP7 between Shab Hill and Ullen Wood are all ecologically connected features that produced high levels of bat activity from a diverse species composition. Lesser horseshoe bats, which are listed as an Annex II species were recorded more times at CP6 than at any other location. Additionally, this species was recorded on every survey visit, suggesting that this feature is flight route for this species used year-round.

8.7.122 Full results can be found in ES Appendix 8.7 Bat crossing point survey report (Document Reference 6.4).

Bat trapping and radio-tracking surveys

8.7.123 A total of 253 bats were captured at 12 trapping sites in July and September 2019, and May 2020 combined. In July 2019, 60 bats were captured consisting of 11 species. In September 2019, 106 bats were captured of ten species. However, the latter survey session included the trapping of bats at a swarming site (Royal George Cave), which alone recorded 58 bats over two nights of survey. In May 2020, 87 bats were captured of 10 species, including 28 bats from the same swarming site/cave trapped in September 2019.

8.7.124 The proportions of some bats differed between surveys sessions. In July, the greatest proportions of captures were from brown long-eared bats (25%), Brandt's bat (20%) and whiskered bat (18%). However, in September 2019 and May 2020 these proportions had reduced and other species such as Natterer's and Daubenton's were captured more frequently. The Annex II species proportions were slightly different over the three survey sessions. Over twice the number of Bechstein's were captured in September compared to July 2019 and May 2020, and greater horseshoe bats were not recorded in July 2019. No barbastelles were captured in May 2020. Lesser horseshoe bats were regularly captured during all three survey sessions and were the most consistently recorded of the Annex II species.

8.7.125 The sex ratio of the bats captured and those selected for radio-tracking was male dominated. The general area appears to be important for males of Annex II species and this is supported by consistent captures of Bechstein's and barbastelle bats on both the July and September 2019 survey sessions. The capture of the male greater horseshoe in September, and regular captures of male lesser horseshoe on both 2019 surveys, also highlights the potential mating and transitional (pre-hibernation) role of the study area to these bat populations.

In May 2020 breeding (pregnant) greater horseshoe bats were also captured at a cave roost near Birdlip.

8.7.126 The combination of woodland and subterranean (cave) habitats in the area, is likely to provide an important resource for these species and other species such as *Myotis* and long-eared bats where swarming behaviour at such sites is key part of the mating cycle (Parsons, Jones, Davidson-Watts and Greenaway, 2003[69]).

8.7.127 Although breeding noctule and common pipistrelle bats were captured during the breeding season (July), they numbered only one bat of each species, which did not indicate the presence of a local breeding population. Breeding lesser horseshoe and brown long-eared bats were frequently captured indicating the presence of local breeding population(s). The lesser horseshoe was tagged and subsequently located roosting in the Crickley Hill area confirming a maternity roost within 10m of the DCO Boundary at Haroldstone House Cottages (see Table 8-14). The most significant finding of the May 2020 session was the capture, tagging and confirmation of breeding/pregnant greater horseshoe bats near Birdlip at the Royal George Cave.

8.7.128 A total of 23 bats were fitted with radio transmitters during the July (7 bats) and September (9 bats) 2019, and May (7 bats) 2020 survey sessions. The majority of these bats (18) were Annex II species, with five Bechstein's (all males), eight lesser horseshoe bats, two barbastelles and three greater horseshoe bats tracked throughout the night to obtain movement data. In addition, three Natterer's (one in each survey session) and two Daubenton's (September 2019 and May 2020) were tagged for roost finding purposes.

8.7.129 The radio-tracking analysis and the core area determination showed high use of part of the scheme area. The road corridor area west of the Air Balloon roundabout supported multiple crossing points for tagged Annex II species over the Existing A417 between the Crickley Hill woodland areas and the woodland/pasture habitats to the south. The current mature tree/woodland vegetation is likely to assist bats in crossing the existing road, in particular around the area east of the Flyup 417 Bike Park/Dog Lane. There was also a high level of foraging/flying behaviour immediately to the north and south of the existing road corridor, which was also likely to be related to the presence of the woodland habitats in this area.

8.7.130 There was less east west flying behaviour, with only one lesser horseshoe travelling from Ullen Wood to the Crickley Hill area. One Bechstein's also travelled from Crickley Hill to the Colesbourne across the A417 to the east; however, this bat never returned to the study area during the tracking subsequently undertaken.

8.7.131 The bats captured in the Ullen Wood complex and other trappings sites to east of the A417 generally remained in the area and did not cross this part of the scheme area.

8.7.132 A total of 27 roosts were recorded for all bats tagged during July and September 2019, and May 2020. The majority of roost sites (15) were confirmed in trees or located in woodland where access was not possible (and therefore assumed to be a tree roost through triangulation). The remainder of roosts (10) were located in buildings including houses and agricultural buildings and two roosts were located in underground sites (cave and an old mine). Most of these roosts are

outside of the DCO Boundary (those located within 100m are included in Table 8-11 to Table 8-15).

8.7.133 In conclusion, taking the presence of all four Annex II species, the current status and presence of roost sites, including the maternity population of lesser horseshoe bats, it is considered that the foraging and commuting assemblage of the four Annex II bat species in the area of the A417 at Birdlip are of national importance. The remaining foraging and commuting assemblage of the rest of the bat species recorded in the area of the scheme (namely common and soprano pipistrelle, Nathusius' pipistrelle, noctule, serotine, Leisler's, *Myotis* species and brown long-eared) are of county importance.

8.7.134 Full results can be found in ES Appendix 8.8 Bat advanced survey technical report CONFIDENTIAL (Document Reference 6.4).

Badger

Desk study

8.7.135 Five badger records were returned within 1.2 miles (2 kilometres) of the route options in the 2017 desk study. Three records of badger were provided in the updated 2019 desk study. Two of these records are of road casualties on the A417 in June and August of 2019 approximately 500m to the west of the scheme. The other is approximately 1.2 miles (2 kilometres) south of the scheme at Elkstone.

8.7.136 Four main areas of badger activity and associated setts were identified during the 2006 Stage 2 assessment[22] at [redacted]

Field surveys

8.7.137 Walkover surveys in January and February 2019 identified 106 setts including five active main setts within 500m of the scheme. The main areas of activity recorded in 2019 corresponds to the areas of activity identified during previous surveys undertaken in 2006.

8.7.138 Badger bait marking surveys of the five active main setts were undertaken in March and April 2019 to identify the territories of each badger clan and confirmed badger activity within the study area. Based on the results from the bait marking surveys, there are four territories within the scheme boundary at [redacted] to the [redacted] of the scheme (already severed by the Existing A417), [redacted] in the centre of the scheme and [redacted] at the [redacted] extent of the scheme.

8.7.139 Emma's Grove and surrounding fields were surveyed for the presence of badger setts in March 2021. No badger setts were recorded.

8.7.140 Badgers are a common and widespread species and are afforded protection due to historical issues of persecution rather than because of their conservation status. However, due to their intrinsic appeal and role in an ecosystem each badger clan is resource of local importance.

8.7.141 Further details on the results including maps showing the various territories can be found in ES Appendix 8.9 Badger survey report CONFIDENTIAL (Document Reference 6.4).

Birds

Desk study

8.7.142 The 2006 Stage 2 assessments identified a range of common breeding birds, nine Red List Species of High Conservation Concern and 14 Amber List Species of Medium Conservation Concern. It also identified records of barn owl within Ullen Wood (possible breeding roosts), and within two mature oaks adjacent to the scheme at Nettleton Bottom.

8.7.143 The 2017 desk study identified a range of breeding birds within the study area including a number of Red and Amber listed species of conservation concern and Schedule 1 species including barn owl. The 2019 desk study included one record of a barn owl over the A417 in Bentham; one record of a barn owl in Brimpsfield and one record of a barn owl hunting near a road verge in Brockworth, all recorded in 2017.

Field surveys

Breeding birds

8.7.144 Breeding bird surveys in April and June 2019 recorded 55 species within arable fields and their margins and identified in places, a high density of breeding territories of seed-eating species including skylark (*Alauda arvensis*), linnet (*Linaria cannabina*) and yellowhammer (*Emberiza citronella*). Woodlands and other areas with trees and hedgerows were found to hold species of conservation concern such as marsh tit (*Poecile palustris*), spotted flycatcher (*Muscicapa striata*), song thrush (*Turdus philomelos*), mistle thrush (*Turdus viscivorus*) and bullfinch (*Pyrrhula pyrrhula*).

8.7.145 The breeding bird surveys undertaken in 2019 indicate breeding populations of birds comprising a number of Red listed species (skylark, linnet, marsh tit, song thrush, yellow hammer, spotted flycatcher, tree pipit (*Anthus trivialis*,) and Amber listed species (bullfinch, dunnock (*Prunella modularis)*, kestrel (*Falco tinnunculus)*, meadow pipit (*Anthus pratensis)*, stock dove (*Columba oenas)*, willow warbler (*Phyllosccopus trochilus)*), which form a breeding bird assemblage of county importance.

8.7.146 Further details on the results, including figures, can be found in ES Appendix 8.10 Breeding bird technical report (Document Reference 6.4).

Wintering birds

8.7.147 Wintering bird surveys undertaken in October 2018 and February 2019 indicated good numbers of wintering birds with 53 species recorded including (as maximum counts recorded on site across the study area) 18 yellowhammer (BTO Red List[70]), 184 common gull (*Larus canus*) (BTO Amber List), 178 golden plover (*Pluvialis apricaria*), 72 lapwing (*Vanellus vanellus*) (BTO Red List), 557 fieldfare (*Turdus pilaris*) (BTO Red List) and 412 redwing (*Turdus iliacus*) (BTO Red List). Key areas highlighted from the surveys where large numbers of birds were recorded on single surveys, included the Shab Hill area and arable land, notably to the east of the scheme.

8.7.148 The wintering bird surveys undertaken across 2018/2019 indicates wintering populations of birds comprising thirteen Red list species and nine Amber list species, which form a wintering bird assemblage of county importance.

8.7.149 Further details on the results, including figures, can be found in ES Appendix 8.11 Wintering bird survey report (Document Reference 6.4).

Barn owl

8.7.150 Stage 1 and 2 habitat and potential nest identification surveys in May 2019 identified large areas of suitable Type 1 (optimum habitat to support prey species) and Type 2 (sub-optimal habitat to support prey species) habitat at Shab Hill, Flyup 417 Bike Park and Crickley Hill/Bentham area. Surveys identified 119 PNS within 0.9 miles (1.5 kilometres) of the scheme including evidence of barn owl roosts at Flyup 417 Bike Park and Little Witcombe comprising two ARS, of which one was recorded within 100m of the scheme, and two TRS were recorded within 500m of the scheme.

8.7.151 Stage 3 nest verification surveys were undertaken of PNS within 500m of the scheme in July and August 2019. Of 43 PNS identified within 500m of the scheme, 33 were accessible for further survey, the remaining being inaccessible due to height of the feature or lack of land access. Two further PNS were identified within 500m of the scheme during the Stage 3 surveys. A total of 35 PNS were surveyed using either ground-level inspections, inspections using ladders, and/or dusk emergence surveys. Surveys identified that eight of these PNS were suitable for breeding barn owls although none showed signs of current breeding. Evidence of barn owl roosting (through the presence of pellets) was found at seven PNS. Barn owl foraging activity was observed at two locations in the area close to Shab Hill during bat surveys in 2019.

8.7.152 Barn owl is a Schedule 1 species and is susceptible to sharp population declines as a result of factors including harsh weather, low prey availability and habitat loss and fragmentation. The evidence from baseline surveys undertaken in 2019 and incidental sightings of this species indicate that up to three breeding pairs of barn owls are likely to be present within 500m of the DCO Boundary in the region of Rushwood Kennels and Stockwell Farm.

8.7.153 The barn owl population within the study area is a resource of county importance.

8.7.154 Further details on the results, including figures, can be found in ES Appendix 8.12 Stage 1 and 2 Barn Owl survey report CONFIDENTIAL (Document Reference 6.4), ES Appendix 8.13 Stage 3 Barn Owl survey report CONFIDENTIAL (Document Reference 6.4) and ES Figures 8.15 to 8.19 (Document Reference 6.3).

Dormouse

Desk study

8.7.155 No records of dormouse, a European Protected Species, were returned in the 2017 desk study or in the 2019 update within 1.2 miles (2 kilometres) of the scheme from GCER. The National Dormouse Database (People's Trust for Endangered Species[71]) provides a record approximately 1.6 miles (2.6 kilometres) north of the scheme from 2017.

Field surveys

8.7.156 Suitable habitat for dormice is present within the study area including broadleaved woodland and species-rich hedgerows. Much of the broadleaved woodland at the site generally has poor understorey, which is not optimal for dormice, but the

woodland margins provide diverse structure and species diversity offering more suitable habitat. A number of areas of mixed plantation woodland provide suitable habitat as well as a network of hedgerows providing valuable linking habitat to the wider landscape.

8.7.157 The presence/likely absence surveys at thirteen areas of potential dormice habitat during 2018 and 2019 identified no confirmed evidence of dormice. Nest tubes at five sites contained some fresh leaves but no woven structures identifiable as a dormouse nest. The surveyed sites included Ullen Wood at the north of the study area which is partially connected to Emma's Grove woodland with bramble scrub along a stock fenceline. Whilst Emma's Grove was not surveyed for dormice due to access constraints, its small extent, fairly isolated position and the absence of dormice from adjacent surveyed habitats indicate that it is unlikely to support a viable population of dormice.

8.7.158 Although a dormouse record has been provided 1.2 miles (2 kilometres) north of the study area, dormice were not recorded in the two most northerly and largest woodland areas within the study area, Crickley Hill and Ullen Wood. Based on survey results a population of dormice are not considered to be present within the scheme.

8.7.159 Further details on the results, including figures, can be found in ES Appendix 8.14 Dormouse survey report (Document Reference 6.4).

Amphibians

Desk study

8.7.160 The 2006 Stage 2 Assessment[22] reported surveys of three ponds; the clay and stone lined dew pond at Crickley Hill Cricket Club and two ponds at Stockwell Farm. No evidence of great crested newt was identified during these surveys.

8.7.161 Four records of great crested newt were returned in the 2017 desk study within 1.2 miles (2 kilometres) of the scheme. Twenty-five additional records were provided in the updated 2019 desk study from GCER. One record of a female great crested newt was returned from a cellar in Brimpsfield approximately 0.6 miles (1 kilometre) south-west of the southern extent of the scheme. Twenty-four records were submitted under a Natural England mitigation licence for great crested newt from Bentham Dog Lane Fields pLWS approximately 150m east of the DCO Boundary at the western extent of the scheme and approximately 370m north of the Existing A417. The great crested newt report associated with these records is available on the Tewksbury Borough Council website[72]. As well as the ponds within Bentham Dog Lane Fields pLWS stated above, the report indicates the presence of a small pond at Bentham Country Club situated at the end of a drainage channel with a great crested newt population which is within the DCO Boundary. The report concludes a medium metapopulation of great crested newt is located within ponds at Bentham Dog Lane Fields pLWS to the north of the Existing A417. Presence absence surveys of these ponds were not undertaken in relation to the assessment of this scheme as surveys were being carried out by another consultancy in 2019 for a separate scheme.

8.7.162 The 2019 data search returned one record of section 41 NERC Act 2006 priority species common toad (*Bufo bufo*) over 0.6 miles (1 kilometre) from the scheme in Cowley. Previous desk study records returned three records approximately 590m

north of the scheme in Crickley hill as shown in ES Appendix 8.15 Great crested newt survey report (Document Reference 6.4).

Field surveys

8.7.163 Thirty three waterbodies were identified within 500m of the scheme boundary. HSI surveys in May 2018 concluded that 21 provided habitat suitable to support great crested newts ranging from poor to excellent. The remaining 22 waterbodies were either dry or man-made features such as swimming pools which were considered unsuitable to support great crested newts.

8.7.164 eDNA surveys were carried out on sixteen ponds in June 2018 and May 2019 to establish the presence or likely absence of great created newts. Waterbodies that were not subject to eDNA included those that were dry at the time of survey. Surveys identified three ponds with a positive eDNA result; Pond 15 in Birdlip and Pond 2a on the western edge of Crickley Hill fall within 500m of the scheme; 356m and 149m respectively. Due to the distance between these two ponds of 1.1 miles (1.8 kilometres) and the physical barrier in the form of the A417, they are considered to be associated with separate populations. Pond 26a at Birdlip also returned a positive eDNA result. This pond was included due to proximity to the original scheme options but is now just over 500m from the scheme. It is, however, within 500m of pond 15 and therefore considered to be associated with the same metapopulation of the Birdlip area.

8.7.165 Due to the proximity of pond 2a to the scheme, population surveys were carried out. The maximum number of great crested newts recorded was two female adults, indicating a small population. Pond 15 was not surveyed further as was considered to be over 500m from the main scheme alignment and scheme boundary at the time of survey. It is however, 356m west of the Existing A417 which is to be repurposed as the Air Balloon Way walking, cycling and horse riding (WCH) route. Common toad was also recorded in Pond 2a.

8.7.166 An eDNA survey was carried out at the small pond within the DCO Boundary at Bentham Country Club in April 2021. As identified from the desk study, a previous planning application had concluded the presence of great crested newt at this pond in 2019. The eDNA survey result was positive confirming that great crested newts are still present.

8.7.167 A further three ponds are located within land at National Star College and golf course which now fall within 500m of the north of the scheme boundary due to a scheme boundary alteration in 2020 for potential drainage works. One pond is a small depression at the end of a culvert within the golf course, one a large fishing lake and a smaller pond near the lake appears to be spring fed with very little emergent vegetation. HSI surveys on these ponds undertaken in September 2020 indicated poor habitat suitability for great crested newts. Surveys of the lake and spring fed pond returned negative results for great crested newt eDNA in April 2021. The golf course pond returned a positive result. This was an unexpected result given the poor habitat suitability of the pond and the lack of known breeding ponds nearby and therefore a second eDNA survey of this pond was undertaken in May 2021 which returned a negative result. From the habitat suitability assessment of the pond, its ephemeral nature and the second negative test within the peak breeding period, it is concluded that this pond is not used for breeding by great crested newt.

8.7.168 Great crested newts are a European protected species and they are widespread across the county. Therefore, the three populations of great crested newt (at Bentham, Crickley Hill and Birdlip) are each of county importance. The non-breeding use of a pond at National Star College and golf course is not considered to represent a separate additional breeding population. The positive eDNA result from that location is likely to relate to dispersal of individual newts from another population, potentially from that at Crickley Hill.

8.7.169 Populations of section 41 NERC Act 2006 species common toad that occur within the study area are of local importance.

8.7.170 Further details on the results, including figures, can be found in ES Appendix 8.15 Great crested newt survey report (Document Reference 6.4).

Reptiles

Desk study

8.7.171 The 2006 Stage 2 Assessment identified populations of common lizard (*Zootoca vivipara*) and slow worm (*Anguis fragilis*) at two sites within the study area.

8.7.172 The 2017 desk study returned records of all four widespread species of reptile; common lizard, slow worm, adder and grass snake (*Natrix helvetica*) within 1.2 miles (2 kilometres) of the scheme. The updated desk study from 2019 returned 191 records of reptiles. Adder, slow worm and common lizard were all recorded at Crickley Hill and Barrow Wake SSSI in 2019. Eighty-one records of adder were provided from Crickley Hill and Barrow Wake SSSI in 2019. These records were of both males and females. Eleven records of common lizard, 58 records of slow worm and 18 records of grass snake were returned from Crickley Hill and Barrow Wake SSSI. Common lizard and slow worm records were returned from within Birdlip Quarry within the DCO Boundary.

Field surveys

8.7.173 Habitat assessment surveys identified eighteen sites with potential to support the widespread reptile species: adder, grass snake, common lizard and slow worm. Sites 6,18, 25, 43, 44, 45, 47 and the SGARG site were considered to have high quality habitat for reptiles. Sites 2, 3, 8,10, 21, 39, 41, 46 and 49 were considered to have medium quality habitat for reptiles. Site 48 was assessed as having poor quality habitat to support reptiles but was connected to higher quality habitat. Locations of site are shown in Appendix 8.16 Reptile survey technical report (Document Reference 6.4).

8.7.174 Reptiles were identified at 17 of the 18 sites surveyed across the length of the scheme. Reptiles were not found at site 48 at the entrance to Crickley Hill.

8.7.175 All four widespread reptile species were recorded at four of the survey sites; 8, 6, 41 and SGARG. Sites 8 and 6 are at the southern extent of the scheme within and to the north of Birdlip Quarry. The SGARG site at Crickley Hill and site 41 adjacent to Dog Lane are situated to the north of the A417.

8.7.176 Ten of the eighteen survey sites (sites 2, 3, 6, 8, 10, 41, 43, 44, 46 and 49 support good populations[73] of at least one reptile species with exceptional populations of slow worms recorded at the SGARG site at Crickley Hill and site 47, a calcareous grassland field south-west of Air Balloon roundabout.

8.7.177 Adders were found at eight of the survey sites which were grouped in three areas at Crickley Hill and to the north of the A417, Shab Hill area and survey sites at the southern extent of the scheme near Birdlip Quarry. A good population of adder was recorded at the SGARG site. An anecdotal sighting of an adder at hedgerow 18 south-west of Shab Hill was also recorded during hedgerow surveys in 2019.

8.7.178 Based on guidance from Froglife[73], each site was assessed to evaluate its importance for reptiles. Eight of the 18 survey sites are important or key sites for reptiles supporting either an assemblage of three or more species or exceptional populations of reptiles. These sites are sites 2, 6 and 8 at the south of the scheme in and adjacent to Birdlip Quarry, sites 18 and 25 in the Shab Hill area, sites 41 and the SGARG site to the north of the A417 and site 47 to the west of the Air Balloon roundabout. Of the remaining sites, site 39 to the south of the A417 at Flyup 417 Bike Park is the only site to support low populations (slow worm and common lizard only) and not be connected to habitat supporting larger populations or assemblages.

8.7.179 With the exception of site 39, which has a reptile assemblage of local importance, the assemblages of reptiles within the DCO Boundary throughout the rest of the scheme are of county importance.

8.7.180 Further details on the results, including figures, can be found in ES Appendix 8.16 Reptile survey technical report (Document Reference 6.4).

Otter

Desk study

8.7.181 No signs of otter were identified during the 2006 Stage 2 assessment. A single otter record, a road casualty from 2015 was identified in the 2017 desk study from a residential garden near Horsbere Brook approximately 800m south-west of the site. The updated 2019 desk study included one record of an otter sighting at Horsbere Brook approximately 1.1 miles (1.85 kilometres) from the scheme and two reports of otter feeding signs in Brockworth.

8.7.182 The desk study and consultation with Gloucester Wildlife Trust confirmed that otters are present in the area and known to use Horsbere Brook, the northern section of Norman's Brook, the Upper Frome, all of which are part of the River Severn Catchment, and the River Churn which is part of the River Thames catchment.

Field surveys

8.7.183 Where access allowed, habitat suitability and field sign surveys for otter were undertaken within 1.2 miles (2 kilometres) of the scheme options in 2018 and 2019.

8.7.184 An unnamed tributary of the River Frome located in Brimpsfield Park was surveyed in July and August 2018 and May 2019. Presence of otter was confirmed by the presence of spraint, footprints and potential holts.

8.7.185 Surveys at Horsbere Brook, the tributary of Norman's Brook and Coldwell Bottom revealed no evidence of otter. The southern section of the tributary of Norman's Brook within the DCO Boundary is severed from the northern open reaches by a long culvert, reducing the suitability of the watercourse for otter. Due to this and due to the seasonal flow, it is likely to be used only very occasionally by otters

exploring the far reaches of catchments or potentially moving between catchments.

8.7.186 Otters are a European Protected Species and are now widespread and found in most counties throughout the country. Therefore, the otter population within the study area is of county importance.

8.7.187 Further details on the results, including figures, can be found in ES Appendix 8.17 Otter technical report (Document Reference 6.4).

Water vole

Desk study

8.7.188 No signs of water vole were identified during the 2006 Stage 2 assessment. No records of water vole were returned in the 2017 desk study, or in the 2019 update from GCER although Gloucestershire Wildlife Trust confirmed presence of water vole in Horsbere Brook approximately 1.9 miles (3 kilometres) from the scheme.

Field survey

8.7.189 Low suitability water vole habitat was identified at two watercourses; the tributary of Norman's Brook and Upper Frome, within 250m of the scheme. Each watercourse was surveyed in both August 2018 and May 2019 for field signs and returned no evidence of water voles.

8.7.190 Water voles are considered to be absent from the study area of the scheme.

8.7.191 Further details on the results, including figures, can be found in ES Appendix 8.18 Water vole technical report (Document Reference 6.4).

White-clawed crayfish

Desk study

8.7.192 No records for white-clawed crayfish were returned within 1.2 miles (2 kilometres) of the scheme in either the 2017 or updated 2019 desk study.

8.7.193 During technical working group meetings in April 2019, the EA commented that white-clawed crayfish are unlikely to be present in the River Churn due to the capture of signal crayfish in this watercourse. Reports that white-clawed crayfish may exist still within tributaries of the Churn are unsubstantiated. The EA also advised of populations of white-clawed crayfish outside of the study area in Climperwell Brook approximately 2 miles (3.2 kilometres) south-west of the scheme, Painswick stream approximately 2.4 miles (3.96 kilometres) south-west of the scheme and Slad Brook approximately 4.5 miles (7.3 kilometres) south-west of the scheme.

Field survey

8.7.194 Habitat assessments in October 2018 identified suitable habitat for white-clawed crayfish at the tributary of Norman's Brook and the Upper Frome tributaries. Although suitable refugia such as cobbles, tree roots and undercut banks were identified at the tributary of Norman's Brook, the fluctuating nature of the watercourse reduces the potential to support a viable population. The survey reaches of the Upper Frome (i.e. those nearest to the scheme) overall had

unsuitable habitat. However, in lower reaches further south, suitable habitat with a flow regime more suited to white-clawed crayfish was identified.

8.7.195 Manual hand search and baited trapping surveys also undertaken in October 2018 found white-clawed crayfish to be absent from the tributary of Norman's Brook and the lower section of the Upper Frome.

8.7.196 No non-native invasive signal crayfish were recorded during the surveys.

8.7.197 Due to the lack of white-clawed crayfish records within 1.2 miles (2 kilometres) of the scheme and the negative result during field surveys, white-clawed crayfish are presumed absent from the reaches of watercourses within the study area, although they are considered to be present further downstream within the Upper Frome.

8.7.198 Further details on the methodology including limitations, results, including figures, can be found in ES Appendix 8.19 White-clawed crayfish technical report (Document Reference 6.4).

Terrestrial invertebrates

Desk study

8.7.199 The data search as part of this assessment returned 93 records of invertebrate species between 2007 and 2016. Records returned included six Schedule 5 of the WCA 1981 butterflies, 20 SPI (listed under NERC Act 2006), nine Red Listed species and five other notable species. Locations of records were varied but locations with larger number of records included: Crickley Hill, Barrow Wake, Groveridge Banks Key Wildlife Site, Groveridge Hill (south of Brimpsfield), Leckhampton Hill and Charlton Kings Common SSSI and Westerleigh Cottage (Cowley).

8.7.200 Twenty-five species of invertebrates listed as priority species were returned from the 2019 desk study between 2017 and 2019. These include pretty chalk carpet (*Melanthia procellata)*, buff ermine (*Spilosoma lutea)* and mottled rustic (*Caradrina morpheus)*, all recorded within Crickley Hill.

8.7.201 The National Trust's Nature Conservation Evaluation of Crickley Hill[62], reports a significant diversity of grassland invertebrates including two Red Data Book species, a SPI butterfly (dingy skipper (*Erynnis tages*), nationally scarce snails, beetles, moths and bees, most associated with short-turf herb-rich areas. Veteran beech pollards along the edge of Shortwood Belt support a range of nationally scarce wood-decay invertebrates, mostly beetles. The report suggests that Crickley Hill is considered to be at least of regional importance for wood-decay (saproxylic) invertebrates, primarily beetles but other groups are of interest too. Wood-decay species include a range of nationally scarce species. Other species of significant interest include the fever fly (*Dilophus bispinosus)* for which Crickley Hill is only the seventh known locality in Britain and the fungus gnat (*Grzegorzekia bushyae)* for which Crickley Hill is only the third known site globally.

8.7.202 An additional invertebrate survey[74] on wood-decay invertebrate species focussing on Crickley Hill and The Scrubbs woodland at Crickley Hill was undertaken in the 2019 survey season. Three hundred and nine invertebrate species were recorded, with 34 species having a conservation status, including four with Red List status. Twelve Coleoptera were nationally scarce, 16 Diptera were nationally

scarce and one nationally rare. The saproxylic beetle fauna at Crickley Hill is considered, based upon the Index of Ecological Continuity[75], to be of national importance.

8.7.203 Roman snail and aquatic invertebrates are considered in separate sections.

Field survey

8.7.204 The terrestrial invertebrate surveys undertaken in 2019 and 2020 recorded a number of scarce and rare species. In summary, three Red List species; bee fly (*Villa cingulate)*, nomad bee (*Nomada lathburiana)* and picture-winged fly (*Oxyna nebulosi),* a total of 29 nationally scarce species and five SPI; dingy Skipper, cinnabar moth (*Tyria jacobaeae),* brown banded carder bee *(Bombus humilis),* small heath butterfly (*Coenonympha pamphilus*) and pearl-bordered fritillary (*Boloria euphrosyne)* were recorded.

8.7.205 Field surveys recorded the nationally scarce Cistus Forester moth (*Adscita Geryon)* at site 1 - The Quarry and at site 7 - west of Crickley Hill and the Chalk Hill Blue (*Lysandra coridon)* butterfly species at site 7 also. Both species are mentioned on the Crickley Hill and Barrow Wake SSSI citation.

8.7.206 The most productive sites for scarce invertebrates are considered to be site 1- Birdlip Quarry, site 5 - Short Wood, site 6 - Crickley Hill, site 7 - West of Crickley Hill and site 10 - Barrow Wake. Site 9 (grazed calcareous grassland adjacent to Barrow Wake) is noteworthy as it is the only site with the Red List species of fly (*Oxyna nebulosior)* or the nationally scarce bee (*Hyaleus signatus)*.

8.7.207 Six of the nine sites surveyed (sites 1, 5, 6, 7, 9 and 10) recorded a high diversity of scarce invertebrates including SPIs or Red List species. These sites are woodland sites, a quarry and calcareous grassland.

8.7.208 The invertebrate assemblage within Crickley Hill, which includes invertebrate survey sites 5, 6 and 7 is of national importance based upon the invertebrate reports (2015, 2019) but specifically due to saproxylic beetle fauna associated with deadwood habitats.

8.7.209 The invertebrate assemblages at Birdlip Quarry (site 1) and within and adjacent to the Barrow Wake unit of Crickley Hill and Barrow Wake SSSI, (sites 9 and 10) are of county importance.

8.7.210 The remainder of survey sites, sites 2, 3, and 8 comprise lower quality grassland or scrub habitat that support invertebrate assemblages of local importance or below.

8.7.211 Further details on the results, including figures and site locations, can be found in ES Appendix 8.20 Terrestrial invertebrate survey report (Document Reference 6.4).

Roman snail

Desk study

8.7.212 [redacted]

[redacted]

Field survey

8.7.213 [redacted]

8.7.214 [redacted]

8.7.215 [redacted]

8.7.216 [redacted]

Aquatic invertebrates

Desk study

8.7.217 The data search returned invertebrate biological records and associated biological indices from ten EA monitoring sites between 2000 and 2019. Three of the monitoring sites were located within the wider river network but are not hydrologically connected to the scheme. A further seven sites outside of the wider river network but with hydrological connectivity to waterbodies within the study area were selected on the basis that they were the closest to the scheme. These sites provide further understanding of the baseline invertebrate communities present in watercourses influenced by the scheme.

8.7.218 Eleven invertebrate species of conservation value were identified. All invertebrate species of conservation importance were recorded on the River Churn and/or the River Frome. No invertebrate species of conservation value were recorded in the tributary of Norman's Brook.

8.7.219 No Invasive Non-Native Species (INNS) were found on the River Churn or the tributary of Norman's Brook. In the River Frome, the INNS signal crayfish listed on Schedule 9 of the WCA 1981 was recorded.

8.7.220 No species of conservation importance or INNS were reported to have been recorded on Painswick Stream during the desk study.

Field study

8.7.221 Across the three sampling seasons and seven survey sites the Community Conservation Indicator (CCI) scores varied between low and very-high reflecting high variability in the conservation value of taxa recorded. The highest CCI scores achieved from each site across the sampling seasons are discussed below.

8.7.222 In the tributary of Norman's Brook CCI scores at AQ1, AQ2 and AQ7, as shown on ES Figure 8.21 Aquatic macroinvertebrate monitoring sites (Document Reference 6.3), varied between fairly high and very high. One nationally notable invertebrate species was recorded; the riffle beetle (*Riolus subviolaceus).* Aquatic invertebrate baseline data associated with spring head habitat connected to the tributary of Norman's Brook (AQ7) identified communities typical of small or temporary headwater streams.

8.7.223 The Average Score Per Taxon and the Number of taxa according to the Whalley Hawkes Paisley Trigg Method (WHPTASPT and WHPTNTAXA respectively) values obtained from sites within the tributary of Norman's Brook are indicative of moderate to good levels of diversity and proportions of taxa which are sensitive to general degradation.

8.7.224 In the River Frome, CCI scores achieved fairly high at both sites (AQ3 and AQ4). No invertebrate species of conservation value were recorded and no INNS were recorded.

8.7.225 WHPTASPT and WHPTNTAXA values obtained from sites within River Frome suggested low diversity and low proportions of taxa which are sensitive to general degradation. The site AQ4 returned WFD status classification of poor for 2020 combined season classification, providing further evidence for an impaired invertebrate community.

8.7.226 In the River Churn CCI scores varied between fairly high and high. The INNS signal crayfish *(Pacifastacus leniusculus)* was also recorded.

8.7.227 WHPTASPT and WHPTNTAXA values obtained from sites within the River Churn are indicative of moderate to good levels of diversity and proportions of taxa which are sensitive to general degradation. The site AQ5 returned WFD status classification of moderate for 2020 combined season classification, suggesting a moderate deviation from the invertebrate community expected to be present at this site in pristine conditions.

8.7.228 In conclusion, taking the community level conservation value present at the sites and the presence of a nationally notable species, the aquatic invertebrate communities present in the tributary of Norman's Brook within the scheme are of county importance.

8.7.229 Taking account of the community level conservation values recorded at sites within the River Frome and the River Churn, the aquatic invertebrate communities present in both watercourses adjacent to the scheme are of local importance.

8.7.230 Further details on the limitations of this study and results; including biological indices can be found in ES Appendix 8.22 Aquatic invertebrate survey report (Document Reference 6.4) and in ES Figure 8.20 Environment Agency (desk study) aquatic macroinvertebrate monitoring sites (Document Reference 6.3) and

ES Figure 8.21 Aquatic macroinvertebrate monitoring sites (Document Reference 6.3).

Fish

Desk study

8.7.231 The data search returned 80 records between 2000 to 2019 from 21 EA monitoring sites. No EA monitoring sites were identified to fall within the scheme. As a result, the closest sites to the scheme and hydrologically connected waterbodies were selected.

8.7.232 Records of 17 fish species were provided from EA monitoring sites, four of which are of conservation importance: brown trout (*Salmo trutta*) is a NERC Act 2006 SPI and UK BAP Priority Species; European eel is a NERC Act 2006 SPI, Critically Endangered on Global Red List and a UK BAP Priority Species; European bullhead (*Cottus gobio*); and lamprey species (brook lamprey (*Lampetra planeri)* adult and river lamprey (*Lampetra fluviatilis*)/brook lamprey species ammocoetes, these lamprey species cannot be identified from one another in the field) which are listed on Annex II of the Habitats Directive and protected under the Habitats Regulations 2017. River lamprey is also a NERC Act 2006 SPI and UK BAP Priority Species.

8.7.233 Records of brown trout were returned from Painswick stream, the River Frome, and Horsbere Brook. Records of European eel were returned from Painswick stream, River Frome, Horsbere Brook and Hatherley Brook. Records of bullhead and lamprey (brook lamprey and lamprey species ammocoetes) were reported on the River Frome. No records of species of conservation importance were returned for the River Churn or Norman's Brook.

Field study

8.7.234 Fish habitat assessments were carried out in October 2019 and January 2020 at six reaches within the scheme (tributary of Norman's Brook) and in close proximity (Horsbere Brook and tributaries of the River Churn and River Frome).

8.7.235 The tributary of Norman's Brook upstream of the Existing A417 (Site 1) and downstream of the Existing A417 (Site 2) were considered to provide suitable habitat for brown trout, juvenile lamprey, European eel and bullhead. However, a number of significant barriers, notably the Existing A417 culvert and numerous other obstructions to fish passage downstream were recorded and the watercourse is therefore considered disconnected to the wider catchment. As a result, anadromous salmonids and anadromous sea lamprey and river lamprey are considered highly unlikely to be present due to numerous barriers to fish passage identified during the fish habitat assessment, notably the Existing A417 culvert. There is potential for the tributary of Norman's Brook to support an isolated population of brown trout, bullhead and brook lamprey. European eel (a catadromous migrant) has the potential to be present if able to surpass the barriers to migration identified.

8.7.236 Horsbere Brook, near Little Witcombe (Site 3) had large portions of river that were unsuitable for fish as it was culverted. Despite this, some areas of habitat meeting the requirements for salmonid parr and fry life stages were identified. Adult habitat was absent.

8.7.237 The surveyed section of an unnamed tributary of River Churn, near Coberley (Site 4) was predominantly unsuitable for fish due to insufficient water depth, however a small amount of mixed juvenile (parr/fry) habitat was recorded. No barriers to fish passage were identified within this site.

8.7.238 The surveyed section of an unnamed tributary of River Churn, near Colwell Bottom (Site 5) and an unnamed tributary of the River Frome (Site 6) were both highly fragmented by impassable weirs, barriers and culverts. Nevertheless, there is potential for the reach to support isolated populations of brown trout and bullhead.

8.7.239 Fish habitats identified during 2019 and 2020 surveys within and in close proximity to the scheme were found to be impacted by habitat fragmentation, hydrological fluctuations and anthropogenic changes. The fish assemblage within these watercourses are of local importance.

8.7.240 Further details on the results can be found in ES Appendix 8.23 River habitat survey and fish habitat assessment report (Document Reference 6.4) and in ES Figures 8.5 to 8.12. (Document Reference 6.3).

Other section 41 Species of Principal Importance (SPI)

8.7.241 The 2017 – 2019 data search as part of this assessment returned four records of hedgehog (*Erinaceus europaeus*) within 1.2 miles (2 kilometres) of the DCO Boundary. Records are from Brockworth, Witcombe and Cowley with the nearest record being approximately 0.6 miles (1 kilometre) south-west of the western extent of the scheme. The habitat within the DCO Boundary is suitable for hedgehog and other species potentially present such as harvest mouse (*Micromys minutus*), brown hare (*Lepus europaeus*) and polecat (*Mustela putorius*).

8.7.242 Populations of these SPI that occur within the scheme are considered to be of local importance.

Future baseline

8.7.243 As set out in ES Chapter 4 Environmental assessment methodology (Document Reference 6.2), the “Do-Minimum” and “Do-Something” scenarios have been set out, with the “Do-Minimum” scenario representing the future baseline with minimal interventions and without new infrastructure.

8.7.244 The ecological baseline conditions described above represent those which currently exist in the absence of the scheme and at the time of writing. As stated in section 3 of CIEEM’s *Guidelines for Ecological Impact Assessment in the UK and Ireland* [9], potential changes in baseline conditions also need to be identified in order to assess impacts.

8.7.245 Based on the above information and current land use, the future baseline in the absence of the scheme is unlikely to change significantly by 2040. Subtle changes are expected due to climate change, such as some movements of certain species and local population changes; and there would be a likely reduction in ash trees due to ash dieback disease however, the overall habitats and species composition in the study area are expected to be broadly similar to that of the existing baseline. Therefore, the future baseline would remain the same as set out in the existing baseline.

8.8 Potential impacts

8.8.1 A highway scheme has the potential to impact important biodiversity features in a number of ways during construction and operation. The potential impacts to habitats and species could be direct or indirect, positive or negative, permanent or temporary, reversible or irreversible and can vary in extent/magnitude, frequency and timing.

Construction

8.8.2 The majority of potential impacts will be during the construction phase. The duration of the construction works is currently estimated to be at least 33 months, commencing nine months after the start of environmental preparatory work, giving an overall construction period of 42 months. The potential impacts of the scheme during this phase are likely to be:

Habitat loss

8.8.3 Habitat loss is a direct impact of the construction phase of the scheme involving clearance of habitat resulting in a change of land use from countryside (predominantly farmland, pasture and woodland) to highway and associated infrastructure, such as drainage works and earthworks.

8.8.4 Habitat loss may be permanent or temporary. Land within the highway boundary would be permanently lost, whereas some areas that would be used as site compounds or haul roads during construction would be temporarily lost and the habitat reinstated post-construction either to new habitat or to the previous land use such as agricultural land.

Habitat fragmentation

8.8.5 The scheme has potential to cause fragmentation of habitats including those within, or functionally linked to, designated sites. Fragmentation occurs when a habitat is transformed into a number of smaller patches of smaller total area which are isolated from each other. Smaller fragments of habitat are less able to sustain viable populations of species, leading to isolation both within and between populations of floral and faunal species. As populations become more isolated, they are liable to suffer loss of genetic vigour and become more susceptible to threats from invasive species and climate change[77]. Recolonisation from other sites and habitat patches is also less frequent with larger separation distances between the patches. Fragmentation of habitat may also result in displacement to alternative habitat that may result in reduced foraging success and increased competition and predation. Collectively these impacts can compromise the ability of core sites or populations to cope with external pressures, making them less resilient to change. Fragmentation may impact the daily or seasonal routine of animals, the annual cycle of organisms, or may be relevant to persistence and movement of species in terms of metapopulation dynamics and genetic mixing of populations. Therefore, the effects of increased fragmentation in terms of population declines and local extinctions may not become evident for many years after the impact has occurred.

Habitat damage or degradation

8.8.6 Wooded habitats, single trees and hedgerows to be retained within or adjacent to the scheme are at risk of damage during the construction phase of the works.

Such damage may include physical injury to the trunk and crown, soil compaction to the root zone, severed roots, smothered roots, increased wind and light exposure or stress due to grade and drainage changes. Such impacts could lead to reduced stability and longevity of the trees or hedgerow habitat.

8.8.7 Habitats within or adjacent to the scheme and those that are hydrologically connected to it, are sensitive to potential impacts from pollution events from dust[78], fuel and chemical spills; from changes in air quality due to vehicle emissions; and from sediment run-off from construction areas causing degradation of habitat. Dust deposition, especially from activities such as material crushing, could have a direct effect on sensitive habitat such as ancient woodland or calcareous grassland affecting vegetation by smothering, reducing ability to photosynthesise and respire. Dust leached into soils can affect the chemical composition of the soil and therefore plant health or plant communities. Indirect changes may occur as a result of increased susceptibility of degraded habitats to environmental stresses such as disease and pests and indirect impacts on fauna may occur, as the quality or suitability of foraging habitat is reduced.

8.8.8 Traffic emits oxides of nitrogen (NOx) which can be deposited on vegetation as nitrogen. Changes in air quality related to nitrogen deposition from vehicle emissions may occur due to the increase in construction traffic. Nitrogen deposition can change species composition and reduce species richness, favouring species of nitrogen loving grasses and sedge species. This is of particular concern for sensitive habitats that are less tolerant of increases in nitrogen deposition, such as calcareous grassland or lichens and bryophyte within ancient woodland. The assessment of impacts on designated sites and veteran trees within 200m of the ARN has been completed using the outputs from air quality modelling as detailed in Chapter 5 Air quality (Document Reference 6.2).

8.8.9 Groundwater-dependent terrestrial ecosystems (GDTE), could be affected by local hydrological changes as a result of the construction phase of the scheme, especially during the creation of cuttings. Excavations and changes to the limestone and mudstone geology could impact levels and extent of flow, affecting networks of springs found throughout the study areas.

Disturbance

8.8.10 Disturbance from visual sources (including human activity and artificial lighting) and from noise or vibration during construction could have adverse impacts on sensitive species. This could lead to abandonment of territory or of young, increased predation risk, or use of critical energy reserves.

8.8.11 Disturbance from light sources can also result in adverse impacts on nocturnal species such as bats. The effect of road lighting is complex and varies for different species, but potential impacts include roost disturbance and abandonment, severance and loss of foraging and commuting habitats, and a decline in the availability of airborne invertebrate prey within bat foraging habitats.

Species mortality and injury

8.8.12 Species mortality or injury can occur during construction of highways. Less mobile species, or animals that are hibernating or have young, are likely to be most vulnerable to direct mortality due to vegetation clearance during the construction phase.

8.8.13 Animals that are particularly at threat of local extinction include fish and aquatic invertebrates due to their juvenile or reproductive stages being within watercourses where works are proposed.

8.8.14 There is potential for mortality or injury due to collision with vehicles during construction, but less so than during the operational phase of the scheme. Animals that are particularly susceptible and are at risk from collision are badger, otter, bats and birds, especially barn owl due to the severance of existing movement corridors.

Operation

8.8.15 The operational phase of the scheme is considered to be when the scheme becomes active including the highway open to traffic and associated infrastructure such as public rights of way are open to the public. The potential impacts of the scheme during this phase are likely to be:

Habitat degradation

8.8.16 Degradation of habitats may occur due to increased visitor pressure. Habitats may be damaged by excessive trampling, cycling or horse riding; littering; and pollution or compaction of soils, which may also affect tree roots. An increase in numbers of dog walkers or horse riders may increase enrichment of low nutrient grasslands, affecting species composition.

8.8.17 Degradation may also occur due to pollution either from surface water run-off from the highway or from changes to air quality, specifically increases in nitrogen deposition. Elevated NOx concentrations which can be deposited on vegetation as nitrogen are generally considered to be the main threat to vegetation from vehicle emissions.

8.8.18 Vascular plants take up nitrogen through their roots and some can be absorbed above ground via stomata or the cuticle. Effects of nitrogen deposition on trees and woodlands can include faster growth leading to destabilisation, nutrient imbalance leading to reduced crown densities, crown discolouration and abnormal branching patterns, altered composition in mycorrhiza (fungus which supply water and mineral nutrients to the tree) which can result in reduced growth and increased sensitivity to natural stresses. The Air Pollution Information System (APIS) website[18] provides examples of responses of beech trees to increased nitrogen deposition, which include increase in bark lesions, increase in canker, increase in pathogenic fungi, increase in beech aphids, and a change to flowering patters, seed and litterfall production.

8.8.19 Increased nitrogen deposition also affects the understory vegetation, ground flora and non-vascular plants such as lichen and bryophyte communities. These species are particularly vulnerable as they can absorb nitrogen through their entire surface. Nitrogen deposition can cause changes in species composition within woodlands and grasslands, with an increase in species that can tolerate an increase nitrogen levels, resulting in a decrease in biodiversity. Increased nitrogen deposition can also lead to reduced resilience to abiotic factors such as drought and to pests and pathogens[79].

Disturbance

8.8.20 The potential impact of disturbance on ecological receptors is similar as during construction. There will be less potential impact from noise and vibration of machinery but additional potential for disturbance from traffic noise and car lights.

8.8.21 As in the construction phase, disturbance from light sources can result in adverse impacts on nocturnal species such as bats and also barn owl. The effect of road lighting is complex and varies for different species, but potential impacts include roost disturbance and abandonment, severance and loss of foraging and commuting habitats, and a decline in the availability of airborne invertebrate prey within bat foraging habitats.

Species mortality and injury

8.8.22 Species mortality or injury can occur during operation of highways.

8.8.23 Many animals are killed by vehicle collision on UK roads each year and this is likely to be the case for the scheme in the absence of mitigation in the form of wildlife crossings either under or over the road, wildlife exclusion fencing and strategic habitat creation.

8.8.24 Animals that are particularly susceptible and are at risk from collision are badger, bats, otter and birds, especially barn owl due to the severance of existing movement corridors which species are loyal too and in the case of certain bat species and barn owl, their low flight.

8.9 Design, mitigation and enhancement measures

8.9.1 The mitigation hierarchy is described in Table 4-5 of ES Chapter 4 Environmental assessment methodology (Document Reference 6.2). The first stage of the mitigation hierarchy is to seek engineering design to avoid or eliminate any potential impacts and adverse effects on biodiversity features as described in section 8.8 Potential impacts. Impacts have been avoided for instance, through changes to the horizontal or vertical alignment of the scheme, junction strategy, structures or other aspects of the scheme layout; and through changes in the timing, methods and/or materials to be used in construction. This is referred to as embedded mitigation. Where it is not possible to avoid an impact entirely, the design should seek to reduce the magnitude of the impact and provide essential mitigation or compensation.

8.9.2 The following sections outline these measures and how they would reduce the impact of the scheme on biodiversity. Details are provided in ES Figure 7.11 Environmental masterplan (Document Reference 6.3) and in Annex D Landscape and Ecological Management Plan (LEMP) of ES Appendix 2.1 Environmental Management Plan (EMP) (Document Reference 6.4). The EMP is an iterative document. Towards the end of the construction period the EMP (ES Appendix 2.1 EMP (Document Reference 6.4)) would be refined to include essential environmental information needed by the body responsible for the future maintenance, monitoring and operation of the asset.

8.9.3 Enhancement measures have also been included, going above and beyond what is required to mitigate and compensate for the adverse effects of the scheme.

Embedded mitigation

8.9.4 The scheme assessed within this ES includes a number of engineering design measures that have been incorporated to avoid or reduce the impacts of habitat loss, habitat fragmentation, habitat degradation and species disturbance and mortality and thus avoid or reduce significant adverse environmental effects.

8.9.5 These measures have been identified and developed through the design process, including consultation with stakeholders and statutory bodies and form part of the scheme design. Embedded design measures relevant to biodiversity include:

- Three badger culverts.
- Crickley Hill bat underpass.
- Three greened overbridges (the Gloucestershire Way crossing and Stockwell and Cowley overbridges).

8.9.6 Details on the embedded mitigation measures are described in full within ES Chapter 2 The project (Document Reference 6.2) Table 2-2 (Structures) and Section 2.7 Environmental mitigation design measures and are referred to throughout this assessment.

8.9.7 The landscape design shown in ES Figure 7.11 Environmental Masterplan (Document Reference 6.3) replaces priority habitats with a greater amount than that lost. The landscape design focusses on provision of priority habitats which are present within the Cotswold AONB; lowland calcareous grassland, lowland broadleaved woodland and native species rich hedgerows. There would be an increase in all these habitats post construction as shown in Table 8-18. The location and design of habitats has considered the draft Nature Recovery Network Map provided by Gloucestershire Wildlife Trust in 2020 and habitats required for specific ecological mitigation as described below. ES Figure 7.11 Environmental masterplan (Document Reference 6.3) provides green infrastructure which would help to deliver climate change resilience for both habitat and wildlife connectivity. This would be in line with Defra's Biodiversity 2020[3], which establishes principles for the consideration of biodiversity and the effects of climate change.

8.9.8 Through the embedded mitigation measures, the scheme design is aims to maximise opportunities to conserve and enhance biodiversity features in and around the scheme.

Essential mitigation – Construction

8.9.9 Essential mitigation would be implemented in order to mitigate for potential impacts of the construction phase as described within section 8.8 Potential impacts, which are not avoided by the embedded mitigation that forms part of the design.

8.9.10 Essential mitigation includes environmental best practice working methods during the construction phase of the scheme that would avoid or reduce impacts to adjacent designated sites, habitats and species from pollution events, e.g. protection from contamination of surface water or dust deposition. These measures are included within ES Appendix 2.1 EMP (Document Reference 6.4). These measures provide mitigation for impacts upon multiple biodiversity features and they are therefore summarised below, with each specific feature to which they are relevant identified within section 8.10 Assessment of likely significant effects.

8.9.11 Annex G of ES Appendix 2.1 EMP (Document Reference 6.4) includes site-specific methods to protect sensitive habitats, especially aquatic habitat from pollution events during the construction phase. Measures include the use of silt busters or bales to prevent silt or contaminants from being released into watercourses such as the tributary of Norman's Brook. Such precautions would be undertaken in accordance with relevant legislation and undertaken in compliance with the relevant Guidance for Pollution Prevention (GPP) and industry best practice (GPP5, CIRIA).

8.9.12 ES Appendix 2.1 EMP (Document Reference 6.4) includes site-specific measures to protect sensitive habitats, such as woodland and calcareous grassland from dust deposition caused by activities such as material crushing. Measures include:

- The location of the material crushing compound would be over 200m from Ullen Wood ancient woodland and the crusher would be sensitively located within the compound area so that dust generating activities would be furthest from the woodland, taking into account prevailing wind directions.
- Water sprinkler systems would be used whenever there is a risk of dust emissions.
- Screening bunds or barriers would be installed to protect retained vegetation.
- No material crushing or demolition would be undertaken in high prevailing winds in the direction of the ancient woodland or calcareous grassland such as at Barrow wake SSSI.
- Crushed materials would be removed from site as soon as possible.

8.9.13 These measures would be secured through the requirements in the draft DCO and would be contractual requirement of the contractor.

8.9.14 Essential mitigation during the construction phase is identified in the Register of Environmental Actions and Commitments (REAC), contained within ES Appendix 2.1 EMP (Document Reference 6.4). This has been developed to avoid or reduce the potential construction impacts on habitats and species such as habitat loss, habitat severance, disturbance and species mortality.

8.9.15 Further mitigation specific to individual biodiversity features is detailed below.

Designated Sites

8.9.16 Habitat would be lost due to construction in the Barrow Wake unit of the Crickley Hill and Barrow Wake SSSI. Habitat loss would occur at the northern extent of the Barrow Wake unit due to the widening of the A417. This habitat loss would include an area of approximately 0.09ha predominantly of calcareous grassland due to construction of the cutting slope and a drainage cascade. Where calcareous grassland is lost, it will be reinstated using a local seed source. Approximately 500m^2 of broadleaved woodland habitat comprising some young roadside planting would be lost at the southern end of the unit due to the construction of the roundabout on the B4070 Barrow Wake road at the entrance to the car park. In total, approximately 1,400m^2 (0.1ha) of habitat within the SSSI would be lost and would require replacement habitat in compensation.

8.9.17 Although broadleaved woodland would be lost within the SSSI, there is a preference from the landowner, Gloucestershire Wildlife Trust, and Natural England to compensate for SSSI habitat lost with creation of calcareous grassland. This compensatory habitat would be part of a larger area of calcareous grassland, totalling approximately 10,543m^2 (1.05ha), created also as

replacement for loss of Common Land as shown on ES Figure 12.4 Special category land (Document Reference 6.3). It would be planted in the location of the Existing A417 adjacent to Barrow Wake, thus returning approximately 1,700m^2 of hardstanding within the SSSI boundary to calcareous grassland and effectively re-joining SSSI habitat.

8.9.18 The Environmental Masterplan (ES Figure 7.11 Environmental masterplan (Document Reference 6.3)) shows the creation of two new habitat patches of calcareous grassland to provide habitat stepping-stones to the north and south of the scheme that would mitigate the impacts of fragmentation, by providing functional habitat connectivity for species associated with Crickley Hill and Barrow Wake SSSI units to disperse. A habitat patch of 12ha including 6ha of calcareous grassland and 6ha of broadleaved woodland and scrub would be created adjacent to Ullen Wood, and a habitat patch of 5ha including 4.7ha of calcareous grassland and 0.3ha of scrub would be created adjacent to Emma's Grove woodland. These areas would provide habitat stepping stones which would be contiguous with existing areas of semi-natural broadleaved woodland, calcareous grassland and scrub and are intended to be of sufficient size to meet the habitat requirements for relatively immobile organisms that do not actively move through the landscape, such as calcareous grassland plant species.

8.9.19 Locations of the habitat patch creation align with Natural England guidance that recommends habitat patches be located no more than 200m apart for habitat-specialised species[77]. Both habitat patches occur within 200m of the Crickley Hill units of the SSSI and the southern habitat patch occurs within 200m of the Barrow Wake unit of the SSSI, with a 10m wide corridor of calcareous grassland providing direct connectivity. The patches themselves are less than 200m apart and are connected by a 25m wide corridor of calcareous grassland on the Gloucestershire Way crossing. Whilst not provided specifically as essential mitigation for SSSI fragmentation, the calcareous grassland habitat on the Gloucestershire Way crossing enhances the connectivity between the habitat patches providing a stepping-stone for grassland plant and invertebrate species.

8.9.20 The grassland species mix for the habitat patches would include specific foodplants for invertebrates found within the SSSI such as cowslip *(Primula veris)* for the duke of burgundy butterfly, horseshoe vetch (*Hippocrepis comosa)* for the chalk hill blue and dingy skipper and scabious (*Scabiosa*) species for marsh fritillary.

Irreplaceable habitat - Ancient Woodland and veteran trees

Ancient Woodland

8.9.21 Mitigation to protect ancient woodland habitat includes the implementation of a buffer zone with protective fencing of at least 15m between the construction works and the edge of Ullen Wood canopy edge in accordance with Natural England guidelines[10]. This is achieved for the majority of the interface between the scheme and the woodland including in the area of construction for the Gloucestershire Way crossing. There is one location at the western tip of Ullen Wood, adjacent to the A436, where this buffer has not been achieved for approximately 50m of the 80m tip of the woodland. Works in proximity to ancient woodland will be carried out with an arboricultural clerk of works present to set up tree protection measures to prevent damage to trees or their root systems.

8.9.22 It is acknowledged that some overhanging branches from Ullen Wood to the A436 could require pruning to protect trees from accidental damage by construction machinery. Such works would be carried out by suitably experienced arboriculturalists to maintain the health of the trees. Such protection measures required are included in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.23 Dust deposition due to demolition, earthworks and construction has the potential to affect sensitive habitats and plant communities such as ancient woodland at Ullen Wood. Mitigation to reduce dust deposition would be implemented as detailed above in paragraph 8.9.12 and detailed in the ES Appendix 2.1 EMP (Document Reference 6.4).

Veteran trees

8.9.24 Table 8-17 shows the trees within or adjacent to the DCO Boundary which without mitigation to protect them, may be impacted as a result of damage to the root protection areas (RPA) or canopy. The veteran tree (Ref 155073) in the Air Balloon public house garden is situated in an area to be landscaped adjacent to attenuation basins. No earthworks would be required in this immediate area, so although it is within the scheme alignment it is possible to protect and retain this tree. Five trees would be within areas with permissive access for drainage maintenance and these trees would be retained and the root zones protected. A further nine trees would be within temporary land take or adjacent to the DCO Boundary and would also require protection of root and canopy extents.

Table 8-17 Veteran trees potentially impacted due to construction

Tree Reference	Species	Grid Reference	Location	Location within DCO Boundary	Mitigation
Arboricultural Survey					
T67 duplicate of 143975	Ash	394661 215041	East of Shab Hill	In area of permissive access land take for drainage	Retain and protect RPZ
T109	Beech	393801 215090	Shab Hill Crescent woodland	Adjacent to DCO Boundary and utilities works	Retain and protect RPZ
T172	Beech	393405 216114	Air Balloon Cottages	Adjacent	Protect root zone and canopy
T174	Beech	392985 215893	Cold Slad Lane	In area of permissive access land take for drainage	Protect root zone and canopy
T190	Oak	392468 215646	Flyup 417 Bike Park	In area of permissive access land take for drainage	Protect root zone and canopy
T205	Sycamore	392208 215833	Dog Lane, (north side)	In area of permissive access land take for drainage	Protect root zone and canopy
Woodland Trust records					
143975 duplicate T67	Ash	394669 215039	East of Shab Hill	In area of temporary and permissive	Retain and protect RPZ

Tree Reference	Species	Grid Reference	Location	Location within DCO Boundary	Mitigation
				access land take for drainage	
143988	Ash pollard	394663 215043	East of Shab Hill	In area of temporary and permissive access land take for drainage	Retain and protect RPZ
155073	Orchard apple	393468 216101	Air Balloon public house	Within DCO Boundary in drainage earthworks area	Retain and protect RPZ
196380	Beech	394538 214492	Stockwell Farm hedgerow	In area of permanent land take	Retain and protect RPZ
157	Ash	393618 216361	North of Crickley Hill Entrance	Adjacent to DCO Boundary on Leckhampton Road	Retain and protect RPZ
159	Ash	393632 216392	North of Crickley Hill Entrance	Adjacent to DCO Boundary on Leckhampton Road	Retain and protect RPZ
141310	Ash	394328 213747	Opposite Golden Heart Inn	Adjacent to DCO Boundary	Retain and protect RPZ
141309	Ash	213740 141310	Opposite Golden Heart Inn	Partially within permanent land take	Retain and protect RPZ
T19	Ash	394606213601	A417 near Nettleton Bottom and Birdlip Quarry	Within permanent land take	Retain and protect RPZ
T17	Ash	395191 213519	Cowley Lane stopped up section	Partially within permanent land take	Retain and protect RPZ

8.9.25 Veteran trees that can be retained would be protected using methods in accordance with the British Standards BS 2837:2012 to include fencing of root zone area but also applying protective buffer zones in accordance with Natural England Guidance[10].

8.9.26 A further three veteran trees listed as being within or adjacent to the DCO Boundary are within areas of retained vegetation within Emma's Grove and would not be impacted by the construction works, i.e. no specific mitigation measures are required for these trees. A further three veteran trees fall within the road footprint and would be unavoidably lost due to the construction of the scheme as described in 8.10 Assessment of likely significant effects.

8.9.27 Retained veteran trees and those lost are shown on ES Figure 7.9 Retained vegetation (Document Reference 6.3). Measures for protection are further detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

Invasive and non-native species

8.9.28 A pre-construction check for Schedule 9 listed invasive plant species, both terrestrial and aquatic, would be undertaken at the appropriate time of year to inform any requirement to avoid or remove invasive species.

8.9.29 The implementation of biosecurity best practice described as 'check, clean, dry' would help to mitigate any potential mobilisation of invasive aquatic plant species and also chytrid fungus, which effects amphibians. Measures for dealing with invasive species and implementing biosecurity measures are incorporated in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

Woodland and scattered trees

8.9.30 Semi-natural broadleaved woodland accounts for the majority of woodland to be lost, especially woodland along the verges and embankments of the Existing A417 from Brockworth to Air Balloon roundabout and also loss of beech woodland and mixed broadleaved woodland at Shab Hill. Some mature woodland comprising predominantly ash and hazel coppice, totalling approximately 1,500m^2, would also be lost at the northern tip of Emma's Grove woodland. A 15m buffer has been implemented between the haul roads and construction compounds and the retained area of Emma's Grove woodland which although is not considered to be ancient woodland, is priority habitat.

8.9.31 Where this buffer has not been achieved an arboricultural clerk of works will be present to oversee initial works and set up protection measures. Such protection measures are included in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.32 A total of approximately 7.5ha of new broadleaved woodland species of native variety characteristic of existing woodland would be planted along the southern verge of the new A417 from Brockworth to the Crickley Hill area to replace woodland lost during construction and to ensure continuity of woodland habitat along this section of the scheme for the benefit of bat species. Mixed broadleaved woodland and a buffer of scrub species of approximately 5ha in area would also be planted around the borders of a field to the south of Ullen Wood. This would provide a woodland edge buffer for the ancient woodland. Similarly, additional trees and scrub would be planted on the eastern and northern edge of Emma's Grove to create a tiered buffer of vegetation including hazel scrub and small trees.

8.9.33 Established hazel stands within Emma's Grove, which would otherwise be lost to construction, would be coppiced at the appropriate time of year and translocated to other areas of the woodland to be retained or planted within the new woodland scrub buffer.

8.9.34 Where woodland and scattered trees can be retained, the root zones and canopies would be protected during construction. Measures for protection are included in ES Appendix 2.1 EMP (Document Reference 6.4) and refer to root protection areas stated in ES Appendix 7.6 Arboricultural Impact Assessment (Document Reference 6.4).

8.9.35 A coppiced wych elm tree within an important hedgerow is marked as notable by the Woodland Trust. This tree is within an area of land which would be used for the material crushing compound and Gloucestershire Way crossing construction compound. It would not be possible to retain the tree within a viable layout for the compound. This tree would be coppiced and translocated to a hedgerow receptor site.

8.9.36 Where land is not required for construction, habitat creation, translocation and woodland planting would be undertaken in the first 12 months of the programme

(2023-2024) before commencement of construction. This would enable earlier establishment of vegetation. This is applicable for woodland planting to the south of Ullen Wood and adjacent to Emma's Grove.

8.9.37 Species selection for new planting would include a diverse mix of native trees of local provenance or preferably sourced and grown in the UK, and characteristic of the local area. Where appropriate, the inclusion of a proportion of non-native species suited to hotter drier summers and warmer wetter winters would also be considered to provide resilience against the effects of climate change. No ash would be replanted due to the spread of ash die-back disease. However, species would be selected that offer similar habitat for lichens and invertebrates, have similar pollen and nectar production or provide similar food resource. No single species can replace all the characteristics of ash, however using aspen, alder, field maple, disease-resistant elm, sycamore, oak, hazel and rowan in the landscape planting would provide many of the habitat niches[80]. The target habitat type for woodland creation would be lowland mixed deciduous woodland HPI, with long-term management to maximise its biodiversity value. Proposed woodland planting is shown on ES Figure 7.11 Environmental masterplan (Document Reference 6.3).

8.9.38 Planting new woodland and scrub either adjacent to existing high value habitat such as Ullen Wood or where woodland is lost or fragmented would provide valuable edge habitat to protect the core areas of woodland from variable environmental factors and stresses such as increased wind exposure and pollution. The diverse species mix and structure of edge habitat would provide a transition between two habitat types, usually woodland and grassland, and therefore would support a wider array of species. Planting of edge habitat would maximise biodiversity delivery and increase the resilience of existing woodland to climate change.

8.9.39 Scattered trees and lines of trees are found throughout the study area generally within grassland fields and along minor roads. Historic maps show areas of likely wood pasture, which some of these trees could be relics of, such as at the south-eastern corner of Crickley Hill. Specimen trees would be planted within meadows south of Ullen Wood to replicate wood pasture habitat, in combination with appropriate grassland establishment and management. Avenues of trees would be recreated in the location of Cowley and Stockwell overbridges and scattered trees would be included along the road verges of the Air Balloon Way. Locations of specimen tree planting and trees within hedgerows throughout the scheme are shown on ES Appendix 2.1 EMP (Document Reference 6.4).

Grassland

8.9.40 As shown in Table 8-18, the majority of grassland recorded within the study area is improved or poor semi-improved grassland managed largely as grazing land. Small areas of species-rich semi-improved neutral grassland exist within the study area at Shab Hill, including small relic areas with calcareous grassland species that has been lost due to lack of appropriate management. Unimproved and semi-improved calcareous grassland is present in the Crickley Hill and Barrow Wake SSSI. Several fields to the west of the Air Balloon public house were recorded as semi-improved calcareous grassland, managed as horse-grazed pasture. The most notable area of marshy grassland is present at Bushley Muzzard SSSI, approximately 185m west of the scheme.

8.9.41 The most notable grassland habitat within the scheme is calcareous grassland and areas of neutral species-rich meadows. The majority of grassland habitat creation would be calcareous grassland with smaller areas of neutral species-rich grassland, including attenuation basins, to maximise the areas of priority habitat which is distinctive to the area. Grassland verges of the Existing A417 that would be repurposed to a WCH route as part of the scheme would be widened to create species-rich calcareous grassland. Seeds of native and local provenance would be used, and species chosen which are beneficial for pollinators and other notable invertebrates present in the area. Substrate would be created using low fertility excavated materials or subsoil and no imported topsoil would be required.

8.9.42 A field of high botanical value known to contain an abundance of orchids and assessed as NVC community MG5a was recorded to the north of Shab Hill. The topsoil containing the seed bank from this field would be stored and retained in order to use it in areas of neutral species-rich grassland habitat creation (including attenuation basins) or enhancement within the scheme. Methodologies will be developed through detailed design and included in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.43 Methods to store and reinstate grassland turfs are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.44 Drainage basins throughout the scheme would be seeded with a native species-rich seed mix and be subject to low intensity management to maximise their biodiversity value.

Hedgerows

8.9.45 Hedgerow surveys identified 12 species-rich hedgerows within 50m of the scheme. Ten of these are classified as important hedgerows under the wildlife criteria of the Hedgerows Regulations 1997 and an additional three hedgerows qualify as important due to features other than biodiversity.

8.9.46 The scheme would impact 21 intact hedgerows of the 34 hedgerows surveyed. In total, approximately 3,473 linear metres of hedgerows would be lost, of the overall 5,463 linear metres within the DCO Boundary, including approximately 1,250m of important hedgerow, the locations of which are shown in ES Appendix 8.2 Hedgerow technical report (Document Reference 6.4).

8.9.47 The root zones and canopies of hedgerows and hedgerows with trees, to be retained would be protected during construction. A buffer of at least 2m between temporary works and compound areas and hedgerows would be implemented to protect the root zones of hedgerows and maintain valuable edge habitat for the benefit of wildlife. Measures for protection are included in ES Appendix 2.1 EMP (Document Reference 6.4) and refer to root protection areas stated in ES Appendix 7.6 Arboricultural Impact Assessment (Document Reference 6.4).

8.9.48 Sections of hedgerows of particular importance and species richness that would be lost (Hedgerows 1, 2, 9,17, 20, 21, 22, 29) would be coppiced where suitable in the first year of the programme (2023-2024) in advance of the commencement of construction. The hedgerow coppice stools would be translocated to other areas of the scheme where hedgerow planting is planned or to in-fill gaps in defunct hedgerows to improve habitat connectivity and mitigate for habitat loss. As part of this process, at least a 300mm depth of the soil containing hedgerow ground flora would also be translocated to form banks in which to plant the

hedgerows. Details of translocation methods are detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.49 New hedgerows with standard trees would be planted along much of the eastern section of the scheme and would connect areas of woodland or existing habitat where possible to mitigate hedgerow loss and habitat fragmentation. Newly planted hedgerows would be species-rich, comprising a mix of at least seven woody native species of local provenance, planted every 30m, and in keeping with species recorded in the area. Planting would include species such as hazel and honeysuckle to provide potential food and nesting resource for dormice to encourage future colonisation by this species. Early hedgerow planting on land that would not be required for construction of the scheme would occur in the first suitable season prior to commencement of works to allow some establishment in advance of habitat loss. New hedgerow planting would total 9,024m exceeding the amount of hedgerow lost by a ratio of 2.5:1.

8.9.50 Areas of hedgerow translocation and planting, including a species list, are detailed in in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4) and ES Figure 7.11 Environmental masterplan (Document Reference 6.3).

Amphibians

8.9.51 The implementation of biosecurity best practice described as 'check, clean, dry'[81] would help to mitigate any potential spread of chytrid fungus, which effects amphibians. Measures for implementing biosecurity measures are incorporated in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.52 Sensitive timing of works to avoid winter dormancy/hibernation periods and non-licensed methodologies of ecologically supervised vegetation clearance would be implemented to ensure that no loss of great crested newt habitat occurs and that killing or injury of individual newts is avoided. This mitigation will be implemented for temporary drainage maintenance works required to a culvert adjoining a pond at the far western end of the scheme that supports great crested newt, for clearance of habitat along the northern verge of the Existing A417 that is located within 250m of pond 2a that supports great crested newt, and for minor drainage works adjacent to the non-breeding pond at the National Star College and golf course.

Bats

8.9.53 In addition to mitigation embedded into the design as detailed in ES Chapter 2 The project (Document Reference 6.2), the principles of the essential mitigation for bats are described below (with details to be agreed through the licencing process in relation to roost impacts):

- Pre-construction surveys would be undertaken prior to any tree clearance and demolition of buildings, to ensure there would be no new bat roost in trees and buildings to be cleared. If any new roosts are identified these would need to be included within the scheme bat mitigation licence and mitigation agreed with Natural England.
- The bat roosts in buildings 28 and 31 and four roosts in three trees (BAT ID 246245, T33 and T63) as shown on ES Figure 8.4 Combined Bat survey results CONFIDENTIAL (Document Reference 6.3) would be lost as a result of the scheme, and would be removed under a mitigation licence obtained from Natural England. Suitable alternative roosting habitat would be provided close

to existing foraging and commuting routes. Lesser horseshoe and brown long-eared day roosts at building 28 will be replaced adjacent to the existing building with the provision of a new bat barn with the inclusion of a cool tower (to provide a hibernation roost) as part of a wider package of mitigation and enhancement for the ecological network connectivity for bats. Four crevice bat boxes would also be provided for the loss of the common pipistrelle day roost in Building 31. The exclusion of the roosts would take place at an appropriate time of year when the bats would be least vulnerable. The nature and location of the replacement roosts, timing of the exclusion (where appropriate) and timing of the building demolition and tree felling would all be in accordance with the licence method statement, which would be developed in consultation with Natural England. Draft protected species licences for bats will be reported and submitted separately from the DCO Application and referred to in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

- Following pre-construction surveys, any trees where the potential for roosting bats could not be ruled out after survey would be soft-felled. This methodology is detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).
- There would be provision of a mix of bat boxes erected on retained trees, as well as pole-mounted where necessary, within the vicinity of roosts likely to be disturbed by construction activity, to mitigate for disturbance to these roosts by providing alternative roosting opportunities further away from the sources of disturbance.
- Improvements to a derelict World War II structure (building 91b, a confirmed night roost of lesser horseshoe bats, as shown on ES Figure 7.11 Environmental masterplan (Document Reference 6.3)) would be undertaken to consolidate its construction and increase its suitability for this Annex II species as well as crevice-dwelling species recorded in the area. This would also contribute to addressing disturbance impacts by providing alternative roosting opportunities during construction.
- Relocation of existing roost features would occur where possible, to be carefully removed and strapped to retained mature trees within Highways England ownership as close as possible to their original locations.
- Veteranisation techniques would be employed to create habitats in younger trees that are otherwise found on older more mature trees.
- Complementary to these techniques, fruit trees (including wild cherry and crab apple) have been included in the woodland and scrub planting mix (as detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4)) to provide medium-term mitigation for roosting bats. Fruit trees enter senescence or ‘veteranise’ much earlier than most tree species, therefore starting to decay at a younger age, leading to the earlier development of cavities and other features that could provide new roosting sites for bats[82]. These features would also provide many other wildlife benefits, especially for saproxylic invertebrates.

8.9.54 Any building or tree roost within 50m, depending on type of roost, environmental factors and type of construction activity within the area, could also require a disturbance mitigation licence from Natural England and associated method statements drawn up to reduce potential disturbance impacts, such as noise and lighting on these roosts during construction (as detailed within ES Appendix 2.1 EMP (Document Reference 6.4)).

8.9.55 All vegetation clearance would be undertaken within the first preparatory year (2023-2024) of the construction phase. Dead hedges would be used to allow bats to continue using key commuting routes, as detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.56 Work during hours of darkness (taken as the period 30 minutes before sunset to 30 minutes after sunrise) will be avoided as far as practicable and where unavoidable, the Contractor will agree any exceptions with the Ecological Clerk of Works (ECoW) in advance of construction activities. Should night working be required, these will be discussed with the ECoW and appropriate mitigation put in place as determined by the ECoW (particularly concerning lighting). These could include:

- Temporary lighting used for construction will be switched-off when not in use and positioned so as not to spill on to adjacent land, watercourses, sensitive receptors or key bat flight lines within the area surrounding the works.
- Directed lighting will be used to minimise light pollution for construction compounds and to ensure no light spill over 0.5 Lux on any identified bat commuting and foraging areas or roosting habitat or watercourses.
- Lighting levels around construction compounds will be kept to the minimum necessary for security and safety by the contractor.
- Dark conditions will be maintained within 20m of identified bat roosts.

8.9.57 Lighting designed to be sensitive to bats would also reduce impacts on other nocturnal wildlife such as owls, otters and badgers. Lighting design is detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4) and secured through the DCO.

Badgers

8.9.58 Badgers have been found to be active across the scheme. In addition to mitigation embedded into the design such a badger culverts and badger fencing, as detailed in ES Chapter 2 The project (Document Reference 6.2), and best practice working methods, the following mitigation for badgers would be undertaken;

- A pre-construction survey for badgers (activity and setts) would be carried out (this is detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).
- No works or tracking of heavy machinery would occur within 30m of retained active badger setts.
- Any active setts that would be lost or predicted to be affected as a result of the scheme construction would be closed under a Natural England development licence between the months of July and November prior to commencement of construction. These setts would be determined following the pre-construction survey.
- Loss of main setts would be mitigated by provision of alternative setts in suitable habitat, taking account of factors like drainage, within the current territory of the main sett to be closed under licence from Natural England. This would be undertaken at least four weeks[83] in advance of the main sett closure. Current survey data indicates that one main sett would require closure and an artificial sett created.
- Key foraging habitat near the artificial sett to be created would be retained. In compiling the landscape design as detailed in Figures 7.11 Environmental

Masterplan (Document Reference 6.3) appropriate planting has been incorporated into the design to account for where losses of badger foraging resources have occurred.

- All excavations would be closed overnight, or ramps or another means of escape provided to reduce risk of trapping or injuring wildlife as detailed in ES Appendix 2.1 EMP (Document Reference 6.4).
- Landscape planting would be designed to direct badgers to the three new wildlife culverts (detailed in ES Chapter 2 The project (Document Reference 6.2)) and the [redacted] which provide additional crossing routes for badgers.

Breeding and Wintering birds

8.9.59 A number of Red and Amber listed breeding species and notable winter bird species were recorded within 250m of the DCO Boundary, supported by a diverse habitat assemblage across the landscape including open and arable fields, woodlands, hedgerow and scrub.

8.9.60 Schedule 1 of the WCA 1981 birds were not recorded breeding in the study area, although three Schedule 1 species (hobby (*Falco Subbuteo),* red-backed shrike (*Lanius collurio) and* red kite (*Milvus milvus)*) were noted during the breeding season in the study area.

8.9.61 Pre-construction surveys for Schedule 1 birds would be undertaken. If Schedule 1 birds are found breeding on site or within a distance from the construction works that would make them susceptible to disturbance, such as 100m for barn owl[84], then advice would be sought from a suitably qualified ecologist to ensure that illegal damage or disturbance would not occur.

8.9.62 Construction activities could result in injury or mortality of individual birds, and/or damage or destruction of their active nests. For this reason, vegetation clearance would be planned to be undertaken between September and February to avoid the core breeding bird season, which is considered as March-August inclusive. If clearance within the bird nesting season is unavoidable, vegetation clearance works would adopt a precautionary working method with an ecological watching brief as detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). No netting of vegetation would be used to deter birds from suitable habitat (including buildings) prior to clearance or demolition)

8.9.63 Suitable habitat replacement and creation of woodland, hedgerow and grassland would begin, where possible, before construction during the first year of the programme (2023 – 2024) to reduce the time lag between habitat loss and establishment of replacement habitat for breeding bird and wintering bird assemblages.Early tree planting would occur where construction would not be required, such as the field to the south of Ullen Wood, and hedgerow planting or buffering would occur to the south of the Existing A417.

8.9.64 Nesting bird boxes would be provided for a range of species, including marsh tit, spotted flycatcher, tawny owl (*Strix aluco*), kestrel (*Falco tinnunculus*) and stock dove (*Columba oenas*). Boxes would be installed in habitat to be retained prior to habitat clearance and prior to the bird nesting season (March-August, inclusive) to provide some opportunities for displaced birds (from loss of breeding habitat) to relocate and nest. Indicative locations of bird boxes are shown on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3).

8.9.65 Skylarks are known to be present in the fields to the south of Ullen Wood. This area would be partially planted with woodland, but the central area would be retained and enhanced as a meadow to maintain suitable ground nesting habitat to be functional during scheme construction. Areas of grassland will be left open with no tree planting within 100m so as not to provide predator perches in close proximity to ground nesting species.

8.9.66 Details of all mitigation measures including the location of bird boxes is incorporated within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.67 Provision of planting and its management to replace suitable habitat lost due to the scheme are detailed and incorporated within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

Barn owl

8.9.68 The evidence from baseline surveys and incidental sightings of this species indicate that up to three breeding pairs of barn owl are likely to be present within 500m of the DCO Boundary in the region of Rushwood Kennels and Stockwell Farm. Construction activities could result in barn owls being disturbed, injured and/or killed, in the absence of mitigation or suitable working practices. To reduce these risks the mitigation below will be implemented.

8.9.69 A pre-construction survey for roosting or nesting barn owl would be undertaken in all suitable habitat within 100m of the scheme.

8.9.70 Habitat manipulation techniques would be employed to deter barn owls from entering construction areas, to include mowing long grass to reduce foraging potential.

8.9.71 Species-rich grassland meadow areas in the Shab hill area would be managed to provide barn owl foraging habitat, providing rough grassland to encourage prey species. Management of calcareous grassland habitat to be created would also include uncut field margins to provide strips of foraging habitat for barn owl. These areas would include a previously arable field used as the western compound where barn owl roosts have been identified nearby and grassland currently grazed to the south of Ullen Wood. This field would be screened from the road with woodland planting and planted in the first year of the programme prior to construction, which would also seek to provide a commuting route for barn owls to the foraging resource. Locations are indicated on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3) and incorporated within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

Reptiles

8.9.72 Reptiles were identified at 17 locations across the scheme and the presence of the four widespread reptile species (adder, grass snake, common lizard and slow worm) together was identified at four of these locations. Exceptional numbers of slow worms were recorded at Crickley Hill and south-west of the Air Balloon roundabout.

8.9.73 Construction activities would result in individual reptiles being injured and/or killed, in the absence of mitigation or suitable working practices. To reduce the risk of reptile killing or injury the mitigation below will be implemented.

8.9.74 A translocation exercise would be carried out encompassing all key reptile areas (supporting either an assemblage of three or more species or exceptional populations of reptiles) and all areas where adder have been recorded within the scheme. Translocations would be undertaken prior to vegetation clearance for construction. All reptiles found during this exercise would be moved to suitable receptor sites on and off site and as agreed with relevant landowners. These sites would be areas where the size of existing reptile populations are already known and where habitat can be enhanced to increase the carrying capacity of the habitat for reptiles, or areas of new reptile habitat creation. The creation and/or enhancement of habitat to support translocated reptiles would be undertaken, and habitats allowed to establish, in advance of translocations. A habitat creation site of approximately 1.5ha for reptiles would be created to the north of the Birdlip Quarry in the first year of the programme (2023 – 2024) prior to construction, extending to 3ha on completion of the works in that area. Retained reptile habitat and receptor sites, if adjacent to the scheme, would be protected with reptile fencing for the duration of the construction phase.

8.9.75 In areas outside of key reptile areas, where low number of reptiles were recorded, habitat manipulation using phased and directional vegetation reduction to displace reptiles to retained habitat would be undertaken. This would occur in suitable weather and within the reptile active season of April to October, prior to construction. This habitat would then be maintained as unsuitable for reptiles for the duration of the construction phase to ensure that reptiles do not re-colonise areas where they would be at risk of harm.

8.9.76 The dismantling of stone walls that offer potential reptile hibernacula will be sensitively timed to avoid the reptile hibernation period. A preconstruction survey to identify these sites would be carried out.

8.9.77 Habitat suitable for reptiles would be included in the landscaping of the scheme, including a translocation receptor site on land adjacent to Birdlip Quarry and other areas of neutral species rich grassland. In these locations, and in other areas across the scheme, habitat mosaics would be created comprising long grassland, scrub, hedge-banks and bare ground with south facing banks for basking and log piles created with wood from vegetation clearance to provide suitable refuge locations and hibernacula.

8.9.78 These measures are further detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

Otter

8.9.79 Otters were confirmed to be present along the Upper Frome and Horsebere Brook watercourses within the study area, although they are also known to be present in the wider area within the River Churn and northern reaches of Norman’s Brook. No evidence of otter was recorded within the DCO Boundary.

8.9.80 A pre-construction survey of all wooded areas adjacent to watercourses within the scheme would be carried out to confirm the presence or absence of any otter holts within the construction area and to inform the requirement for any Natural England mitigation licence.

8.9.81 Working within 50m of a watercourse could cause disturbance to otters. Details of working time restrictions to reduce potential disturbance to dispersing and foraging otter would depend upon the pre-construction surveys and mitigation

licence requirements (if required). Any required restrictions would be detailed within further iterations of Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.82 All excavations would be closed overnight, or ramps or another means of escape provided to reduce risk of trapping or injuring wildlife as detailed in ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.83 Restrictions on working hours to avoid night working (taken as the period 30 minutes before sunset to 30 minutes after sunrise) would be implemented so that there would be no light spill in the vicinity of watercourses and other key bat flight lines, or roosts and adjacent habitats. Any temporary task lighting required would be directional lighting and designed to ensure no light spill over 0.5 Lux on any identified bat commuting and foraging areas or roosting habitat or watercourses. Lighting designed to be sensitive to bats would also reduce impacts on other nocturnal wildlife such as owls, bats and badgers. Lighting design is detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4) and secured through the DCO.

Terrestrial invertebrates

8.9.84 Notable terrestrial invertebrates are found across the scheme primarily within calcareous grassland and woodland habitat including deadwood and habitat mosaics comprising short-sward vegetation, rank grassland, deadwood and scrub.

8.9.85 Construction activities would result in approximately 0.09ha of unimproved calcareous grassland, 2.44ha of semi improved calcareous grassland and 9.85ha of broadleaved semi-natural woodland being permanently or temporarily lost as part of the works under the scheme. Some of this habitat includes calcareous grassland at Barrow Wake SSSI. Areas of other grassland and woodland habitat loss which area also of benefit to invertebrate species are detailed in Table 8-18.

8.9.86 Mitigation measures would include landscape planting designed to replace that lost and incorporate features beneficial to invertebrates throughout the scheme. Habitat creation would include the planting of 75.31ha of species-rich calcareous and 7.52ha of neutral grassland with species beneficial to insects including pollinators. Species mixes would seek to include plants that provide a food source for scarce species identified onsite and especially within the SSSIs such chalkhill blue (*Lysandra coridon)*, green hairstreak (*Callophrys rubi*), marsh fritillary (*Eurodryas aurinia)*, Duke of Burgundy fritillary (*Hamearis Lucina)* and the day flying cistus forester moth (*Adscita Geryon)*.

8.9.87 Strategically located calcareous grassland habitat creation to replace lost habitat and to mitigate the impact of increased fragmentation of habitat in relation to Crickley Hill and Barrow Wake SSSI would be provided, as detailed in the mitigation for designated sites above.

8.9.88 A proportion of felled trees would be retained on-site where possible as habitat piles and to eventually create deadwood habitat to benefit invertebrates. Deadwood and surrounding leaf litter found in areas that would be cleared for the scheme, especially in and adjacent to Emma's Grove, would be moved to suitable areas of retained habitat on site preferably within the same woodland to ensure maintenance of invertebrate habitat, in particular for wood-decay (saproxylic)

invertebrates, e.g. beetles. Some dead wood would be moved to areas of habitat or new planting to increase ecological connectivity of this habitat.

8.9.89 Existing deadwood can be translocated at any time of year but should be done carefully to avoid damage and should be moved to a location with similar shade conditions to its original location. Freshly felled wood should be moved in the winter, or soon after its felling, before egg-laying adults start to inhabit it. Well-structured wood piles should be created from felled wood under ecological supervision to allow the creation of a range of microclimatic conditions, including relatively dry saproxylic niches at the top of the stack, these being the conditions favoured by many of the rarer dead wood specialists. In order to maximise the range of microclimatic conditions within the wood piles, they should be created in a range of light conditions, including full shade, dappled conditions, and full sun. It should be noted that larger pieces of wood (for example, trunks and larger branches of at least 0.5m in width and a few metres in length) would be of greater value than smaller pieces.

8.9.90 A proportion of the realigned verges or embankments would also be managed so that areas of bare ground and sparsely vegetated well-drained and calcareous soils would be present. In addition, 2.6ha of rockface embankments would be allowed to colonise naturally and would provide additional habitat for invertebrates.

8.9.91 Management and monitoring of the created grassland and woodland habitat and enhancement of retained habitat to ensure its continued suitability for target invertebrate species is incorporated into Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

[redacted]

8.9.92 [redacted]

8.9.93 [redacted]

8.9.94 [redacted]

8.9.95 [redacted]

Aquatic invertebrates

8.9.96 Direct and indirect impacts on aquatic invertebrates are anticipated within the tributary of Norman's Brook. No indirect impacts are predicted within the River Frome, the River Churn or their associated tributaries.

8.9.97 During the construction phase, there would be no works within tributaries associated with the River Frome or those associated within the River Churn. As such, no loss of aquatic habitat is expected.

8.9.98 Measures to prevent pollution to watercourses would be implemented during the construction phase as referenced above in paragraph 8.9.11 and detailed in ES Appendix 2.1 EMP (Document Reference 6.4)

8.9.99 The scheme design includes the realignment of the tributary of Norman's Brook and the loss of several springheads due to embankments. Adverse direct impacts relating to habitat loss, water quality and flow changes would be mitigated by the provision of alternative aquatic and associated riparian habitat, creation of new springhead habitat via groundwater transfer and provision of seasonal flows.

8.9.100 Sensitive timing and methodologies for works involving the tributary of Norman's Brook realignment will be implemented to minimise direct impacts to aquatic invertebrates through avoid killing or injury as detailed in ES Appendix 2.1 EMP (Document Reference 6.4).

8.9.101 Aquatic invertebrate baseline data associated with spring head habitat connected to the tributary of Norman's Brook (AQ7) identified communities typical of small or temporary headwater streams. A drainage solution would be implemented to intercept and divert spring water into the realigned tributary of Norman's Brook. A focus for detailed design would be to incorporate discharges of groundwater to the riparian zone where appropriate, creating springhead habitat adjacent to the realigned channel. For more information, see the hydrogeological assessment in ES Chapter 13 Road drainage and the water environment (Document Reference 6.2).

Fish

8.9.102 There is potential for direct impacts within the tributary of Norman's Brook to fish such as European bullhead, European eel, brown trout and brook lamprey due to the temporary loss of habitat and river realignment.

8.9.103 Sensitive timing and methodologies for works involving the tributary of Norman's Brook realignment would be implemented to avoid killing or injury of fish (including eggs laid in spawning habitats) and pre-construction fish translocation.

8.9.104 Most adverse effects would be mitigated by standard mitigation such as the provision of alternative aquatic habitat and fish translocation prior to dewatering and river diversion. The detailed design of the new river habitat in the diverted channel would be agreed in consultation with Environment Agency specialists and be informed by pre-construction fish surveys. The detailed design would focus on balancing the habitat requirements (substrate, depth, flow types and refuges) of fish species (if present) and other aquatic species, with returning the river to a

more natural step-pool habitat that would have existed prior to modification of the river by numerous weirs. A Section 27a exception permit would be required from the Environment Agency to catch fish by means other than rod and line during the translocation. To mitigate the effects of disturbance to fish populations, in-channel works and the dewatering of the tributary of Norman's Brook would proceed following pre-construction fish surveys to inform the strategy and methodology for the fish translocation, including receptor sites.

Essential mitigation - Operation

8.9.105 Essential mitigation would be implemented in order to mitigate for potential impacts of the operational phase as described within section 8.8 Potential impacts that could not be avoided within the embedded mitigation through design.

8.9.106 Essential mitigation during the operational phase is identified in the Register of Environmental Actions and Commitments (REAC), contained within ES Appendix 2.1 EMP (Document Reference 6.4). This has been developed to avoid or reduce the potential impacts on habitats and species as a result of the operational phase of the scheme.

Designated Sites

8.9.107 Signage and interpretation boards would be situated at suitable locations of the site, such as on the Air Balloon Way and entrances to the Cotswold Way crossing to educate the public regarding the biodiversity of the site and the sensitivity of sites such as Barrow Wake, Crickley Hill and Emma's Grove. Interpretation boards would include geodiversity and heritage information also. The design and exact locations of these boards would be discussed and agreed at the detailed design stage to help avoid or reduce any impacts arising from recreational visitor pressure on sensitive sites.

Irreplaceable habitat – Ancient woodland and veteran trees.

8.9.108 Approximately 2.1ha of ancient semi-natural woodland within Ullen Wood will be subject to a level of increased nitrogen deposition from vehicle emissions that would be likely to result in a reduction in species richness and/ or changes to species composition of the habitat. There are no feasible mitigation options to reduce the impacts of nitrogen deposition upon the ancient woodland. Compensatory measures are described in Section 8.10.

8.9.109 In addition, a veteran beech tree (ref 196380 and Air quality receptor EVT21) located approximately 830m to the east of the Existing A417 will also be subject to a level of increased nitrogen deposition that would be likely to degrade this habitat feature. Mitigation will focus on relieving other threats and pressures to this veteran beech tree, with the aim of ensuring that the overall condition/ longevity of the tree is not affected.

8.9.110 The impacted veteran beech tree is within a section of important hedgerow to be retained within the scheme boundary, adjacent to PROW Cowley restricted byway 36. In addition to nitrogen deposition, other typical threats to veteran trees[85] that are relevant to the impacted beech tree include: lack of conservation-led management of the tree and surrounding land; and farming activities resulting in root compaction and other damage from livestock and machinery. Mitigation will aim to alleviate these pressures to benefit the health of the tree, by reducing risks of future structural failure, moderating competition from adjacent woody

vegetation, and reducing risk of damage from farming operations and browsing animals. This will be achieved through: introduction of sensitive, gradual arboricultural management of the tree to maintain its longevity whilst respecting its veteran features; management of adjacent woody vegetation to control competition for light and water; and erection of fencing to create buffer zones to exclude vehicles, animals and WCH. The tree forms part of a field boundary and the tree itself and the land to the south of this boundary falls within the scheme boundary. A permanent protective buffer zone will be established within the scheme boundary to protect the tree from operational impacts, in accordance with Natural England Guidance on protecting trees from development[10]. The land to the north of the tree will remain in agricultural use (sheep-grazed pasture) and the exclusion zone within this field would extend to at least beyond the extent of the canopy of the tree, in accordance with guidance on controlling access to veteran trees for livestock[85].

Barn Owl

8.9.111 Mitigation would include strategic planting of woody species of a height of at least 3m in areas considered to be of high collision risk i.e. at Shab Hill Junction to encourage barn owls to fly at a safe distance above the road network.

8.9.112 Grass verges and embankments adjacent to the road would be managed as short grassland, with arisings removed in order to reduce the potential for long tussocky grassland with a deep thatch layer that would support barn owl prey species. This would decrease the foraging potential and collision risks to barn owls.

Enhancement

8.9.113 Enhancement is a measure that is over and above what is required to mitigate the adverse effects of a scheme.

8.9.114 The NPSNN states that opportunities for building in biodiversity features should be maximised and the scheme should show how it has taken advantage of opportunities to conserve and enhance biodiversity. Opportunities have been taken to connect previously isolated woodlands such as Emma's Grove, Ullen Wood and woodland near Birdlip radio station with new woodland and hedgerow planting to create connectivity of habitats throughout the landscape. In addition, gaps in hedgerows such as along Cowley Wood Lane would be planted to provide greater habitat connectivity.

8.9.115 The landscape design focusses on provision of priority habitats that are present within the Cotswold AONB. Natural England and Gloucestershire Wildlife Trust's vision for the scheme was to increase the area of lowland calcareous grassland. The current area of unimproved and semi-improved calcareous grassland within the scheme boundary is approximately 4.9ha (of which 2.53ha would be lost). A total of 75.31ha would be created following construction of the scheme. Whilst some of this area would be to compensate for the loss of SSSI calcareous grassland and mitigate the impacts of further fragmentation of SSSI habitat or loss of foraging habitat, the very large increase in calcareous grassland area exceeds that created for mitigation and is considered an enhancement. Furthermore, a 25m wide corridor of calcareous grassland will be provided across the Gloucestershire Way crossing, providing a continuous habitat link for calcareous grassland flora and fauna to disperse through the landscape. This is an enhancement in comparison to the Existing A417 which has no such provision.

8.9.116 Areas of Ullen Wood ancient woodland have been the focus of a woodland restoration project in recent years funded by the Forestry Commission and supported by CCB. This comprises the implementation of conservation-led woodland management measures including selective thinning of trees, rotational coppicing of hazel, and erection of deer exclusion fencing. The restoration project is understood to have been implemented across a relatively small proportion of Ullen Wood. Opportunities will be sought to expand the woodland restoration project to additional areas of Ullen Wood, in conjunction with CCB and the landowner/s. The aim would be to reduce the impact of typical threats and pressures to ancient woodland that are relevant to Ullen Wood such as browsing by deer, decline in woodland management and increasing levels of shade[86]. Enhancement measures would aim to alleviate these pressures and improve the overall conservation status of the ancient woodland by improving woodland structure, creating variation of light conditions in the woodland and increasing diversity of the ground flora.

8.9.117 Dormouse surveys recorded no evidence of dormice populations within the scheme, however there are records of dormice within 1.2 miles (2 kilometres) of the scheme. Landscaping design would aim to connect isolated blocks of woodland and plant species would be selected to contain species favoured by dormouse for foraging and nesting, such as hazel and honeysuckle, to allow future colonisation of dormice. The 37m wide Gloucestershire Way crossing, which would include two species rich hedgerows, would provide connectivity over the road which does not currently exist, further enabling the dispersal of this European protected species and other mammal species across the wider landscape in the future.

8.9.118 Hedgerows on the Gloucestershire Way crossing would be planted on hedge-banks that would be constructed to provide suitable south facing habitat for reptiles and invertebrates.

8.9.119 The existing stone-built bus stop, which would be decommissioned as part of the de-trunking and repurposing of the A417, would be retrofitted to form an artificial bat roost in order to increase roosting opportunities in this area. Similarly, bat roosting opportunities would be incorporated into the unlit Crickley Hill bat underpass.

8.9.120 Subject to detailed design of the entrance grills, badgers and other wildlife could also use the underpass designed for bats at the western end of the scheme at chainage 1+085. Badger surveys showed a territory to span both sides [redacted] in this location and badgers are thought to use the existing [redacted] Therefore, the bat underpass at CH 1+100 would provide a safer method of crossing within the existing territory. Grove Farm underpass would also be suitable to be used by species such as bats, badger, fox and deer. Badger fencing would tie in with this structure to encourage its use and prevent access of animals to the highway.

8.9.121 A limited amount of selected scrub and small tree clearance would be undertaken at Emma's Grove, subject to landowner consent, at the location of the Barrows and approach paths to them. This would be primarily a heritage enhancement to enable greater access to and interpretation of a heritage resource, but creation of a glade and enhancement of rides within the woodland would provide variation in light conditions within the woodland, enhancing the habitat for woodland ground flora and in turn, birds and invertebrates.

8.9.122 Enhancements are detailed as part of Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.10 Assessment of likely significant effects

8.10.1 The assessment of effects takes into account the potential impacts to each ecological receptor outlined in Section 8.8 and following the implementation of embedded design and essential mitigation measures outlined in section 8.9 Design, mitigation and enhancement measures to determine the significance of the residual effects. The effects have been separated into construction and operation effects.

8.10.2 As described in ES Chapter 4 Environmental assessment methodology (Document Reference 6.2), the assessment of effects of construction covers the effects on biodiversity features during the construction period to the Opening year. The operation section addresses the effects of traffic movement and human activity once the road is opened, rather than the physical presence of the scheme (which is dealt with in construction only).

8.10.3 It is considered that the flexibility afforded by the proposed LoD would not give rise to any materially new or materially worse adverse or better beneficial ecological effects from those from those predicted in the assessment. Ecological constraints have informed limits in certain areas to ensure there are no deviations that would introduce new or materially worse ecological effects than those reported in this section, for example, no lateral deviation has been incorporated for works near sensitive ecological receptors such as designated sites, ancient woodland and veteran trees.

Construction effects

8.10.4 The impacts on ecological receptors likely to occur during the construction phase are described for each receptor in the following sections.

Statutory designated sites of international importance

Cotswold Beechwoods SAC

8.10.5 **Habitat extent:** No land take within the Cotswold Beechwoods SAC is required and there would be no direct impacts as a result of habitat loss.

8.10.6 **Nitrogen deposition**: The SAC is within 200m of the ARN and has been assessed for air quality impacts because it is sensitive to nitrogen deposition. As described in ES Chapter 5 Air quality (Document Reference 6.2), there is no change predicted in nitrogen deposition (0.00 N/ha/yr) within the SAC as a result of the construction phase of the scheme and no air quality impacts to designated habitats are predicted.

8.10.7 **Hydrological changes**: The hydrogeological conceptual model presented in ES Appendix 13.7 Hydrogeological impact assessment (Document Reference 6.4) identifies that the drawdown in groundwater levels associated with cuttings along the scheme does not extend to any groundwater fed systems of the SAC. The assessment of impacts on groundwater dependant terrestrial ecosystems (GWDTE) presented in ES Appendix 13.8 GWDTEs Assessment concludes that there is no linkage between the potential impacts from the road to groundwater levels and the habitats within the SAC that are dependent on springs and seepage from high groundwater levels.

8.10.8 Due to the distance from the scheme, no other impacts on the SAC are anticipated during the construction phase. No observable impacts on Cotswold Beechwoods SAC are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the international level and not significant.**

8.10.9 Further details of the assessment of impacts upon Cotswold Beechwoods SAC are provided within the Habitat Regulations Assessment: Screening Report (Document Reference 6.5) and Habitats Regulations Assessment: Statement to Inform an Appropriate Assessment (Document Reference 6.5).

Wye Valley and Forest of Dean Bat Sites SAC

8.10.10 **Habitat extent (including functionally linked habitat):** No land take within the SAC is required and there would be no direct impacts as a result of habitat loss. The SAC is located over 20km from the scheme. Due to this distance the bat foraging and commuting routes present within the scheme boundary are not considered part of the core roost sustenance zones for the lesser and greater horseshoe bat populations that are the qualifying interests of the SAC. As such the effects of the loss of any suitable foraging or commuting habitat associated with the scheme would not affect the integrity of the SAC.

8.10.11 Due to the distance from the scheme, no other impacts on the SAC are anticipated during the construction phase. No observable impacts on Wye Valley and Forest of Dean Bat Sites are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the international level and not significant.**

8.10.12 Further details of the assessment of impacts upon Wye Valley and Forest of Dean Bat Sites SAC are provided within the Habitat Regulations Assessment: Screening Report (Document Reference 6.5).

North Meadow and Clattinger Farm SAC

8.10.13 **Nitrogen deposition**: This SAC is over 20km from the scheme boundary. The SAC is within the study area for assessment of air quality impacts only, because it is within 200m of the ARN and the site is sensitive to nitrogen deposition. As described in ES Chapter 5 Air quality (Document Reference 6.2), there is no change predicted in nitrogen deposition (0.00 N/ha/yr) within the SAC as a result of the construction of the scheme and no impacts on air quality from construction are predicted.

8.10.14 No observable impacts on North Meadow and Clattinger Farm SAC are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the international level and not significant.**

<u>Statutory designated sites of national importance</u>

Crickley Hill and Barrow Wake SSSI

8.10.15 **Habitat extent:** The Crickley Hill units of the SSSI are situated to the north of the A417 and will not be impacted by habitat loss during the construction phase of the works. Works are anticipated within the Barrow Wake unit of Crickley Hill and Barrow Wake SSSI as a result of the widening of the Existing A417, the creation of a roundabout as part of the upgrade of the B4070 Birdlip link road from Shab

Hill junction and the re-purposing of part of the Existing A417. The latter is due to the fact that the historic SSSI boundary of the Barrow Wake unit covers the existing highway, which has therefore, fragmented the SSSI.

8.10.16 Works at the northern extent of the Barrow Wake unit of Crickley Hill and Barrow Wake SSSI would incur the loss of approximately 900m^2 (0.09ha) of predominantly calcareous grassland with some localised tree loss. Approximately 560m^2 (0.056ha) of this habitat would be permanently lost to the cutting embankment (rock face) and a drainage cascade. Approximately 340m^2 (0.034ha) of habitat would be lost during the construction phase but would be reinstated as calcareous grassland following completion of the works. Impacts to this area of the SSSI are considered to be unavoidable due to geological constraints on the scheme design, although viable solutions to reduce habitat loss will continue to be sought at the detailed design stage.

8.10.17 The creation of a roundabout on the B4070 Barrow Wake Road would not result in the loss of any calcareous grassland, the main qualifying feature of the Barrow Wake SSSI unit. There would however be a loss of approximately 500m^2 (0.05ha) of road verge habitat either side of the current underpass structure. Existing vegetation in these locations comprises young to semi-mature trees, such as ash, hazel, willow and hawthorn, with ruderal species. This habitat is not considered to be high value habitat within the designated area. Impact to mature trees has been avoided where possible, although where ash trees are present the management of ash die back will need to be considered with regard to retention of these trees. Similarly, a limited area of up to 1m wide on the western edge of the B4070 Barrow Wake Road adjacent to the proposed roundabout would be impacted to enable the rerouting of utilities and to provide a working area for the building of a stone wall required to mitigate for light spill from traffic. Vegetation in these locations is scrub and broadleaved trees. The impact of these works on mature trees will be minimised wherever possible.

8.10.18 Works to de-trunk the Existing A417 within the SSSI would not result in any significant tree loss along the verges of the Existing A417 or any priority grassland habitat. These areas will be retained and protected. An area of approximately 2,000m^2 of existing highway would be removed within the SSSI to create a WCH route (the Air Balloon Way) and wider calcareous grassland verges.

8.10.19 Works to upgrade the Barrow Wake car park and widen the path to connect to the Air Balloon Way would not result in any loss of SSSI habitat. The calcareous grassland to the east of the carpark supports a population of musk orchid and this area would be protected throughout construction. Any stone walls built to provide a barrier between the car park and SSSI, and also prevent light spill from car lights, will be built on hard standing.

8.10.20 The loss of approximately 1,400m^2 (0.14ha) of calcareous grassland and wooded habitat within the SSSI would be compensated for by the creation of calcareous grassland in a greater quantity than that lost. This would be part of a larger area of replacement Common Land as shown on ES Figure 12.4 Special category land (Document reference 6.3), totalling approximately 10,534m^2 (1.053ha) and comprising part of the Existing A417 carriageway and areas of existing verge habitat, both trees and grassland, to be retained. The existing carriageway would be used for the WCH route and habitat creation. The Common Land replacement therefore includes the conversion of approximately 3,600m^2 (0.36ha) of

hardstanding to calcareous grassland, of which approximately 1,000 m^2 (0.1ha) is currently hardstanding within the SSSI boundary.

8.10.21 The loss during the construction phase of approximately 0.09ha of predominantly calcareous grassland at the northern extent of the Barrow Wake unit of the SSSI would result in the permanent/irreversible reduction of a habitat type for which the SSSI is designated. The extent of impacted habitat would be small, and its loss would not affect the integrity of the SSSI. The habitat loss would represent a minor adverse impact upon the SSSI.

8.10.22 The conversion of approximately 0.36ha of hardstanding to calcareous grassland as part of Common Land replacement, including 0.1ha within the SSSI boundary, would result in a permanent addition to the area of calcareous grassland within and adjacent to the Barrow Wake unit of the SSSI. This would positively affect the integrity of this resource once established. The creation of calcareous grassland at the end of the construction phase of the scheme would occur in the appropriate planting season, approximately three years after the original habitat loss. It is also acknowledged that grassland would take between three years and five years to establish but would take ten to twenty years or more to reach the target botanical condition. Taking this time lag into consideration, the habitat compensation for the loss of the habitat within the SSSI together with the additional calcareous grassland created for Common Land would represent a minor beneficial impact upon the SSSI.

8.10.23 **Habitat fragmentation:** The Crickley Hill units of Crickley Hill and Barrow Wake SSSI border the Existing A417 to the north for a length of approximately 515m. Woodland, grassland and scrub vegetation habitats immediately to the south of the A417 are contiguous with designated habitats within the Barrow Wake unit of the SSSI, which occurs at a distance of 70m from the Crickley Hill units of the SSSI at the closest point. The non-designated woodland, scrub and grassland between the SSSI units are likely to provide a functional link that supports the dispersal of plant and invertebrate species between the SSSI units. The current gap in functionally linked habitat for the Existing A417is approximately 12m wide along the 515m section of existing road that borders the SSSI. Construction of the scheme would temporarily widen this gap between functionally linked habitats to approximately 100m. Once new grassland and woodland planting has established, the permanent gap between functionally linked habitats that connect to the SSSI units along this section would be approximately 30m wide for 170m, and 60m wide for 345m (including the road verge and bare rock face of the new cutting).

8.10.24 The Favourable Conservation status for lowland calcareous grassland, such as that within the SSSI, is influenced by the functional attributes of supporting off-site habitat, e.g. contiguous or connected areas of suitable habitats, and also by functional connectivity with the wider landscape[87]. The widening of the road corridor for the scheme would reduce the connectivity between habitats that are functionally linked to the SSSI units along the section to the west of Air Balloon roundabout.

8.10.25 These functional attributes are also likely to be important to the metapopulation dynamics of invertebrate species of conservation concern that are found within the SSSI, such as marsh fritillary which requires an extensive network of well-connected habitat patches to achieve long-term population stability. Metapopulations of other invertebrate species included in the SSSI citation are

also likely to depend upon connectivity of habitat between the SSSI units, such as cistus forester moth and chalkhill blue that were recorded in surveys both to the north and south of the Existing A417Reduced habitat connectivity between the SSSI units as a result of proposed widening of the existing road corridor would likely be detrimental to the movement and persistence of invertebrate metapopulations in the long-term.

8.10.26 The Environmental Masterplan (ES Figure 7.11 Environmental Masterplan (Document Reference 6.3)) includes the creation of two new habitat patches to the north and south of the scheme respectively that would mitigate the impacts of fragmentation, by providing functional habitat connectivity for species associated with the Crickley Hill and Barrow Wake SSSI units to disperse. This mitigation is described under 'essential mitigation' in section 8.9 Design, mitigation and enhancement measures. Whilst not provided specifically as essential mitigation for SSSI fragmentation, the calcareous grassland habitat on the Gloucestershire Way crossing further enhances the connectivity between the habitat patches for grassland plant and invertebrate species.

8.10.27 The habitat patches, or stepping stones, would counteract the impacts of increased fragmentation from the scheme on the Crickley Hill and Barrow Wake SSSI, by providing new functionally connected areas of similar habitat that would benefit species dispersal and enable populations of plants and invertebrates associated with the SSSI to expand their distribution. This would prevent populations within the core sites of the SSSI from becoming more isolated and less genetically diverse and would facilitate recolonisation for species prone to local extinction.

8.10.28 The predicted unmitigated impacts of fragmentation relate to metapopulation dynamics and genetic mixing of populations, rather than the daily or seasonal routine of animals, or the annual cycle of organisms. Such effects would be likely to take many years to be realised. Calcareous grassland provided within new habitat patches would establish to a functional level to facilitate dispersal within three to five years (albeit would likely take longer to reach good condition). The impacts of habitat fragmentation on the SSSI are therefore considered to be temporary/reversible due to the time lag between clearance of habitats that provide connectivity between the SSSI units and mitigation habitats being functional. Given the nature of the impacts, the duration of this time lag is not considered to affect the integrity or key characteristics of the SSSI. With mitigation, increased habitat fragmentation would represent a negligible adverse impact upon Crickley Hill and Barrow Wake SSSI.

8.10.29 **Nitrogen deposition:** As described in ES Chapter 5 Air quality (Document Reference 6.2), there is predicted to be around 420 additional heavy goods vehicle movements associated with the main construction phase of the scheme (2023 – 2026). The greatest predicted change in nitrogen deposition at the SSSI arising from construction is a change of 0.1kg N/ha/yr at 10m from the scheme boundary, within the Barrow Wake unit of the SSSI. This represents a 0.97% increase in deposition against the lower critical load. Further than 10m from the scheme boundary, the change reduces to 0.5% and below. The current baseline level of nitrogen deposition is 44.3kg N/ha/yr which is in excess of the critical load of 10-20kg N/ha/yr. The temporary increase in nitrogen deposition of less than 1% against lower critical load is considered to result in no observable impact upon the SSSI.

8.10.30 **Pollution:** The Barrow Wake unit of Crickley Hill and Barrow Wake SSSI (partly within scheme boundary) and the calcareous grassland habitat components of the SSSI (adjacent to the site) are at risk of habitat damage and degradation as a result of elevated levels of airborne dust from the works, pollution events or sediment run-off during construction of the scheme. Impacts would be avoided or reduced through implementation of construction best practice working methods as summarised above in paragraphs 8.9.10 to 8.9.13. Measures to protect retained habitat and species within the SSSI are detailed in ES Appendix 2.1 EMP (Document Reference 6.4) and all works within SSSIs would be undertaken according to a method statement and agreed and signed off by Natural England. With implementation of this mitigation, impacts upon the SSSI would be temporary/reversible and would not affect its integrity. Deposition of dust, pollution and sediment run-off from construction works would be represent a negligible adverse impact upon the SSSI.

8.10.31 In summary, Crickley Hill and Barrow Wake SSSI would be adversely impacted by the loss and fragmentation of habitat and degradation (dust pollution) from construction activities. These impacts range in scale from negligible adverse to minor adverse. **The residual effect of these impacts associated with the scheme is considered to be moderate adverse at the national level, and significant.**

8.10.32 Crickley Hill and Barrow Wake SSSI would be beneficially impacted by the creation of calcareous grassland habitat within and adjacent to the SSSI, which would represent a minor beneficial impact. **The residual effect of this impact associated with the scheme is considered to be moderate beneficial at the national level, and significant.**

Bushley Muzzard Brimpsfield SSSI

8.10.33 **Hydrological changes:** Bushley Muzzard and Brimpsfield SSSI is located approximately 218m west of the scheme and is designated for lowland fen habitat which is a GWDTE. Excavation of cuttings and changes to the limestone and mudstone geology could impact levels and extent of flow, affecting the networks of springs found throughout the study areas. The hydrogeological conceptual model presented in ES Appendix 13.7 Hydrogeological impact assessment (Document Reference 6.4) identifies that the drawdown in groundwater levels associated with cuttings along the scheme does not extend to any groundwater fed systems of the SSSI. The assessment of impacts on GWDTE presented in ES Appendix 13.8 GWDTEs Assessment concludes that there is no linkage between the potential impacts from the road to groundwater levels and the habitats within the SSSI that are dependent on springs and seepage from high groundwater levels.

8.10.34 Due to the distance from the scheme, no other impacts on the SSSI are anticipated during the construction phase. No observable impacts on Bushley Muzzard and Brimpsfield SSSI are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the national level and not significant.**

Cotswold Commons and Beechwoods SSSI

8.10.35 The majority of this SSSI is a component of the Cotswold Beechwoods SAC and the construction impacts relevant to the SSSI are the same as those described for the SAC (paragraphs 8.10.5 - 8.10.9). The reason for designation of the majority

of the SSSI is broadly the same as that for the designation as the SAC, i.e. ancient beech woodland habitat. The SSSI is also designated for additional areas of calcareous grassland that do not form part of the SAC. The closest area of this designated grassland to the scheme is at Cranham Common, over 3km from the scheme boundary. Due to this distance, no additional impacts from construction are predicted to the areas of SSSI grassland habitat that do not fall within the SAC boundary.

8.10.36 No observable impacts on Cotswold Commons and Beechwoods SSSI are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the national level and not significant.**

Leckhampton Hill and Charlton Kings Common SSSI.

8.10.37 Leckhampton Hill and Charlton Kings Common SSSI is located approximately 0.7 miles (1.2km) north-east of the scheme boundary. No land take from within the SSSI is required. Air quality modelling does not predict any changes in nitrogen deposition during the construction phase of the scheme. Due to the distance of the SSSI from the scheme, no other impacts are predicted as a result of the construction phase.

8.10.38 No observable impacts on Leckhampton Hill and Charlton Kings Common SSSI are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the national level and not significant.**

Non-statutory designated sites

8.10.39 Several non-statutory designated sites fall within or adjacent to the scheme boundary. These sites are: Barrow Wake Local Wildlife Reserve (LWR) and Crickley Hill LWR, which are partly within the scheme boundary; Ullen Wood LWS and River Frome Mainstream and tributaries LWS, which are adjacent to the scheme; and the potential LWSs, Haroldstone Fields and Bentham Dog Lane Fields, which are also adjacent to the scheme.

Barrow Wake Local Wildlife Reserve (LWR)

8.10.40 **Habitat extent**: Barrow Wake LWR is within the Barrow Wake unit of Crickley Hill and Barrow Wake SSSI and the construction impacts relevant to the LWR are the same as those described for the SSSI. The LWR is designated for the same calcareous grassland habitat that is one of the reasons for designation of the SSSI. The impacts to this habitat and any residual effects are reported in paragraphs 8.10.15 to 8.10.32 of the statutory designated sites section above.

Crickley Hill Country Park (LWR)

8.10.41 **Habitat extent**: Crickley Hill Country Park LWR is partly within the Crickley Hill units of Crickley Hill and Barrow Wake SSSI. Construction works within Crickley Hill Country Park LWR are limited to minimal works outside of the SSSI to link the entrance road to Leckhampton Hill Road. Encroachment onto grassland adjacent to the access road where levelling may be required would be up to 2m at the most for a length of up to 25m. If turf would be damaged by the works it would be lifted and stored appropriately to be reinstated after the short-term works. This would result in temporary, reversible damage to the LWR that is small in extent and

would not affect its integrity. Methods to store and reinstate grassland turfs are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4)

8.10.42 In summary, Crickley Hill County Park LWR would be subject to negligible adverse impacts from habitat loss and degradation as a result of construction activities. **The residual effect associated with the scheme is considered to be slight adverse at the county level, and not significant.**

Ullen Wood LWS

8.10.43 Ullen Wood LWS is an ancient woodland and the impacts and any residual effects of construction upon this site are reported in paragraphs 8.10.53 to 8.10.57 of the irreplaceable habitats section below.

River Frome mainstream and tributaries LWS

8.10.44 **Pollution**: The River Frome mainstream and tributaries LWS of county importance is adjacent to the DCO Boundary at the southern end of the scheme. Work in this location would be to reroute utilities within the hardstanding of the road. With implementation of the construction best practice mitigation measures to avoid pollution of aquatic habitats, as described in paragraph 8.9.11, there would be no direct or indirect impacts on the LWS. No observable impacts on River Frome mainstream and tributaries LWS are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the county level and not significant.**

Haroldstone Fields pLWS

8.10.45 **Habitat extent**: Haroldstone Fields potential Local Wildlife Site (pLWS) of county importance is a field to the north of the Existing A417to the west of Crickley Hill Country Park. It is a steep south-facing field of currently unmanaged calcareous grassland and neglected grape vines. At the southern extent of the field is a densely planted strip of young coniferous trees with no ground flora adjacent to the highways verge, which comprises scrub and scattered standard trees. Installation of horizontal drainage may be required at this location for slope stabilisation. This would directly impact approximately 5m of land on the existing highways slope adjacent to the pLWS, to enable the directional drilling of drainage pipes into the hillside, which would extend 30-50m into the hillside, i.e. beneath the pLWS. These works would result in the loss of planting on the highways slope adjacent to the pLWS, rather than vegetation within the pLWS. No observable impacts on the pLWS site are predicted as a result of the horizontal drainage works.

8.10.46 Soil pinning for slope stabilisation may be required in the vicinity of Haroldstone Fields pLWS. The requirement for this would not be confirmed until either detailed design or during construction. For the purposes of this assessment it is assumed that soil pinning would be required during the construction phase of the scheme. This would result in the permanent/irreversible loss of approximately 0.25ha of predominantly coniferous tree planting and some broadleaved trees adjacent to the A417. These areas would be allowed to re-vegetate as grassland and scattered scrub once the soil pinning was complete, with management implemented to prevent the re-establishment of trees or dense scrub. The pLWS extends to approximately 3ha, and its primary interest feature is the mosaic of grassland habitats present. The small loss of non-grassland habitats resulting

from the soil pinning works would represent a minor adverse impact on the pLWS which would not affect the integrity of the site.

8.10.47 **Nitrogen deposition:** At Haroldstone Fields pLWS, air quality modelling shows the change of nitrogen deposition during construction is a change of 0.1kg/ha/yr, which represents a 0.5% increase in deposition against the lower critical load of 10kg N/ha/yr for the first 10m of the modelled transect. Baseline levels of nitrogen deposition are 44.32kg N/ha/yr nearest the road. The impact of nitrogen deposition during construction at Haroldstone Fields pLWS would have no observable impact on the calcareous grassland, which is the interest feature for the non-statutory site.

8.10.48 In summary, Haroldstone Fields LWS would be subject to a minor adverse impact from habitat loss as a result of construction activities. **The residual effect associated with the scheme is considered to be slight adverse at the county level, and not significant.**

Bentham Dog Lane Fields pLWS

8.10.49 **Habitat extent**:There would be no habitat loss from Bentham Dog Lane fields pLWS of county importance as a result of the construction phase of the scheme.

8.10.50 **Nitrogen deposition**: Impacts from habitat degradation are considered unlikely at this site despite the proximity to the western extent of the scheme. Air quality modelling results show a 0.1% increase in nitrogen deposition against the lower critical load at Bentham Dog Lane Fields. Due to the temporary nature, very small increases and high baseline level of nitrogen deposition above the critical load, it is considered that there would be no observable impact upon this site from increased nitrogen deposition during the construction phase of the scheme.

8.10.51 No observable impacts on Bentham Dog Lane fields pLWS are predicted as a result of the construction phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the county level and not significant.**

Other non-statutory sites

8.10.52 No habitat loss, degradation or any other observable impacts from construction are predicted at other non-statutory sites within the study area, as listed in

Table 8-8, due to the distance of these sites from the scheme.

Irreplaceable Habitat – Ancient woodland and veteran trees

Ancient Woodland

8.10.53 Ullen Wood LWS is designated as ancient woodland and considered to be irreplaceable habitat of national importance.

8.10.54 **Habitat extent**: There will be no direct loss of ancient woodland during the construction phase of the scheme due to avoidance as part of the design. The western edge of Ullen Wood is adjacent to the A436. If tree limbs overhanging the existing A436 carriageway require pruning during the construction phase in this area, the works would be undertaken by experienced arboriculturists so as not to cause damage to mature or veteran trees. Pruning works would result in temporary/reversible damage that would be minor in extent and would not affect the integrity or key characteristics of the ancient woodland. The pruning works would represent a negligible adverse impact upon the ancient woodland.

8.10.55 In order to protect the woodland from damage and degradation, mitigation to protect ancient woodland habitat includes the implementation of a buffer zone with protective fencing of at least 15m between the construction works and the edge of Ullen Wood canopy edge, in accordance with Natural England guidelines[10]. Where this buffer has not been achieved an arboricultural clerk of works will be present to oversee initial works and set up protection measures. Such protection measures are included in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). With the implementation of a buffer zone and protective measures for tree protection, there would be no observable impact of habitat loss upon the ancient woodland, during the construction phase of the scheme.

8.10.56 **Dust pollution**:A material crushing compound, which in the previous iteration of the scheme was situated adjacent to Ullen Wood ancient woodland, has been relocated to the southern side of the proposed mainline, over 200m away from the woodland boundary, to reduce the potential impacts of habitat degradation as a result of dust deposition. Mitigation to further reduce dust deposition would be implemented as detailed above in paragraph 8.9.12 and detailed in the ES Appendix 2.1 EMP (Document Reference 6.4). With the implementation of this mitigation, dust deposition would result in temporary/reversible damage that would not affect the integrity or key characteristics of the ancient woodland. Dust deposition arising from construction works would represent a negligible adverse impact upon the ancient woodland.

8.10.57 Construction traffic in the three year construction phase would not result in increases in nitrogen deposition greater than 1% of the lower critical load (10kg N/ha/yr) at Ullen Wood during the construction phase. Due to the temporary nature and small scale of change there would be no observable impact upon this site from increased nitrogen deposition during the construction phase of the scheme.

8.10.58 In summary, Ullen Wood ancient woodland and LWS, would be subject to negligible adverse impacts from pruning works associated with construction activities. **The residual effect associated with the scheme is considered to be slight at the national level and not significant.**

Veteran trees

8.10.59 **Habitat extent**: The design has minimised the loss of veteran trees, although the scheme would result in the unavoidable loss of three veteran trees during the early construction phase of the scheme prior to the commencement of works due to their location within the proposed road alignment. The trees that would be lost are a sycamore (T57) near Stockwell Farm, and beech trees (T126 and 127) between Emma's Grove and Ullen Wood. A further 18 veteran trees that are situated either within land required temporarily for construction works or are adjacent to the DCO Boundary would be protected and retained, as described in the mitigation section 8.9 Design, mitigation and enhancement measures. It is not possible to mitigate for the loss of veteran trees as they are irreplaceable features. The loss of three veteran trees would be a permanent/irreversible impact that would negatively affect the key characteristics of this resource. The loss of veteran trees would represent a major adverse impact.

8.10.60 As partial compensation for the loss of veteran trees, young trees of the same species as those to be lost will be planted with space around them to develop an open crown. This will comprise scattered tree planting within the meadow south of Ullen Wood, which is in close proximity to the veteran trees to be lost.

8.10.61 **Nitrogen deposition**: Construction traffic would result in an increase in nitrogen deposition of 1% against the lower critical load at the veteran Apple tree at the Air Balloon public house tree ref 155073 (Air quality receptor EVT84). The change in nitrogen deposition is 0.1kg N/ha/yr. In accordance with the assessment methodology within LA 105, this would represent a negligible adverse impact on the veteran tree. No other veteran trees within 200m of the ARN would experience a change in nitrogen deposition levels during the construction phase of the scheme.

8.10.62 In summary, the veteran tree resource would be adversely impacted by degradation and direct loss from construction activities. These impacts range in scale from negligible adverse to major adverse. **The residual effect associated with the scheme is considered to be large adverse at the national level, and significant.**

Habitats

8.10.63 Impacts and effects on habitats of local importance and above that do not form part of designated sites or irreplaceable habitats are reported below.

8.10.64 The new section of the scheme would run through open countryside, resulting in the loss and severance of habitat as will the widening of the Existing A417at Crickley Hill. As shown in Table 8-18, habitat losses would include 12.42ha of semi-natural broadleaved woodland and 2.53ha of calcareous grassland. The majority of haul routes would be within the highway and would not result in additional permanent or temporary habitat loss. Smaller satellite compounds and welfare units required at each overbridge or underpass structure would be within existing areas of permanent land take and at Barrow Wake would be on existing hard standing within the carpark, with the exception of compounds required for the Gloucestershire Way crossing and the Cotswold Way crossing.

8.10.65 ES Figure 7.11 Environmental Masterplan (Document Reference 6.3) has been developed to replace any semi-natural habitats permanently lost as a result of the scheme and to enhance retained habitats. This strategy includes the creation of

habitat corridors along the length of the scheme, providing links to off-site habitats including previously isolated woodland blocks, and compensatory measures for the loss of one Annex 1 tufa formation. The strategy has focussed on maximising the delivery of species-rich calcareous grassland, whilst ensuring that there is a net gain in area of all other habitat types of county value (including all HPIs). As a result, there would be a 72.88ha net gain in area of calcareous species-rich grassland within the scheme boundary.

8.10.66 Table 8-18 shows the areas of habitat that would be retained and lost within the construction phase of the scheme and areas of different habitat planted post construction. The largest areas of habitat loss would be of improved grassland, poor semi-improved grassland, arable land and semi-natural broadleaved woodland.

Table 8-18 Habitat losses and gains associated with the scheme

Phase 1 habitat type	Total habitat within the DCO Boundary (ha)	Total retained	Area of habitat lost (ha) (permanent and temporary land take)	New habitat (as shown on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3))	New proposed planting hectares (ha) and metres (m) for hedgerow	Net permanent gain or loss (ha) and metres (m) for hedgerow
Semi-natural broadleaved woodland	20.04	7.62	12.42	Native broadleaved woodland	25.57	9.59
Broadleaved plantation woodland	6.45	2.89	3.56			
Coniferous plantation woodland	0.39	0	0.39	n/a	n/a	-0.39
Mixed plantation woodland	1.34	0.51	0.83	n/a	n/a	-0.83
Scrub (dense)	2.37	0.43	1.94	Scrub including woodland edge buffer planting	4.34	2.40
Semi-improved neutral grassland	10.90	1.92	8.98	Species rich neutral grassland (includes within drainage basins)	7.60	-1.38
Unimproved calcareous grassland	0.60	0.51	0.09	Limestone grassland (calcareous conservation grassland)	75.41	72.88
Semi-improved calcareous grassland	4.34	1.91	2.44			
Improved grassland	46.70	11.97	34.73	n/a	n/a	-34.73
Poor semi-improved grassland	55.62	19.45	36.17	n/a	n/a	-36.17

Phase 1 habitat type	Total habitat within the DCO Boundary (ha)	Total retained	Area of habitat lost (ha) (permanent and temporary land take)	New habitat (as shown on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3))	New proposed planting hectares (ha) and metres (m) for hedgerow	Net permanent gain or loss (ha) and metres (m) for hedgerow
Tall ruderal	1.07	0.07	1.00	n/a	n/a	-1.00
Standing water	0.02	0.02	0	n/a	n/a	0.00
Total Hedgerow	5,463m	1,990m	3,473m	Hedgerow (native species-rich)	9,024m	5,551m
Arable land	25.77	1.32	24.45	n/a	n/a	-24.45
Amenity grassland	1.82	0.38	1.43	n/a	n/a	-1.43
				Rock face (naturalised vegetation)	2.63	2.63

8.10.67 A LEMP has been written and included as Annex D of ES Appendix 2.1 EMP (Document Reference 6.4) to ensure the establishment and success of habitat created to replace any habitats permanently lost as a result of the scheme and to maintain habitat connectivity along the length of the scheme. This document will be updated iteratively as the scheme progresses.

Woodland/Trees

8.10.68 The majority of woodland recorded within the study area is broadleaved semi-natural woodland. The largest areas of woodland are designated woodland sites at Crickley Hill and Barrow Wake SSSI, Cotswold Beechwoods SAC and Ullen Wood ancient woodland. Smaller parcels of woodland including plantation woodlands are quite isolated and surrounded by farmland. Impacts on woodland within statutory and non-statutory desiginated sites are assessed above in the designated sites section or irreplaceable habtiat section with regard to ancient woodland.

8.10.69 Of the 28.22ha of all woodland within the DCO Boundary, construction of the scheme would result in the loss of the following areas of woodland and trees valued as of local importance and above:

- Semi-natural broadleaved woodland of national importance (HPI) (12.42ha lost).
- Plantation broadleaved woodland of county importance (3.56ha lost).
- Plantation mixed woodland of local importance (0.83ha lost).
- Scattered broadleaved trees of local importance (excluding veteran trees, assessed separately as irreplaceable habitat).

Broadleaved woodland, mixed woodland and scattered trees

8.10.70 The majority of broadleaved woodland that would be lost would be semi-natural, including those areas along the verges and embankments of the Existing A417from Brockworth to Air Balloon roundabout and also loss and severance of beech woodland and mixed broadleaved woodland at Shab Hill. The construction would also remove approximately 1,500 m^2 of the northern edge of Emma's

Grove woodland. A small area of plantation broadleaved woodland would also be lost at Stockwell.

8.10.71 The 12.42ha loss of semi-natural broadleaved woodland, and scattered trees, during the early construction phase of the scheme for preparatory works (spring 2023 to spring 2024) is adverse, permanent and irreversible. The extent of this loss would negatively affect the integrity of this habitat resource. The habitat loss would represent a major adverse impact upon semi-natural broadleaved woodland and scattered trees.

8.10.72 The 3.56ha loss of plantation broadleaved woodland and 0.83ha of mixed plantation woodland during the early construction phase of the scheme (spring 2023 to spring 2024) is adverse, permanent and irreversible and the extent of this loss would not negatively affect the integrity of this habitat resource. The habitat loss would represent a minor adverse impact upon plantation broadleaved and mixed woodland.

8.10.73 Compensatory woodland planting comprising a diverse native mix of species to replace woodland lost, would be planted along the southern verge of the new A417 from Brockworth to Crickley Hill to replace habitat that would be lost and to replace the continuous wooded corridor. Woodland planting is also proposed around the edges of a field bordering Ullen Wood, currently used as grazing pasture, which would provide a buffer for the ancient woodland. Similarly, additional trees would be planted around the eastern edge of Emma's Grove to create a tiered buffer of vegetation, including hazel scrub and other small trees. Woodland would also be planted at the approaches to the new Gloucestershire Way crossing, which with hedgerow and tree planting, would provide connectivity of habitat between Ullen Wood and Emma's Grove. Woodland planting is shown on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3).

8.10.74 The root zones and canopies of scattered trees to be retained would be protected during construction. Measures for protection are included in ES Appendix 2.1 EMP (Document Reference 6.4) and refer to root protection areas stated in ES Appendix 7.6 Arboricultural Impact Assessment (Document Reference 6.4). Replanting of specimen trees and trees within hedgerows is detailed in ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.75 With the planting of 25.57ha of broadleaved semi-natural woodland, and additional scattered trees within pasture and hedgerows, (as shown in Table 8-18), as well as retention and protection of trees and woodland as detailed in ES Appendix 2.1 EMP (Document Reference 6.4), there would be a gain of approximately 9.59ha of broadleaved woodland habitat. There would be improved connectivity of previously isolated woodland blocks, once this woodland was established, that would positively affect the integrity of this biodiversity resource.

8.10.76 The habitat creation would occur in suitable planting seasons as early as possible throughout the construction programme. Areas of early planting in the first preparatory year of the programme would be undertaken where possible to reduce the time lag between habitat loss to habitat planting and establishment. This would include the field south of Ullen Wood, with the exception of land required to construct the Gloucestershire Way crossing, as indicated on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3).

8.10.77 It is acknowledged that in many areas, the planting would not be possible until the scheme is completed, which is currently programmed for 2026, three years after

woodland is cleared. It is considered that the trees would establish by the design year (15 years afer opening) although it may take approximately 30 years for areas to develop woodland characteristics. Despite this time lag, the improved connectivity of habitat and total area of broadleaved woodland creation to be managed favourably for biodiversity, would represent a major beneficial impact upon this biodiversity resource.

8.10.78 In summary, habitat loss of plantation broadleaved and mixed woodland across the scheme would be a minor adverse impact. **The residual effect associated with the scheme on plantation woodland is considered to be slight adverse at the local level, and not significant.**

8.10.79 Habitat loss of semi-natural broadleaved woodland and trees across the scheme would be a major adverse impact. **The residual effect of this loss associated with the scheme on semi-natural broadleaved woodland and trees is considered to be large adverse at the national level, and significant.**

8.10.80 In addition, there would be a major beneficial impact on broadleaved woodland due to new woodland creation. **The residual effect of this habitat creation associated with the scheme is considered to be large beneficial at the national level, and significant.**

Hedgerows

8.10.81 The scheme would impact 21 intact hedges of the 34 hedges surveyed within the scheme. Of the hedgerows affected, the scheme would impact 11 of the 13 important hedgerows (Hedgerow reference 1, 2, 9, 17, 17a, 22, 23, 24, 27, 28 and 29), seven of which are species-rich hedgerows (1, 2, 9, 17, 22, 27 and 28). Two further impacted hedgerows are species-rich but not classified as important (20 and 21). In total, approximately 0.8 miles (1.25 kilometres) of important hedgerow would be lost.

8.10.82 A total of 5.6 miles (9.02 kilometres) of new species-rich intact hedgerow would be created across the scheme, including sections formed from existing translocated hedgerows. This created hedgerow would result in an overall gain of approximately 3.4 miles (5.5 kilometres) of hedgerow habitat of a composition which would qualify as important hedgerow under the Hedgerow Regulations, once established. Hedgerows would be planted to fill gaps in defunct hedgerows and to connect isolated blocks of woodland, offering improved connectivity of hedgerows and woodland habitat.

8.10.83 The loss of 2.2 miles (3.5 kilometres) of hedgerow habitat, of which approximately 0.8 miles (1.25 kilometres) is important hedgerow, in accordance with the Hedgerow Regulations, would result in the permanent/irreversible damage to this biodiversity resource, the extent of which would negatively affect the integrity of the resource. The timing of the loss would be in the first year of the construction phase, currently between February 2023 and March 2024. The habitat loss would represent a major adverse impact upon important and priority habitat hedgerows.

8.10.84 The creation of approximately 5.6 miles (9.02 kilometres) of species-rich native hedgerow would result in a permanent addition to the retained resource of hedgerow of 3.4 miles (5.5 kilometres) of species-rich hedgerow that would positively affect the integrity of this resource, once established. Hedgerow planting would occur in the appropriate planting season throughout the phasing of the scheme, including early planting and translocation where land is not required

for construction, to reduce the time lag between habitat lost and new habitat establishment. Early planting areas are identified on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3). It is considered that hedgerows would establish within three to five years but may take ten years to reach the good condition of a mature hedgerow. The habitat creation would represent a major beneficial impact upon this biodiversity resource.

8.10.85 In summary, important and priority hedgerow habitat would be subject to a major adverse impact from direct loss resulting from construction activities. **The residual effect of this habitat loss associated with the scheme is considered to be large adverse at the national level, and significant.**

8.10.86 Important and priority hedgerow habitat would be subject to a major beneficial impact from new hedgerow planting. **The residual effect of this habitat creation associated with the scheme is considered to be large beneficial at the national level, and significant.**

Grassland

8.10.87 The scheme would result in the following direct losses of grassland types, valued as being of local importance and above:

- Calcareous grassland – unimproved - national importance (HPI) (0.09ha).
- Calcareous grassland – semi-improved - county importance (2.44ha).
- Neutral grassland - semi-improved, species-rich grassland - national importance (HPI) (4.5ha).
- Neutral grassland - semi-improved (other) - local importance (4.48ha).
- Neutral grassland poor semi-improved - local importance (36.17ha).

Calcareous grassland

8.10.88 Unimproved Calcareous grassland is only found within Crickley Hill and Barrow Wake SSSI. The loss of 0.09ha of unimproved calcareous grassland and potential habitat degradation at the Barrow Wake unit of the Crickley Hill and Barrow Wake SSSI are discussed and assessed in the designated sites section.

8.10.89 Two fields to the east of Barrow Wake and west of the Air Balloon public house were recorded as semi-improved calcareous grassland, one managed as horse-grazed pasture and one unmanaged. The latter, adjacent to the Air Balloon public house, measuring approximately 0.5ha of semi-improved calcareous grassland, would be lost due to the location of the satellite compound required for construction of the Cotswold Way crossing. The NVC survey recorded this field as poor condition NVC community CG3 grassland. Its poor condition is due to the lack of management. This field would be reinstated as calcareous grassland with a tree line post construction.

8.10.90 Within the valley at Shab Hill are small relic areas of semi-improved calcareous grassland on a south-facing bank in mosaic with neutral grassland found within the rest of the valley. These relic and transitioning areas of semi-improved calcareous grassland would be lost under the main scheme alignment.

8.10.91 The majority of grassland creation throughout the scheme, on all road verges, embankments and previously arable and pasture land, would be lowland calcareous grassland of NCV communities CG3- CG5 in keeping with the local landscape, to compensate for habitat lost, mitigate habitat fragmentation and to maximise the creation of priority habitat. The creation of calcareous grassland

habitat would be approximately 75.41ha (a net gain of 72.88ha) as shown on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3). Seeds of native and local provenance would be used. Methods of habitat creation would be developed during detailed design but would include consideration of methods such as using green hay from the Cotswold area.

8.10.92 The loss of 2.44ha of semi-improved calcareous grassland of county importance, from fields west of the Air Balloon public house and Shab Hill at early construction phase would result in permanent/irreversible damage that would negatively affect the integrity of the resource. The habitat loss would represent a major adverse impact upon this biodiversity resource.

8.10.93 Creation and restoration of calcareous grassland would occur in the appropriate season throughout the phasing of the scheme including early creation where possible within the first year of the construction programme. Early planting areas are identified on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3). In other areas, it may be possible to create habitat as the scheme progresses, but restoration of compound areas would be at the end of the construction phase, three years after existing habitat is lost. It is considered that grassland would establish within three to five years[88] but would take ten to twenty years or longer to reach good condition. This would vary depending on the quality of the ground initially, the ability of the surrounding habitat to enable dispersal of species and the management regime. Management regimes and monitoring requirements of habitats are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.94 The creation of 75.41ha of species-rich calcareous grassland would represent a large permanent increase in the extent of this habitat in the local landscape. This habitat creation would positively affect the integrity of this biodiversity resource and this would represent a major beneficial impact upon this resource.

8.10.95 In summary, calcareous grassland (non-SSSI grassland) would be subject to a major adverse impact due to loss resulting from construction activities. **The residual effect of habitat loss associated with the scheme is considered to be slight adverse at the county level, and not significant.**

8.10.96 In summary, calcareous grassland would be subject to a major beneficial impact due to creation of calcareous grassland throughout the scheme. **The residual effect associated with the scheme is considered to be moderate beneficial at the county level, and significant**.

Neutral semi-improved species rich grassland

8.10.97 There are localised areas of neutral species-rich grassland within the DCO Boundary. Most notably, a grazed and managed meadow, measuring approximately 4.5ha, of high botanical value to the north of Shab Hill which is categorised as species-rich MG5a NVC community, contains an abundance of orchids and is considered to be an area of lowland meadow habitat of principal importance. This meadow falls within the main alignment of the scheme and its loss would be unavoidable. The topsoil and seed bank from this field would be stored and retained in order to use it in areas of nearby habitat creation within the scheme.

8.10.98 Drainage attenuation basins throughout the scheme would be seeded with a native species-rich seed mix and be subject to low intensity management to

maximise their biodiversity value. A total of 7.60ha of neutral species-rich grassland (semi improved) would be created as shown on ES Figure 7.11 Environmental Masterplan (Document Reference 6.3). Seeds of native and local provenance would be used or seeds from retained topsoil from the scheme. Grassland establishment typically takes three to five years with appropriate management but would take longer to reach good condition. This would vary depending on the quality of the ground initially, the ability of the surrounding habitat to enable dispersal of species and the management regime. Management regimes and monitoring of habitats are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.99 The loss of 4.5ha of neutral species-rich grassland habitat that qualifies as lowland meadow priority habitat of national importance, in the early stages of the construction programme, would result in permanent/irreversible damage that would negatively affect the integrity of the resource. The habitat loss would represent a major adverse impact upon this biodiversity resource.

8.10.100 Due to stakeholder preference for creation of calcareous grassland throughout the scheme, only 7.60ha of species rich neutral grassland would be created and the majority of this would be within attenuation basins which would largely be dry. Further compensation for the loss of neutral species-rich grassland is provided by the large net gain in area of species-rich calcareous grassland, which vastly outweighs the loss in area of existing neutral and calcareous grassland combined. The beneficial effect of this compensatory habitat provision is reported under calcareous grassland above.

8.10.101 In summary, neutral semi-improved species rich grassland would be subject to a major adverse impact due to loss resulting from construction activities. **The residual effect associated with the scheme is considered to be large adverse at the national level, and significant.**

Neutral semi-improved and poor semi-improved grassland

8.10.102 Within the valley at Shab Hill is an area of unmanaged grassland, categorised as a mosaic of neutral grassland which is largely NVC community MG9b. This area of grassland has greater ecological value for the fauna it supports in terms of foraging habitat than its floristic condition. The majority of the grassland is within the proposed new alignment for Shab Hill Junction and therefore would be lost. The southern extent of the grassland would be retained.

8.10.103 Poor semi-improved grassland, managed as grazing pasture, would be lost between Air Balloon roundabout and Shab Hill.

8.10.104 In areas where construction impact would be minimal, such as the fields to the west of the Shab Hill junction where utilities diversions are required, the poor semi-improved grassland would be enhanced to create more species rich grassland.

8.10.105 The loss of 4.48ha of other neutral semi-improved grassland and 36.17ha of poor semi-improved grassland within the early construction phase of the scheme would result in permanent/irreversible damage that would negatively affect the integrity of the resource. The habitat loss would represent a major adverse impact upon this biodiversity resource. **The residual effect associated with the scheme is considered to be slight adverse at the local level, and not significant.**

Tufaceous vegetation

8.10.106 The scheme would result in the loss of one feature (G231) with qualifying vegetation of the Annex 1 habitat H7220 Petrifying springs with tufa formation (*Cratoneurion*) as a result of the realignment of the tributary of Norman's Brook. This habitat is of regional importance. Whilst translocation of the tufaceous crust and associated plant assemblage was considered as a mitigation measure, several factors would be required to align for the groundwater to reach a suitable level of high saturation and then for precipitation to occur and accumulate. In consultation with specialists, translocation was therefore ruled out due to the intricacies between the groundwater and the rock it flows through and also due to the lack of any known precedent elsewhere.

8.10.107 A drainage solution would be implemented to intercept and divert spring water into the realigned tributary of Norman's Brook. A focus for detailed design would be to ensure that groundwater transferred is discharged in the riparian zone, creating springhead habitat adjacent to the realigned channel where appropriate where tufa could form if the conditions are suitable as mentioned above.

8.10.108 The loss of the tufaceous vegetation feature (G231) would result in permanent/irreversible damage that would negatively affect the integrity of the resource. This habitat loss would represent a major adverse impact upon this biodiversity resource.

8.10.109 To compensate for this loss, off-site restoration of existing tufaceous formations in degraded condition will be undertaken. Three areas of tufaceous vegetation have been identified within the vicinity of the Scheme where opportunities for improvement and enhancement exist, i.e. degraded habitat which could be restored and enhanced via changes to land and/or habitat management to remove the cause of degradation. Habitat improvement works considered to be suitable across these sites are straightforward, comprising the reduction of encroaching scrub and trees to reduce shading of the springs, exclusion of livestock to prevent damage through poaching and removal of debris. Such habitat improvement works would encourage development of the kind of tufaceous vegetation that can be regarded as the M37 (*Palustriella commutata - Festuca rubra)* spring community.

8.10.110 Compensation will include restoration of features such as those above, subject to further detailed consultation with Natural England and consideration of any additional or alternative restoration opportunities identified through this consultation. Restoration works to benefit tufaceous vegetation would be undertaken with a long-term management plan secured to maintain the improved conditions. The enhancement of degraded tufaceous vegetation would be a permanent improvement to this resource that would positively affect the integrity of the resource. This habitat improvement would represent a major beneficial impact upon this biodiversity resource.

8.10.111 The methodology and results for the assessment of compensation options are provided within ES Appendix 8.25 Tufa-forming springs: selection of potential compensation sites (Document Reference 6.4) and full compensatory measures are included in ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.112 In summary, tufa habitat would be subject to a major adverse impact due to loss of tufa habitat from construction activities. **The residual effect of habitat loss**

associated with the scheme is considered to be large adverse at the regional level, and significant.

8.10.113 In addition, tufa habitat would be subject to a major beneficial impact due to enhancement measures at other tufa sites to compensate for the tufa habitat loss. **The residual effect of habitat enhancement associated with the scheme is considered to be moderate beneficial at the regional level, and significant.**

Protected species

Bats (roosts)

8.10.114 **Roost loss:** Construction would result in the loss of a common pipistrelle day roost in Building 31 Woodside House (local importance) and the loss of lesser horseshoe and brown long-eared day roosts in Building 28 (county and local importance respectively). Construction would also result in the loss of four tree roosts consisting of: one Natterer's day roost (BAT ID 246245: county importance); one common pipistrelle day roost (T33; local importance); and one multi-species day roost of common pipistrelle and a *Myotis* species (T63; county importance).

8.10.115 Replacement roosts would be provided under a mitigation licence from Natural England. The destruction of the roosts would take place at an appropriate time of year when the bats are least vulnerable. Existing tree roosting features would be salvaged where possible through careful section-felling and strapping onto nearby trees and at a similar height and orientation to that of the original tree roost. Where this is not possible, suitable bat boxes would be provided as an alternative.

8.10.116 A small bat barn would be provided for the loss of the lesser horseshoe and brown long-eared day roosts. This feature is not being provided in compensation for the loss of existing bat roosts, as no confirmed hibernation roosts will be lost. This is part of a wider package of mitigation and enhancement for ecological network connectivity for bats. Nonetheless, the cool tower would provide suitable roosting features for the species identified within the study area. The provision of this particular artificial roost would increase the potential roosting features within the area, so the loss of trees along Norman's Brook that are considered to be suitable as roosts would not be expected to reduce the availability of potential roosting features in the study area.

8.10.117 Four crevice bat boxes would also be provided, the locations and details of the replacement roosts are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.118 With this mitigation implemented, the loss of these roosts would result in a single occurrence at an appropriate time of year for roost removal, of temporary/reversible damage to the bat populations that would not affect their integrity. The roosts loss would represent a negligible adverse impact upon the local bat populations.

8.10.119 **Disturbance**: Activities resulting in increased levels of noise, vibration or light can lead to bats abandoning roosts.

8.10.120 The lesser horseshoe maternity roost/multi-species roost at Haroldstone House cottages, which lies within 20m of the scheme and is of regional importance, would be subject to a single occurrence of short-term (approximately two weeks)

disturbance effects including noise, vibration, movement of plant and personnel for the rerouting of services. Given the roost status, the works would be programmed to avoid the maternity period in order to reduce disturbance impacts, as detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). With this mitigation implemented, disturbance impacts to this roost would result in temporary/reversible damage to the bat populations that would not affect their integrity. This disturbance would represent a negligible adverse impact upon the local bat populations.

8.10.121 Within the DCO Boundary, there are:

- Three tree roosts (T239 *Myotis* sp. day roost of county importance; T163 and T235 common pipistrelle day roosts of local importance).
- Two common pipistrelle day roosts (in buildings 5b and 21, of local importance), one *Myotis* day roost (in building 21, of county importance).
- One lesser horseshoe day roost (in building 33a, of county importance).
- One lesser horseshoe night roost (in building 91b, of county importance).

8.10.122 It is not possible to specify exactly when disturbance arising from construction adjacent to these roosts would occur until the detailed construction programme has been finalised, though some indicative dates of works and the roosts they could disturb include:

- Construction of the Crickley Hill bat underpass within the period April 2024 to April 2025 (T235 located approximately 45m north-west).
- Construction within the Shab Hill area within the period April 2024 to January 2025 (adjacent to building 91b).
- Construction of the Air Balloon way within the final six months of the construction period (February 2026 to August 2026) (building 33a located at northern end).

8.10.123 The majority of other building roosts identified within 20m of the scheme (19a, 23, 91a, 16b, 45, 8a, 91, 60, 15, 44 and 32) and one of the tree roosts identified within 20m of the scheme (T229) are day/night/transitional roosts used by single or small numbers of individuals and as such are of local importance. The five other building roosts and two other tree roosts within 20m of the scheme (namely the common pipistrelle maternity roost (building 20), three *Myotis* sp. day roosts (building 20, building 32 and T24), lesser horseshoe night roost (building 91a), serotine roost (building 8a) and Bechstein's day tree roost (Bat ID 239873)) are of county importance. As above, it is not possible to specify exactly when disturbance to each roost would occur until the detailed construction programme is finalised by the contractor, although some indicative dates of works and the roosts they could disturb include:

- Construction between Air Balloon roundabout and Shab Hill commencing April 2023 (within vicinity of Bat ID 239873).
- Construction within the Shab Hill area within the period April 2024 to January 2025 (adjacent to buildings 44, 45, 91 and 91a).
- Construction of the Air Balloon way within the final six months of the construction period (February 2026 to August 2026) (building 32 located at northern end)No maternity roosts are present between 20m and 50m of the scheme. Roosts in buildings between 20m and 50m of the scheme (Buildings 33, 60b, 8b, 9, 38 and 41) are day roosts of common pipistrelle (local importance), two serotine roosts (one day roost and one unconfirmed roost,

precautionary county importance due to unconfirmed roost status), one lesser horseshoe roost (one day roost of county importance), a *Myotis* species day roost of county importance, and an unidentified roost of precautionary county importance. All roosts in trees between 20m and 50m of the scheme (T193, ID 239870, ID 240308, ID 239870, ID240308) are day roosts of *Myotis* sp., barbastelle, and Natterer's bats are of county importance (due to barbastelle).

8.10.124 As above, it is not possible to specify exactly when disturbance to each roost would occur until the detailed construction programme has been finalised by the contractor, though some indicative dates of works and the roosts they could disturb include:

- Construction between Air Balloon roundabout and Shab Hill commencing April 2024 for approximately nine months (within vicinity of Bat ID 240308 and 239870).
- Construction of the Air Balloon way within the final six months of the construction period (February 2026 to August 2026) (buildings 33 and 38 located at northern end).

8.10.125 Given the type of roosts present up to 50m away from the scheme, and the nature of the rural environment, it is likely that these bats would use alternative existing roosts in the wider landscape during times of particularly disturbing construction activities. Nonetheless, construction phase mitigation measures would be implemented through a disturbance mitigation licence from Natural England and associated method statements drawn up to reduce potential disturbance impacts, such as noise and lighting on these roosts during construction. The principles of these measures, including sensitive timing, are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). These measures would be refined in consultation with Natural England once the construction programme is finalised. With this mitigation implemented, disturbance impacts to these roosts would result in temporary/reversible damage to the bat populations that would not affect their integrity. This damage may comprise repeated occurrences within the anticipated years of construction (2023 – 2026). This disturbance would represent a negligible adverse impact upon the local bat populations.

8.10.126 In summary, bats would be subject to negligible adverse impacts from the loss of roost sites and disturbance (noise, vibration and lighting) as a result of construction activities. **The residual effects of these impacts associated with the scheme are considered to be slight adverse at the county level, and not significant**.

Bats (foraging and commuting assemblage)

8.10.127 **Habitat fragmentation:** Construction would result in the severance and fragmentation of foraging habitat and commuting habitat, notably the following areas identified as important for bat activity: Crickley Hill Farm; wooded corridor along the Existing A417west of the Air Balloon roundabout, particularly the southern side along the tributary of Norman's Brook; Cold Slad; intersection of hedgerows, tree lines and farm track north of Shab Hill; Ullen Wood; Shab Hill crescent woodland; tree-lined road along Stockwell Farm; and Birdlip Quarry. Habitat fragmentation is likely to affect all species in the identified assemblages, including the four Annex II species. The only species likely to be exempt from these impacts are the open habitat adapted species (noctule, Leisler's bat, and serotine). Key roosts identified during surveys which would likely be impacted by

such fragmentation include the lesser horseshoe maternity roost at Haroldstone Cottages, the greater horseshoe day/mating/satellite breeding roost near Birdlip and the common pipistrelle maternity roost at Stockwell Farm.

8.10.128 The provision of the Crickley Hill bat underpass under the widened A417 at chainage 1+100 and The Gloucestershire Way crossing to the north of Shab Hill would provide essential mitigation for bats to address these fragmentation impacts. In addition, the detrunking of the A417, the two enhanced overbridges provided at Cowley and Stockwell, along with the additional Grove Farm underpass created for Grove Farm access (which would cross under the A417 from Cold Slad Lane) would all contribute to improving the permeability of the scheme for bats, reducing fragmentation impacts.

8.10.129 Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4) includes the creation of a linked mosaic of higher quality habitats, including drainage swales, hedgerows and wood pasture, which would increase the foraging habitat to the east and west of the scheme, in order to further reduce the fragmentation impacts.

8.10.130 Construction phase mitigation would include the retention of vegetation along known commuting routes for as long as possible, timing of works including the early construction of the Crickley Hill bat underpass and the Gloucestershire Way crossing, the use of dead hedges to reduce loss of connectivity (where possible) and the use of early planting in the first year of the programme (2023-2024), including the use of translocated hedgerows (as detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4)). With implementation of these measures, the effects of habitat fragmentation would still be likely to require some bats to seek alternative foraging resources, travelling greater distances and thus expending more energy during construction. Fragmentation impacts would peak during the anticipated years of construction (2023-2026) and gradually decrease as new habitat creation matures. Fragmentation of bat foraging and commuting habitat would result in temporary/reversible damage to bat populations that would negatively affect their integrity.

8.10.131 In summary, the bat assemblage would be subject to a moderate adverse impact from fragmentation of foraging and commuting habitats as a result of construction activities. **The residual effect associated with the scheme is considered to be moderate adverse at the national level, and significant.**

Badgers

8.10.132 **Mortality, injury and disturbance:** Construction activities may result in direct mortality or injury of badgers within setts or disturbance from noise and vibration which can lead to abandonment of setts and young or in the case of vibration could lead to collapse of sett tunnels. The potential for mortality and disturbance would occur throughout the anticipated construction years (2023-2026). To avoid this, suitable working methodologies and measures would be implemented during the construction phase as detailed in section 8.9, Design, mitigation and enhancement measures and in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.133 Sett closures during the early construction phase of the scheme for preparatory works would be conducted under ecological supervision in accordance with a Natural England licence which would ensure no mortality, injury or trapping of badgers. The licence methods are referred to in Annex D LEMP of ES Appendix

2.1 EMP (Document Reference 6.4). There would be no observable impact on the badger population from mortality or disturbance during construction.

8.10.134 **Habitat loss**: The scheme would result in the permanent loss of badger foraging habitat and badger setts during the early construction phase of the scheme (2023-2024). All setts within 30m from construction works where works would damage setts, would require closure under a Natural England licence between July and November. Survey results show that there is [redacted] within the scheme boundary that would be permanently lost. The loss of a main sett would be unavoidable. Provision of an artificial sett, and recorded use by badger, would be required prior to closure of the main sett. Additional setts within 30m of the DCO Boundary include [redacted] which potentially require closure during the construction phase depending on the nature of the works. Closure of the main sett within 30m is not anticipated as works in this location would involve habitat creation and a 30m exclusion zone would be implemented to protect the sett.

8.10.135 The loss of habitat including setts would result in temporary/reversible damage to the badger population that would negatively affect its integrity until compensatory habitats are established. This habitat loss would represent a moderate adverse impact upon the badger population.

8.10.136 **Severance:** Site clearance and construction could lead to isolation of badger populations both within and between clans, which in a worst-case scenario could lead to local extinctions. Severance could cause an increase in conflict and competition due to a temporary reduction in territory size and foraging resource. Such adverse effects would be reduced by careful construction programming so that certain crossing areas would remain available to badgers prior to final crossing points in the form of wildlife culverts being completed. Temporary fencing would be installed to funnel badgers to these areas throughout the construction phase (2023-2026).

8.10.137 The creation and enhancement of habitats, the provision of wildlife culverts under the scheme, the Gloucestershire Way multi-purpose crossing and two smaller Cowley and Stockwell overbridges which also include verges and hedgerow habitat, would mitigate severance of habitat and identified territories. With the implementation of the above mitigation and embedded mitigation as part of the design detailed in ES Chapter 2 The project (Document Reference 6.2), severance of habitats and territories would result in temporary/reversible damage to the badger population during the construction phase that would negatively affect its integrity. Severance of habitat would represent a moderate adverse impact on badgers.

8.10.138 In summary, the badger population would be subject to moderate adverse impacts from loss and severance of habitat as a result of construction activities. **The residual effects associated with the scheme are considered to be slight adverse at the local level, and not significant.**

Breeding and wintering bird assemblages

8.10.139 **Injury/direct mortality**: Mitigation measures include timing of vegetation clearance and pre-construction nest checks (if works cannot be timed outside of the breeding bird season) to avoid injury/direct mortality and/or destruction of nests would be avoided. These are described in section 8.9, Design, mitigation

and enhancement measures and detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). There would be no observable impact on the breeding or wintering bird assemblages resulting from injury or direct mortality during the construction phase of the scheme.

8.10.140 **Breeding habitat**: Construction activities would result in the loss of breeding bird habitat, notably 2.1miles (3.5 kilometres) of hedgerows, 17.2ha of woodland and 47.68ha of grassland (calcareous, semi improved and poor semi improved neutral grassland) as well as 24.45ha of arable land. Survey results indicate that breeding territories of skylark and yellowhammer would be most impacted by the scheme. Of the 23 skylark territories identified, seven would be permanently lost, seven would be lost temporarily during the construction phase and nine would not be directly affected. In total, approximately 20ha of known skylark breeding area would be lost.

8.10.141 To mitigate for loss of woodland and hedgerow breeding habitat during the construction phase, early planting of trees and hedges would be undertaken where possible to reduce the time lag between habitat loss and establishment. Nesting bird boxes would also be provided for a range of species impacted within retained woodland as detailed in the mitigation section 8.9 Design, mitigation and enhancement measures. Areas of early planting and indicative locations for bird boxes are shown on ES Figure 7.11 Environmental masterplan (Document Reference 6.3). Once established, there would be a gain of 9.59ha of broadleaved woodland and 3.4 miles (5.6 kilometres) of hedgerow habitat available for breeding birds such as linnet and yellowhammer throughout the scheme. There would be a net gain of 72.88ha of calcareous grassland, largely replacing lower value improved and poor semi-improved grassland. This includes habitat creation such as the meadow south of Ullen Wood that would still be suitable for ground nesting species.

8.10.142 The loss of breeding habitat would result in temporary/reversible damage to the breeding bird assemblage of county importance that would negatively affect its integrity. This habitat loss would represent a moderate adverse impact upon the breeding bird assemblage.

8.10.143 **Foraging habitat:** The habitat losses during the construction phase would reduce foraging opportunities for the local bird assemblages and fragment retained areas of habitat, until new habitat creation was established. Where possible, habitat replacement would begin before construction to reduce the time lag between loss and creation. In addition, the provision of native and species-rich hedgerows on all overbridges would provide additional habitat and connectivity of habitat for birds across the scheme.

8.10.144 Provision of planting and its management is incorporated within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4) to reduce the effect of fragmentation on breeding and wintering birds. The loss and fragmentation of foraging habitat would result in temporary/reversible damage to the breeding and wintering bird assemblages until new habitats are established, and this impact would negatively affect the integrity of the assemblages. This would represent a moderate adverse impact upon breeding and wintering bird assemblages.

8.10.145 **Disturbance, including sound and lighting**: Construction activities on site would be likely to displace breeding and wintering birds both within the scheme and in adjacent habitat due to disturbance from increased noise levels and visual disturbance. Noise levels would increase overall, and most would likely be regular

occurrences within the anticipated years of construction (2023-2026), meaning that birds may become habituated to them. It is not possible to specify exactly when and how long each area of the scheme would be subject to disturbance until the detailed construction programme has been finalised by the contractor, however areas such as the material crushing compound to the north of Shab Hill would likely experience disturbance throughout the active construction phase from 2024-2026.

8.10.146 Visual disturbance could also reduce the suitability of habitat for foraging. Lighting of construction areas and access routes could disturb owls, e.g. tawny owl, causing them to avoid affected foraging areas and/or impact roosting. To mitigate, construction lighting would be kept to an absolute minimum, be motion sensored and directed away from sensitive habitat as stated in the mitigation section 8.9 Design, mitigation and enhancement measures.

8.10.147 To mitigate for loss of available habitat due to displacement from disturbance to both breeding and wintering birds, provision of lighting design, schedule of works, early planting and its management is detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). Disturbance from construction activities would result in temporary/reversible damage to breeding and wintering bird assemblages that would not affect their integrity. This disturbance would represent a negligible adverse impact upon the breeding and wintering bird assemblages.

8.10.148 In summary, the breeding and wintering bird assemblages would be adversely impacted by the loss of breeding habitat, loss and fragmentation of foraging habitat and disturbance (noise and lighting) from construction activities. These impacts range in scale from negligible adverse to moderate adverse. **The residual effects associated with the scheme are considered to be slight adverse at the county level, and not significant.**

Barn owl

8.10.149 **Injury/direct mortality:** there is potential for injury and/or mortality of barn owls directly caused by construction activities. This could occur through disturbance causing abandonment of a nest (resulting in the death of dependent young birds), destruction of active nests, and/or collisions with construction vehicles. ES Appendix 2.1 EMP (Document Reference 6.4) includes details of how these risks would be reduced including sensitive timing of the works and site speed limits. There would be no observable impact on the barn owl population resulting from injury or direct mortality during construction works.

8.10.150 **Breeding and roosting habitat:** None of the PNS surveyed within 500m of the scheme were occupied by breeding barn owls at the time of survey. Eight were considered suitable for occupation by nesting barn owls. Whilst no evidence of breeding was found at any PNS, they could become occupied by breeding barn owls in the future and should be subject to re-survey prior to commencement of construction if they are to be removed or undergo significant disturbance. Barn owl populations undergo significant fluctuations, depending on factors such as the availability of prey species and weather conditions. Therefore, it is possible that breeding barn owls could occur in locations where they have previously been recorded as being absent.

8.10.151 There is also the potential for the loss of one ARS (within 100m of the scheme) and potential for disturbance impacts on two TRS (within 500m of the scheme)

during the construction phase. It is likely that barn owls would temporarily disperse from areas undergoing disturbance from construction effects and would find alternative roost sites, as there are suitable alternative sites in the vicinity.

8.10.152 Pre-construction surveys would be undertaken on all identified PNS, TRS and ARS considered suitable to ascertain whether barn owls are present or absent from works areas. The clearance and construction activities that would be required to implement the scheme would result in adverse impacts upon PNS. The loss of breeding and roosting habitat would result in temporary/reversible damage to the barn owl population that would not affect its integrity. This habitat loss would represent a negligible adverse impact upon the barn owl population.

8.10.153 **Foraging habitat:** Permanent loss and fragmentation of Type 1 and Type 2 barn owl foraging habitat would occur as a result of construction. This is likely to be of particular significance on high quality foraging habitats around Shab Hill. It is likely that barn owls would temporarily disperse from disturbed areas of habitat and would forage in more distant and possibly less productive habitats. This has the potential to increase the risk of mortality through collision with vehicles and/or from reduced prey availability. It also has the potential to decrease breeding success for the same reasons. The loss and fragmentation of foraging habitat would result in permanent/irreversible damage to the barn owl population that would negatively affect its integrity. This habitat loss would represent a major adverse impact upon the barn owl population.

8.10.154 **Increased lighting and disturbance:** Lighting of construction areas and access routes could cause owls to avoid affected foraging areas and/or have an impact on roosting. An increase in noise and physical disturbance during construction activities has the potential to cause abandonment of roosts and/or nests, particularly if disturbance occurs during the early breeding season when birds are egg-laying or incubating. The distance (from disturbance) at which barn owls would abandon a nest would vary depending on the level of disturbance, length of disturbance and the existing disturbance levels that the birds experience. Studies suggest disturbance from human activity can be caused up to an upper limit of 100m from the nest site[89], although the distance at which nesting barn owls become intolerant to the approach of humans and works activities can vary depending on levels of localised day to day activity and their choice of nesting locations, often in active farm buildings, indicates a degree of tolerance to human activity by some pairs. Lighting during construction would be designed to be sensitive to bats, which in turn would benefit barn owls. Measures to include sensitive lighting design, timing of activities, pre-construction surveys and appropriate working distances are included in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4), which would ensure physical disturbance is avoided. Disturbance from construction activities would result in temporary/reversible damage to the barn owl population that would not affect its integrity. This disturbance would represent a negligible adverse impact upon the barn owl population.

8.10.155 In summary, the barn owl population would be adversely impacted by the loss of breeding and roosting habitat, loss and fragmentation of foraging habitat and disturbance from construction activities. These impacts range in scale from negligible adverse to major adverse. **The residual effects associated with the scheme are considered to be moderate adverse at the county level, and significant.**

Amphibians

8.10.156 **Direct mortality and habitat loss**: A population of great crested newt are using a small pond adjoining a drainage ditch that is within the far western end of the scheme, at the southern extent of a complex of four further ponds that are further from the scheme within Bentham Dog Lane Fields pLWS. This feature is included within the scheme to allow for access to a culverted section of the ditch for inspection, cleaning and potentially repair of the culvert and headwall where the ditch joins the pond. No major physical works are proposed to the culvert. If temporary habitat disruption and reinstatement became required to facilitate these works, reasonable avoidance measures would be implemented to ensure that no loss of great crested newt habitat would occur and that risk to individual newts was reduced to a negligible level, i.e. licensable impacts to great crested newt would be avoided. This would principally be achieved through planning the timing and duration of works for periods when great crested newts would be unlikely to be present within any affected habitat. In addition, any works at this location would follow a precautionary non-licensed working method, including a watching brief by a suitably qualified ecologist.

8.10.157 A separate small population of great crested newt have been recorded in Pond 2a in the Crickley Hill area. This terrestrial habitat within 100m and 250m radii of this pond is of high quality for great crested newt in the form of woodland, scrub and grassland. Habitat losses within 250m of this pond would comprise approximately 0.25ha of woodland alongside the Existing A417at a distance of approximately 240m from the pond. Given the small size of population and the large extent of high quality terrestrial habitat in closer proximity to the pond than the habitat to be impacted, it is considered unlikely that the habitat to be lost as a result of the scheme is of value to this great crested newt population. The clearance of habitat within 250m of the pond that is not separated by the Existing A417 would follow a precautionary non-licensed working method, including a watching brief by a suitably qualified ecologist.

8.10.158 Non-breeding use of a pond at National Star College and golf course by great crested newt has been identified. The works proposed as part of the scheme within 250m of this pond relate to creation of a minor drain through a field of managed poor semi-improved grassland. Loss of terrestrial habitat of value to great crested newt is unlikely to be required. If through detailed design, temporary habitat disruption and reinstatement became required to facilitate these works, reasonable avoidance measures would be implemented to ensure that no permanent loss of great crested newt habitat would occur and that risk to individual newts was reduced to a negligible level, i.e. licensable impacts to great crested newt would be avoided.

8.10.159 A further population of great crested newt have been recorded in Ponds 15 and 26A in Birdlip. No habitat losses would occur within 250m of pond 15 or within 500m of pond 26A. Approximately 0.4ha of habitat would be lost within 500m of pond 15 as a result of scheme, largely loss of trees and scrub along existing road verges. Given the distance from the pond it is considered unlikely that the habitat to be lost as a result of the scheme is of value to this great crested newt population.

8.10.160 With the implementation of precautionary working methods there would be no observable impact upon the great crested newt populations through mortality or

habitat loss. **The residual effect associated with the scheme is considered to be neutral at the county level and not significant.**

Reptiles

8.10.161 **Direct mortality**: Construction activities could result in individual reptiles being injured and/or killed in the absence of mitigation or suitable working practices. For this reason, a translocation exercise would be carried out in key reptile habitat and sites where adders were recorded where there is not suitable or sufficient adjacent habitat retained, and displacement of reptiles would occur in other areas where lower numbers of reptiles were recorded. Translocation sites would be protected with reptile fencing for the duration of the construction phase. Translocation sites and methodology are detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). With the implementation of mitigation, mortality of reptiles during construction would be minimal and there would be no observable impact on the reptile populations arising from direct mortality of reptiles during construction works.

8.10.162 **Habitat loss**: Construction activities would result in approximately 2.6ha of key reptile habitat being lost. A further 4ha of habitat identified as being optimum for reptiles and supporting good and low populations of reptiles would be lost. These areas were identified as most suitable for reptiles, but it is acknowledged that all long grassland, woodland edge and hedgerows may support reptiles. The areas of these habitats lost are detailed in Table 8-18. Mitigation measures would include the creation of grassland, hedgerow and woodland habitat creation suitable for reptiles and incorporation of features beneficial to reptiles, especially adders and grass snake, such as hibernacula and log piles. Habitat creation includes a translocation site of approximately 3ha for reptiles within the DCO Boundary adjacent to Birdlip Quarry. Habitat creation for reptiles is detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). The two overbridges at Cowley and Stockwell and the Gloucestershire Way crossing would include hedgerows suitable for use by reptiles, resulting in three crossings available for use by reptiles to reduce fragmentation of habitat.

8.10.163 The loss of habitat would result in temporary/reversible damage to the reptile assemblages at key reptile areas such as Shab Hill, Birdlip Quarry and west of Air Balloon roundabout, that would negatively affect their integrity. This habitat loss would represent a moderate adverse impact upon reptile assemblages within the scheme.

8.10.164 In summary, the reptile assemblage would be subject to a moderate adverse impact from habitat loss as a result of construction activities. **The residual effect associated with the scheme is considered to be slight adverse at the county level, and not significant.**

Otter

8.10.165 Field surveys confirmed the presence of otter within the study area in tributaries of the Upper Frome, to the south of the scheme. Desk study records also confirm the presence of otter at Horsbere brook, near the western extent of the scheme. The local otter population is considered to be of county importance.

8.10.166 The construction of the scheme in close proximity to watercourses has the potential to affect otters within the study area through habitat loss, fragmentation and degradation.

8.10.167 **Habitat loss:** Otter are recorded in the northern section of Norman's Brook to the north of the A417 but were not recorded in the southern reaches of the tributary of Norman's Brook. It is considered unlikely that otters attempt to cross the A417 from north to the south either over ground or via the long culvert under the road, but it is possible that the tributary of Norman's Brook could be used very occasionally by otters exploring the far reaches of catchments or potentially moving between catchments from the south. The tributary of Norman's Brook would be realigned further south of its existing alignment to allow for the widening of the A417 and associated earthwork embankments and planting. The channel would be designed to enable dispersal of otter along the new channel. The realignment of the tributary of Norman's Brook resulting in temporary habitat loss as the channel is diverted would result in a temporary and reversible impact to the otter population that would not affect its integrity. Habitat loss during the realignment of the tributary of Norman's Brook would represent a negligible adverse impact upon the otter population.

8.10.168 **Disturbance**: The only watercourse that would be directly affected by the scheme is the southern reach of the tributary of Norman's Brook. No works are proposed to Horsbere Brook, the Upper River Frome and its tributaries, or the River Churn and ephemeral tributary Coldwell Bottom. The southern section of Norman's Brook tributary within the DCO Boundary shows no signs of use by otters including no signs of otter holts, likely due to severance from the northern reaches of Norman's Brook by a long culvert under the A417. Due to this and due to the seasonal flow, it is likely to be used only very occasionally by otters exploring the far reaches of catchments. The realignment of the tributary of Norman's Brook would temporarily disturb otter from using this watercourse during the construction works. Pre-construction surveys would determine presence or likely absence of otters from the watercourse prior to realignment and to inform any further mitigation requirements, such as working distances, timing of works during daylight hours and avoidance of lighting in the proximity of watercourses. Disturbance from construction activities would result in temporary and reversible damage to the otter population that would not affect its integrity. This disturbance would represent a negligible adverse impact upon the otter population.

8.10.169 **Pollution:** Pollution events in the absence of mitigation could cause short and long-term impacts upon aquatic habitat that otter depend upon for survival. With the implementation of construction best practice mitigation measures to avoid pollution of aquatic habitats, as described in paragraph 8.9.11, there would be no observable impact on the otter population from habitat degradation resulting from construction works.

8.10.170 In summary, the otter population would be subject to negligible adverse impacts from habitat loss and disturbance as a result of construction activities**. The residual effects associated with the scheme are considered to be neutral at the county level, and not significant.**

Terrestrial invertebrates

8.10.171 The assemblages of terrestrial invertebrates associated with the Crickley Hill and Barrow Wake units of the SSSI, are of national and county importance respectively. The assemblage of invertebrates at Birdlip Quarry is of county importance. Habitats supporting these notable invertebrate assemblages include calcareous grassland, woodland including deadwood and habitat mosaics (including short-sward vegetation, rank grassland, deadwood and scrub).

8.10.172 The remainder of land within the scheme supports invertebrate assemblages of up to local importance using more widespread semi-improved grassland, woodland, hedgerow and scrub habitats.

8.10.173 The invertebrate assemblages within Crickley Hill and Barrow Wake SSSI and the habitats upon which they depend are the reasons for the designation of the Crickley Hill and Barrow Wake SSSI. The impacts upon these features and relevant mitigation measures are detailed fully under the Designated Sites headings of section 8.9 Design, mitigation and enhancement measures and section 8.10 Assessment of likely significant effects. The sections below address impacts to invertebrate assemblages that are not associated with the SSSI.

8.10.174 **Habitat loss and fragmentation:** Construction activities across the scheme would result in losses of approximately 11.51ha of grassland of at least moderate species diversity (i.e. excluding losses of improved and poor semi-improved grassland), 1.94ha of dense scrub, 2.2 miles (3.5 kilometres) of hedgerow and 12.42ha of semi-natural broadleaved woodland. Approximately 1ha of scattered scrub and grassland at the 4ha Birdlip Quarry site, which supports a county value assemblage of invertebrates, would be lost during the construction phase of the scheme.

8.10.175 The landscape design shown in ES Figure 7.11 Environmental Masterplan (Document Reference 6.3) includes net gains in the area of each of these broad habitat types, including 72.88ha of species-rich calcareous grassland, 2.40ha of scrub, 3.4 miles (5.6km) of hedgerow and 9.59ha of broadleaved woodland. Broadleaved woodland habitat creation would include features to benefit invertebrates such as log piles and deadwood translocated from lost habitats. Road verges would also be planted with species beneficial to invertebrates and managed to ensure a variety of habitat niches, including bare ground, as detailed in section 8.9 Design, mitigation and enhancement measures.

8.10.176 Where possible, habitats would be created prior to construction, [redacted] that would also benefit invertebrates. It is however, recognised that there would be a time lag of several years (habitat dependent) between the majority of habitat loss and the full establishment of the compensatory habitats within the scheme. Habitat loss and fragmentation would therefore result in temporary/reversible damage to invertebrate assemblages across the wider scheme that would negatively affect their integrity. This would represent a moderate adverse impact.

8.10.177 **Direct mortality**: Site clearance and construction would be likely to result in mortality of terrestrial invertebrates as habitats are cleared incrementally across the scheme within the first preparatory year of the construction phase. Mitigation measures to reduce mortality include sensitive timing of grassland removal and translocation of valuable species-rich grasslands, leaf litter and logs, including deadwood from lost habitats, which are detailed in Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4).

8.10.178 It is considered that mortality would result in temporary/reversible damage to terrestrial invertebrate assemblages that would negatively affect their integrity. This would represent a moderate adverse impact on invertebrate assemblages.

8.10.179 In summary, the terrestrial invertebrate assemblages (not associated with the SSSI) would be subject to moderate adverse impacts from habitat loss and

fragmentation, and mortality, as a result of construction activities**. The residual effects associated with the scheme are considered to be slight adverse at the county level, and not significant.**

[redacted]

8.10.180 [redacted]

8.10.181 [redacted]

8.10.182 [redacted]

8.10.183 [redacted]

Aquatic invertebrates

8.10.184 Direct and indirect impacts on aquatic invertebrates of county importance would be anticipated within the tributary of Norman's Brook. No direct or indirect impacts are identified within the River Frome, the River Churn or their tributaries. Changes to the groundwater flow into the Rivers Churn and Frome are not predicted to be impacted by the construction of the road. No change would be expected in the hydrological regime of either river. No reduction in water quality would be expected due to reduced dilution of pollutants.

8.10.185 Direct and indirect impacts on aquatic invertebrates of county importance are likely within the tributary of Norman's Brook. The scheme design includes the realignment of the tributary of Norman's Brook and the loss of several springheads due to embankment construction.

8.10.186 **Direct mortality:** Whilst sensitive timing and methodologies for works involving the tributary of Norman's Brook realignment will be implemented, some mortality of invertebrates from communities of conservation importance is likely. Direct mortality would result in temporary/reversible damage to aquatic invertebrate populations which would represent a moderate adverse impact.

8.10.187 **Habitat loss:** Construction of the scheme would result in the permanent loss of aquatic habitats which support aquatic invertebrates including the tributary of Norman's Brook and associated springheads. Aquatic habitat loss within the tributary of Norman's Brook would be mitigated by the realignment of the tributary of Norman's Brook following relevant guidance and EA permits. The detailed design of the new river habitat in the diverted channel would be agreed in consultation with EA specialists. The detailed design would focus on balancing the habitat requirements (substrate, depth, flow types and refuges) of aquatic communities present, with returning the river to a more natural step-pool habitat that would have existed prior to modification of the river by numerous weirs.

8.10.188 A drainage solution would be implemented to intercept and divert spring water into the realigned tributary of Norman's Brook. A focus for detailed design would be to incorporate discharges of groundwater to the riparian zone where appropriate, creating springhead habitat adjacent to the realigned channel. Further detail is provided in hydrogeological assessment in ES Chapter 13 Road drainage and the water environment (Document Reference 6.2).

8.10.189 Colonisation of the realigned channel with aquatic invertebrates would occur naturally as a result of natural drift from upstream and via airborne colonisation. Furthermore, translocation of invertebrates from nearby undisturbed areas of Norman's Brook would be undertaken to facilitate the colonisation of the aquatic invertebrate community within the new channel.

8.10.190 Habitat loss would result in temporary/reversible damage to aquatic invertebrate populations. Habitat loss would represent a moderate adverse impact upon aquatic invertebrate populations.

8.10.191 **Pollution:** Habitats close to the scheme, such as hydrologically connected aquatic habitats, are sensitive to effects from construction such as pollution events from fuel and chemical spills and from sediment run-off. Runoff of substrate associated with construction could result in increased siltation of the tributary of Norman's Brook watercourse as it becomes seasonally wet. This could result in the temporary reduction of aquatic invertebrate abundance and diversity. Construction best practice mitigation measures would be implemented to avoid pollution of aquatic habitats, as described in paragraph 8.9.11.

8.10.192 Changes to the groundwater flow into the Rivers Churn and Frome are not predicted to be impacted by the construction of the road. No change would be expected in the hydrological regime of either river. No reduction in water quality would be expected due to reduced dilution of pollutants.

8.10.193 With the implementation of the mitigation measures outlined above, there would be no observable impact on aquatic invertebrates of habitat degradation resulting from construction works.

8.10.194 In summary, the assemblage of aquatic invertebrates within the tributary of Norman's brook would be subject to moderate adverse impacts from direct mortality and habitat loss as a result of construction activities. **The residual effects associated with the scheme are considered to be slight adverse at the county level, and not significant.**

Fish

8.10.195 No direct impacts on fish within the River Churn or Frome are anticipated, as no construction works would be required within these rivers. There would be no

predicted indirect impacts to the River Frome and the River Churn through hydrological changes.

8.10.196 The construction of the scheme is likely to affect fish within the tributary of Norman's Brook through direct mortality, and habitat loss and degradation.

8.10.197 **Direct mortality:** Mortality of species is highly likely in the absence of mitigation or suitable working practices. Construction activities could result in adult fish of conservation importance being directly killed or injured, eggs laid in spawning habitats destroyed or damaged, juveniles killed or injured, and hypoxia through dewatering resulting in death.

8.10.198 Pre-construction surveys would be conducted to confirm species presence/absence and to inform the strategy and methodology for a fish translocation which would be implemented to reduce mortality. With this mitigation implemented, direct mortality would result in temporary/reversible damage to fish populations that would not affect their integrity. Direct mortality would represent a negligible adverse impact upon fish populations.

8.10.199 **Habitat loss:** Habitat suitable for brown trout, juvenile lamprey, European eel and European bullhead identified in the tributary of Norman's Brook would be lost during construction works. Mitigation will be provided within the detailed design of the new river habitat in the diverted channel, which will be agreed in consultation with Environment Agency specialists and be informed by pre-construction fish surveys. The detailed design will focus on balancing the habitat requirements (substrate, depth, flow types and refuges) of fish species and other aquatic species, with returning the river to a more natural step-pool habitat that would have existed prior to modification of the river by numerous weirs. Within the realignment, the scheme design would aim to maintain the springs and groundwater flows. These flows would be intercepted by a drainage system installed beneath the embankment and intermittently diverted into the reconstructed stream. The reconstructed stream would continue to be recharged by its tributaries.

8.10.200 With the implementation of the mitigation in terms of habitat creation and groundwater transfer, habitat loss would result in temporary/reversible damage to fish populations that would not affect their integrity. Habitat loss would represent a negligible adverse impact upon fish populations.

8.10.201 **Pollution**: Habitats close to the scheme, such as hydrologically connected aquatic habitats, are sensitive to effects from construction such as pollution events from fuel and chemical spills and from sediment run-off. Runoff of substrate associated with construction could result in increased siltation of the tributary of Norman's Brook watercourse as it becomes seasonally wet. This could result in the temporary reduction of fish abundance and diversity. Construction best practice mitigation measures would be implemented to avoid pollution of aquatic habitats, as described in paragraph 8.9.11.

8.10.202 With the implementation of the mitigation measures outlined above, there would be no observable impact on fish populations of habitat degradation resulting from construction works.

8.10.203 **Habitat loss:** Habitat suitable for brown trout, juvenile lamprey, European eel and European bullhead identified in the tributary of Norman's Brook would be lost during construction works. The brook would be realigned under relevant guidance and EA permits. Construction activities at confirmed locations where fish

populations are noted (through pre-construction surveys) would be sensitively timed as stated in the construction mitigation section 8.9 Design, mitigation and enhancement measures.

8.10.204 With the implementation of the mitigation outlined above (habitat creation and groundwater transfer), habitat loss would result in temporary/reversible damage to fish populations that would not affect their integrity. Habitat loss would represent a negligible adverse impact upon fish populations, which is assessed as a neutral effect and not significant.

8.10.205 In summary, the fish assemblage would be subject to negligible adverse impacts from direct mortality and habitat loss as a result of construction activities. **The residual effects associated with the scheme are considered to be neutral at the local level, and not significant.**

Other Section 41 Species of Principal Importance

8.10.206 **Habitat loss and fragmentation:** Construction activities would result in the incremental clearance of habitats across the scheme between February 2023 and March 2024. This includes loss of a range of habitats suitable for SPI such as hedgehog, including woodland, scrub, grassland, and hedgerows. Clearance would also temporarily reduce connectivity between retained areas of these habitats. Compensatory habitat creation would restore connectivity and would increase the areas of less intensively managed habitats that are likely to be of greatest value to most SPIs, including native broadleaved woodland, species-rich grassland and species-rich hedgerow. Habitat losses and gains are detailed within Table 8-18.

8.10.207 Where possible, new habitats would be created prior to construction, but it is recognised that there would be a time lag of several years (habitat dependent) between the majority of habitat loss and the full establishment of the compensatory habitats within the scheme. Therefore, it is considered that habitat loss and fragmentation from construction works would result in temporary/reversible damage to populations of other SPI that would negatively affect their integrity. Habitat loss would have a moderate adverse impact upon SPI populations.

8.10.208 **Direct mortality** or injury of SPI could occur at any time during site clearance and construction in the absence of mitigation or suitable working practices. Habitat clearance designed and timed to be sensitive to these species, alongside habitat manipulation clearance techniques to deter species away from areas, would remove or reduce these risks. Any SPI individuals found during construction would be moved by the ECoW to the most appropriate mitigation areas. This approach is detailed within Annex D LEMP of ES Appendix 2.1 EMP (Document Reference 6.4). With the implementation of mitigation, mortality of SPI during construction would be minimal and there would be no observable impact on SPI populations arising from direct mortality during construction works.

8.10.209 In summary, SPI populations would be subject to a moderate adverse impact from loss and fragmentation of habitat as a result of construction activities. **The residual effect associated with the scheme is considered to be neutral at the local level, and not significant.**

Operation effects

Statutory designated sites of international importance

Cotswold Beechwoods SAC

8.10.210 **Nitrogen deposition**: The SAC is within 200m of the ARN and has been assessed for air quality impacts because it is sensitive to nitrogen deposition. The air quality assessment predicts a decrease in annual mean nutrient nitrogen deposition at the SAC as a result of operation of the scheme (-1.1kg N/ha/yr at the closest point of the SAC to the ARN in 2026). As such no impacts to designated habitats via nitrogen deposition are predicted during operation. Further details of the air quality modelling are provided within ES Chapter 5 Air quality (Document Reference 6.2).

8.10.211 **Pollution**: No impacts on the SAC are anticipated from changes to surface water during operation due to the operational drainage design, including flow volume and quality control measures incorporated into the scheme design to provide a sustainable drainage system (SuDS). As described in Chapter 13 Road drainage and the water environment (Document Reference 6.2), the scheme will comprise a road drainage scheme that will capture pollutants within road run-off and remove pollutants before the treated run-off is discharged. The scheme will provide a betterment on the existing road drainage system and improve the water quality of receiving waterbodies.

8.10.212 **Recreational visitor pressure:** The proposed Cotswold Way crossing will reconnect walking and cycling routes along the Cotswold Way National Trail, which is severed by the Existing A417trunk road. Currently pedestrians and cyclists must cross three lanes of traffic at the Air Balloon roundabout, which is hazardous and likely to deter people from using this route. The Cotswold Way crossing will link to Crickley Hill Country Park and as such is likely to increase the number of users of the Country Park that cross the A417 to access areas to the south of the scheme for recreational purposes.

8.10.213 The Cotswold Way crossing will connect the National Trail to the Air Balloon way to be provided as part of the scheme along a 1.7 mile (2.7km) section of the detrunked A417. It is considered that this major new recreational route for walking, cycling and horse-riding (WCH), with additional car parking at the Golden Heart Inn and connectivity to the Gloucestershire Way crossing and other improved public rights of way (PRoW) delivered as part of the scheme, will serve to meet the needs of the majority of additional users crossing the A417 at the Cotswold Way crossing. These measures are detailed in Chapter 12 Population and human health (Document Reference 6.2) and the PRoW Management Plan in ES Appendix 2.1 EMP Annex F (Document Reference 6.4).

8.10.214 The improved PRoW network provided by the scheme is likely to divert/ concentrate visitors away from the SAC, which is approximately 1.24 miles (2km) further south-west in walking distance from the Cotswold Way crossing, following the National Trail. An increase in recreational pressure that would impact the qualifying features of the SAC is not considered likely to occur as a result of the scheme.

8.10.215 In summary, no observable impacts on Cotswold Beechwoods SAC are predicted as a result of the operation phase of the scheme. **The residual effect associated**

with the scheme is considered to be neutral at the international level and not significant.

8.10.216 Further details of the assessment of impacts upon Cotswold Beechwoods SAC are provided within the Habitat Regulations Assessment: Screening Report (Document Reference 6.5) and Habitats Regulations Assessment: Statement to Inform an Appropriate Assessment (Document Reference 6.5).

Wye Valley and Forest of Dean Bat Sites SAC

8.10.217 **Direct mortality:** A disused mine at Birdlip, approximately 270m to the south-west of the scheme, is used as a transitional roost in the early breeding season by a small number of female greater horseshoe bats, which are assumed to form part of the qualifying population of the SAC. Of the six female greater horseshoe bats recorded in May 2020 within this mine, three originated from the Woodchester Mansion maternity site, 10.9 miles (17.6km) south-west of scheme, which is not part of the SAC designation. The three remaining bats have not been recorded breeding at Woodchester and are likely to originate from Dean Hall maternity roost (Ransome Pers. Comm.), 15.3 miles (24.6km) west of the scheme and part of the SAC. The count of three female bats likely to be from the SAC would represent approximately 0.7% of the adult population count of the Dean Hall roost within the SAC (424 bats from latest published data from 2018[90]). This transitional usage is likely to last for around 4-6 weeks per year, before mature females return to their maternity roosts. The closest part of the scheme to this transitional roost is the section of Existing A417to be detrunked. The scheme will result in the new route of the A417 being relocated more than 0.6 miles (1km) further from the roost than its current location.

8.10.218 The radio-tracking study undertaken for the scheme tracked two of the female greater horseshoe bats in late May 2020 to sample their movements in relation to the habitats within the scheme boundary (Full results can be found in ES Appendix 8.8 Bat advanced survey technical report CONFIDENTIAL (Document Reference 6.4). The results of the radio-tracking showed that these bats frequently crossed the Existing A417 road corridor to the west of the Air Balloon roundabout, in the vicinity of Dog Lane, to move between foraging areas. This includes crossing both above the road and use of an existing underpass to the far west of the scheme. Construction of the scheme will include the removal of woodland vegetation adjacent to the A417 and the widening of the road corridor to the west of the Air Balloon roundabout. This is likely to increase the existing mortality risk from vehicle collisions to individual bats that are crossing above the road along this section.

8.10.219 An increased risk of mortality to the estimated <1% of the SAC population crossing the scheme for approximately 10% of the year is not considered to represent a threat to achievement of favourable conservation status of the qualifying population of greater horseshoe bat within the SAC.

8.10.220 No observable impacts on Wye Valley and Forest of Dean Bat Sites SAC are predicted as a result of the operation phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the international level and not significant.**

North Meadow and Clattinger Farm SAC

8.10.221 **Nitrogen deposition**: The SAC is within 200m of the ARN and has been assessed for air quality impacts because it is sensitive to nitrogen deposition. The air quality assessment predicts that the operational phase of the scheme would not result in an increase in annual mean nitrogen deposition greater than 1% of the lower critical load at the SAC. The change in nutrient nitrogen deposition at the SAC as a result of operation of the scheme is considered to be imperceptible (0.02kg N/ha/yr at the closest point of the SAC to the ARN in 2026). As such no impacts to designated habitats via nitrogen deposition are predicted during operation. Further details of the air quality modelling are provided within ES Chapter 5 Air Quality (Document Reference 6.2).

8.10.222 No observable impacts on North Meadow and Clattinger Farm SAC are predicted as a result of the operation phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the international level and not significant.**

Statutory designated sites of national importance

Crickley Hill and Barrow Wake SSSI

8.10.223 **Recreational visitor pressure:** The Crickley Hill component of Crickley Hill and Barrow Wake SSSI is a Country Park of national importance that is heavily used by the public, with around 250,000 visitors per year, the majority of whom are walkers attracted by the views. Visitor studies indicate that over 90% of visitors arrive by car/van. The studies show that public awareness and use of the Barrow Wake component of the SSSI is much lower with very few visitors to Crickley Hill also making use of Barrow Wake on the day of their visit. The Cotswold Way National Trail between Crickley Hill and Barrow Wake currently crosses the A417 at grade (i.e. at the same level). With the road being used daily by more than 34,000 vehicles it is considered that this may supress movement of visitors between the two sites.

8.10.224 The scheme will include a diversion of the Cotswold Way National Trail across a footbridge, the Cotswold way crossing, that will cross over the A417 and connect to the Air Balloon Way, which is designed to provide a new recreational route for WCH. This element of the scheme has potential to increase visitor numbers to the Barrow Wake unit of the SSSI which could degrade the habitats for which the site is designated.

8.10.225 The scheme introduces numerous improvements to the PRoW network, the design of which has considered and minimised the potential for impacts to the SSSI. The Air Balloon Way would navigate a route adjacent and separate to the Common Land (which includes all of the designated habitats of the Barrow Wake unit of the SSSI), to help ensure cyclists and horse riders avoid the Common Land that permits use to walkers only (as required by the Countryside and Rights of Way Act 2000). Users who wish to access the Barrow Wake Car Park would join the Air Balloon Way from its existing access north of the Car Park, with the access improved as part of the scheme to better accommodate WCH. Use of drystone walls and/or other physical barriers and/or clear signage would help demark routes for these users to help manage the separation between the Common Land and unauthorised users, to be agreed at the detailed design stage as outlined in the PRoW Management Plan in ES Appendix 2.1 EMP Annex F (Document Reference 6.4).

8.10.226 In terms of access for walkers, Badgeworth Footpath 89, which currently runs through Barrow Wake SSSI, is proposed to be diverted to connect the Grove Farm underpass to the Air Balloon Way which would help divert recreational activity from the northern end of the Barrow Wake component of the SSSI.

8.10.227 The scheme includes numerous proposals that seek to improve accessibility and connectivity across the PRoW network within the study area, as detailed in Chapter 12 Population and human health (Document Reference 6.2) and the PRoW Management Plan in ES Appendix 2.1 EMP Annex F (Document Reference 6.4). This improved PRoW network will better connect Crickley Hill, Barrow Wake, the Gloucestershire Way, the Air Balloon Way, and provide additional free car parking at the Golden Heart Inn. The Air Balloon Way will provide easy and attractive terrain for some of the largest demographic groups using Crickley Hill, who are identified as seniors and families with younger children undertaking short to mid-length walks. This should provide alternative and accessible recreational provision for the high number of visitors currently using the Crickley Hill component of the SSSI, and should help to divert these users away from the Barrow Wake component of the SSSI which offers less suitable terrain for such groups.

8.10.228 It is acknowledged that the viewpoint close to the car park at Barrow Wake will be a particular draw for visitors that are walking the Air Balloon Way. The grassland habitat in closer proximity to this location is more likely to be impacted by increased visitor numbers, albeit that this is already a relatively well used part of the SSSI. Segregated routes, signage and other measures to deter public access from sensitive features would be discussed and agreed at the detailed design stage, to help reduce and avoid adverse impacts on SSSI habitats that could arise from additional visitors attracted to the viewpoint and immediate surrounds. It is also considered that The Air Balloon Way and roundabout at the B4070 would improve natural surveillance at Barrow Wake car park and the approach road and could therefore reduce anti-social behaviour that currently contributes to littering and degradation of SSSI habitat at Barrow Wake.

8.10.229 There are also concerns over increased mountain bike users to Crickley Hill and Barrow Wake SSSI. Local mountain bike clubs have set meeting points at the Royal William public house and the Royal George public house in Birdlip, whilst the Flyup 417 Bike Park offers an attractive formalised facility. The design of the Air Balloon Way is not thought to provide any increased incentive to attract mountain bikers to the area, being more appropriate for road bikes or tourers who are less likely to deviate from designated tracks.

8.10.230 In terms of horse riders, The Air Balloon Way and the Cotswold Way crossing would also be open to horse riders with provision for parking of three horse boxes at the southern end of the scheme adjacent to the Golden Heart Inn. There is an existing bridleway through Crickley Hill connecting to the local road network which riders from the Air Balloon Way could use but there is also increased connectivity to the new Cold Slad Lane and Dog Lane route along with the Grove Farm underpass which give additional options for circular routes to the south of Crickley Hill. The Gloucestershire Way crossing and Stockwell and Cowley overbridges would provide additional opportunities for circular routes for horse riders to the east. The number of horse riders within Crickley Hill Country Park is not considered likely to increase significantly as a result of the scheme. Furthermore, segregated routes, signage and other measures to deter public access from sensitive features would be discussed and agreed at the detailed design stage to

help reduce or avoid any impacts of WCH on ecological sites, for example with managed interfaces between bridleways and SSSI.

8.10.231 The impacts of increased recreational pressure on the SSSI would be permanent. However, with the implementation of the major alternative recreational routes provided by the scheme and the provision of segregated routes, signage and other measures to deter public access from sensitive features, any damage to habitats from impacts such as increased trampling and degradation of vegetation would not affect the integrity or key characteristics of the SSSI. Habitat degradation from increased recreational pressure would represent a minor adverse impact upon Crickley Hill and Barrow Wake SSSI.

8.10.232 **Water pollution:** No impacts to the SSSI are anticipated from changes to surface water during operation due to the operational drainage design, including flow volume and quality control measures incorporated into the scheme design to provide a sustainable drainage system (SuDS). As described in Chapter 13 Road drainage and the water environment (Document Reference 6.2), the scheme will comprise a road drainage scheme that will capture pollutants within road run-off and remove pollutants before the treated run-off is discharged. No observable impacts on Crickley Hill and Barrow Wake SSSI from surface water pollution are therefore predicted to occur as a result of the operational phase of the scheme.

8.10.233 **Nitrogen deposition:** An improvement in air quality is predicted at the Barrow Wake unit of the Crickley Hill and Barrow Wake SSSI. The new roundabout at the entrance to the car park of the Barrow Wake unit of the SSSI would result in an increase in daily traffic using this part of the road network adjacent to the designated site. This increase would be outweighed by a much larger reduction in road traffic in close proximity to the eastern boundary of the Barrow Wake unit of the SSSI from the decommissioning of the . The Existing A417 is located within 80m of the SSSI unit for the vast majority of the eastern boundary of the SSSI unit. The scheme would increase the separation distance between the majority of the eastern boundary of the SSSI unit and the A417 to over 600m.

8.10.234 As described in ES Chapter 5 Air quality (Document Reference 6.2), the maximum reduction in nitrogen deposition is predicted to be -7.6kg N/ha/yr from the “Do-Minimum” baseline prediction for 2026 of 43.3kg N/ha/yr to 35.7kg N/ha/yr in 2026 with the operation of the scheme, which is a 76% decrease of nitrogen deposition against the lower critical load. This measurement is from a point on transect ED1, 20m away from the current road alignment near the entrance to Barrow Wake carpark.

8.10.235 Improvements in air quality are also predicted at the Crickley Hill Units of the SSSI as traffic would be moved further away from the designated site due to a widening of the road to the south. The maximum reduction in nitrogen deposition is predicted to be -5.61kg N/ha/yr from the “Do-Minimum” baseline prediction for 2026 of 45.5kg N/ha/yr to 39.9kg N/ha/yr in 2026 with the operation of the scheme which is a 56.1% decrease of nitrogen deposition against the lower critical load.

8.10.236 Reductions in nitrogen deposition on habitats within Crickley Hill and Barrow Wake SSSI would have a permanent beneficial impact on the designated site. However, the reduced levels of nitrogen deposition are still above the modelled lower critical load for calcareous grassland and broadleaved woodland of 10 – 20kg N/ha/yr. The reductions would not therefore affect the key characteristics or

integrity of the designated site. These reductions would represent a minor beneficial impact on the SSSI.

8.10.237 In summary, Crickley Hill and Barrow Wake SSSI would be subject to a minor adverse impact from habitat degradation due to recreational pressure in the operational phase of the scheme. **The residual effect associated with the scheme is considered to be slight adverse at the national level, and not significant.**

8.10.238 In addition, Crickley Hill and Barrow Wake SSSI would be subject to a minor beneficial impact from a reduction in nitrogen deposition during the operational phase of the scheme. **The residual effect associated with the scheme is considered to be slight beneficial at the national level, and not significant.**

Bushley Muzzard and Brimpsfield SSSI

8.10.239 **Recreational visitor pressure:** A footpath runs through Bushley Muzzard SSSI from the garden of the Golden Heart Inn. It is not considered likely that use of this footpath would increase greatly from current levels as a result of the additional parking at the Golden Heart Inn, due to the provision of the Air Balloon Way which would provide a more obvious route from this location. Therefore, there would be no observable change in the visitor use of the footpath arising from the changes to the PRoW network that form part of the scheme. No observable impacts upon Bushley Muzzard and Brimpsfield SSSI are predicted from changes in recreational visitor pressure arising from the scheme.

8.10.240 **Water pollution:** No impacts to the SSSI are anticipated from changes to surface water during operation due to lack of proximity to the new road alignment. No observable impact on Bushley Muzzard SSSI from surface water pollution is therefore predicted to occur as a result of the operational phase of the scheme.

8.10.241 **Nitrogen deposition:** Bushley Muzzard and Brimpsfield SSSI is further than 200m from the ARN and is therefore outside of the study area for air quality impacts. It is therefore considered that there will be no observable impact on the SSSI due to nitrogen deposition as a result of the operational phase of the scheme.

8.10.242 In summary, no observable impacts to Bushley Muzzard and Brimpsfield SSSI are predicted as a result of the operation phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the national level, and not significant.**

Cotswold Commons and Beechwoods SSSI

8.10.243 The majority of this SSSI is a component of the Cotswold Beechwoods SAC and the operational impacts relevant to the SSSI are the same as those described for the SAC (paragraphs 8.10.210 - 8.10.216). The reason for designation of the majority of the SSSI is broadly the same as that for the designation as the SAC, i.e. ancient beech woodland habitat. The SSSI is also designated for additional areas of calcareous grassland that do not form part of the SAC. The closest area of this designated grassland to the scheme is at Cranham Common, over 3km from the scheme boundary. Due to this distance, no additional impacts from the operational phase of the scheme are predicted to the areas of SSSI grassland habitat that do not fall within the SAC boundary.

8.10.244 In summary, no observable impacts to Cotswold Commons and Beechwoods SSSI are predicted as a result of the operation phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the national level, and not significant.**

Leckhampton Hill and Charlton Kings Common SSSI

8.10.245 Recreational pressure: The new short section of bridleway from the Cotswold Way crossing along Leckhampton Road to the north is only to enable safe access to the road from the new junction and would be segregated from adjacent land by a stone wall. It would not link directly into any other existing bridleways and it is therefore considered unlikely that there would be an increase of horse riders within Leckhampton Hill and Charlton Kings Common SSSI as a result of the operational phase of the scheme. No observable impacts upon Leckhampton Hill and Charlton Kings Common SSSI are predicted from changes in recreational visitor pressure arising from the scheme.

8.10.246 **Pollution:** No impacts to the SSSI are anticipated from changes to surface water during operation due to lack of proximity to the new road alignment. No observable impact on Leckhampton Hill and Charlton Kings Common SSSI from surface water pollution is therefore predicted to occur as a result of the operational phase of the scheme.

8.10.247 **Nitrogen deposition:** The scheme would result in a maximum change in nitrogen deposition which is less than 1% increase against the lower critical load for both calcareous grassland and broadleaved woodland. The predicted change of up to 0.08kg N/ha/yr is considered to result in no observable impact to the SSSI as a result of the operational phase of the scheme.

8.10.248 In summary, no observable impacts to Leckhampton Hill and Charlton Kings Common SSSI are predicted as a result of the operation phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the national level, and not significant.**

Non-Statutory Sites

Barrow Wake Local Wildlife Reserve (LWR)

8.10.249 Barrow Wake LWR is within the Barrow Wake unit of Crickley Hill and Barrow Wake SSSI and the operational impacts relevant to the LWR are the same as those described for the SSSI. The LWR is designated for the same calcareous grassland habitat that is one of the reasons for designation of the SSSI. The impacts to this habitat and any residual effects are reported in the statutory designated sites section above.

Crickley Hill Country Park (LWR)

8.10.250 Crickley Hill Country Park LWR is partly within the Crickley Hill units of Crickley Hill and Barrow Wake SSSI and the operational impacts relevant to the LWR are the same as those described for the SSSI. The LWR is in part designated for the same calcareous grassland habitat that is one of the reasons for designation of the SSSI. The impacts to this habitat and any residual effects are reported in the statutory designated sites section above.

Ullen Wood LWS

8.10.251 Ullen Wood LWS is an ancient woodland and the impacts and any residual effects of operation upon this site are reported in the irreplaceable habitats section below.

River Frome mainstream and tributaries LWS

8.10.252 The River Frome mainstream and tributaries LWS is adjacent to the scheme boundary at the southern end of the scheme. No impacts to the LWS from changes to surface water during operation are predicted due to the operational drainage design, which includes flow volume and quality control measures incorporated into the scheme design to provide a sustainable drainage system (SuDS). No other observable direct or indirect impacts are predicted to the LWS as a result of the operational phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the county level and not significant.**

Haroldstone Fields pLWS

8.10.253 **Nitrogen deposition:** A decrease in nitrogen deposition of 44.4% against the lower critical load is predicted at Haroldstone Fields pLWS due to the road alignment moving south away from the site. The reduction in nitrogen deposition at the site would be up to -4.4kg/ha/yr, in the closest 10m the scheme. Reduced nitrogen deposition would have a permanent beneficial impact on the habitats, however the levels would remain above the lower critical load for calcareous grassland and broadleaved woodland of 10-20kg N/ha/yr. The reductions will not therefore affect the key characteristics or integrity of the designated site. These reductions would represent a minor beneficial impact on the pLWS.

8.10.254 **Habitat degradation:** No observable direct or indirect impacts as a result of surface water pollution events or visitor pressure are anticipated during the operational phase of the scheme due to the setting of the sites topography in relation to the operational road network (i.e. up a steep hill) and the lack of public access to the site.

8.10.255 No impacts to the pLWS from changes to surface water during operation are predicted due to the operational drainage design, and the topography of the site in relation to the operational road network (i.e. up a steep hill). No other observable direct or indirect impacts are predicted to the pLWS as a result of the operational phase of the scheme.

8.10.256 In summary, Haroldstone Fields pLWS would be subject to a minor beneficial impact as a result of a decrease in nitrogen deposition during the operational phase of the scheme. **The residual effect associated with the scheme is considered to be slight beneficial at the county level, and not significant**.

Bentham Dog Lane Fields pLWS

8.10.257 **Nitrogen deposition:** The scheme would result in a maximum change in nitrogen deposition which is less than 1% increase against the lower critical load relevant to Bentham Dog Lane Fields pLWS. The predicted change of up to 0.08kg N/ha/yr is considered to result in no observable impact to the pLWS as a result of the operational phase of the scheme.

8.10.258 **Pollution:** No impacts to the pLWS are anticipated from changes to surface water during operation due to lack of proximity to the new road alignment. No other observable direct or indirect impacts are predicted to the pLWS as a result of the operational phase of the scheme.

8.10.259 In summary, no observable impacts to Bentham Dog Lane Fields pLWS are predicted as a result of the operation phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the county level, and not significant.**

Other non-statutory sites

8.10.260 No impacts from nitrogen deposition, pollution, recreational pressure or any other observable impacts from operation are predicted at other non-statutory sites within the study area, as listed in

Table 8-8, due to the distance of these sites from the scheme.

Irreplaceable Habitat – Ancient woodland and veteran trees

Ancient Woodland

8.10.261 Ullen Wood LWS is an ancient woodland of national importance situated to the north east of the scheme adjacent to the existing A436. As a result of the scheme, the A436 roundabout would be within 45m of the woodland and the new A436 and A417 alignment would be within 25m of the woodland at its nearest point, although the road would be within a deep cutting.

8.10.262 **Nitrogen deposition**: Air quality modelling shows a maximum increase in nitrogen deposition within the ancient woodland of 1.08kg N/ha/yr, which is a 10.8% increase against the lower critical load for broadleaved woodland at 10kg N/ha/yr. The lower critical load would also be substantially exceeded in the "Do-Minimum" baseline in 2026, with total nitrogen deposition predicted at over 34kg N/ha/yr throughout the woodland.

8.10.263 A *Natural England Commissioned Report* (NECR210)[91] concludes that at levels of nitrogen deposition above the upper end of critical load, additional increments of long-term nitrogen deposition are associated with further declines in species richness across a range of semi-natural habitats. Following the assessment methodology within *LA 105*, which references NECR210, the threshold for an increase in nitrogen deposition that would likely lead to loss of one species at Ullen Wood is 0.4kg N/ha/yr. The predicted increase in nitrogen deposition exceeds 0.4kg N/ha/yr across approximately 2.1ha of Ullen Wood, which comprises ancient semi-natural woodland. Permanent degradation of this area of habitat is predicted through a reduction in species richness and/or changes in species composition. There are no feasible mitigation measures that would avoid or reduce this predicted increase in nitrogen deposition. Habitat degradation arising from increased nitrogen deposition in Ullen Wood is therefore considered to permanently affect the integrity of the ancient woodland, which would represent a major adverse impact.

8.10.264 **Recreational pressure:** Ullen Wood is accessible to the public by a footpath which connects to the Gloucestershire Way long distance path to the south of the woodland via a section of 'other route with public access (ORPA). The additional PRoW network as part of the scheme will improve connection to this footpath, with links directly from the Gloucestershire way crossing and from the Ullen Wood junction. The path through the woodland is well marked and areas of private woodland are well signposted to dissuade people from straying from the footpath. Due to the circular route provided through the field to the south of Ullen Wood, it is not anticipated that there will be a large increase in walkers using the woodland footpath. It is therefore considered that there will be no observable impact from recreational pressure on the ancient woodland as a result of the scheme during the operational phase.

8.10.265 **Pollution**: Due to the topography and the position of the road within cutting at this location, degradation of the woodland habitat as a result of surface water pollution events is not predicted. No observable impacts on Ullen Wood from surface water pollution will occur as a result of the operational phase of the scheme.

8.10.266 In summary, Ullen Wood ancient woodland would be subject to a major adverse impact from an increase in nitrogen deposition as a result the operational phase

of the scheme. **The residual effect associated with the scheme is considered to be large adverse at the national level, and significant.**

8.10.267 Native broadleaved woodland habitat creation will be provided to compensate for the predicted degradation of 2.1ha of ancient woodland within Ullen Wood from nitrogen deposition. The landscape design includes a buffer of woodland and scrub planting to the south-west of Ullen Wood, as shown in ES Figure 7.11 Environmental Masterplan (Document Reference 6.3). This buffer has been designed to include a minimum of 2.1ha of compensatory woodland creation in a location where the predicated change in nitrogen deposition is below the 0.4kg N/ha/yr threshold for habitat degradation.

Veteran trees

8.10.268 **Nitrogen deposition:** Air quality modelling shows an increase in nitrogen deposition to a veteran beech tree within the scheme boundary (ref 196380 and Air quality receptor EVT21) of 1.04kg N/ha/yr. This represents a 10.4% increase against the lower critical load (for broadleaved woodland) at 10kg N/ha/yr. The lower critical load would also be substantially exceeded in the Do-Minimum" baseline in 2026, with total nitrogen deposition predicted at over 30kg N/ha/yr.

8.10.269 Following the assessment methodology within LA 105, which references NECR210, the threshold for an increase in nitrogen deposition that would adversely impact veteran trees is 0.4kg N/ha/yr. The predicted increase in nitrogen deposition exceeds this value for the veteran beech tree. Nitrogen deposition adversely affects beech trees in several ways (as described in section 8.8) and permanent degradation of this habitat feature is predicted.

8.10.270 Three further veteran trees (Air Quality receptor references EVT 13, 42 and 98) would experience an increase in nitrogen deposition slightly above 1% of the lower critical load at 1.2 – 1.3%. All of these trees are further than 1.2 miles (2 kilometres) from the scheme boundary. The predicted absolute change in nitrogen deposition for these trees would be an increase of 0.12 - 0.13kg N/ha/yr. At that level the changes in nitrogen deposition upon these veteran trees is not considered to result in any observable impact.

8.10.271 Mitigation measures will improve the health of the impacted veteran beech tree by relieving existing threats and pressures on the tree. The degree to which these measures will counteract degradation of the habitat from nitrogen deposition are not quantifiable. Therefore, habitat degradation from increased nitrogen deposition is considered to permanently affect the integrity of the veteran beech tree within the scheme boundary, which would represent a major adverse impact. **The residual effect associated with the scheme is considered to be large adverse at the national level, and significant.**

<u>Habitats – semi-natural broadleaved woodland (non-ancient)</u>

8.10.272 **Recreational pressure:** There may be increased visitors following the Gloucestershire Way long distance footpath through Emma's Grove woodland as a result of the changes to the PRoW network that form part of the scheme. Interpretation boards to educate visitors on the sensitivity of the woodland and selective clearance of vegetation to improve the public footpath and provide clearer access through the woodland to the heritage feature would reduce adverse impacts on the woodland. With these measures, no observable impacts upon the woodland are predicted as a result of the operational phase of the

scheme. **The residual effect associated with the scheme on semi-natural broadleaved woodland is considered to be neutral at the national level, and not significant.**

Protected species

Bats

8.10.273 **Direct mortality:** Collision resulting in mortality of bats could occur in areas where bats would attempt to cross the highway when following existing or new linear features (hedgerows, tree lines, and other features). This is particularly relevant to the woodland species present along the scheme such as horseshoe bats, which are more reluctant to fly in the open and tend to commute along linear features in the landscape and woodland edges. Although agile and manoeuvrable in flight, most bat species fly at low speeds (< 20km/h) and many fly close to the ground (0-4m: e.g. Russell et al. 2009[92], Berthinussen and Altringham 2012[93]), particularly when crossing open spaces, at heights that may bring them into the path of oncoming vehicles.

8.10.274 Studies have highlighted three mortality peaks during the year[94]: at the end of hibernation, when adults need to intensively forage in order to build up energy supplies; at the end of summer, when young-of-the-year begin to fly and are in dispersal phase; and from September to October, when bat populations are at their peak numbers, seeking to mate and to build up fat reserves for hibernation. Juvenile bats are considered to be more vulnerable to collision mortality; as such, the close proximity of any maternity roost may heighten the risk of collision. Embedded mitigation would include the provision of false cuttings and associated planting where the scheme is on embankment (to be planted as soon as possible before opening) to provide suitable cover to help raise bat flight paths above the level of traffic. Structural planting on both sides of the scheme would help guide bats towards safe crossing points, where the risk of collision is reduced; these provisions include:

- Crickley Hill bat underpass
- Gloucestershire Way crossing
- Cowley overbridge
- Stockwell overbridge

8.10.275 The presence of the Existing A417 is also relevant as there is already likely to be mortality of bats occurring through vehicle collisions along this road, albeit this is unquantifiable. The impact of the scheme would therefore be any increased collision risk and mortality relative to the baseline situation. The mitigation measures incorporated into the scheme are considered suitable to maintain a permeable landscape for foraging and commuting bats in the wider landscape, including a number of safe crossing points to reduce the risk of collisions.

8.10.276 It is acknowledged that the provision of the safe crossing points would not mitigate all of the increased collision risk to bat species, particularly whilst the structural planting to guide bats towards the features is still establishing and whilst bat populations are habituating to alternative foraging/commuting routes. Increased mortality arising from the scheme would result in permanent/irreversible damage to commuting and foraging bats that would not be considered to affect the integrity of the bat populations. Increased mortality from

vehicle collisions would result in a minor adverse impact on commuting and foraging bats.

8.10.277 **Disturbance (lighting):** Increased light levels associated with the live traffic in the eastern section of the scheme could deter bats and alter their behaviour. However, the measures incorporated into the scheme such as cuttings, solid parapets on all overbridges, the de-trunking of a section of the Existing A417 and planting regime are considered to mitigate the impacts associated with increased light spill from vehicle lights onto surrounding habitat. With mitigation, increased light levels from traffic would result in permanent/irreversible damage to commuting and foraging bats that would not affect the integrity of the bat populations. This would comprise repeated occurrences once the scheme is operational until bat populations are habituated to alternative foraging/commuting routes. This would represent a minor adverse impact on commuting and foraging bats.

8.10.278 **Disturbance (noise):** A number of roosts would be subject to higher noise levels as a result of the scheme in operation. In turn, a number of roosts would see a reduction in noise levels as a result of the scheme in operation. Increased noise levels could also affect foraging bats, specifically the species that use passive listening as a foraging technique.

8.10.279 The roosts which would be subject to the highest noise level increases as a result of the scheme in operation are Buildings 44, 45, 91a and 91b (all located around Shab Hill), as detailed in Table 8-19. These roosts would all be expected to experience an increase in noise level of more than 10 dB(A).

Table 8-19 Predicted adverse change in noise level at each identified bat roost

Building ID	Description	Operation long-term change in noise level dB(A) (baseline to operational)	Roost Details
44	Disused commercial building at Shab Hill	>= 10 (42 to 55)	Common pipistrelle day roost (local importance)
45	Workshop at Shab Hill	>= 10 (43 to 56)	Common pipistrelle day roost (local importance)
91A	Stone outbuilding at Shab Hill	>= 10 (42 to 52)	Common pipistrelle day roost and lesser horseshoe night roost (county importance)
91B	Abandoned brick building at Shab Hill	>= 10 (42 to 53)	Lesser horseshoe night roost (county importance)

8.10.280 Whilst these increases in noise level may be deemed an adverse effect in EIA terms for humans, see ES Chapter 11 Noise and vibration (Document Reference 6.2), there is little evidence to show what constitutes a significant adverse effect for bats. In their paper on the effects of anthropogenic noise on foraging bats, Schaub, et al (2008[95]) identify that whilst traffic noise and other sources of intense broadband noise are shown to degrade the suitability of foraging areas, there are many examples of bats roosting in extremely noisy situations (bell towers of churches or under motorway bridges). Through the embedded design mitigation as shown on the landscape design in ES Figure 7.11 Environmental Masterplan (Document Reference 6.3), there would be an increase in foraging habitat such as calcareous grassland and broadleaved woodland that would be accessible to the roosts subject to a significant increase in noise level around Shab Hill. It

should also be noted that some roosts would benefit from a decrease in noise levels, in particular (but not limited to) the lesser horseshoe and serotine day roost in Building 60B, the lesser horseshoe day roost in building 33a, the *Myotis* sp. day roosts in buildings 66 and 68, and the *Myotis* sp. day roosts in T24 and T239. No observable impacts of noise during operation on roosting bats are predicted, either positive or negative.

8.10.281 In summary, the bat assemblage would be subject to minor adverse impacts from disturbance from lighting and increased risk of injury or mortality as a result of the operation of the scheme. **The residual effects associated with the scheme are considered to be slight adverse at the regional level, and not significant**.

Badger

8.10.282 **Risk of mortality and injury**: There is an increased risk of mortality through traffic collision, associated with badgers crossing the new carriageway which would sever existing badger ranges. The inclusion of crossing points in the form of three badger culverts have been included in the design of the scheme where the road would sever identified badger territories which would restore safe crossing points for badgers within their territories and across the wider landscape. An access [redacted] would offer another crossing opportunity between woodland to the north and south of the Existing A417. The three overbridges; [redacted] would also provide opportunities for badgers to cross the new road, with the Gloucestershire Way crossing and the Stockwell overbridge located in known badger ranges.

8.10.283 The installation of permanent badger fencing and hedgerow, woodland tree and scrub planting would assist in encouraging and channelling movement of badgers away from the highway and to the crossing points throughout the operational phase of the scheme. These features, as shown on ES Figure 7.11 Environmental masterplan (Document Reference 6.3), would be installed prior to the completed road network opening.

8.10.284 With the appropriate mitigation implemented the risk of mortality to badgers would be reduced in comparison to the current situation. Reduced mortality risk would result in a permanent improvement for the badger population that would not affect its integrity.

8.10.285 In summary, badger clans would be subject to a minor beneficial impact from measures to reduce mortality during the operational phase of the scheme. **The residual effect associated with the scheme is considered to be slight beneficial at the local level and not significant**.

Breeding and wintering birds

8.10.286 **Increased risk of road mortality:** The Existing A417 already poses a risk to birds from collisions, however the scheme would increase this risk with the wider extent from dualling. The provision of the greened crossing points in the form of the Gloucestershire Way crossing and Stockwell and Cowley overbridges and the embedded landscaping including steep embankments and reduced vegetation on verges (used for foraging/connectivity) would improve connectivity and reduce mortality risk. In addition, planting of trees and hedgerows would assist in encouraging and channelling movement of birds over the bridges as safe crossing points. With this mitigation implemented, direct increase in mortality would result

in permanent/irreversible damage to bird assemblages that would not affect their integrity. Direct mortality would represent a minor adverse impact upon bird assemblages.

8.10.287 **Disturbance, including noise and lighting:** The scheme would increase operational disturbance through primarily noise and lighting (from traffic), especially in areas of complex junctions such as Shab Hill junction. Increased noise would be likely to displace birds both away from the immediate scheme area, but also adjacent habitats where sound level changes are significant, and disturbance could cause functional habitat loss.

8.10.288 The conversion of the southern section of the Existing A417 to a WCH route (Air Balloon Way) would be likely to increase suitability of adjacent habitats for birds due to the removal of traffic and therefore decrease disturbance from noise and lighting in this area. The reduction of noise is indicated in ES Figure 11.2 Operational noise contour map - future assessment year (2041) (Document Reference 6.3).

8.10.289 Areas of grassland habitat created close to the new road as part of the scheme that would be beneficial for ground nesting birds are predicted to experience similar operational noise levels to those areas currently used by breeding birds such as skylark during baseline surveys. Therefore, the habitat would continue to provide functional habitat for breeding birds that are habituated to a similar noise level. With the creation of additional habitat, disturbance would result in permanent/irreversible damage to bird assemblages that would not affect their integrity. Disturbance would represent a minor adverse impact upon bird assemblages.

8.10.290 In summary, the breeding and wintering bird assemblage would be subject to minor adverse impacts from road mortality and disturbance from noise and lighting as a result of operational activities. **The residual effect associated with the scheme is considered to be neutral at the local level, and not significant.**

Barn owl

8.10.291 The population of barn owl within the scheme boundary is considered to be of county importance. The operation of the scheme has the potential to affect barn owl through mortality and disturbance, including noise and lighting.

8.10.292 **Increased risk of injury/mortality:** the realignment and widening of the road, improvements to traffic congestion and increased traffic speed would cause an increased risk of road mortality to barn owls. This is particularly relevant to young birds dispersing in the autumn months. The ARS identified in the Stage 1 and 2 report near Flyup 417 Bike Park show that barn owls are present within 100m of the Existing A417 and are at high risk from road mortality. Studies estimate that between 3,000 and 5,000 barn owls are killed on roads annually, with over 90% of these fatalities occurring on major roads (motorways and dual carriageways)[96]. The rough grass verges alongside major roads provide long stretches of habitat for barn owl prey species and birds would frequently fly across the road at low height, resulting in the potential for direct conflict with traffic. The presence of major roads can cause the absence of breeding barn owls within 0.3 miles (0.5 kilometres) on either side of the road, with negative impacts detected up to 15.5 miles (25 kilometres) away from a major road[97]. Where the road realignment crosses existing areas of Type 1 and 2 habitats, mortality through collision with vehicles is likely to be highest.

8.10.293 Mitigation would include strategic planting of woody species of a height of at least 3m in areas considered to be of high collision risk, for example at Shab Hill to encourage barn owls to fly high over the road network. Planting design has aimed to provide suitable foraging and commuting routes for barn owls to connect existing habitat each side of the road corridor where barn owls are known to be present and also to direct barn owl to overbridges to use as safe crossing points. Grass verges would be managed as short grassland, and areas within junctions would include scrub planting to reduce the habitat suitability for small mammals and therefore decrease the foraging potential for barn owls near the road network. Consideration will also be given at detailed design to reducing the perching potential of fence posts and signage within road verge locations more likely to attract barn owl.

8.10.294 Increased mortality of barn owl would result in permanent/irreversible damage to the barn owl population that would negatively affect its integrity. Increased mortality risk would represent a major adverse impact on the barn owl population.

8.10.295 **Disturbance, including noise and lighting:** The scheme would increase operational disturbance of foraging barn owl at night through noise and lighting (from vehicles). Disturbance from this source would result in permanent/irreversible damage to the barn owl population that would not affect its integrity. Disturbance would represent a minor adverse impact upon the barn owl population.

8.10.296 In summary, the barn owl population would be adversely impacted by disturbance from noise and lighting (from vehicles) and increased risk of injury or mortality from operational activities. These impacts range in scale from minor adverse to major adverse. **The residual effects associated with the scheme are considered to be moderate adverse at the county level, and significant**.

Amphibians

8.10.297 No observable direct or indirect impacts during the operational phase of the scheme upon great crested newt are anticipated.

Reptiles

8.10.298 No observable direct or indirect impacts during the operational phase of the scheme upon reptiles are anticipated.

Otter

8.10.299 It is considered unlikely that otters would attempt to cross the A417 from north to south either over ground or via the long culvert under the road, but it is possible that the tributary of Norman’s Brook could be used very occasionally by otters exploring the far reaches of catchments or potentially moving between catchments from the south.

8.10.300 Due to the lack or records within 250m of the scheme, no signs of otter within the tributary of Norman’s Brook and only occasional use likely, no observable direct or indirect impacts during the operational phase of the scheme upon otter are anticipated. **The residual effect associated with the scheme is considered to be neutral at the county level, and not significant.**

Terrestrial invertebrates [redacted]

8.10.301 **Increased risk of mortality:** The notable invertebrate assemblages associated with the Crickley Hill and Barrow Wake SSSI units respectively, are separated by the Existing A417. Mortality of invertebrates is likely to be occurring through vehicle collisions along the existing road, and the impact of the scheme would therefore be any increased collision risk and mortality relative to the baseline situation. Most relevant studies show a positive correlation between traffic volume and insect mortality, although the response varies between species, with some indication that increased traffic speeds can reduce mortality of butterflies[98]. It is considered that changes to traffic volume and speed arising from the scheme could cause an increase in invertebrate mortality. This impact would be mitigated at the population level through the measures incorporated into the scheme to reduce fragmentation for invertebrate species between Crickley Hill and Barrow Wake SSSI units. As such, no observable direct or indirect impacts during the operational phase of the scheme upon terrestrial invertebrate assemblages are anticipated.

Aquatic invertebrates

8.10.302 No impacts on aquatic invertebrate communities through increased sedimentation, hydrological changes to springheads and increased pollution events through surface run off or groundwater feeds will occur during operation due to embedded mitigation in the design. These measures are described within ES Chapter 13 Road drainage and the water environment (Document Reference 6.2), including road drainage and attenuation ponds to mitigate impacts. As such, there would be no observable impact on aquatic invertebrates from the operational phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the county level, and not significant.**

Fish

8.10.303 No impacts on fish through increased sedimentation, hydrological changes to springheads and increased pollution events through surface run off or groundwater feeds will occur during operation due to embedded mitigation in the design. These measures are described within ES Chapter 13 Road drainage and the water environment (Document Reference 6.2), including road drainage and attenuation ponds to mitigate impacts. As such, there would be no observable impact on the fish assemblage from the operational phase of the scheme. **The residual effect associated with the scheme is considered to be neutral at the local level, and not significant.**

Other Section 41 Species of Principal Importance

8.10.304 Populations of the other SPI species within the study area are considered to be of local importance. There would be an inherent risk of mortality through traffic collision, associated with SPIs crossing the carriageway. Wildlife crossing points have been included in the design in the form of culverts and overbridges and an underpass to improve connectivity and reduce mortality risk, as well as the provision of badger fencing throughout the scheme to prevent access to the road network. With these measures, the risk of mortality from operation of the scheme would be reduced for several SPI in comparison to the current situation. Reduced mortality risk would result in a permanent improvement for SPI populations that

would not affect their integrity. This would represent a minor beneficial impact upon SPI populations.

8.10.305 In summary, SPI populations would be subject to a minor beneficial impact as a result of mitigation measures to reduce the impacts from increased risk of mortality during the operational phase of the scheme. **The residual effect associated with the scheme is considered to be slight beneficial and the local level and not significant.**

8.11 Monitoring

8.11.1 Where significant adverse environmental effects are reported for a scheme, projects shall undertake monitoring in accordance with general principles in paragraph 5.1 of LA 104.

8.11.2 Monitoring of proposed mitigation would be undertaken to ensure its success in delivering the required outcome or function for the ecological receptor, either habitat or a specific species. Monitoring would be required within the pre, during and post construction phases of the scheme. The anticipated monitoring is provided within Table 8-20 and further details are provided in the Landscape and Ecological Management Plan (LEMP) which forms Annex D of ES Appendix 2.1 EMP (Document Reference 6.4).

Table 8-20 Summary of monitoring requirements

Ecological receptor	Monitoring Phase	
	Pre/During Construction	Post-Construction
Irreplaceable habitats	• Protection measures of retained veteran trees and ancient woodland will be monitored throughout the construction phase to ensure of the efficacy.	• Monitoring for change in species composition would be required in Ullen Wood during the operational phase of the scheme to ensure the efficacy of conservation management techniques in preventing degradation of woodland habitat from increased nitrogen deposition. • Monitoring of the condition of the veteran beech tree to be impacted by nitrogen deposition to ensure the efficacy of sensitive arboricultural management and protective measures to prolong the longevity of the tree.
Habitats	• Habitat creation and habitat translocation that occurs prior to construction would require monitoring during construction to ensure it is establishing and is not damaged during construction activities. • Protection measures of retained trees and woodland will be monitored throughout the construction phase to ensure of the efficacy.	• Habitat enhancement, restoration and compensatory habitat planting would be monitored, and maintenance regimes implemented, to ensure establishment to high quality habitat and intended functionality is being delivered, including translocated habitats (trees, hedgerows and turf/topsoil) and compensatory tufa habitat. This would include habitat connectivity across greened overbridges (Gloucestershire Way crossing, Cowley overbridge and Stockwell overbridge), woodland planting or new calcareous grassland creation.
Bats	• Monitoring would be required pre- and during construction at identified crossing points for bats and along landscape scale transects for comparative analysis[99]. • Works under European Protected Species licences for bats would require ecological presence during works, monitoring of the species, including retained roosts subject to disturbance, and any mitigation such as habitat creation would be necessary.	• Works under European Protected Species licences for bats would require monitoring post construction, including monitoring of the retained roosts subject to disturbance, and any mitigation such as replacement roosts and habitat creation. • Monitoring of the Gloucestershire Way crossing and the Crickley Hill bat underpass for the first five years would be required to assess its effectiveness, along with the other important crossing features monitored before and during construction. • Monitoring for use of the greened overbridges (Gloucestershire Way crossing, Cowley overbridge and Stockwell overbridge) by bats would be undertaken for the first five years by a suitably qualified ecologist post-construction.

		• Bat landscape scale transects for comparative analysis of bat activity before and after construction to build data on the effectiveness of mitigation. • Bat boxes would be monitored in Year 1, 3 and 5 post-construction, and replaced where necessary as part of the EPS licence commitments.
Badgers	• Wildlife fencing installed as part of mitigation for badgers, to exclude animals from the construction area, would require monitoring throughout construction to ensure the fencing is maintained. • Works under Natural England development licences to exclude badgers from active setts and create artificial setts would require monitoring by a suitably qualified ecologist.	• Monitoring of three badger culverts and artificial setts created would be required post construction completion to ensure use and ensure the functionality of the structures in accordance with the Natural England Licence conditions.
Barn owl		• Regular monitoring of barn owl would be undertaken to assess the effectiveness of mitigation measures implemented such as tree planting and verge management and to check the roadsides along the new road alignment for any barn owl mortalities. Monitoring of the new road for any mortalities would be undertaken once a month during the first three years of the new road being operational.
Reptiles	• Wildlife fencing installed as part of translocation exercises for reptiles would require monitoring throughout construction to ensure the fencing is maintained by a suitably experienced ecologist.	• Receptor sites for reptiles would be monitored post construction. This would be in agreement with relevant stakeholders such as GWT. Monitoring would be undertaken at one year, three years and five years post construction.
[redacted]	• [redacted]	• [redacted]
Aquatic invertebrates		• Monitoring surveys to cover the realigned tributary of Norman's Brook both upstream and downstream of the Existing A417, new outflows, and potentially additional locations within the catchment, based on the outcome of ongoing surface water flow and quality monitoring.

Fish		• Post-construction fish monitoring (electric fishing) surveys would be required within Norman's Brook, both upstream and downstream of the Existing A417. • Post-construction fish monitoring (electric fishing) surveys may be required in other locations within the catchment, based on the outcome of ongoing surface water flow and quality monitoring.
Other section 41 NERC Act 2006 species		• Monitoring for use of the greened overbridges (Gloucestershire Way crossing, Cowley overbridge and Stockwell overbridge) by other section 41of the NERC Act 2006 species and species such as deer would be undertaken by a suitably qualified ecologist post-construction to gather data and monitor the effectiveness of the design.

8.12 Summary

8.12.1 The assessment of impacts of the scheme on biodiversity has identified a range of effects during construction and operation. The likely residual *significant* effects during construction and operation are summarised in Table 8-21 and Table 8-22 respectively and ES Chapter 16 Summary (Document Reference 6.2).

Table 8-21 Summary of assessment of likely significant construction effects

Ecological receptor	Description of potential impact	Embedded design, mitigation, and enhancement measures	Importance of receptor	Duration and reversibility	Magnitude of impact	Significance of potential effect
Barrow Wake Unit of Crickley Hill and Barrow Wake SSSI	Habitat Loss. Loss of calcareous grassland and broadleaved trees within the Barrow Wake Unit of the SSSI	Reinstatement and compensatory planting in the form of calcareous grassland to replace SSSI habitat lost.	National	Permanent/ irreversible	Minor Adverse	Moderate adverse (significant)
Barrow Wake Unit of Crickley Hill and Barrow Wake SSSI	Conversion of hardstanding Existing A417) within the SSSI boundary to calcareous grassland.	The conversion of approximately 3,600m^2 of hard standing to calcareous grassland, of which approximately 1,000 m^2 is currently hardstanding within the SSSI boundary, would result in a permanent addition to the area of calcareous grassland within and adjacent to the Barrow Wake unit of the SSSI.	National	Permanent	Minor beneficial	Moderate beneficial (significant)
Semi-natural broadleaved woodland and scattered trees	Loss of semi-natural broadleaved woodland along verges and embankments, and loss and severance of beech woodland at Shab hill.	Retention and protection of woodland and trees wherever loss can reasonably be avoided	National	Permanent/ irreversible	Major adverse	Large adverse (significant)
Broadleaved woodland	Creation of approximately 25.57ha of woodland	n/a	National	Permanent	Major beneficial	Large beneficial (significant)
Veteran trees	Loss of three veteran trees	It is not possible to mitigate against the loss of veteran trees.	National	Permanent/ irreversible	Major adverse	Large adverse (significant)
Hedgerows	Loss of approximately 2.2 miles (3.5km) of important and species-rich hedgerows.	Translocation of valuable hedgerows where appropriate and protection of retained hedgerows.	National	Permanent/ irreversible	Major adverse	Large adverse (significant)
Hedgerows	Planting of approximately 5.6 miles (9.02km) of	n/a	National	Permanent	Major beneficial	Large beneficial (significant)

Ecological receptor	Description of potential impact	Embedded design, mitigation, and enhancement measures	Importance of receptor	Duration and reversibility	Magnitude of impact	Significance of potential effect
	native species-rich hedgerow					
Species-rich neutral grassland	Habitat loss	The topsoil and seed bank from this field would be stored and retained in order to use it in areas of nearby habitat creation within the scheme.	National	Permanent/ irreversible	Major adverse	Large adverse (significant)
Calcareous species-rich grassland	Creation of approximately 75.41ha across the scheme	n/a	County	Permanent	Major beneficial	Moderate beneficial (significant)
Petrifying springs with tufa formation	Loss of Annex 1 habitat	It is not possible to mitigation the loss of the tufa habitat.	Regional	Permanent/ irreversible	Major adverse	Large adverse (significant)
Petrifying springs with tufa formation	Restoration of Annex 1 habitat	Compensation measures at other tufa springs subject to further consultation with NE	Regional	Permanent/ irreversible	Major beneficial	Moderate beneficial (significant)
Assemblages of bats which include Annex II species	Temporary loss and fragmentation of foraging and commuting features.	Construction mitigation (timing of works i.e. retention of vegetation along known commuting routes for as long as possible).	National	Temporary/ reversible	Moderate adverse	Moderate adverse (significant)
Barn owl	Loss and fragmentation of foraging habitat.	Replacement foraging habitats would mitigate the loss and fragmentation of barn owl foraging habitat but would require an establishment period before they become suitable foraging habitats.	County	Permanent/ irreversible	Major adverse	Moderate adverse (significant)

* Where a receptor has a range of importance values, for example hedgerows of varied importance the highest value relevant to the significant effect is shown in this table.

Table 8-22 Summary of assessment of likely significant operation effects

Ecological receptor	Description of potential impact	Embedded design, mitigation, and enhancement measures	Importance of receptor	Duration and reversibility	Magnitude of impact	Significance of potential effect
Non-statutory site Ullen Wood LWS and ancient woodland	Habitat degradation of 2.1ha of ancient woodland from increased nitrogen deposition from vehicle emissions	2.1ha of native broadleaved woodland habitat creation will be provided to compensate for the predicted degradation of 2.1ha of ancient woodland within Ullen Wood from nitrogen deposition, in a location where the predicated change in nitrogen deposition is below the 0.4kg N/ha/yr threshold for habitat degradation	National	Permanent/ irreversible	Major adverse	Large adverse (Significant)
Veteran beech tree within scheme boundary	Habitat degradation from increased nitrogen deposition from vehicle emissions	Mitigation to alleviate other threats and pressures on the tree by reducing risks of future structural failure, moderating competition from adjacent woody vegetation, and reducing risk of damage from farming operations and browsing animals. This will be achieved through introduction of sensitive arboricultural management, management of adjacent woody vegetation and establishment of protective buffer zone around the tree.	National	Permanent/ irreversible	Major adverse	Large adverse (Significant)
Barn owl	Increased risk of mortality and injury through traffic collisions, and severance of habitat, due to increased traffic speed and wider road.	Strategic planting of woody species to encourage barn owls to cross the road at a safe height, and the width of grass verges would be reduced in sensitive areas. Habitat on roadside verges would also be managed as short grassland so as not to provide suitable foraging habitat for barn owl adjacent to the road.	County	Permanent/ irreversible	Major adverse	Moderate adverse (significant)

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