A47 Wansford to Sutton Dualling

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6.3 Environmental Statement Appendices
Appendix 8.3 – Terrestrial Invertebrate Survey Report

APFP Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

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ENVIRONMENTAL STATEMENT APPENDICES
Appendix 8.3 Terrestrial Invertebrate Survey Report

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A47 WANSFORD

Terrestrial Invertebrate Survey Report

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SEPTEMBER 2020

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Executive summary

Abrehart Ecology was commissioned by SWECO UK Limited to undertake a terrestrial invertebrate survey of land identified as falling within the preferred route option of the A47 Corridor Improvement Plan that extends from its junction with the A1 (Wansford) in the west to Great Yarmouth in the east. This report details the terrestrial invertebrate surveys for a proposed 1.6 miles (2.5 kilometre) dual-carriageway, which would be constructed partially off-line to the north and partially off-line to the south of the existing A47, very near Wansford. This same area was surveyed in 2017. A full terrestrial invertebrate survey was conducted in 2020 with a range of sampling techniques used during four visits in May, June, July and August.

The survey area is predominantly arable, improved/semi-improved pasture. In addition, there are small patches of woodland, old trees with decay features, old hedgerows, a mature poplar plantation, field boundaries and waterbodies, including the River Nene and tributaries. Just to the north of the proposed route is Sutton Heath Bog, which adds to the overall terrestrial invertebrate interest of the wider area.

341 species were recorded during the surveys, including **18 species with National Conservation Status**. The status of five of these species requires updating in light of recent range expansions The most notable species recorded during the survey was the Phoenix Fly *Dorycera graminum* – a Nationally Rare, S41 BAP Priority Species, the click beetle *Ampedus quercicola* and the false darkling beetle *Osphya bipunctata.* These two beetles are Nationally Scarce and associated with dead/decaying wood. *Osphya bipunctata* is rarely recorded and its ecology is poorly known.

The most valuable habitats in the survey area are the old broadleaves trees, dead standing trees and deadwood as they support a huge assemblage of specialist animals that depend on centuries of habitat continuity in the same area. The dispersal of these species is often poor, so improving habitat connectivity is important. There is also a network of old hedgerows throughout the site. These too are important for a range of terrestrial invertebrates, including saproxylic insects as many of them depend on nectar sources such as hawthorn *Crataegus* as adults. There is a significant amount of saproxylic habitat in the small patch woodland immediately to the south of the end of Sutton Heath Road and to the east of the dismantled railway. This one patch of woodland and the old hedgerows bordering it and extending along the existing A47 and towards the River Nene are the most valuable habitats for terrestrial invertebrates in the survey area.

The proposed road scheme could enhance the area for terrestrial invertebrates if it is planned and executed in a sympathetic manner with the appropriate mitigation. The creation of habitat corridors alongside the route linking existing habitats and created habitats further from the route will benefit terrestrial invertebrates in what is currently a largely sterile agricultural landscape. Creating a mosaic of habitats (species rich grassland, bare ground, scrub, woodland, nectar-rich hedges and waterbodies) alongside both sides of the route and creating valuable habitat that will improve connectivity through the landscape.

Mitigating for the loss of old trees and standing dead trees is practically impossible, so where feasible, significant trees, alive or dead, should be retained and protected during the development work.

1 Introduction

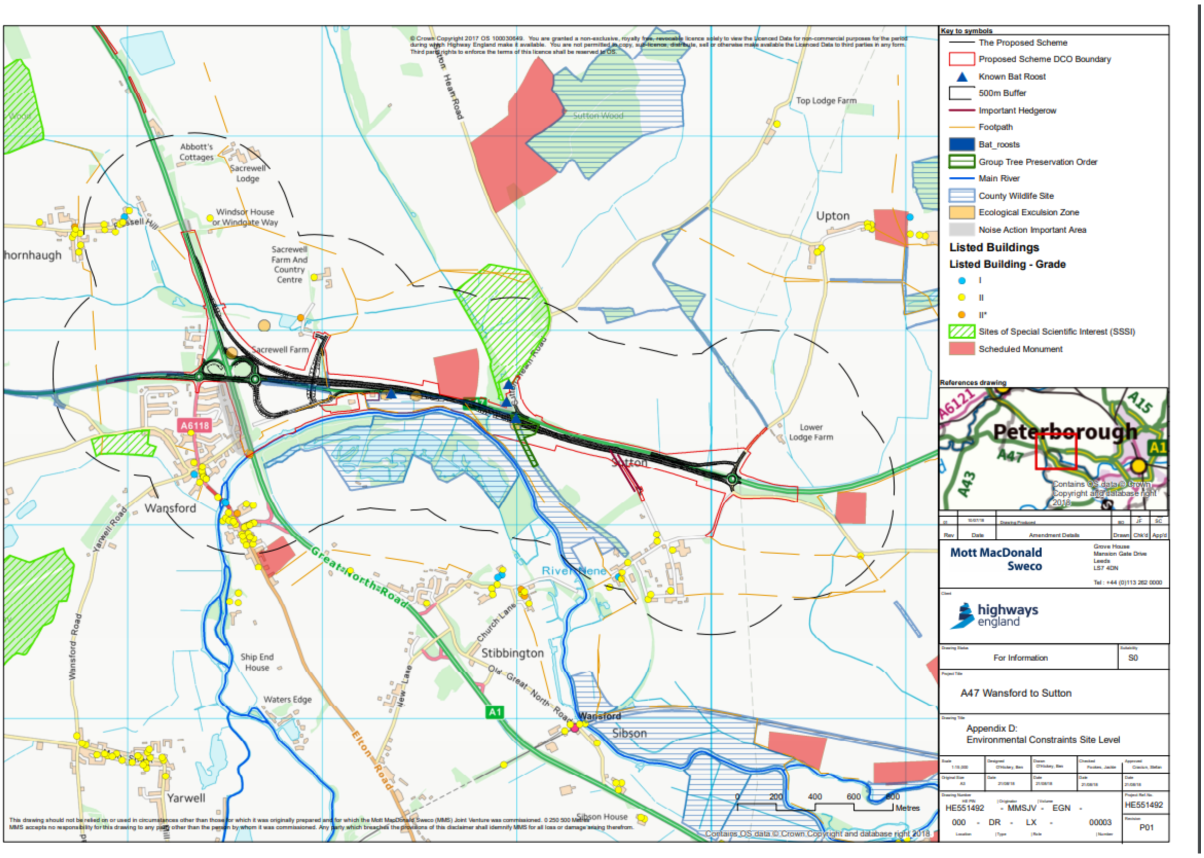
1.1 Overview

Abrehart Ecology was commissioned by SWECO UK Limited to undertake a terrestrial invertebrate survey of land for the proposed A47 Wansford to Sutton dualling scheme. The proposed scheme consists of a new 1.6 miles (2.5 kilometre) dual-carriageway, which would be constructed partially off-line to the north and partially off-line to the south of the existing A47. The dual-carriageway would tie into the existing carriageway at the eastern roundabout at the A1 / A47 interchange and at the Nene Way Roundabout at the eastern end of the Proposed Scheme. At the western end, the Proposed Scheme would also include a free-flow link between the A1 southbound carriageway and the new eastbound carriageway of the A47. The existing Wansford east roundabout, would be enlarged as part of the proposals to accommodate A47 westbound traffic.

1.2 Site location and setting

The study site is a linear corridor representing the proposed preferred route of a new section of the A47, a major trunk road connecting Peterborough (and thus the A1) with the ports of Great Yarmouth and Lowestoft. The preferred route will be an off-line dual carriageway, departing the existing carriageway just east of Blofield (TG 345 099) and re-joining it, immediately east of North Burlingham (TG 373 099), approximately 10 km east of Norwich within a rural area of Norfolk.

Figure 1: Proposed Scheme and Environmental Constraints



1.3 Previous surveys

A previous survey has been conducted on the site. It is unclear who commissioned this survey and who carried out. However, 81 species were reported, of which nine have a National Conservation Status.

1.4 Aims and objectives

1.4.1 Aim

The aim of the survey was to sample the terrestrial invertebrate fauna of the site and make recommendations for mitigation in view of the proposed road scheme.

1.4.2 Objectives

- To review reports based on previous surveys of the site;
- To conduct a terrestrial invertebrate survey of the site;
- To produce a report including findings, an evaluation of key habitat and species assemblages and an appraisal of the potential conservation value of the site's habitats for invertebrates; and
- To provide recommendations for mitigation, further surveys and monitoring.

2 Methodology

2.1 Desk study

Prior to conducting fieldwork, the previous survey report and other reports pertaining to the scheme were reviewed.

2.2 Field survey

2.2.1 Timing

The accurately reflect the invertebrate diversity of the sites, four surveys were conducted during the summer of 2020:

- 13th May
- 22nd June
- 28th July
- 19th August

Target notes were made to reference both features of value as invertebrate habitat and general habitat as an aide-memoire. A photographic record was also made of key features recorded during the survey, these providing resolution to target note data.

2.2.2 Sampling

During each visit, the following sampling protocol was employed in each of the discrete survey areas:

- 1 x 10 minutes transects with a sweep net where vegetation is vigorously swept;
- 1 x 2 min suction samples with vacuum sampler;
- 20 mins of beating scrub and taller vegetation with a beating tray;
- 4 x vane traps for the sampling of saproxylic invertebrates – only deployed on old/veteran trees;
- Direct searching and spot sampling.

Sweep sampling allows the capture of terrestrial invertebrates in the sward and dense vegetation, including very mobile species. The vacuum sampler allows the capture of ground-dwelling species, including leaf-litter and tussock dwelling invertebrates. Vane traps are a very effective means of sampling of saproxylic invertebrates, especially beetles. The animals fly into the transparent vanes and drop into the preservative-filled container. These can be left in situ for the duration of a survey and emptied once a month. Pitfall traps were installed, but were disturbed by wild animals.

The methodology broadly follows methods outlined in NERR005 (Drake *et al*., 2007), a manual produced by Natural England, which sets out standard approaches to invertebrate survey and analytical techniques for the purposes of conservation evaluation.

2.2.3 Limitations

Every effort was made to record habitat features of potential conservation value for invertebrates at a suitable resolution to inform a robust scoping study. However, the recognition of key habitat features with potential to support important invertebrate species or species assemblages is based on knowledge and experience. It cannot be guaranteed that habitats considered to have high conservation potential would be confirmed as such if surveyed in detail, or conversely, some habitat features supporting uncommon species or species assemblages may have been overlooked during the survey. Access requirements made it difficult to visit the site proactively when the weather dictated good conditions for sampling terrestrial invertebrates. Two of the visits had to be made in poor weather. This would have had an impact on the total number of species recorded during the surveys.

3 Results

3.1 Desk study

3.1.1 Sites

There are no internationally or nationally designated ecological sites within 200 metres of the Proposed Scheme. There are however 5 Sites of Special Scientific Interest (SSSI) (Sutton Heath Bog (within 200m of the Proposed Scheme), Wansford Pasture, Old Sulehay Forest, West Abbots & Lounds Wood and Castor Hanglands) within approximately 1.6 Kilometres of the Proposed Scheme and therefore these may be located within 200m of the Proposed Scheme ARN once it has been defined.

3.1.2 Species

The 2017 survey recorded 81 species, nine of which were of conservation concern: the wood ant *Formica rufa* (Near Threatened), small heath butterfly *Coenonympha pamphilus* (Near Threatened), cinnabar moth Tyria jacobaeae (S41-reasearch only), the ground bugs *Megalonotus antennatus* and *M. praetextatus* (both Nationally Scarce), bordered shieldbug *Legnotus limbosus*, the beetles *Choleva spadicea, Dactylosternum abdominale, Tachinus solutus* and *Tachyporus solutus* (all Nationally Scarce). However, the methodology and data in this survey report have various shortcomings, so the list and the notable species recorded during this survey must be treated with caution.

3.2 Field survey

3.2.1 Survey area

The majority of the route for the proposed scheme is arable farmland or improved pasture, which is of very limited value to terrestrial invertebrates. Botanically diversity and vegetation structure in these areas are poor. The margins around these fields have better botanical diversity, but they are still rather poor.

Areas of grassland between the existing A47 and River Nene have a slightly more diverse flora but these were being cut during the first visit and all the cuttings were left in place. This practice enriches the soil and significantly reduces plant diversity of the long-term. Roadside verges are generally dense swards of grass or tall ruderal vegetation and regularly cut providing little habitat structure, floral diversity or features of interest to terrestrial invertebrates. Roadside verges along the A47 from the A1 roundabout to just beyond the Sacrewell Farm junction have higher botanical diversity and in parts there are south facing slopes. However, due to regular cutting and nutrient enrichment from spray these areas are only moderately valuable to terrestrial invertebrates.

Hedgerows and marginal vegetation along the riverbank and tributaries possess a higher number of features likely to be of value to terrestrial invertebrates. Portions of these hedgerows appear to be very old and have a good variety of resources, e.g. abundant nectar sources, dead/decaying wood, etc. The majority of the woodland is plantation with little developed structure. However, a stand of mature Poplars bordering the river Nene is of greater value. Abundant evidence of the hornet clearwing moth *Sesia apiformis* was found in these trees. A section of woodland adjacent to the A47 and dismantled railway is older and has significant amounts of standing and fallen deadwood. This woodland and the adjoining old hedgerows are the most valuable habitats to terrestrial invertebrates in the whole site. Vane traps were positioned on the standing dead trees in this woodland to sample the saproxylic invertebrates.

There are also a number of willow trees along the Nene with significant features of decay and surrounded by large amounts of deadwood. These are also valuable to terrestrial invertebrates, but less so than species such as oak and ash. These trees were examined for evidence of goat moth *Cossus cossus* activity – a Nationally Scarce, Biodiversity Action Plan species. A large number of other Nationally Scarce/Rare species are associated with these trees, primarily because of sap runs. No evidence of the goat moth was found in these trees.

In the 2017 survey, the bank along the west of the dismantled railway was said to have “a diverse grassland cover with some structure including tussocks, mounds and bare patches, and was orientated to catch the afternoon sun; this was considered to have features likely to support a diverse and interesting invertebrate fauna including rare or endangered species”. Little evidence of this could be seen in 2020. The ground was heavily shaded by trees with low botanical diversity.

3.2.2 Invertebrate species recorded in 2020

341 invertebrate species were recorded (see Appendix for full list). Of these, 18 have a National Conservation Status (Table 1). The majority of the species with a National Conservation Status are

saproxylic, species associated with dead/decaying wood. There is a significant amount of this habitat in the small patch woodland immediately to the south of the end of Sutton Heath Road and to the east of the dismantled railway. This one patch of woodland and the old hedgerows bordering it and extending along the existing A47 and towards the River Nene are the most valuable habitats for terrestrial invertebrates in the survey area.

The most notable species recorded during the survey was the Phoenix Fly *Dorycera graminum* – a Nationally Rare, S41 BAP Priority Species, the click beetle *Ampedus quercicola* and the false darkling beetle *Osphya bipunctata.* These two beetles are Nationally Scarce and associated with dead/decaying wood. *Osphya bipunctata* is rarely recorded and its ecology is poorly known. In the UK its stronghold is this area and the presence of a gravid female in a vane trap on a standing dead tree in the aforementioned small patch of woodland suggests it could be breeding there.

Table 1: Species with National Conservation Status recorded during the 2020 survey.

Scientific name	Common name	Conservation status	Areas/habitat
Anaglyptus mysticus	A Longhorn Beetle	Nationally Scarce	Saproxylic Very distinctive beetle. Develops in boles and branches of dry or fresh hardwoods, especially where fire-scorched; adults attracted to hawthorn *Crataegus* blossom; larvae under bark and in the wood of very dry dead boles and branches; 2 year cycle, pupae over-wintering.
Platypus cylindrus	Oak Pinhole Borer	Nationally Scarce. Requires updating in light of considerable range expansion	Saproxylic Adults and larvae in galleries extending deep into heartwood, feeding on fungi. Mainly on oak *Quercus*, but also beech *Fagus* and other broad-leaved trees
Rhinocyllus conicus	A Weevil	Nationally Scarce. Requires updating in light of range expansion	Adults and larvae associated with thistles
Enicmus brevicornis	A Minute Brown Scavenger Beetle	Nationally Scarce. Requires updating in light of range expansion	Saproxylic Associated with mouldy bark of beech *Fagus*, birch *Betula*, ash *Fraxinus* and sycamore *Acer pseudoplatanus*

Rhizophagus nitidulus	A Root-eating Beetle	Nationally Scarce	Saproxylic Under sappy bark of freshly dead wood of various broad-leaved trees
Dacne rufifrons	A Pleasing Fungus Beetle	Data Deficient (European)	Saproxylic Adults normally frequent fruiting brackets of the softer polypore fungi on trunks of broad-leaved trees
Hallomenus binotatus	A Polypore Fungus Beetle	Nationally Scarce	Saproxylic Develops in the fruiting bodies of large polypore fungi in ancient wood pastures, particularly in *Laetiporus sulphureus*
Osphya bipunctata	A False Darkling Beetle	Nationally Scarce	Saproxylic Very poorly known. Larvae unknown. In this survey a single, gravid female was found in a vane trap positioned on a standing dead ash *Fraxinus.* Most records are from this part of the UK.
Ampedus quercicola	A Click Beetle	Nationally Scarce	Saproxylic Develops in decayed heartwood of birch *Betula*, beech *Fagus*, hawthorn *Crataegus* and probably other trees; pupate at end of season and hibernate as adult; adults attracted to hawthorn blossom. Primarily associated with ancient wood pastures. A single individual from a vane trap on a standing dead tree.
Athous campyloides	A Click Beetle	Nationally Scarce	Occurs in a wide range of habitats, often on calcareous grassland but also along woodland borders, wooded parkland and gardens. May be associated with trees and fallen timber. Larvae develop in a wide range of situations

Epiphanis cornutus	A False Click Beetle	Near Threatened (European). Requires updating in light of range expansion	Saproxylic Discovered in the UK in the 1960s and is now established and widespread, though only occasionally recorded. In the UK mostly occurs in long established woodland rich in saproxylic beetles generally, the larvae are known to develop in decaying wood of various broadleaf and conifer trees
Dorcatoma flavicornis	A Spiderweb Beetle	Nationally Scarce	Saproxylic Develops in the interior of boughs and trunks of oak which are red-rotten, due to activity of the fungus *Laetiporus sulphureus*; has also been found in a red-rotted ash Fraxinus stump
Euglenes oculatus	An Ant-like Beetle	Nationally Scarce	Associated with decaying hollow Oaks *Ouercus* but has also been reared from other deciduous trees. A very local insect of open ancient woodland throughout southern England.
Lissodema denticolle	A Narrow Bark Beetle	Nationally Scarce	Saproxylic In dead wood of a wide variety of trees including pine *Pinus*. Ecology poor known.
Sesia apiformis	Hornet Clearwing Moth	Nationally Scarce	Saproxylic Larva tunnels between bark and wood in lower trunk and roots of poplars *Populus* sp.
Lasioglossum pauxillum	A Solitary Bee	Nationally Scarce. Requires updating in light of range expansion	Occurs in a wide range of dry habitats but perhaps especially calcareous grasslands and brownfield sites. Various flowers and spring blossoms are visited
Lasius brunneus	An Ant	Nationally Scarce	Saproxylic Nests are usually found within mature but still living trees; they

			have also been found in stumps, hedgerows and timber framed buildings.
Dorycera graminum	Phoenix Fly	Nationally Rare, S41 BAP Priority Species	The ecology of this fly is uncertain. Adults appear to spend almost all their time resting on various leaves, stems or flowers, and although the largest number of individuals have been swept or observed on herbaceous plants, they have also been found on scrub or tree foliage. The larvae could be root feeders. Appears to have undergone a marked decline

NB: Ecological information for the saproxylic species taken from Alexander 2002

3.2.3 Pantheon analysis

The species lists obtained for the site were analysed with Pantheon. Pantheon is an online resource for recording and analysis of invertebrate assemblages developed jointly by the CEH and Natural England became available. The resource includes a modified version of ISIS which was formerly available in spreadsheet form and then as trial versions. However, these versions were used extensively both for common standards monitoring of entomological features of SSSIs and for EcIA purposes.

The Species Quality Indices (SQIs) reflect the proportion of rarities attributed to an assemblage and scores of around 100 generally indicate assemblages comprised of a high proportion of common species. In broad terms, scores of around 140 indicate the presence of assemblages of some conservation value. However, it is important to note that Species Quality Indices (SQIs) calculated from less than 15 species may not be reliable.

Table 2: Habitats & Resources – Broad Biotopes

Broad biotope	No. of species	% representation	SQI	Species with conservation status	Conservation status
open habitats	160	4	114	7	[Nb]|NS|[Na]|Nb|pNS|pNT|Section 41 Priority Species|Section 41 Priority Species - research only|[RDB 3]
tree-associated	101	3	148	13	NT (European)|DD (European)|Nb|NS|Notable|[Nb]|NS|Nb|NS|NS|NS|Nb|NS
wetland	71	3	158	8	Notable|[Nb]|NS|Nb|Notable|NS|NT|NS
shaded woodland floor	1	33	100		

Table 3: Habitats and Resources – Habitats

Broad biotope	Habitat	No. of species	% representation	SQI	Species with conservation status	Conservation status
open habitats	tall sward & scrub	137	5	115	5	NS|Nb|pNS|pNT|Section 41 Priority Species|Section 41 Priority Species - research only|[RDB 3]
tree-associated	decaying wood	57	5	187	13	NS|Nb|Notable|NS|DD (European)|Nb|NT (European)|NS|NS|NS|Nb|NS|[Nb]
wetland	peatland	36	3	183	4	NS|Notable|NS|NS
wetland	marshland	32	4	139	3	NT|Nb|NS
tree-associated	arboreal	26	2	100		
open habitats	short sward & bare ground	19	1	116	2	[Na]|[Nb]
tree-associated	shaded woodland floor	19	2	100		
wetland	running water	15	1	175	1	[Nb]
wetland	wet woodland	9	3	100		
tree-associated	wet woodland	9	4	100		
wetland	lake	2	2	400	2	[Nb]|Nb
open habitats	upland	1	<1	100		

Table 4: Habitats and Resources – Specific Assemblage Types

Broad biotope	Habitat	SAT	No. of species	% representation	SQI	Species with conservation status	Conservation status	Code	Reported condition
tree-associated	decaying wood	bark & sapwood decay	33	7	184	6	Nb|NS|Nb|Notable|[Nb]|NS	A212	Favourable
tree-associated	decaying wood	heartwood decay	12	7	225	4	Nb|NS|NT (European)|NS	A211	Favourable
open habitats		scrub edge	7	3	100			F001	Unfavourable (7 of 11 species)

tree-associated	decaying wood	fungal fruiting bodies	5	6	160	2	NS|DD (European)	A213	Unfavourable (5 of 7 species)
open habitats		rich flower resource	4	2	100	1	[Na]	F002	Unfavourable (4 of 15 species)
wetland	peatland	reed-fen & pools	3	3	200			W314	Unfavourable (3 of 11 species)
open habitats	short sward & bare ground	bare sand & chalk	2	<1	250	1	[Nb]	F111	Unfavourable (2 of 19 species)
open habitats	short sward & bare ground	open short sward	2	1	100			F112	Unfavourable (2 of 13 species)
open habitats		scrub-heath & moorland	2	<1	100			F003	Unfavourable (2 of 9 species)
open habitats	tall sward & scrub	montane & upland	1	<1	100			F221	Unfavourable (1 of 8 species)

4 Discussion

4.1 Discussion of results

The previous survey, conducted in 2017, reported 81 species, nine of which have a national conservation status, but the validity of this data is questionable. This survey recorded 341 species, 18 of which have a National Conservation Status. Some of these need to be reviewed in light of recent range expansions.

On a landscape (broad biotope) level, the Pantheon analysis attributed 160, 101, 71 and 1 species to ‘open habitats’, ‘tree-associated’, wetland’ and ‘shaded woodland floor’, respectively (Table 2). Proportionately, the ‘open habitats’, ‘tree associated’, wetland and ‘shaded woodland floor’ classifications support 4%, 3%, 3% and 33%, respectively of the national pool of species attributed in the Pantheon database. These findings would be expected in consideration of sampling effort being concentrated largely on open habitats with abundant trees.

On the Pantheon ‘habitat’ level tier, there were seven assemblages attributed with a sufficient number of species recognised in ISIS to be considered robust, i.e. >15 species (Table 3). 137 species were attributed to the ‘tall sward and scrub’ assemblage, which basically includes species associated with taller grassland, scrub and scrub edge habitats. 57, 36, 32, 26, 19 and 19 species were attributed to the ‘decaying wood’, ‘peatland’, marshland, ‘arboreal’, ‘short sward and bare ground’ and ‘shaded woodland floor’, respectively.

The ‘decaying wood’ habitat supports a fauna of some conservation value as the SQI (species quality index) score is 187. If compared with the threshold score set in ISIS for an assemblage to be considered in

'Favourable Condition' (FC), i.e. equivalent to an assemblage of National importance, a score of 187, which is significantly higher than the threshold target of 160. Similarly, the 'peatland' habitat supports a fauna of some conservation value as it has a SQI of 183. This habitat is well represented in areas slightly outside the sampling area, i.e. Sutton Heath Bog and it is likely that species from here move through the landscape to pockets of similar habitat alongside the River Nene.

In conservation assessment Specific Assemblage Types (SATs) are generally regarded as the most valuable metrics for assessing site quality (Table 4). This is because SATs are made up of species with a high degree of habitat specialisation. Such species tend to be both uncommon and representative of sites supporting habitat of quality in terms of conservation value. However, SATs often require targeted sampling of specific habitat features and are not always well represented in broad-brushstroke surveys designed to gain an overall, or baseline assessment of a site's value.

From the Pantheon output the SAT with the highest SQI and a number of species high enough to provide a reliable result was 'bark and sapwood decay' (SQI 184). This assemblage is in a favourable condition. The SQI for 'heartwood decay' was 225, but the number of species in this SAT was 12, which is slightly less than the threshold of 15. This limits the reliability of the result.

In terms of total area, much of the site is of limited value to terrestrial invertebrates because of the large areas of agricultural land. In terms of invertebrate conservation, the most interesting habitats across the site are old trees with decay features and wetlands.

5 Mitigation recommendations and further work

5.1 Introduction

This section of this report outlines the mitigation proposed to protect the most valuable habitats for terrestrial invertebrates and enhancing the overall area, so it supports a greater diversity of these animals. This section does not constitute a full outline of the mitigation on the site, this will be provided and will be evolved during detailed design. Throughout determining the mitigation to be implemented, the mitigation hierarchy of avoid, mitigate, compensate, enhance is followed.

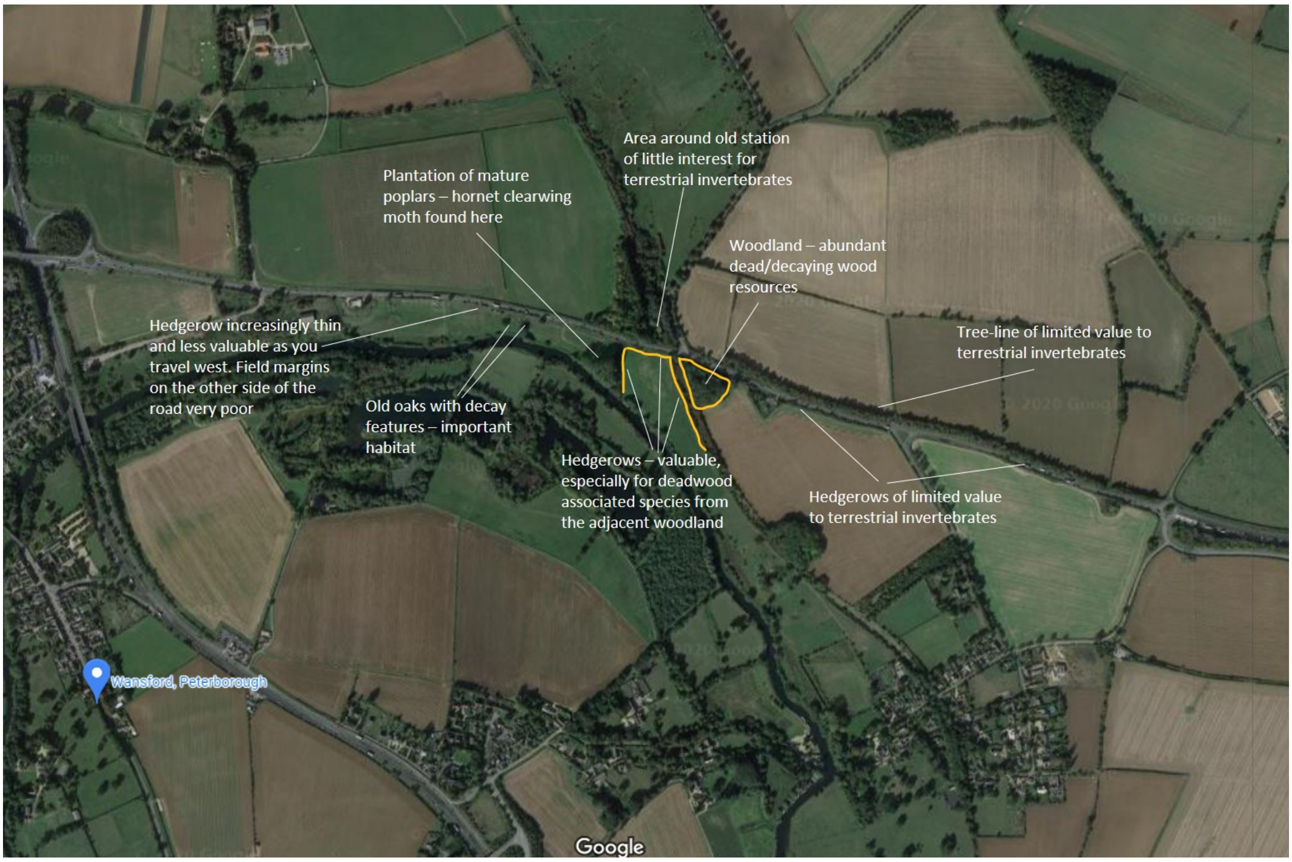
5.2 Design mitigation

5.2.1 Avoidance of impacts to invertebrate populations (design)

In line with the mitigation hierarchy, the first step of the proposed mitigation for impacts to invertebrate populations will be avoidance. Within the development, all the most valuable habitats should be retained and buffered. Specifically, these are the living trees with decay features, standing dead trees and fallen deadwood in the small triangle of woodland approximately in the middle of the survey area (Figure 2). The nectar-rich hedgerows in close proximity to the wood are also important as they provide vegetation complexity, deadwood and nectar. The latter is valuable to the saproxylic insects in the small triangle of woodland as many of them require nectar as adults.

Where possible, these should be protected and buffered from development. Native nectar sources should be planted along the development to increase habitat connectivity.

Figure 2: Habitats throughout the survey area and their value to terrestrial invertebrates



5.2.2 Habitat design mitigation

The main negative impacts of the road would be as follows:

- The loss of valuable existing habitats
- Damage to existing habitats
- A barrier to dispersal for many terrestrial invertebrates
- Light pollution
- Air pollution
- Water pollution

Each of these and the appropriate mitigation is discussed below.

5.2.2.1 Habitat loss mitigation

Much of the proposed route is across agricultural land, which has very little value for terrestrial invertebrates. Some areas of more valuable habitat will be lost, but, on the whole, this can be compensated for by the creation of new habitats. The entire length of the proposed new road could be designed with nature in mind to create a ribbon of valuable habitat through the landscape. With sufficiently wide margins, embankments and SUDs the road could offer a mosaic of habitats from woodland, scrub, florally diverse grassland, bare ground and waterbodies. Indeed, if designed and executed correctly this would be considerably better for nature than the agricultural landscape through which it passes.

South facing embankments lend themselves to the creation of species rich grassland and scrub with areas of bare ground. The Weymouth Relief Road (WRR) in Dorset is a perfect example of how a road scheme if planned and executed correctly can transform an otherwise sterile agricultural landscape into a haven for wildlife. Butterflies are useful bioindicators and in this respect the WRR has had a huge positive impact. When the WRR was opened in 2011, only two species of butterfly were recorded, but by 2018 this number had jumped to 30.

Some of the learnings from the WRR project can be applied here. It is crucial that the retained habitats are enhanced and better connected so that animals can more easily move through the landscape. An interesting design mitigation to offset any losses of habitat along the proposed route would be the creation of habitat to better connect more valuable resources, especially old/veteran trees.

The degree to which linear transportation infrastructure verges constitute a habitat and/or a corridor for insects in temperate landscapes is presently unclear (Villemay *et al.* 2018). There is currently limited evidence on how wide the margin/verge should be or what the plant species/habitat composition should be (Villemay *et al.* 2018).

The loss of any old hedgerows or old/veteran trees is difficult/impossible to mitigate for. These habitats support a rich community of saproxylic invertebrates that have very specific habitat requirements. Simply cutting existing trees and leaving the timber in a buffered area will only provide habitat for a small proportion of these species. Providing dead wood in a range of situations, e.g. on the ground and standing dead will support a greater range of species, but efforts must be made to offer a continuity of dead-wood resources in the greater landscape, planting nectar sources and facilitating the dispersal of species by improving habitat connectivity. Any old/veteran trees should be protected and buffered. Deadwood, either standing or on the ground, is valuable to a huge range of species. This should be left where it is. If this is not possible it could be moved a short distance and left in a variety of situations, e.g. shade, partial shade and full sun.

Nectar sources are especially important for many dead-wood insects when they emerge as adults. Native shrubs and trees should be planted to offer a better and more complete sequence of nectar sources. Cherry plum, goat willow, blackthorn and hawthorn will provide nectar from February until late May. This sequence can be further enhanced with further willows, wild cherry, apple, pear, wayfaring tree, field maple, dogwood, etc. This sequence of nectar sources would also benefit a huge range of other species and should be employed throughout the development.

5.2.2.2 Damage to retained habitats mitigation

Buffers must be established around the retained high value habitats. This is especially important for old/veteran trees and dead wood as they the most valuable habitats in the area. It is important that these habitats are buffered from disturbance during the development to prevent contamination of the air and groundwater.

5.2.2.3 Barrier to dispersal mitigation

Roads negatively affect the abundance and diversity of insects because it is a physical barrier to movement. Some groups of insects are strong fliers, but mortality of these will be high when they are crossing the road (Muñoz *et al.* 2015). Many other terrestrial invertebrates have very poor dispersal ability and roads are sufficiently wide to act as barriers to flying insects (Andersson *et al.* 2017).

I have demonstrated in my research that the populations of some species can be isolated from one another by seemingly insignificant barriers, such as small areas of unsuitable habitat (Piper and Compton 2003). In this regard, a road without wildlife corridors could completely prevent the movement of some species through the landscape.

Connecting retained habitats and created habitats will benefit all fauna and flora in the area. A margin of mosaic habitat either side of the road that connects to retained and created habitats would prevent the road becoming a barrier to dispersal.

5.2.2.4 Light pollution mitigation

Light pollution during the works and from the lights on the completed road will have an impact on the populations of terrestrial invertebrates. It has been shown in many studies that artificial light at night (ALAN) has a negative impact on insects (Grubisic *et al* 2018). ALAN can increase overall environmental pressure on insect populations, and this is particularly important in agroecosystems where insect communities provide important ecosystem services (such as natural pest control, pollination, conservation of soil structure and fertility and nutrient cycling), and are already under considerable environmental pressure (Grubisic *et al* 2018).

Valuable, retained habitats are sufficiently close to the proposed route for light pollution to be an important consideration. Nocturnal species in these habitats will be drawn to the artificial lighting used during the development and the lights illuminating the finished road.

To mitigate the impact of light pollution it is recommended that lighting be used sparingly and only where necessary during the development and on the completed road. Where artificial lighting is crucial units should be used that illuminate specific areas without producing lots of ‘waste’ light. Lighting units should also use wavelengths of light that are less attractive to nocturnal insects. White/bluish wavelengths are much more attractive to nocturnal insects than orange wavelengths.

5.2.2.5 Air pollution mitigation

The traffic travelling along the proposed route will lead to an increase local air pollution, but it is unclear how this compares to the current agricultural pollution of the area. The deposition of nitrogen (in the form of nitrous oxide) from motor vehicles, especially near busy roads, means that fossil fuels are also a major contributor to soil nitrogen levels (NERC 2005). Direct effects may occur in the immediate vicinity of major roads and in urban areas, caused by high NOx emissions from vehicles. NOx may lead to ground flora changes related to eutrophication (APIS 2019).

In the habitats that have been studied in any detail this eutrophication can lead to grasses becoming dominant at the expense of overall species diversity (Baxter and Farmer 1994). Broadly, lower plant diversity will result in lower diversity of terrestrial invertebrates.

Near a major road, these changes to the vegetation can be detected up to 200m from the carriageway (Angold 1997). Near smaller roads the effect is less far reaching and there is a positive correlation between traffic density and the width of the zone that is seen to be affected (Angold 1997). The build of vehicle-borne nitrogen in roadside habitats is likely to cumulative, so that the impact of a road on roadside wildlife will increase with time (Bobbink et al. 1990).

The switch to electric vehicles will reduce the amount of nitrogen entering road-side habitats, but it will be several decades before these account for the majority of vehicles on our roads. Buffer zones to minimise the input of pollution from vehicle exhausts are recommended. These could consist of a margin of trees and tall shrubs nearest to the road with grassland and scrub communities further away from the road.

5.2.2.6 Water pollution mitigation

The surface run-off from the new road will carry a range of pollutants. All measures must be used to prevent this surface water entering existing water bodies, especially those in high value habitats. The creation of SUDs in appropriate places along the route will allow for the collection of this run-off.

5.3 Additional mitigation

In addition to the design mitigation above, during detailed design and construction of the development, it is likely that additional actions may be required to safeguard the current invertebrate populations. These actions may include:

- Clear demarcation of areas that are to be retained with minimal disturbance to the buffers. Many species of invertebrate overwinter as eggs, larvae or adults in the soil, leaf-litter, under bark, etc. so it is imperative that these habitats are not disturbed in the buffers surrounding the more important retained habitats;
- Old/veteran trees to be retained and buffered;
- Standing dead wood to be retained and buffered;

- Any standing dead trees and large pieces of dead wood to be retained and buffered;
- Old hedgerows to be retained and buffered.
- Large, clear boundaries around the retained areas/trees to protect from machinery, excavations and general disturbance;
- Habitat creation and management plans to be evolved with the detailed design and phasing of the development (i.e. outlining the habitats within the development parcels) to create and enhance habitats;
- Habitat manipulation to displace invertebrates into retained habitats adjacent to habitats to be removed;
- It is imperative that the long-term management of the habitats (both retained and created) be agreed before the development. In addition, the management should be for communities -specifically the saproxylic assemblages - rather than for single species;
- The planting of native nectar sources to provide a blossom sequence that will benefit many terrestrial invertebrate species. Cherry plum, goat willow, blackthorn and hawthorn will provide nectar from February until late May. This sequence can be further enhanced with further willows, wild cherry, apple, pear, wayfaring tree, field maple, dogwood, etc.;
- The creation of species-rich grassland, scrub and bare ground habitats.

6 Conclusions

A full terrestrial invertebrate survey was conducted in 2020 with a range of sampling techniques used during visits in May, June, July and August.

341 species were recorded during the surveys, including **18 species of conservation concern**. The most notable species recorded during the survey was the Phoenix Fly *Dorycera graminum* – a Nationally Rare, S41 BAP Priority Species, the click beetle *Ampedus quercicola* and the false darkling beetle *Osphya bipunctata.* These two beetles are Nationally Scarce and associated with dead/decaying wood. *Osphya bipunctata* is rarely recorded and its ecology is poorly known.

The most valuable habitats in the survey area are the old oak trees as they support a huge assemblage of specialist animals that depend on centuries of habitat continuity in the same area. The dispersal of these species is often poor, so improving habitat connectivity is important.

The proposed road scheme could enhance the area for terrestrial invertebrates if it is planned and executed in a way that sympathetic to nature conservation. The creation of habitat corridors alongside the route linking existing habitats and created habitats further from the route will benefit terrestrial invertebrates in what is currently a largely sterile agricultural landscape. Creating a mosaic of habitats alongside both sides of the route, creating valuable habitat between retained and protected areas will improve connectivity through the landscape.

It is recommended that old/veteran trees, deadwood habitats and old hedgerows be protected and buffered during the development.

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APPENDIX A: SPECIES LIST FOR THIS SURVEY

Status Key: Nb= Notable B; NS= Nationally Scarce; NR= Nationally Rare; N= Notable; NA= Not assessed; RDB3= Red Data Book 3; RDB1= Red Data Book 1; S41= Section 41 priority species; S41-R= Section 41 priority species – research only

Species	Common Name	Status
Amischa analis	A Rove Beetle	
Anotylus nitidulus	A Rove Beetle	
Anotylus rugosus	A Rove Beetle	
Anotylus sculpturatus	A Rove Beetle	
Bisnius fimetarius	A Rove Beetle	
Callicerus obscurus	A Rove Beetle	
Cypha longicornis	A Rove Beetle	
Drusilla canaliculata	A Rove Beetle	
Gabrius splendidulus	A Rove Beetle	
Gyrohypnus angustatus	A Rove Beetle	
Homalota plana	A Rove Beetle	
Ilyobates propinquus	A Rove Beetle	
Lesteva longoelytrata	A Rove Beetle	
Nehemitropia lividipennis	A Rove Beetle	
Omalium caesum	A Rove Beetle	
Oxypoda haemorrhoa	A Rove Beetle	
Pella limbata	A Rove Beetle	
Quedius semiobscurus	A Rove Beetle	
Sepedophilus nigripennis	A Rove Beetle	
Siagonium quadricorne	A Rove Beetle	
Stenus cicindeloides	A Rove Beetle	
Stenus clavicornis	A Rove Beetle	
Stenus flavipes	A Rove Beetle	
Stenus fulvicornis	A Rove Beetle	
Sunius propinquus	A Rove Beetle	

Tachinus rufipes	A Rove Beetle	
Tachyporus dispar	A Rove Beetle	
Tachyporus hypnorum	A Rove Beetle	
Tachyporus pusillus	A Rove Beetle	
Abax parallelepipedus	A Ground Beetle	
Agonum viduum	A Ground Beetle	
Agonum thoreyi	A Ground Beetle	
Amara aenea	A Ground Beetle	
Amara similata	A Ground Beetle	
Anchomenus dorsalis	A Ground Beetle	
Badister bullatus	A Ground Beetle	
Bembidion biguttatum	A Ground Beetle	
Bembidion guttula	A Ground Beetle	
Bembidion mannerheimii	A Ground Beetle	
Bembidion obtusum	A Ground Beetle	
Carabus nemoralis	A Ground Beetle	
Carabus violaceus	A Ground Beetle	
Demetrias atricapillus	A Ground Beetle	
Elaphrus riparius	A Ground Beetle	
Leistus spinibarbis	A Ground Beetle	
Leistus ferrugineus	A Ground Beetle	
Nebria brevicollis	A Ground Beetle	
Notiophilus biguttatus	A Ground Beetle	
Notiophilus rufipes	A Ground Beetle	
Paradromius linearis	A Ground Beetle	
Poecilus cupreus	A Ground Beetle	
Pterostichus madidus	A Ground Beetle	
Pterostichus melanarius	A Ground Beetle	
Pterostichus strenuus	A Ground Beetle	
Trichocellus cognatus	A Ground Beetle	

Apion frumentarium	An Apionid Weevil	
Ceratapion gibbirostre	An Apionid Weevil	
Ischnopterapion loti	An Apionid Weevil	
Ischnopterapion virens	An Apionid Weevil	
Perapion violaceum	An Apionid Weevil	
Protapion fulvipes	An Apionid Weevil	
Anthonomus rubi	A Weevil	
Datonychus melanostictus	A Weevil	
Drupenatus nasturtii	A Weevil	
Eubrychius velutus	A Weevil	
Euophryum confine	A Weevil	
Graptus triguttatus	A Weevil	
Hypera pollux	A Weevil	
Hypera postica	A Weevil	
Mecinus pascuorum	A Weevil	
Nedyus quadrimaculatus	A Weevil	
Parethelcus pollinarius	A Weevil	
Phyllobius maculicornis	A Weevil	
Phyllobius oblongus	A Weevil	
Phyllobius pyri	A Weevil	
Phyllobius roboretanus	A Weevil	
Phyllobius virideaeris	A Weevil	
*Rhinocyllus conicus**	A Weevil	[Nb]
Sitona lineatus	A Weevil	
Zacladus geranii	A Weevil	
Dryocoetes villosus	A Bark Beetle	
*Platypus cylindrus****	A Bark Beetle	[Nb]
Xyleborinus saxesenii	A Bark Beetle	
Bruchus atomarius	A Seed Beetle	
Bruchus rufimanus	A Seed Beetle	

Altica lythri	A Flea Beetle	
Crepidodera aurata	A Flea Beetle	
Crepidodera fulvicornis	A Flea Beetle	
Crepidodera plutus	A Flea Beetle	
Neocrepidodera ferruginea	A Flea Beetle	
Neocrepidodera transversa	A Flea Beetle	
Phyllotreta undulata	A Flea Beetle	
Sphaeroderma testaceum	A Flea Beetle	
Cassida viridis	A Leaf Beetle	
Chrysolina staphylaea	A Leaf Beetle	
Cryptocephalus fulvus	A Leaf Beetle	
Galerucella lineola	A Leaf Beetle	
Gastrophysa viridula	A Leaf Beetle	
Gastrrophysa polygoni	A Leaf Beetle	
Lochmaea crataegi	Hawthorn Leaf Beetle	
Oulema melanopus	Cereal Leaf Beetle	
Phaedon tumidulus	A Leaf Beetle	
Brachypterus glaber	A Short-winged Flower Beetle	
Atomaria atricapilla	A Silken Fungus Beetle	
Agrilus angustulus	A Jewel Beetle	
Agrilus laticornis	A Jewel Beetle	
Agrilus biguttatus	A Jewel Beetle	
Thanasimus formicarius	A Chequered Beetle	
Agapanthia villosoviridescens	A Longhorn Beetle	
Grammoptera ruficornis	A Longhorn Beetle	
Tetrops praeustus	A Longhorn Beetle	
*Anaglyptus mysticus***	A Longhorn Beetle	Nb
Anobium inexspectatum	A spider beetle	
Anobium punctatum	Furniture Beetle	
Dorcatoma chrysomelina	A spider beetle	

*Dorcatoma flavicornis**/***/**** *	A spider beetle	NS
Hedobia imperialis	A spider beetle	
Ochina ptinoides	A spider beetle	
Ptilinus pectinicornis	A spider beetle	
*Euglenes oculatus*** *	An Ant-like Beetle	NS
Glischrochilus hortensis	A Sap Beetle	
Cerylon ferrugineum	A Minute Bark Beetle	
Cerylon histeroides	A Minute Bark Beetle	
*Lissodema denticolle** *	A Narrow Bark Beetle	NS
Salpingus planirostris	A Narrow Bark Beetle	
*Epiphanis cornutus**/*** *	A false click beetle	NTe
Pyrochroa serraticornis	Red-headed cardinal beetle	
Orchesia undulata	A False Darkling Beetle	
*Osphya bipunctata** *	A False Darkling Beetle	NS
Lagria hirta	A Darkling Beetle	
Dorcus parallelipipedus	Lesser stag beetle	
Ctesias serra	Cobweb beetle	
Sinodendron cylindricum	Rhinoceros beetle	
*Enicmus brevicornis*** *	A Minute Brown Scavenger Beetle	Notable
Enicmus testaceus	A Minute Brown Scavenger Beetle	
Abraeus perpusillus	A Clown Beetle	
Paromalus flavicornis	A Clown Beetle	
*Rhizophagus nitidulus*** *	A Root-eating Beetle	Nb
Rhizophagus perforatus	A Root-eating Beetle	
Oedemera lurida	A False Blister Beetle	
Mordellochroa abdominalis	A Tumbling Flower Beetle	
Anaspis garneysi	A False Flower Beetle	
Anaspis lurida	A False Flower Beetle	
Rhagonycha limbata	A Soldier Beetle	
Agriotes sputator	A Click Beetle	

Ampedus quercicola	A Click Beetle	NS
*Athous campyloides***	A Click Beetle	Nb
Athous haemorrhoidalis	A Click Beetle	
Melanotus castanipes	A Click Beetle	
Dasytes aeratus	A Soft-winged Flower Beetle	
Cis nitidus (=castaneus)	A Tree-fungus Beetle	
Mycetophagus multipunctatus	A Hairy Fungus Beetle	
Mycetophagus piceus	A Hairy Fungus Beetle	
Mycetophagus quadripustulatus	A Hairy Fungus Beetle	
*Dacne rufifrons***	A Pleasing Fungus Beetle	Dde
Anisotoma humeralis	A Round Fungus Beetle	
Catops fuliginosus	A Round Fungus Beetle	
Sciodrepoides watsoni	A Round Fungus Beetle	
*Hallomenus binotatus*****	A Polypore Fungus Beetle	NS
Sericoderus brevicornis	A Hooded Beetle	
Adalia decempunctata	10-spot Ladybird	
Chilocorus renipustulatus	Kidney-spot Ladybird	
Coccidula scutellata	A Ladybird	
Exochomus quadripustulatus	Pine Ladybird	
Psyllobora vigintiduopunctata	22-spot Ladybird	
Rhyzobius litura	A Ladybird	
Subcoccinella vigintiquattuorpunctata	24-spot Ladybird	
Tytthaspis sedecimpunctata	16-spot Ladybird	
Scirtes hemisphaericus	A Scirtid Beetle	
Hylaeus communis	A Yellow-faced Bee	
Lasioglossum fulvicorne	A Solitary Bee	
Lasioglossum parvulum	A Solitary Bee	
*Lasioglossum pauxillum***	A Solitary Bee	[Na]
Ancistrocerus trifasciatus	A Solitary Wasp	
*Lasius brunneus***	An Ant	NA

Lasius niger	An Ant	
Myrmica rubra	An Ant	
Myrmica sabuleti	An Ant	
Cephus pygmeus	A Sawfly	
Cheilosia cynocephala	A Hoverfly	
Cheilosia vernalis	A Hoverfly	
Epistrophe eligans	A Hoverfly	
Melanostoma mellinum	A Hoverfly	
Melanostoma scalare	A Hoverfly	
Neoascia geniculata	A Hoverfly	
Neoascia interrupta	A Hoverfly	
Neoascia tenur	A Hoverfly	
Orthonevra brevicornis	A Hoverfly	
Pipizella viduata	A Hoverfly	
Platycheirus albimanus	A Hoverfly	
Platycheirus clypeatus	A Hoverfly	
Xanthogramma citrofasciatum	A Hoverfly	
Beris vallata	A Soldierfly	
Chloromyia formosa	A Soldierfly	
Nemotelus nigrinus	A Soldierfly	
Nemotelus pantherinus	A Soldierfly	
Oplodontha viridula	A Soldierfly	
Oxycera morrisii	A Soldierfly	
Oxycera pygmaea	A Soldierfly	
Pachygaster atra	A Soldierfly	
Vanoyia tenuicornis	A Soldierfly	
Chrysops relictus	A Deer Fly	
Haematopota pluvialis	Cleg	
Geomyza tripunctata	An Opomyzid Fly	
Opomyza germinationis	An Opomyzid Fly	

Lonchoptera lutea	A Spear-winged Fly	
Hercostomus chalybeus	A Long-legged Fly	
Rhaphium antennatum	A Long-legged Fly	
Rhaphium nasutum	A Long-legged Fly	
Campsicnemus picticornis	A Long-legged Fly	
Teuchophorus spinigerellus	A Long-legged Fly	
Dolichopus latilimbatus	A Long-legged Fly	
Syntormon pumilum	A Long-legged Fly	
Sciapus platypterus	A Long-legged Fly	
Myopa testacea	A Bee-grabbing Fly	
Dioctria rufipes	A Robberfly	
Leptogaster cylindrica	A Robberfly	
Machimus atricapillus	A Robberfly	
Chrysopilus asiliformis	A Snipe Fly	
Chrysopilus cristatus	A Snipe Fly	
Rhagio lineola	A Snipe Fly	
Rhagio scolopaceus	A Snipe Fly	
Coremacera marginata	A Snail-killing Fly	
Limnia unguicornis	A Snail-killing Fly	
Psacadina verbekei	A Snail-killing Fly	
Tetanocera arrogans	A Snail-killing Fly	
Themira lucida	A Sepsid Fly	
Themira superba	A Sepsid Fly	
Urophora solstitialis	A Peacock Fly	
Herina frondescentiae	A Picture-Winged Fly	
Empis femorata	A Daggerfly	
Empis tessellata	A Daggerfly	
Platypalpus agilis	A Dance Fly	
Helius longirostris	A Crane Fly	
Molophilus griseus	A Crane Fly	

Molophilus obscurus	A Crane Fly	
Ellipteroides lateralis	A Crane Fly	
Symplecta hybrida	A Crane Fly	
Tipula fascipennis	A Crane Fly	
Tipula pruinosa	A Crane Fly	
Tipula maxima	A Crane Fly	
*Dorycera graminum**	Phoenix Fly	pNS, pNT, S41
Aglais urticae	Small Tortoiseshell Butterfly	
Aphantopus hyperantus	Ringlet Butterfly	
Celastrina argiolus	Holly Blue Butterfly	
Inachis io	Peacock Butterfly	
Lycaena phlaeas	Small Copper Butterfly	
Maniola jurtina	Meadow Brown Butterfly	
Ochlodes sylvanus	Large Skipper Butterfly	
Pieris brassicae	Large White	
Pieris rapae	Small White	
Sesia apiformis	Hornet Clearwing Moth	NS
Thymelicus sylvestris	Small Skipper Butterfly	
Tyria jacobaeae	Cinnabar Moth	
Vanessa atalanta	Red Admiral Butterfly	
Sialis lutaria	Alder Fly	
Podops inuncta	Turtle Shieldbug	
Leptoglossus occidentalis	Western Conifer Seedbug	
Anthocoris nemorum	A Flower Bug	
Cymus glandicolor	A Ground Bug	
Drymus sylvaticus	A Ground Bug	
Drymus ryei	A Ground Bug	
Heterogaster urticae	Nettle Ground Bug	
Scolopostethus thomsoni	A Ground Bug	
Temnostethus (Montandoniella) gracilis	A Flower Bug	

Atractotomus mali	A Plant Bug	
Closterotomus fulvomaculatus	A Plant Bug	
Deraeocoris flavilinea	A Plant Bug	
Dryophilocoris flavoquadrimaculatus	A Plant Bug	
Leptopterna dolabrata	A Plant Bug	
Miris striatus	A Plant Bug	
Notostira elongata	A Plant Bug	
Phytocoris ulmi	A Plant Bug	
Pinalitus cervinus	A Plant Bug	
Pithanus maerkelii	A Plant Bug	
Plagiognathus arbustorum	A Plant Bug	
Teratocoris saundersi	A Plant Bug	
Coreus marginatus	Dock Bug	
Himacerus apterus	Tree Damsel Bug	
Himacerus mirmicoides	Ant Damsel Bug	
Nabis rugosus	A Damsel Bug	
Aphrophora alni	A Froghopper	
Philaenus spumarius	Common Froghopper	
Anoscopus serratulae	A Leafhopper	
Eupteryx vittata	A Leafhopper	
Euscelis incisus	A Leafhopper	
Erzaleus metrius	A Leafhopper	
Grypotes puncticollis	A Leafhopper	
Iassus lanio	A Leafhopper	
Macustus grisescens	A Leafhopper	
Megophthalmus scanicus	A Leafhopper	
Criomorphus albomarginatus	A Planthopper	
Hyledelphax elegantula	A Planthopper	
Javesella pellucida	A Planthopper	
Stenocranus minutus	A Planthopper	

Aphrophora salicina	A Froghopper	
Cercopis vulnerata	A Froghopper	
Aradus depressus	A Flat Bug	
Leptophyes punctatissima	Speckled Bush Cricket	
Tetrix subulata	Slender Ground Hopper	
Omocestus viridulus	Common Green Grasshopper	
Chorthippus brunneus	Common Field Grasshopper	
Chorthippus parallelus	Meadow Grasshopper	
Meconema thalassinum	Oak Bush Cricket	
Forficula auricularia	Common Earwig	
Aeshna cyanea	Southern Hawker Dragonfly	
Aeshna grandis	Brown Hawker Dragonfly	
Aeshna mixta	Migrant Hawker Dragonfly	
Anax imperator	Emperor Dragonfly	
Calopteryx splendens	Banded Demoiselle	
Coenagrion puella	Azure Damselfly	
Coenagrion pulchellum	Variable Damselfly	
Enallagma cyathigerum	Common Blue Damselfly	
Ischnura elegans	Blue-tailed Damselfy	
Libellula depressa	Broad-bodied Chaser Dragonfly	
Pyrrhosoma nymphula	Large Red Damselfly	
Sympetrum striolatum	Common Darter Dragonfly	
Diaea dorsata	A Crab Spider	
Misumena vatia	A Crab Spider	
Philodromus aureolus	A Crab Spider	
Xysticus cristatus	A Crab Spider	
Pardosa pullata	A Wolf Spider	
Agelena labyrinthica	A funnelweb spider	
Clubiona lutescens	A Sac Spider	
Euophrys frontalis	A Jumping Spider	

Heliophanus flavipes	A Jumping Spider	
Dictyna arundinacea	A Mesh-web Spider	
Enoplognatha ovata	A Comb-footed Spider	
Anelosimus vittatus	A Comb-footed Spider	
Theridion mystaceum	A Comb-footed Spider	
Araneus marmoreus	An Orb-weaver Spider	
Araneus diadematus	An Orb-weaver Spider	
Larinioides cornutus	An Orb-weaver Spider	
Nuctenea umbratica	An Orb-web Spider	
Tetragnatha montana	A Large-jawed Orb-weaver	
Pisaura mirabilis	Nursery-web Spider	
Homalenotus quadridentatus	A Harvestman	
Trichoniscus pusillus	Common Pygmy Woodlouse	
Paroligolophus agrestis	A Harvestman	
Oniscus asellus	Common Woodlouse	
Philoscia muscorum	Common Striped Woodlouse	

APPENDIX B: Photographs

Old Railway Station. This is of limited value to terrestrial invertebrates. Poor botanical diversity and eutrophic conditions.

Standing dead ash tree in the small triangle of woodland bordering dismantled railway with vane trap in situ. A number of Nationally Scarce species were found in this one trap and the wood has an abundance of deadwood resources.

Standing dead ash tree in the small triangle of woodland bordering dismantled railway with vane trap in situ. The value of this standing dead tree is increased because it is in a small glade that receives considerable sunlight.

Hedgerow bordering dismantled railway. This is of moderate/high value to terrestrial invertebrates because of the vegetation complexity, nectar and deadwood it provides. It is also very close to the abundance of standing and fallen deadwood in the adjacent triangle of woodland.

Hedgerow running alongside existing A47 with stream border (sallow and willow) and poplar plantation beyond next to the River Nene. These hedgerows are of moderate/high value to terrestrial invertebrates because of the vegetation complexity, nectar and deadwood they provide. They also very close to the abundance of standing and fallen deadwood in the adjacent triangle of woodland.

Meadow bordering River with stream border and poplar plantation in the background. This meadow is of little value to terrestrial invertebrates. It was cut in May and the cuttings were left in situ. Botanical diversity, topographical and vegetation structural complexity are poor.

The Nationally Rare False Darkling Beetle *Osphya bipunctata* with ovipositor extended. A single individual of this beetle – a gravid female - was found in the May-June sample from the vane trap shown above. It is likely this very poorly known species is breeding in this tree.

The Nationally Rare Click Beetle *Ampedus quercicola*. A single individual of this beetle was found in the May-June sample from the vane trap shown above.