# M6 J33
# B2327FTI

## Comparative Ecological Assessment of Air Quality Impacts

April 2020

Lancashire County Council

### Document history and status

| Revision | Date | Description | Author | Checked | Reviewed | Approved |
|---|---|---|---|---|---|---|
| 0 | 21/04/2020 | Original | Gail Rainford | Liz Allchin | Liz Allchin | |
| 1 | 8/06/2020 | Comments addressed | Gail Rainford | Liz Allchin | Liz Allchin | |

### Distribution of copies

| Revision | Issue approved | Date issued | Issued to | Comments |
|---|---|---|---|---|
| | | | | |
| | | | | |

# M6 Junction 33 Options report

| | |
|---|---|
| Project No: | B2327FTI |
| Document Title: | M6 J33 Comparative Assessment of Air Quality Impacts |
| Document No.: | Document No. |
| Revision: | 1 |
| Document Status: | Structure and First draft |
| Date: | 21 April 2020 |
| Client Name: | Lancashire County Council |
| Client No: | |
| Project Manager: | Angela Lopez Garces |
| Author: | Gail Rainford |
| File Name: | M6 J33 Comparative Assessment of Air Quality Impacts |

# 1. Introduction

## 1.1 Background

Lancaster City Council published Local Plan identifies potential housing and employment land to the south of Lancaster, on the west of the A6. In addition, Lancaster University are proceeding with plans to construct a new Health & Innovation Campus next to their existing site on the east of the A6. These developments would generate traffic on the A6 to M6 J33, in addition to the existing traffic to and from Lancaster from the motorway network to the south. The existing A6 is constrained where it passes through Galgate, particularly at the signal-controlled junction with Salford Road/Stoney Lane. There are limited opportunities to improve the junction because of the proximity of properties, and this bottleneck results in frequent congestion on the A6, with long queues on the approaches. The additional traffic generated by the proposed developments could exacerbate this problem.

A broad corridor area and six possible route options within this area have been developed for M6 Junction 33 to alleviate the above problem. The broad corridor area also includes the spine road that will go through the Bailrigg Garden Village that is fixed in this location. Ecological assessment is required to assess the impacts of the six alternative route options.

Exhaust emissions from road traffic may affect plant communities both directly via foliage or indirectly through changes within the soil (Lee *et al.*, 2012) and impacts are greatest within the first 50-100m from the road (Ricardo, 2016). An increase in nitrogen leads to an increase in nitrogen tolerant species such as common nettle (*Urtica dioica*), jack-by-the-hedge (*Alliaria petiolata*), willowherbs (*Epilobium* ssp.) and rank grasses, which will out compete other flora, thereby reducing the number of species present. Lee *et al.* (2012) also found that the abundance of moss species declined at roadside locations.

The objective of this study is to produce a comparative assessment of each of the six route options in relation to the impacts additional nitrogen loads will have on the ecology of habitats and other species present in the study area.

## 1.2 The Purpose of this Report

The purpose of this document is to report on the findings of the ecological comparative assessments of the six routes options designed to alleviate congestion and improve air quality in the A6 along Galgate.

## 1.3 Scheme Description

Six options aimed at providing additional capacity to accommodate new housing developments in the area and reduce congestion in Galgate have been considered in this study.

### 1.3.1 Central 1

The Central 1 route starts at the existing J33 and travels north immediately adjacent to the M6 motorway to Hazelrigg Lane, where there would be a roundabout junction. Hazelrigg Lane would be improved as part of this alignment, with links to the new motorway connection and the Bailrigg Spine Road. The design outline is shown in Figure 1.

### 1.3.2 Central 2: A588

The Central 2 (A588) route is similar to Central 1, with the route starting at J33 of the M6 motorway and would travel north immediately adjacent to the M6 to Hazelrigg Lane where there would be a roundabout junction. Hazelrigg Lane would also be improved as part of this alignment and there would be an additional new road linking the Bailrigg Spine Road and Hazelrigg Lane with the A588. The design outline is shown in Figure 2.

#### 1.3.3 West 1

The route alignment would travel from the roundabout on the A6 at J33 of the M6 motorway, west of Galgate and would meet the Bailrigg Spine Road approximately half way along its length. The design outline is shown in Figure 5.

#### 1.3.4 West 2

The route for West 2 scheme would start south of Galgate and travel west of the village to meet the Bailrigg Spine Road where it passes under the West Coast Mail Line railway. The design outline is shown in Figure 6

#### 1.3.5 East 1

Traveling from an improved J33, this alignment would follow a route east of the M6 to avoid areas of ancient woodland and would travel north towards Hazelrigg Lane. Hazelrigg Lane would also be improved as part of this alignment, to include links to a new motorway connection and the Bailrigg Spine Road. The design outline is shown in figure 3.

#### 1.3.6 East 2

This option would travel north from an improved J33, towards Hazelrigg Lane. This alignment option would lie further east than East 1. Hazelrigg Lane would also be improved as part of this alignment to link with a new motorway connection and the Bailrigg Spine Road. The design outline is shown in Figure 4.

# 2. Air Quality Ecological Assessment

## 2.1 Introduction

Air quality is a consideration for any development proposal involving changes in the nature and locations of emissions to air, with nitrogen being the dominant factor in relation to effects on designated habitats. The Natural England Commissioned Report NECR210 (Caporn *et al*, 2016) states that;

'The problems that result from increased aerial deposition of reactive nitrogen compounds have been recognised only in recent decades but are now believed to be widespread in ecological communities on regional and global scales (Emmett, 2007; Phoenix et al., 2006; Bobbink et al., 2010). There is particular concern over the impacts on natural and semi—natural ecological communities, where the normal low rates of nitrogen supply often provide important limits to ecological processes. For this reason, the most obvious potential influence of pollutant nitrogen deposition is as a fertilizer, i.e. eutrophication, threatening the natural composition of those ecological communities that are well adapted to nutrient-poor soils. Another ecological impact of nitrogen deposition results from soil and water acidification which affects some species directly but also causes impacts through release of toxic metals such as aluminium (Stevens et al., 2010). A wider range of biogeochemical changes are also likely to occur in impacted sites such as nitrogen leaching and nutrient imbalances in soils and vegetation (see RoTAP, 2012)'.

The route options have the potential to impact several designated habitats within 200m of the affected road network (ARN); therefore, an ecological assessment has been carried out to establish the potential effect of greater nitrogen deposition on those designated habitats.

This chapter describes the assessment undertaken and the potential air quality effects arising from each of the route options.

## 2.2 Guidance

Key guidance for the air quality ecological assessment is summarised in Table 2.1.

Table 2.1: Summary of Key Guidance

| Document | Description |
|---|---|
| Design Manual for Roads and Bridges<br>DMRB, Volume 11 Environmental Assessment, Section 3 Environmental Assessment Techniques, LA 105 Air Quality (Highways England, 2019). | This document provides a framework for assessing and reporting the effects of motorway and all-purpose trunk road projects on air quality by determining whether the impacts of the project on designated habitats can trigger a significant air quality effect. |
| Natural England commissioned Report NECR210: Assessing the effects of small increments of atmospheric nitrogen deposition (above the critical load) on semi-natural habitats of conservation importance (Caporn *et al.*, 2016) | This report is used to inform specialist advice on air quality effects on habitat that is used in planning advice, agri-environment schemes and to protect and enhance designated sites. |

## 2.3 Methodology

### 2.3.1 Study Area

The study area was defined as described in the DMRB LA105 (Highways England,2019) as follows:

"*Internationally, nationally and locally designated sites of ecological conservation importance on protected species and on habitats and other species identified as being of principal importance for the conservation of*

*biodiversity (known as designated habitats) within 200m of the ARN shall be included in the air quality assessment".*

and

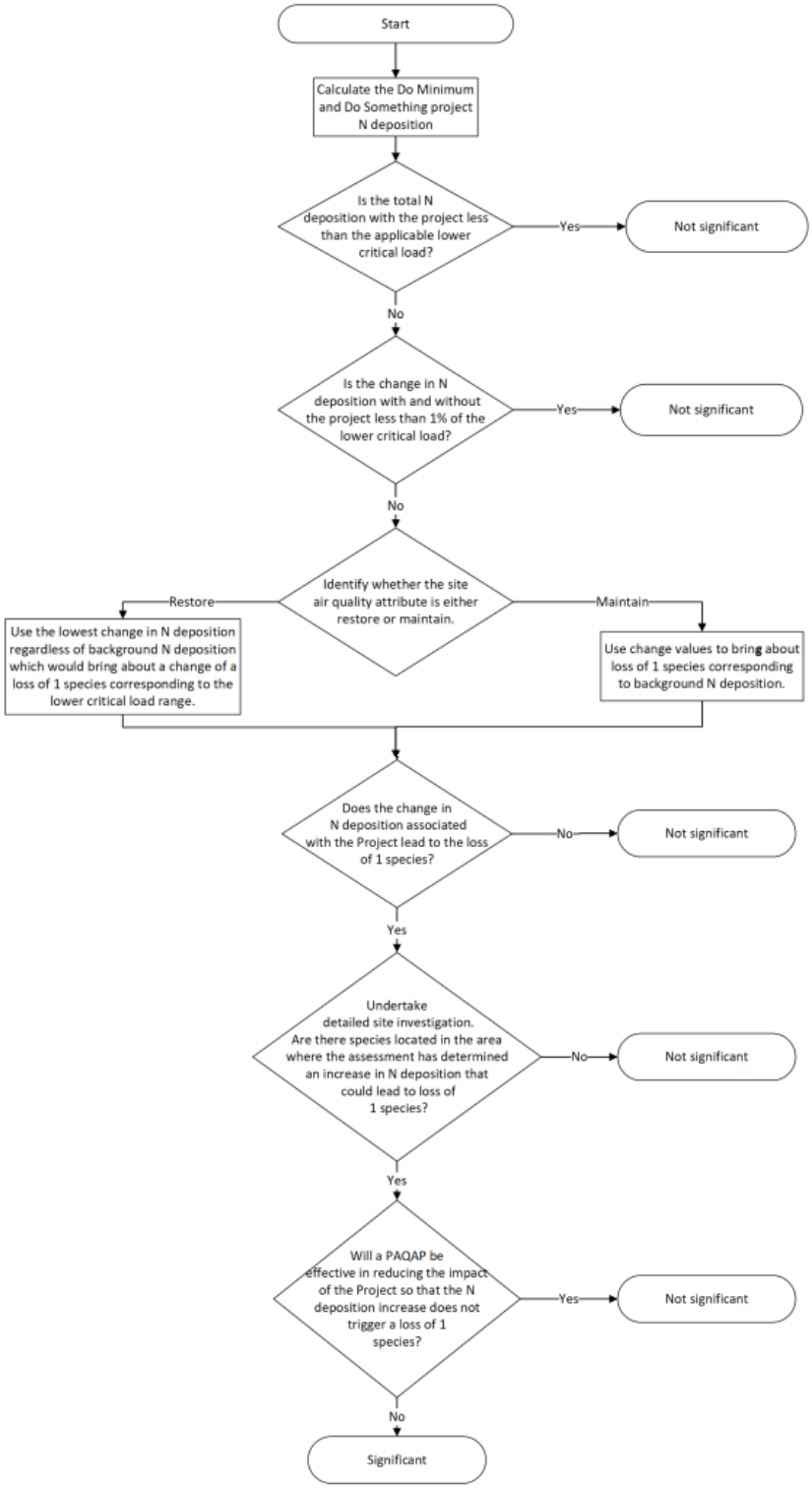
*"Designated include 'Ramsar' sites, Special Protection Areas (SPAs), Special Areas of Conservation (SACs), Sites of Special Scientific Interest (SSSIs), Local Nature Reserves (LNRs), local wildlife sites* (termed Biological Heritage Sites by Lancashire County Council)*, Nature Improvement Areas (NIAs), ancient woodland and veteran trees. Only sites that are sensitive to nitrogen deposition should be included in the assessment."*

For each designated habitat, transect receptor points at 10m intervals were modelled, starting from the nearest point of the designated habitat to the ARN, up to a maximum distance of 200m.

### 2.3.2 Assessment Approach

This assessment has been carried out following guidance detailed within DMRB LA 105 (Highways England, 2019), including the flow diagram reproduced below, and the Natural England Commissioned Report NECR210 (Caporn *et al.*, 2016), where appropriate.

Figure 2.1 Assessment of significant effects on designated sites *(PAQAP = project air quality action plan)*




NOTE *The presumption is that the air quality attribute for most designated habitats has been set to restore and the air quality assessment is completed on this basis.*

The key elements of the assessment are:

- a review of relevant statutory designated sites using MAGIC (www.magic.defra.gov.uk);
- a review of relevant ecological receptors obtained from Lancashire Environmental Records Network (LERN) (including citations for biological heritage sites);
- a check of the Woodland Trust Ancient Tree Inventory to find ancient or veteran trees within the study area (www.ati.woodlandtrust.org.uk);
- a check of aerial photographs to assess surrounding habitats using Google Maps (www.google.co.uk/maps);
- a check of the Air Pollution Information Systems (APIS) for information on levels and effects of nitrogen deposition on habitats and species (www.apis.ac.uk); and
- an assessment of nitrogen impacts on local ecological receptors within 200m of the ARN based on dispersion modelling results provided by the Jacobs Air Quality Team.

### 2.3.3 Local Air Quality Assessment

The assessment of potential air quality effects of each route option was undertaken by Jacobs Air Quality Team. Their results were used to inform the assessment of the effect increases in nitrogen deposition would have on the designated sites listed above. Using the presumptive option to restore as given in Figure 2.1, the base values in Table 21 in NECR210 were used to conclude whether the changes in nitrogen deposition would be likely to have a significant effect on the ecology of the designated sites and for those habitats not included in the table, the habitat with the lowest change in nitrogen deposition, likely to lead to the loss of one species, excluding nutrient impoverished sand dunes, should be used.

### 2.3.4 Modelled Scenarios

The local air quality assessment considers the effects of the six route options in the opening year only (as this is the year in which the largest impacts are likely to occur, due to assumed improvements in vehicle emissions over time).

The Jacobs' Air Quality Team modelled the results of the transect receptor points. Where the change in nitrogen deposition was estimated to be >1% of the lowest possible critical load (i.e. >0.05 kg N/ha/yr), this was used to indicate where changes in nitrogen deposition have the potential to affect a designated site or veteran tree. Where changes in nitrogen deposition were estimated to be less than this amount, it has been assumed that any resulting impacts are unlikely to be significant (see Figure 2.1 above). The results of that assessment are reported in the M6 J33 Options Report (Jacobs, 2020) (Document reference: 14-RO-TAR-F).

Following this initial modelling, where the change in nitrogen deposition for a designated site or veteran tree was greater than 0.4 kg N/ha/yr, a review was undertaken by a competent expert for biodiversity (Ecologist) as to whether the site would be restored or maintained. As detailed in the DMRB LA 105 guidance (and reproduced in Figure 2.1), the presumption is to restore. Where there was data available, the habitats and species present within the sites and the veteran tree species were assessed for sensitivity to an increase in nitrogen deposition.

#### 2.3.4.1 Limitations

This report has been compiled without any site visits being carried out. Many of the designated sites' citations referred to in this report have not been updated for over 10 years; therefore, these sites may no longer contain the species the citation describes. It is usual for most ecological data to be discounted if it is over 10 years old due to the changes that may have occurred over that time. However, the findings of this report are still considered to be valid even if site visits are carried out in the future and baseline conditions found to be substantially different to those described in the citations.

The critical load levels of nitrogen deposition used by the Jacobs' Air Quality Team were based on the minimum recommended value for a range of habitats to use at the screening stage of assessment taken from the APIS

website[1] and are therefore likely to be conservative in many cases. This approach was taken as if the modelled change in nitrogen deposition at any particular site is less than 1% of the lowest possible critical load, then the effect can be considered 'not significant' according to DMRB LA 105 guidance, and further, more detailed assessment is not required.

## 2.4 Results

### 2.4.1 Ecological Receptors

A summary of the ecological receptors (designated sites) included in this review is provided in Table 2.2, the locations of which are shown in Figures 1 to 6 in Appendix A. These sites and the reason for designation are described in more detail in Appendix B. There were no veteran trees identified on the Woodland Trust Ancient Tree Inventory that would be significantly affected by any of the options.

Table 2.2: Ecological receptors included in assessment that are sensitive to nitrogen

| Designated Site | Designation (and LCC Guideline for Site Selection (where applicable)) | Main Habitats |
|---|---|---|
| Berry's Farm and Sellerley Farm Ponds, Conder Green | Biological Heritage Site | Ponds with fine-leaved water-dropwort (*Oenanthe aquatica)*, common water-crowfoot (*Ranunculus aquatilis sens. Str.*), bladder sedge (*Carex versicaria*) and great crested newt (GCN) (*Triturus cristatus*) |
| Long Bank Wood | Biological Heritage Site / Ancient woodland | Semi-natural woodland on golf course with dog's mercury (*Mercurialis perennis*), broad buckler-fern (*Dryopteris dilatata*) and male-fern (*Dryopteris filix-mas*) |
| Wyresdale Road Verges | Biological Heritage Site | Species-rich neutral grassland, with bee orchid (*Ophrys apifera*), adder's tongue (*Ophioglossum vulgatum*), hedge bedstraw (*Galium album*) and common twayblade (*Neottia ovata*). |
| Park Coppice | Biological Heritage Site / Ancient Woodland | Semi-natural woodland, with bluebell (*Hyacinthoides non-scripta*), male fern, scaly male-fern (*Dryopteris affinis*), broad buckler-fern, dog's mercury, wood anemone (*Anemone nemorosa*), enchanter's nightshade (*Circaea lutetiana*), greater stitchwort (*Stellaria holostea*), wood dock (*Rumex sanguineus*), ramsons (*Allium ursinum*) and broad-leaved helleborine (*Epipactis helleborine*). |
| Old Park Wood | Biological Heritage Site / Ancient Woodland | Semi-natural woodland with a mixed canopy, with bluebell, wood anemone, wood sage (*Teucrium scorodonia*), male-fern, scaly male-fern and broad buckler-fern. |
| Little Cockshades Wood | Biological Heritage Site / Ancient Woodland | Semi-natural woodland which had a supressed ground flora due to grazing; however, creeping soft-grass (*Holcus mollis*), wood meadow-grass (*Poa nemoralis*) and wood sorrel (*Oxalis acetosella*) were recorded. |

[1] http://www.apis.ac.uk/indicative-critical-load-values

| Designated Site | Designation (and LCC Guideline for Site Selection (where applicable)) | Main Habitats |
|---|---|---|
| Brunstow Wood | Biological Heritage Site / Ancient Woodland | Small woodland, with bluebell, broad buckler-fern, wood sorrel and greater stitchwort. |

### 2.4.2 Air Quality Assessment Results

A summary of the results of the air quality assessment for each of the route options for the ecological receptors detailed in Table 2.2, is provided in Table 2.3 below. When the change in nitrogen deposition is greater than or equal to 0.4 kg N/ha/yr as a result of the project, there could be significant impacts on biodiversity. The results for sites which could be significantly impacted by each option are coloured red.

Table 2.3: Summary of nitrogen deposition assessment results (only the greatest increase or decrease is shown)

| Designated Site | APIS Data Average Total N Deposition Kg N/ha/yr | Increase in Nitrogen Deposition DS – DM kg N/ha/yr | | | | | |
|---|---|---|---|---|---|---|---|
| | | Central 1 | Central 2 | East 1 | East 2 | West 1 | West 2 |
| Berry's Farm and Sellerley Farm Ponds, Conder Green | 19.97 | 0.01 | -0.01 | 0.00 | 0.00 | **0.43** | 0.15 |
| Long Bank Wood | 29.4 | 0.06 | 0.06 | 0.02 | 0.06 | 0.00 | 0.00 |
| Wyresdale Road Verges | 18.62 | 0.26 | 0.27 | 0.27 | 0.28 | -0.01 | -0.01 |
| Park Coppice | 30.8 | 0.26 | 0.14 | 0.25 | 0.25 | 0.10 | 0.24 |
| Old Park Wood | 30.8 | 0.00 | 0.15 | 0.00 | 0.00 | 0.20 | 0.17 |
| Little Cockshades Wood | 30.8 | -0.01 | -0.01 | **0.46** | 0.14 | 0.00 | 0.00 |
| Brunstow (North) Wood) | 34.72 | -0.02 | -0.02 | 0.00 | 0.01 | -0.01 | 0.01 |
| Brunstow Wood | 34.72 | -0.02 | -0.02 | 0.00 | 0.02 | -0.01 | 0.08 |

## 2.5 Recommendations and Conclusions

The nitrogen deposition assessment results in Table 2.3 indicate that two route options have the potential to impact two ecological receptors as project-related nitrogen deposition changes are above 0.4 kg N/ha/y: Berry's Farm and Sellerley Farm Ponds by West 1 and Little Cockshades Wood by East 1. The consequences of these increases in nitrogen deposition are detailed below, based on the habitats and species listed in the relevant designated site citations.

### 2.5.1 Ponds

There have been few studies on the effects that atmospheric nitrogen deposition may have on freshwaters (APIS, 29th April 2020); however, a study by Morris (1991) found that within wetland habitats nitrogen deposition can

have an impact by increasing fast growing nitrogen-liking species (i.e. eutrophication). This increased productivity may have an influence on succession and primary production within wetlands, which is generally limited by the availability of nitrogen. From aerial photographs [Photography from June 2018, accessed April 2020], many of the ponds within Berry's Farm and Sellerby Farm designated site appear to be within arable or improved grassland fields; therefore, the ponds are likely to be subject to fertiliser inputs and therefore already have high nitrogen levels. It is therefore considered that any additional atmospheric nitrogen input from route option West 1 is unlikely to have a significant detrimental effect on ponds or the GCN population they support. However, it is also noted that the aerial photography was taken in 2018 and the trophic status of these ponds could have changed in this time period and therefore the effect of increased atmospheric nitrogen on these ponds cannot be fully assessed at this time. A recommendation is therefore provided within Section 2.5.3 below to undertake a field-based verification exercise.

### 2.5.2 Woodland (including Ancient Woodland)

The citation for Little Cockshades Wood has not been updated since 1996, when the woodland was unfenced and grazed and changes to this regimen may have taken place in the 24 years since.

A study of beech trees in Italy found that increases in nitrogen levels had a positive impact on forest productivity up to a deposition level of 10kg N/ha/yr per square metre per year, above which increases levelled off (Gentilesca *et al.,* 2018). Other studies of forbs, lichens and bryophytes have shown changes in the species composition but not species richness with increased nitrogen deposition (e.g. less tufted hair-grass (*Deschampsia cespitosa*), Yorkshire fog (*Holcus lanatus*) and bilberry (*vaccinium myrtillus*), and more cleavers (*Galium aparine*), ramsons, meadow grasses (*Poa* ssp.) and common nettle) (Michell *et al,* 2004; Sutton *et al.*, 2009). Verheyen *et al.* (2012) concluded that changes in the tree canopy would have an effect on the amount of nitrogen reaching the ground at different times of the year. Overall, it seems likely that there is a greater effect on the edges of woodland closest to the nitrogen source (Kirby *et al*., 2005).

From aerial photographs [photography from June 2018, accessed April 2020], Little Cockshades Wood appears to be surrounded by arable and improved fields. Consequently, it is likely that the woodland edges are already affected by high levels of nitrogen from fertiliser added to those fields and have more nitrogen-loving species already present (i.e. eutrophication threatening the natural composition of those ecological communities that are well adapted to nutrient-poor soils, soil and water acidification and other biogeochemical changes (Refer to Section 2.1). Therefore, additional atmospheric nitrogen input from the route option East 1 is considered unlikely to have any significant detrimental effect on this woodland. The ground flora in the centre of the woodland is unlikely to be affected by any increase in atmospheric nitrogen deposition because of absorption by the tree canopy.

However, given the age and nature of the desk-based data available, it is recommended that a field verification survey is undertaken to confirm the current botanical status and grazing regimen of Little Cockshades Wood (See Section 2.5.3 Recommendations below).

### 2.5.3 Recommendations

As the grazing regimen may have changed at Little Cockshades Wood since the citation was written, it is recommended that if the East 1 route option is taken forwards, a botanical field survey should be carried out to assess nitrogen-sensitivity of the habitats present and to note indicators of existing elevated nitrogen. This survey should be designed such that they consider the direction and distance to the route, depth of surrounding woodland and canopy cover. This should be followed by a reassessment of the significance of the increases in atmospheric nitrogen deposition on this woodland.

In addition, it is also noted that the status of ponds at Berry's Farm and Sellerby Farm designated site was determined using aerial photography from 2018. It is therefore recommended that if the West 1 route option is taken forwards, a field verification survey is undertaken to confirm the current trophic status of these ponds. This should be followed by a reassessment of the significance of the increases in atmospheric nitrogen deposition on this site.

The veteran tree database held by the Woodland Trust only holds limited data. Veteran trees present within 200 m of the route options may not be in the database and; therefore, not included in this report. It is recommended that surveys to look for veteran trees are carried out on all the habitats within 200 m of all six route options.

### 2.5.4 Conclusion

Overall, it can be concluded it is unlikely any of the route options will have a significant effect on designated habitats that will result in the loss of one species. However, to confirm this, further surveys would be required as detailed in the recommendations above.

# 3. References

Air Pollution Information System (APIS) www.apis.ac.uk [accessed 28th April 2020)].

Bobbink et al., 2010. Bobbink, R. and Hettelinghl, J-P. Eds. (2011) Review and revision of empirical critical loads and dose response relationships. Proceedings of an expert workshop, Noordwijkerhout, 23-25th June 2010.

Bignal, K.L., Ashmore, M.R., Headley, A.D., Stewart, K. and Weigert, K. (2007). Ecological impacts of air pollution from road transport on local vegetation. *Applied Geochemistry*; 22: 1265-1271.

Caporn, S., Field, C., Payne, R., Dise, N., Britton, A., Emmett, B., Jones, L., Phoenix, G., Power, S., Sheppard, L. and Stevens, C. (2016). *Assessing the effects of small increments of atmospheric nitrogen deposition (above critical load) on semi-natural habitats of conservation importance.* Natural England Commissioned Reports, Number 210.

Emmett, B.A., Griffiths, B., Williams, D., and Williams, B. (2007) Task 6: Interactions between grazing and nitrogen deposition at Pwllpeiran: Effects of eutrophication and acidification on terrestrial ecosystems. Final Report (July 2007) NERC-Defra Terrestrial Umbrella (Contract No CPEA18).Gentilesca, T., Angelo, R., Brunetti, M., Gikammarchi, F., Leonardi, S., Magnani, F., van Noije, T., Tonon, G. and Borghetti, M. (2018). Nitrogen deposition outweighs climatic variability in driving annual growth rate of canopy beech trees: Evidence from long-term growth reconstruction across a geographic gradient. *Global Change Biology*; 24 (7): 2898-2912.

Highways England (2019). Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 1 LA 105 Air Quality. Highways England, Transport Scotland, Welsh Government and The Department for Infrastructure.

Kirby, K.J., Smart, S.<., Black, H.I.J., Bunce, R.G.H., Corney, P.N. and Smithers, R.J. (2005). *Long term ecological change in British Woodland 1971-2001).* Research Report 653, English Nature, Peterborough.

Lee, M.A., Davies, L., Power, S.A. (2012). Effects of roads on adjacent plant community composition and ecosystem function: An example from three calcareous ecosystems. *Environmental Pollution*; 163: 273-280.

Morris, J.T (1991). Effects of nitrogen loading on wetland ecosystems with particular reference to atmospheric deposition. Annu.Rev.Ecol.Syst. 1991. 22, 257-79. Phoenix, G.K., Hicks, W.K., Cinderby, S., Kuylenstierna, J.C.I, Stock, W.D., Dentener, F.J., Giller, K.E., Austin, A.T., Lefroy, R.D.B., Gimeno, B.S., Ashmore, M.R. and Ineson, P. (2006), Atmospheric Nitrogen Deposition in World Biodiversity Hotspots: the need for a greater global perspective in assessing N deposition impacts. Global Change Biology, 12, 470-476.

Ricardo A.E.A. (2016). *The ecological effects of air pollution from road transport: an updated review – with supplementary summary of road-traffic measures for reducing emissions. Natural England Commissioned Report NECR199.* Natural England, York.

RoTAP (2012). Review of Transboundary Air Pollution: Acidification, Eutrophication, Ground Level Ozone and Heavy Metals in the UK. Contract Report to the Department for Environment, Food and Rural Affairs. Centre for Ecology & Hydrology.

Sutton, M.A., Wolseley, P.A., Leith, I.D., van Dijk, N., Tang, U.S., James, P.W., Theobald, M.R. and Whitfield, C. (2009). *Estimation of the Ammonia critical levels for epiphytic lichens based on observations at farm, landscape an national scales.* In: Sutton, M.A., Reis, S. and Baker, S.M.H. (eds) (2009). Atmospheric Ammonia. Springer Press.

Verheyan, K., Baeten, L., De Frenne, P., Bernhardt-Romermann, M., Brunet, J., Cornelis, J., Decocq, G., Dierschke, H., Eriksson, O., Held, R., Heinken, T., Hermy, M., Hommel, P., Kirby, K., Naaf, T., Peterken, G., Petrik, P., Pfadenhauer, J., Van Calster, H., Walther, G.R., Wulf. M. and Verstraeten, G. (2012). Driving factors behind the eutrophication signal in understorey plant communities of deciduous temperate forests. *Journal of Ecology*; 100(2): 352-365.

# Appendix A. Figures

# FIGURE 1

Legend

- ARN Scheme Option Central 1
- Scheme Option Central 1
- 200m buffer
- Ancient woodland
- Biological heritage site

Long Bank Wood

Wyresdale Road Verges

Park Coppice

Old Park Wood

Berry's Farm and Sellerley Farm Ponds, Conder Green

Little Cockshades Wood

Brunstow North Wood

Brunstow Wood


| Rev. | Date | Purpose of revision | Drawn | Check'd | Rev'd | Appr'd |
|---|---|---|---|---|---|---|
| 0 | MAR 20 | Initial Issue | RM | GR | HJ | OP |


Jacobs

Cottons Centre, Cottons Lane, London, SE1 2QG, UK.
Tel: +44(0)020 3980 2000
www.jacobs.com


Client: LANCASHIRE COUNTY COUNCIL

Project: M6 J33 OPTIONS APPRAISAL

Drawing Title: COMPARATIVE ECOLOGICAL ASSESSMENT OF AIR QUALITY IMPACTS - CENTRAL 1

Drawing Status: DRAFT

| | | |
|---|---|---|
| Scale @ A3 | 1:50,000 | DO NOT SCALE |
| Jacobs No. | B2327FTI | |
| Client No. | | |

Drawing No.: B2327FTI_M6J33_Extension_AirQualityResults





0 1,000 Metres

# FIGURE 2

Legend

- ARN Scheme Option Central 2
- Scheme Option Central 2
- 200m buffer
- Ancient woodland
- Biological heritage site

Long Bank Wood
Wyresdale Road Verges
Park Coppice
Old Park Wood
Berry's Farm and Sellerley Farm Ponds, Conder Green
Little Cockshades Wood
Brunstow North Wood
Brunstow Wood


| Rev. | Date | Purpose of revision | Drawn | Check'd | Rev'd | Appr'd |
|---|---|---|---|---|---|---|
| 0 | MAR 20 | Initial Issue | RM | GR | HJ | OP |


Jacobs

Cottons Centre, Cottons Lane, London, SE1 2QG, UK.
Tel: +44(0)020 3980 2000
www.jacobs.com


Client: LANCASHIRE COUNTY COUNCIL

Project: M6 J33 OPTIONS APPRAISAL

Drawing Title: COMPARATIVE ECOLOGICAL ASSESSMENT OF AIR QUALITY IMPACTS - CENTRAL 2

Drawing Status: DRAFT

| | | |
|---|---|---|
| Scale @ A3 | 1:50,000 | DO NOT SCALE |
| Jacobs No. | B2327FTI | |
| Client No. | | |

Drawing No.: B2327FTI_M6J33_Extension_AirQualityResults





0 1,000 Metres

# FIGURE 3

Legend

- ARN Scheme Option East 1
- Scheme Option East 1
- 200m buffer
- Sites with potentially significant effect from nitrogen deposition
- Ancient woodland
- Biological heritage site


| Rev. | Date | Purpose of revision | Drawn | Check'd | Rev'd | Appr'd |
|---|---|---|---|---|---|---|
| 0 | MAR 20 | Initial Issue | RM | GR | HJ | OP |


Jacobs

Cottons Centre, Cottons Lane, London, SE1 2QG, UK.
Tel: +44(0)020 3980 2000
www.jacobs.com


Client: LANCASHIRE COUNTY COUNCIL

Project: M6 J33 OPTIONS APPRAISAL

Drawing Title: COMPARATIVE ECOLOGICAL ASSESSMENT OF AIR QUALITY IMPACTS - EAST 1

Drawing Status: DRAFT

| | | |
|---|---|---|
| Scale @ A3 | 1:50,000 | DO NOT SCALE |
| Jacobs No. | B2327FTI | |
| Client No. | | |

Drawing No.: B2327FTI_M6J33_Extension_AirQualityResults

# FIGURE 4

Legend

- ARN Scheme Option East 2
- Scheme Option East 2
- 200m buffer
- Ancient woodland
- Biological heritage site

Long Bank Wood

Wyresdale Road Verges

Park Coppice

Old Park Wood

Berry's Farm and Sellerley Farm Ponds, Conder Green

Little Cockshades Wood

Brunstow North Wood

Brunstow Wood


| Rev. | Date | Purpose of revision | Drawn | Check'd | Rev'd | Appr'd |
|---|---|---|---|---|---|---|
| 0 | MAR 20 | Initial Issue | RM | GR | HJ | OP |


Jacobs

Cottons Centre, Cottons Lane, London, SE1 2QG, UK.
Tel: +44(0)020 3980 2000
www.jacobs.com


Client: LANCASHIRE COUNTY COUNCIL

Project: M6 J33 OPTIONS APPRAISAL

Drawing Title: COMPARATIVE ECOLOGICAL ASSESSMENT OF AIR QUALITY IMPACTS - EAST 2

Drawing Status: DRAFT

| | | |
|---|---|---|
| Scale @ A3 | 1:50,000 | DO NOT SCALE |
| Jacobs No. | B2327FTI | |
| Client No. | | |

Drawing No.: B2327FTI_M6J33_Extension_AirQualityResults





0 1,000 Metres

# FIGURE 5

Legend

- ARN Scheme Option West 1
- Scheme Option West 1
- 200m buffer
- Sites with potentially significant effect from nitrogen deposition
- Ancient woodland
- Biological heritage site

Long Bank Wood

Wyresdale Road Verges

Park Coppice

Old Park Wood

Berry's Farm and Sellerley Farm Ponds, Conder Green

Little Cockshades Wood

Brunstow North Wood

Brunstow Wood


| Rev. | Date | Purpose of revision | Drawn | Check'd | Rev'd | Appr'd |
|---|---|---|---|---|---|---|
| 0 | MAR 20 | Initial issue | RM | GR | HJ | OP |


Jacobs

Cottons Centre, Cottons Lane, London, SE1 2QG, UK.
Tel: +44(0)020 3980 2000
www.jacobs.com


Client: LANCASHIRE COUNTY COUNCIL

Project: M6 J33 OPTIONS APPRAISAL

Drawing Title: COMPARATIVE ECOLOGICAL ASSESSMENT OF AIR QUALITY IMPACTS - WEST 1

Drawing Status: DRAFT

| | | |
|---|---|---|
| Scale @ A3 | 1:50,000 | DO NOT SCALE |
| Jacobs No. | B2327FTI | |
| Client No. | | |

Drawing No.: B2327FTI_M6J33_Extension_AirQualityResults





0 1,000 Metres

# FIGURE 6

Legend

- ARN Scheme Option West 2
- Scheme Option West 2
- 200m buffer
- Ancient woodland
- Biological heritage site


| Rev. | Date | Purpose of revision | Drawn | Check'd | Rev'd | Appr'd |
|---|---|---|---|---|---|---|
| 0 | MAR 20 | Initial Issue | RM | GR | HJ | OP |


Jacobs

Cottons Centre, Cottons Lane, London, SE1 2QG, UK.
Tel: +44(0)020 3980 2000
www.jacobs.com


Client: LANCASHIRE COUNTY COUNCIL

Project: M6 J33 OPTIONS APPRAISAL

Drawing Title: COMPARATIVE ECOLOGICAL ASSESSMENT OF AIR QUALITY IMPACTS - WEST 2

Drawing Status: DRAFT

| | | |
|---|---|---|
| Scale @ A3 | 1:50,000 | DO NOT SCALE |
| Jacobs No. | B2327FTI | |
| Client No. | | |

Drawing No.: B2327FTI_M6J33_Extension_AirQualityResults





0 1,000 Metres

# Appendix B. Descriptions of Ecological Receptors

**Berry's Farm and Sellerley Farm Ponds, Conder Green (Approved 1993, updated 2006)**

Four ponds supporting a population of GCN. Floral species of note that were reported to be present in 2006 included fine-leaved water-dropwort, common water-crowfoot and bladder sedge all species categorised as Vulnerable in the Provisional Lancashire Red Data List of Vascular Plants (Lancashire County Council, 1998) and small pondweed (*Potamogeton berchtoldii*) classified as Sensitive. Other floral species present included water plantain (*Alisma plantago-aquatica*), water-cress (*Rorippa nasturtium-aquaticum*), marsh marigold (*Caltha palustris*), water mint (*Mentha aquatica*), floating sweet-grass (*Glyceria fluitans*), cuckooflower (*Cardamine pratensis*), bog stitchwort (*Stellaria alsine*), water forget-me-not (*Myosotis scorpioides*), tufted forget-me-not (*Myosotis laxa*) and brooklime (*veronica beccabunga*).

**Long Bank Wood (Approved 1992, updated1996)**

Ancient, semi-natural woodland situated on a moderately steep slope on a golf course and divided into two sections. The west was mainly sycamore and oak (*Quercus* sp.) with bluebell in the understorey. The east was mainly oak species with a ground flora of wood sorrel, honeysuckle (*Lonicera periclymenum*), dog's mercury, creeping soft-grass, tufted hair-grass, broad bucker fern and male fern.

**Wyresdale Road Verges (Approved 1993, updated 2013)**

Roadside embankments along Wyresdale Road and Newland Road east of Lancaster. Habitats included species-rich neutral grassland, scrub and young woodland. Species present included bee orchid, adder's tongue, common twayblade, common spotted-orchid (*Dactylorhiza fuchsii*), common centaury (*Centaurium erythraea*), hedge bedstraw (*Galium album*), sneezewort, common knapweed, smooth hawk's-beard (*Crepis capillaris*), oxeye daisy (*Leucanthemum vulgare*), yellow oat-grass (*Trisetum flavescens*), meadow vetchling (*Lathyrus pratensis*), common bird's-foot-trefoil (*Lotus corniculatus*), field wood-rush (*Luzula campestris*), crosswort (*Cruciata laevipes*), meadowsweet (*Filipendula ulmaria*), square stalked St John's-wort (*Hypericum tetrapterum*).

**Park Coppice (Approved, 1993, updated 2005)**

A semi-natural woodland adjacent to the Lancaster Canal. The canopy species included ash, sycamore, oak species, birch, wild cherry and alder. The understorey consists of hazel, holly, hawthorn, elder, bird cherry, guelder rose (*Viburnum opulus*), hornbeam (*Carpinus betulus*) and red current (*Ribes rubrum*).

The ground flora varied across the site with bluebell, male-fern, scaly male-fern, broad buckler-fern, dog's mercury, creeping soft-grass, tufted hair-grass, wood sorrel, wood anemone, lord's-and-ladies (*Arum maculatum*), yellow pimpernel (*Lysimachia nemorum*), hedge woundwort (*Stachys sylvatica*), foxglove, moschatel, enchanter's nightshade, herb-Robert, greater stitchwort, wood dock, raspberry (*Rubus idaeus*), honeysuckle, wood melick, wood sedge, ramsons, opposite-leaved golden-saxifrage, meadowsweet, bugle, hemp-agrimony, cuckooflower, common figwort (*Scrophularia nodosa*), yellow iris and square-stalked St John's-wort. Broad-leaved helleborine was also present rarely.

**Old Park Wood (Approved 1993, updated 2005)**

An ancient semi-natural woodland with a mixed canopy of birch, ash, oak species, sycamore, alder, rowan (*Sorbus aucuparia*), whitebeam (*Sorbus aria*), beech and larch. The understorey was hazel, blackthorn (*Prunus spinosa*), hawthorn, elder, holly and dog-rose (*Rosa canina*). Ground flora species included bluebell, dog's mercury, wood anemone, wood sage, red campion, honeysuckle, false brome (*Brachypodium sylvaticum*), creeping soft-grass, tufted hair-grass, male-fern, scaly male-fern and broad buckler-fern.

**Little Cockshades Wood (Approved 1993, updated 1996**

An ancient and semi-natural woodland with a canopy composed of oak species, birch, alder and ash with a holly and hazel understorey. The woodland was grazed and had a ground flora that consisted of creeping soft-grass, wood meadow-grass and wood sorrel.

**Brunstow (North) Wood (Approved 1993, updated 2011)**

An ancient and semi-natural woodland in a valley of the River Cocker. The canopy was dominated by mature oak species, ash, alder, birch, sycamore, scots pine, larch and wych elm. The wood was grazed by stock and the understory is sparse with rowan, holly and hazel. The ground flora comprised opposite-leaved golden-saxifrage, woodsorrel, enchanter's-nightshade, herb-Robert cuckooflower and foxglove.

**Brunstow Wood (approved 1993, updated 2004)**

Small ancient woodland that had a canopy of oak species, birch, sycamore, ash, sweet chestnut, larch and scot's pine. The understorey comprised hazel, rowan, hawthorn and elder. Ground flora included bluebell, broad buckler-fern, wood sorrel, greater stitchwort, red campion, herb-Robert, hedge woundwort, foxglove, opposite-