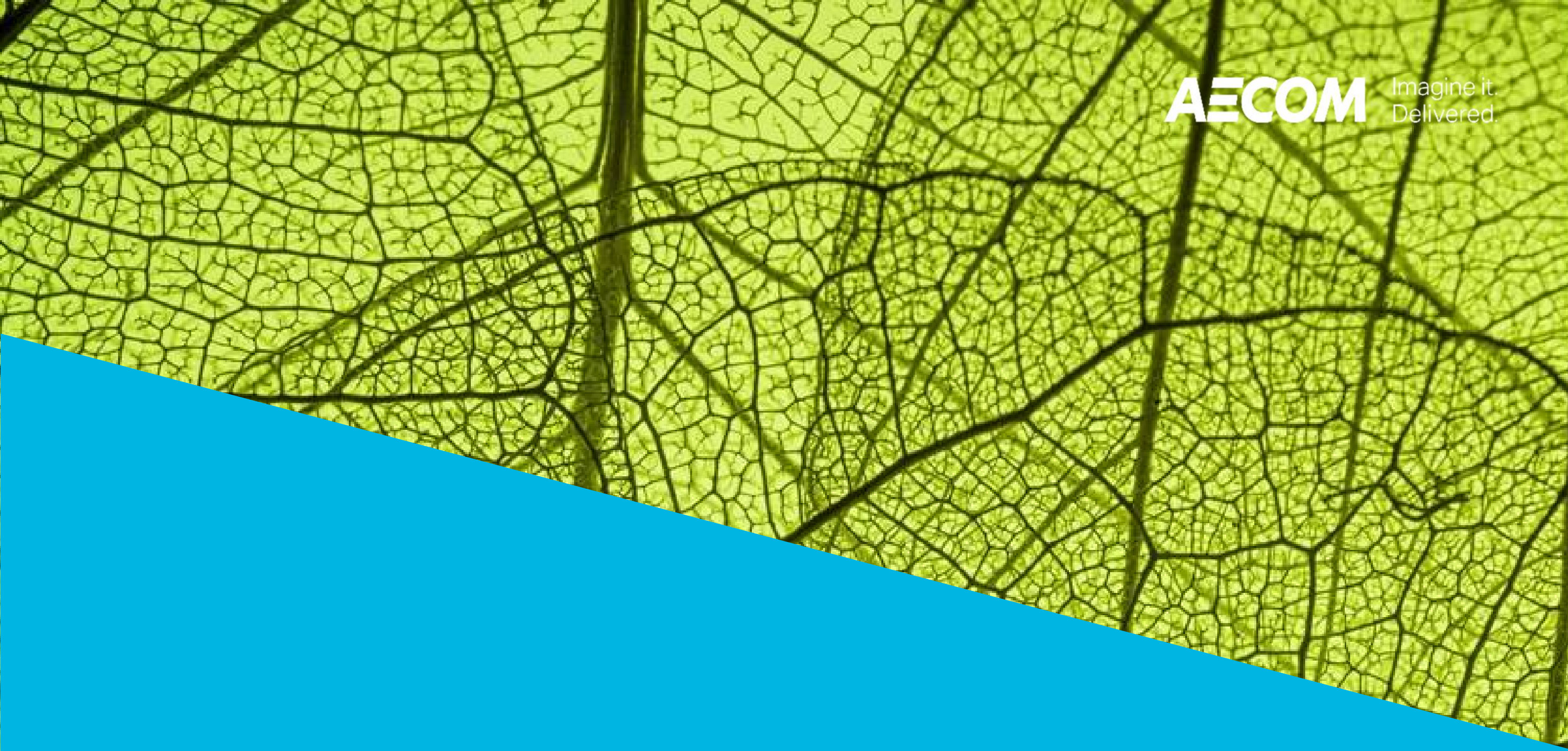

Epping Forest Special Area of Conservation

Review of Air Quality Assessment Modelling Methodology
Technical Note

Epping Forest District Council

21 February 2020

Quality information

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1. Introduction

1.1 An air quality assessment was undertaken in 2018/19 to assess the potential impact of road traffic emissions on the Epping Forest Special Area of Conservation (EFSAC). Key road links within 200m of the EFSAC were included in the model to inform the 2019 Habitat Regulations Assessment (HRA) of the submitted Epping Forest District Local Plan. Habitats within EFSAC are sensitive to concentrations of oxides of nitrogen (NOx) and ammonia (NH_3) and nutrient nitrogen levels and these can be affected by emissions from road traffic. These pollutants were assessed for the 2019 HRA and continue to be the focus of the air quality assessment.

1.2 Epping Forest District Council (EFDC) and the technical team have taken the opportunity to review the assumptions applied in the 2018/19 modelling assessment to ensure that the most appropriate information is used to provide a robust analysis of the likely future traffic conditions. The following scenarios are proposed, with further details outlined in Section 9:

- Scenario 1: 2014 Start of Plan
- Scenario 2: 2017 Baseline for verification (monitoring data collected in 2018-19, annualised to 2017)
- Scenario 3: Projected End of Plan (2033) baseline
- Scenario 4: All development to 2033 excluding modal shift and Woodgreen physical highway works (Do Something End of Plan (2033))
- Scenario 5: All development to 2033 with modal shift and Woodgreen Road/Honey Lane physical highway works (Do Something with Mitigation End of Plan (2033))
- Scenario 6: All 'in-combination' development plus EFDC development proposed to 2023 with no modal shift or Woodgreen Road/Honey Lane physical highway works (Do Something Interim Year (2023))[1]

1.3 The key parameters in determining the predicted concentrations and deposition rates that have been reviewed are:

- composition of the vehicle fleet mix in the base and future years - this is discussed in Section 2
- the methodology used to assess emissions from queuing vehicles- this is discussed in Section 3
- vehicle emission rates of NOx and NH_3- this is discussed in Section 4
- future background concentrations of NO_x, NH_3 and nitrogen deposition- this is discussed in Section 5
- model verification which compares modelled with measured concentrations for a base year and estimates a model adjustment factor which is then applied to all modelled scenarios – this is discussed in Section 6
- the need to consider ozone- this is discussed in Section 7
- the deposition velocities used to estimate nutrient nitrogen deposition – this is discussed in Section 8.

1.4 The methodology review has been prepared having regard to the relevant legal principles established by the Court of Justice of the European Union ("the Court) concerning the proper interpretation and application of Article 6 of the Habitats Directive and *'Managing Natura 2000 Sites - The provisions of*

[1] Following the completion of the first iteration of modelling, further mitigation may need to be modelled in which case an updated version of this scenario will be modelled

Article 6 of the Habitats Directive 92/43/EEC', providing guidelines to the Member States on the interpretation of certain key concepts used in Article 6 of the Habitats Directive that was published by the European Commission on 25 January 2019,[2]

1.5 In its *Waddenzee* ruling [3] the Court emphasised the importance of using the best scientific knowledge when carrying out the appropriate assessment in order to enable the competent authorities to conclude with certainty that there will be no adverse effects on the site's integrity. The appropriate assessment should apply the best available techniques and methods to assess the extent of the effects of the plan or project on the integrity of the site. The assessment carried out under that provision may not have lacunae and must contain complete, precise and definitive findings and conclusions capable of dispelling all reasonable scientific doubt as to the effects of the proposed works on the protected area concerned.[4]

[2] 2019/C 33/01
[3] Case C-127/02, paras 52-54, 59
[4] *Grace v An Bord Pleanála* (Case C-164/17) [2019] PTSR 266, para 39 and the case law cited.

2. Vehicle fleet mix

2.1 The 2019 air quality modelling used a nationally derived Vehicle Fleet Mix (VFM) obtained from Defra's Emissions Factor Toolkit (EFT) v8.0.1 for rural roads in England (not London). The EFT is the standard method for assessing emissions from traffic in the UK. Emission rates of NOx were also obtained from the EFT.

2.2 The HRA 2019 used emission rates from the EFT for the year 2023 for the purposes of providing conservative assumptions on the VFM in the air quality modelling for all future year scenarios bar the DS 5 Scenario. In the case of the DS 5 Scenario, emission rates for 2030 were used in order to provide some understanding of the efficacy of measures that had been included in the Local Plan. The use of emission rates for 2030 was questioned at the Local Plan Examination hearings as it was not considered to be representative of mitigation. Subsequently, the Local Plan Inspector, in her advice letter dated 2 August 2019 (ED98[5][6]), stated at paragraph 14 (ii) in relation to the DS 5 Scenario that:

> *"There is no direct causal link between the mitigation measures proposed in the Plan (and set out at para. 6.18 of the HRA) and the use of the 2030 DEFRA emission factors for modelling the effects of scenario DS5. Thus the evidence provided by the HRA is not robust in this respect."*

2.3 The Defra EFT is based on the average fleet composition for a given year and road type (i.e. urban, rural, motorway) and also whether the road is within London or not. In running the EFT for all scenarios (i.e. both 2023 and 2030), emission factors for rural roads were obtained as these were considered to be the most appropriate for EFSAC. This is in accordance with the Defra EFT guidance as the area being assessed doesn't comprise an urban area with a population of 10,000 or more.

2.4 By using the EFT's 'rural' road vehicle fleet, the modelling did not take account of electric vehicle usage, as the proportion of these vehicle types on rural roads was set as zero in the EFT although hybrids were included. It is noted that a text error in the HRA 2019 stated that the emission rates for 2030 provided the opportunity to reflect increases in the ownership and use of electric vehicles which would be facilitated by the policy requirements of the submitted Local Plan for the provision of Electric Vehicle Charging Points. This implied that the emission rates for 2030 took account of electric vehicles which was not, in fact, the case. Electric vehicles are only included in the vehicle fleet mix in 2030 for urban roads.

2.5 The Defra EFT used was version v8.0.1 which was published in December 2017. An updated version (EFTv9) was published in May 2019. The new version provided a number of updates, which are currently being analysed. These include a new Advanced Fleet Option 'Fleet Projection Tool' that allows users to project their own, user defined, Euro fleet information from a Base Year to a future Projection Year, rather than using the generic average fleet mix. The guidance published alongside the toolkit gives the specific example of how this could be used as being 'a local Euro fleet derived from Automatic Number Plate Recognition (ANPR) surveys.'

2.6 As ANPR surveys were undertaken in 2017, and recognising that the EFT provides options to specify the Euro classification of the fleet used in the emission calculations, as stated in the EFT guidance, to *"... more accurately reflect local conditions ..."*, the Council considers that such an option should be explored, and adopted in this next stage of air quality modelling.

2.7 Further ANPR surveys were undertaken for three days between Tuesday 15 October 2019 and Thursday 17 October 2019 at 8 locations within the EFSAC area in order to capture the majority of vehicles entering into it. These were considered to be neutral days and at a time where there were no school holidays, in line with best practice. Within the context of the approach taken to develop the national EFT VFM, the Council considers that capturing of three days of ANPR data provides a robust and more 'certain' data set and should be used to inform a 'bespoke' VFM for the EFSAC air quality modelling.

2.8 An analysis of the 2017 and 2019 ANPR data will be undertaken.

[5] Case C-164/17; [2019] PTSR 266, para 39 and the case law cited
[6] http://www.efdclocalplan.org/wp-content/uploads/2019/08/ED98-Epping-Forest-Post-hearing-Advice-Aug-2019-V1-final.pdf

Refinements to 2019 HRA Methodology

2.9 The new Advanced Option ‘Simple Entry Euro Compositions’ in EFT v9 will be used to input User Defined Euro Classes (2017 ANPR data) for the baseline modelling scenario (Scenario 2). The NOx/NO_2 results from the baseline modelling assessment will be verified against monitoring data as set out in LAQM.TG(16), annualised to the same year.

2.10 The vehicle fleet used in the future assessment years will be derived from the 2019 ANPR data using the new Advanced Option ‘Fleet Projection Tool’ in EFT v9. This tool is designed specifically to allow the users to project their user defined Euro fleet information from the ANPR derived Euro fleet data to a future Projection Year. The 2019 ANPR data cannot be used to assess air quality in 2019 for model verification as monitoring data for 2019 is not available.

2.11 The future years to be assessed are 2023 (interim year for Scenario 6) and 2033 (end of plan for Scenarios 3-5). Scenarios 3-5 will be assessed using emission rates for 2030 as that is the latest year for which information is available in the EFT, and Scenario 6 will be assessed using emission rates for 2023. As sensitivity tests, Scenarios 3-5 will also be assessed using conservative assumptions.

2.12 The 2030 emission rates will provide an estimate of what is most likely to occur, whilst the more conservative sensitivity tests will illustrate what could happen should the improvements in vehicle emissions not materialise as expected. The emission rates for the sensitivity tests will be determined following the analysis of the projected 2030 emission factors / vehicle fleet (derived from ANPR data) and discussed with Natural England before the sensitivity tests are carried out.

2.13 The use of the ANPR datasets has multiple benefits to the air quality modelling assessment:

- Source apportionment – the predominant source of pollution can be accurately identified to inform more bespoke mitigation measures;
- Vehicle fleet evolution – The EFT v9 fleet projection tool will be used to inform future model scenarios, and specific mitigation measures which may affect the vehicle fleet composition;
- Periodic future ANPR surveys are proposed to track the evolution of the vehicle fleet. These will be scheduled to support the national requirement for Local Plans to be reviewed every five years. Should the vehicle fleet be found to evolve in a different way to that that has been predicted in the air quality modelling, a review of the modelling will be undertaken.

3. Assessment of queuing traffic

3.1 The methodology used to estimate emissions from queuing traffic for the HRA 2019 were based on the Cambridge Environmental Research Consultancy (CERC) methodology. The CERC methodology is one of a number of valid approaches to modelling emissions from queueing traffic.

3.2 Since the original modelling was completed EFDC/AECOM have been in touch with CERC to check the application of the methodology given in CERC's note 60, from 2004.

3.3 The method provides an estimate of the number of vehicles per lane that would pass a point when travelling at 5km/h, assuming an average vehicle length of 4m, which equates to a traffic flow of 30,000 AADT if the queue was continuous for 24 hours per day. In their telephone and email correspondence of 7 December 2019, CERC clarified that this should be applied instead of the forecast traffic flow, not additionally.

3.4 As the 2019 HRA applied the 30,000 AADT flow for queuing traffic as well as the forecast vehicle flow, there was a 'double-counting' of emissions where queuing traffic was modelled. This will be amended and refined in the forthcoming updated modelling work.

3.5 For the 2019 HRA, queue lengths were taken from the VISSIM traffic model. The maximum of the 10-minute average queue length, for a typical hour within each time period, and applied for the duration of the time period in question. If the distance was less than 25m (i.e. ~5 cars) it was not considered to be a queue.

3.6 It should be noted that the queue length parameters previously reported, in the 2019 HRA, followed TfL's VISSIM Model Audit Process (VMAP) guidelines, which limited reported queue length outputs to 500m and underestimated queue lengths on some links. The updated methodology removes this limiting parameter and any queue lengths exceeding 500m will be fully reported in the revised VISSIM outputs and subsequent air quality modelling.

3.7 The 2019 HRA calculated forecast traffic flows using factors from observed traffic counts to convert peak hour flows into 24-hour weekday rather than AADT flows, which should also account for average weekend flows in any calculation. The updated methodology combines observed weekday and weekend traffic count data to derive appropriate expansion factors to calculate AADT flows.

3.8 A further step has been taken, using the observed traffic count data, to apportion the total AADT flows into the following time periods for air quality modelling so as to account for the variation in traffic flow through the day:

AM peak: 0700-1000h (3 hours)
Inter-peak: 1000-1600h (6 hours)
PM peak: 1600-1900h (3 hours)
Off-peak: 1900-0700h (12 hours)

3.9 Ammonia emissions are discussed in Section 4. Given that there is no information on how emissions of NH_3 from road traffic vary with vehicle speed and that the emission factors have a greater level of uncertainty associated with them than those for NOx, it is not considered appropriate to estimate emissions of this pollutant from queuing traffic in the same way as emissions of NOx from road traffic (as was previously presented in 2019 HRA). Emissions of ammonia included in the updated modelling are addressed in Section 4.

Refinements to 2019 HRA Methodology

3.10 The updated air quality model will use the appropriate vehicle flows for each of the time periods. The queue length for each time period will have traffic speeds reduced to 5km/h for the duration of said period. This methodology is in-line with the LAQM.TG(16) methodology for idling traffic ('the EF may be assumed to be equal to that corresponding to the vehicle travelling at 5km/h (the lowest possible speed in the EFT)' - paragraph 7.249), whilst also taking into account the diurnal variation in traffic flows and queue lengths.

3.11 As there is no information available to quantify how NH_3 emissions change at slow speeds or idling, this cannot be taken into account in the modelling. Emissions of NH_3 from queuing traffic will therefore not be included in the updated modelling. Emissions of ammonia included in the updated modelling are addressed in Section 4.

3.12 The removal of the TfL VMAP 500m queue length parameter will increase reported and assessed queueing on some links and responds to representations made during the 2019 hearing, by the Conservators of Epping Forest, regarding the potential underestimation of certain queue lengths. This methodology is considered to be precautionary as the maximum of the modelled 10-minute queue lengths will be applied for the duration of each time period.

4. Emission Factors

NO_x

4.1 Updated NOx emission factors are available from the latest version of the EFT v9. These will be used in the assessment rather than the superseded emission rates from v8.0.1 which were used in the 2019 HRA.

4.2 The release of v9 of the EFT was accompanied by a number of updated tools (e.g. 'NOx-to-NO_2 toolkit') which will be used with the updated EFT.

Ammonia

4.3 Ammonia (NH_3) emissions can be emitted from road vehicles equipped with catalyst devices to control NOx emissions. Ammonia is an unintended by-product of the NOx reduction process on the catalyst and was more pronounced for early generation petrol cars with catalysts (Euro 1 and 2). Factors for later petrol vehicle Euro standards and diesel light duty vehicles are lower. The NH_3 factors for heavy duty vehicles are also low but increase for later Euro V and VI standards due to ammonia slip from the Selective Catalytic Reduction (SCR) system.

4.4 Guidance is provided on how to assess air quality at ecological sites in the Design Manual for Road and Bridges (DMRB) LA105 Air Quality[7]. This guidance requires NOx concentrations and increased nitrogen deposition due to the dry deposition of NO_2 to be assessed. It does not require NH_3 to be assessed as concentrations could be elevated above background levels only within a very small area (within about 10m of the road) so emission rates for NH_3 are not provided.

4.5 Agriculture is the dominant source of ammonia emissions nationally, contributing 84% of English emissions in 2017. In 2017, transport contributed just 2% and waste 4.5%. The locations of and emissions from agricultural sources will be key to determining concentrations in a particular location.

4.6 Emission rates of NH_3 are not included in the EFT as ammonia from traffic is not of concern for human health. The National Atmospheric Emissions Inventory (NAEI) does provide NH_3 emission factors based on information from the EMEP/EEA Emissions Inventory Guidebook (2016, July 2018 update)[8] and COPERT 5 source. Emission factors from the NAEI for each emission standard are illustrated in Table 1, as presented in 'Methodology for the UK's Road Transport Emissions Inventory - Version for the 2016 National Atmospheric Emissions Inventory'[9].

7 Highways England's Design Manual for Road and Bridges (DMRB), LA104 Air Quality, November 2019 (formerly HA 207/07, IAN 170/12, IAN 174/13, IAN 175/13, parts of IAN 185/15), available at: https://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/LA%20105%20Air%20quality-web.pdf

8 https://www.eea.europa.eu/publications/emep-eea-guidebook-2016/part-b-sectoral-guidance-chapters/1-energy/1-a-combustion/1-a-3-b-i/view

9 https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1804121004_Road_transport_emissions_methodology_report_2018_v1.1.pdf

Table 1: NAEI NH_3 Emission Factors (g/km)

Type	Euro standard	Urban	Rural	Motorway
Petrol car and LGV	Pre-Euro 1	2	2	2
	Euro 1	70	131	73
	Euro 2	143	148	83
	Euro 3	2	30	65
	Euro 4	2	30	65
	Euro 5 -6	4	8	22
Diesel car and LGV	Pre-Euro 1 – Euro 4	1	1	1
	Euro 5- Euro 6	2	2	2
HGV rigid + articulated	Pre-Euro 1 – Euro 4	3	3	3
	Euro 5	11	11	11
	Euro 6	9	9	9
Buses and coaches	All	3	3	3

Note: The base emission factors in this table are given for zero accumulated mileage

4.7 The vehicle fleet composition in terms of Euro emission standards, taken from the NAEI fleet projections[10], for the years of interest in this study are shown in Table 2 for petrol cars and Table 3 for rigid HGVs. In 2017, the majority of vehicles are predicted to be Euro 4-6. By 2023, the majority of vehicles are predicted to be Euro 6 with some being Euro 5. Emissions of NH_3 are therefore expected to be slightly lower in 2023 than in 2017. The main sources in all years are expected to be petrol LDVs and HGVs.

Table 2: Fleet Composition for Petrol Cars

Conventional Petrol car	2017	2023	2030
Pre-Euro 1	-	-	-
Euro 1	-	-	-
Euro 2	1%	-	-
Euro 3	10%	-	-
Euro 4	22%	3%	-
Euro 5	33%	14%	1%
Euro 6	34%	83%	99%

Table 3: Fleet Composition for Rigid HGVs

HGV-rigid	2017	2023	2030-2033
Pre-Euro 1	-	-	-
Euro 1	-	-	-
Euro 2	1%	-	-
Euro 3	8%	1%	-
Euro 4	8%	1%	-
Euro 5	26%	7%	-
Euro 6	57%	91%	100%

4.8 The NAEI has estimated NH_3 emissions for each vehicle type in 2017[11] and has taken account of the cumulative mileage of each vehicle type, cold starts and other relevant factors. These emission factors are shown in Table 4. Unlike road vehicle emissions of NOx, the NH_3 emission factors given in the EMEP/EEA Emission Inventory Guidebook and in the NAEI do not vary by speed.

[10] Base 2018 Vehicle Fleet Composition Projections (used in EFT v9) https://naei.beis.gov.uk/data/ef-transport
[11] Fleet Weighted Road Transport Emission Factors 2017 https://naei.beis.gov.uk/data/ef-transport

Table 4: NH_3 Emission Rates by Vehicle Type in 2017

Vehicle Type	Emission rate (g/km)
Petrol cars	0.015
Diesel cars	0.003
Petrol LGVs	0.020
Diesel LGVs	0.003
Rigid HGVs	0.009
Artic HGVs	0.009
Buses	0.003

4.9 The EMEP/EEA Emissions Inventory Guidebook considers that only the NH_3 emission factors for petrol passenger cars with catalysts are considered to be “statistically significant based on sufficiently large set of measured and evaluated data”. For other vehicles emissions, factors are based upon “a small set of data”, or “available literature is used” or “similarity considerations / extrapolation are applied”. This demonstrates that there is considerable uncertainty in the emission factors, although it is based upon the best available information.

4.10 The NAEI comments that ammonia emission estimates are more uncertain than those for sulphur dioxide and NOx, largely due to the nature of the major agricultural sources which are more diffuse and therefore difficult to model spatially. Ammonia emissions have therefore been assigned a moderate uncertainty rating whereas NOx emissions have a low uncertainty rating.

4.11 Currently, hybrid vehicles are treated in the same way as their petrol counterparts for ammonia emissions. Comparing emission factors from a small petrol car to a small hybrid, it can be seen that hybrid vehicles have similar emission rates to Euro 3 or Euro 4 standard vehicles, as shown in Table 5 for Tier 2 exhaust emission factors.

Table 5 Tier 2 exhaust emission factors for passenger cars

Type	Euro standard	NH_3 (g/km)
Petrol car Small	Pre-Euro 1	0.002
	Euro 1	0.092
	Euro 2	0.104
	Euro 3	0.034
	Euro 4	0.034
	Euro 5 -6	0.012
Hybrid Petrol Small	Euro 4 and later	0.033

Source: EMEP/EEA Guidebook Table 3-17

Refinements to 2019 HRA Methodology

4.12 Ideally, vehicle emission rates of ammonia in future years should take into account changes in the vehicle fleet and Euro emission standards. The ANPR survey data will provide more information on the likely EFSAC fleet composition and how it may differ from the national fleet. However, to incorporate this data, a lower tier methodology would likely have to be used, which distinguishes between different Euro standards but does not take into account other parameters such as cumulative mileage and cold starts.

4.13 The NAEI emission factors are provided for an average UK vehicle fleet only in the given year (factors for years up to 2017 are published). As information is not explicitly available to take account of accumulated mileage for each emission standard in future years, the NAEI NH_3 emission factors for the latest year , 2017, will be used for all future years but the change in the proportion of vehicle type (that is the proportions of petrol cars, diesel cars, petrol vans, diesel vans etc) in future years will be taken into account, as was previously undertaken. As emissions from each vehicle type will not decrease in future years, this is a conservative assumption.

4.14 The available evidence suggests that it is reasonable to assume the same emission rates of ammonia from hybrid vehicles and their petrol/diesel counterparts. No change from the previous methodology for hybrids is therefore proposed.

5. Background concentrations and deposition rates

5.1 The updated background maps issued to accompany EFT v9 will be used. Background concentrations of NOx for the year 2023 will be used for Scenario 6 and for 2030 for Scenarios 3-5. As sensitivity tests, Scenarios 3-5 will also be assessed using conservative assumptions, as outlined in paragraphs 2.11 and 2.12.

5.2 Background NH_3 concentrations and nitrogen deposition rates for the 3-year average 2015-2017 will be used for all scenarios. This information will be obtained from the APIS website for the 5 km grid square containing the relevant receptor. This is considered to be a precautionary approach as it is reasonable to anticipate a decrease in background total nitrogen deposition by 2033. Measures expected to contribute towards a decrease within this timescale are the penetration of 'cleaner' vehicles in the national fleet e.g. Euro 6, and the implementation of mitigation measures outlined in the 2019 Clean Air Strategy[12] for agricultural ammonia emissions.

6. NH_3 Monitoring data and model verification

Ammonia monitoring techniques

6.1 Defra monitors NH_3 concentrations as part of the UK Eutrophying and Acidifying Atmospheric Pollutant (UKEAP) at 95 sites. DELTA samplers (DEnuder for Long-Term Atmospheric sampling) are used at 59 of these sites. DELTA samplers require an electrical supply to operate so are not practical for many rural monitoring sites. A secondary network of ALPHA samplers (Adapted Low-cost Passive High Absorption) are employed at a further 49 sites to assess regional and local scale variability in NH_3 concentrations.

6.2 The ALPHA method is calibrated against the DELTA method at 12 sites within the network with a bias adjustment factor of 0.33 applied to the ALPHA results. The DELTA sampler provides the most robust estimates of NH_3 concentrations.

6.3 A comparison of measurements made in 2018 at sites with both types of samplers is shown in Table 6. The ALPHA sampler measurements were in the range -23% to +38% of the DELTA sampler measurements. There appears to be more variation in the ratios than would be the case with NO_2 diffusion tube results (compared with chemiluminescent analysers), bearing in mind that national bias adjustment factors have already been applied to the ALPHA results. This indicates that the NH_3 measurements made using ALPHA samplers have a greater level of uncertainty associated with them than the more robust DELTA samplers.

[12] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770715/clean-air-strategy-2019.pdf

Table 6: Measured Ammonia Concentrations (µg/m^3) by DELTA and ALPHA Samplers at UKEAP sites in 2018

Site	DELTA	ALPHA	Ratio
Auchencorth Moss	0.98	1.26	1.29
Glensaugh	0.37	0.35	0.92
Lynclys Common	2.39	2.36	0.99
Moorhouse	0.58	0.75	1.29
Rothmansted	1.16	1.48	1.28
Stoke Ferry	2.11	2.92	1.38
Sourhope	1.19	0.92	0.77

6.4 Diffusion tubes were used to measure NH_3 in the National Acid Monitoring Network up until 2000. The tubes have been used to measure NH_3 for many decades but with mixed success. Some studies found them to perform satisfactorily whilst others found them to substantially overestimate at ambient levels. Although NH_3 diffusion tubes can be shown to perform adequately, CEH recommends that any implementation should be supported by ongoing reference data[13]. Due to their ready availability and ease of deployment, ammonia diffusion tubes were used to monitor concentrations of the pollutant in EFSAC from May 2018 to February 2019 with some tubes co-located with an ALPHA sampler to enable bias adjustment of the results to improve their accuracy. The locations of the tubes were agreed with the Conservators of Epping Forest.

6.5 A three-month co-location study was undertaken from December 2018 to February 2019 at the London Cromwell Road UKEAP network site in order to derive a bias adjustment factor for the EFSAC diffusion tube survey. The Cromwell Road monitoring station is equipped with the ALPHA passive sampler that measures gaseous ammonia on a monthly basis. A bias adjustment factor of 0.59 was calculated, indicating that the diffusion tubes overestimated NH_3 concentrations by approximately 40% on average in comparison to the ALPHA sampler. This bias adjustment factor was applied to the diffusion tube results.

6.6 At some of the monitoring sites in EFSAC, three tubes were exposed, whilst at other sites, only one tube per month was exposed. There was a large variation in the individual measurements made at the sites with three tubes, during many of the months of the survey indicating that the precision (ability of a measurement to be consistently reproduced) of the tubes was poor.

6.7 Ammonia measurements made using diffusion tubes have a much higher level of uncertainty associated with them compared with diffusion tubes for NO_2 and DELTA/ALPHA samplers for NH_3 and so should be treated with a degree of caution.

Model verification

6.8 In the previous round of air quality modelling, just six months of NO_2 measurements were used for model verification. In addition, the factor derived for NOx was also applied to modelled concentrations of NH_3 as data were not available at the time of modelling to undertake a bespoke verification exercise for the pollutant.

6.9 The full nine months of NO_2 and NH_3 monitoring data are now available. Thus far, the NH_3 monitoring data have been annualised to 2018. The annualisation factor applied to the nine month mean was 1.09 based on the average factor calculated from four national UKEAP monitoring sites (Rothamsted, Burnham Beeches, Alice Holt 2, Thursley Common 2). Three of the sites had similar factors (1.01 -1.06) whilst the fourth factor from Thursley Common 2 was much higher with 1.24. If the fourth site was not included in the analysis, the average verification would reduce to 1.04 and thus reduce the estimated annual mean concentrations by 5%.

13 CEH, Development and types of passive samplers for monitoring atmospheric NO_2 and NH_3 concentrations, The Scientific World , 2001.

6.10 Even at 200m from a road, the EFSAC diffusion tube monitoring data after bias adjustment indicates concentrations of around 2-2.5 µg/m^3. The APIS website indicates that NH_3 concentrations in EFSAC were fairly static between 2006 and 2014 with around 1.1 µg/m^3 but increased in 2016 to around 1.5 µg/m^3. The EFSAC diffusion tube survey measurements were also higher than the measurements made at the four UKEAP sites in the south-east of England and this suggests that the diffusion tubes were over-reading concentrations.

6.11 Using diffusion tube NH_3 measurements to verify model predictions is questionable due to the high level of uncertainty associated with the survey measurements.

Refinements to 2019 HRA Methodology

6.12 The Clean Air Strategy 2019 is working towards reducing ammonia emissions from agriculture, however the size of the reduction expected is not yet known. Therefore, background ammonia concentrations within the EFSAC modelling will be assumed to remain constant.

6.13 A revised verification will be undertaken using the full nine month set of monitoring data annualised to 2017, to correspond with the traffic data collected and used in the 2017 baseline model.

6.14 In light of the uncertainty relating to the NH_3 measurements made in EFSAC using diffusion tubes and the greater uncertainty in NH_3 emissions than of NOx from road traffic, the nitrogen deposition calculations will be based on NO_2, with NH_3 contributions included as a sensitivity test. Similarly, mitigation measures will be primarily focused on NOx.

7. Consideration of ozone

7.1 Natural England queried whether or not there was value in taking ozone into account in the EFSAC air quality modelling, in their letter submitted to the Local Plan Inspector in May 2019 (ED62[14]).

7.2 The action of sunlight on a mixture of nitrogen oxides and organic compounds leads to the formation of ground level ozone (O_3). The chemical reactions producing ozone are quite slow so this pollutant builds up in polluted air over several days under suitable weather conditions. This air often comes from continental Europe. Ozone formation consists of the recombination of atomic and molecular oxygen at lower levels in the atmosphere with the main source of atomic oxygen being the photolysis of NO_2 (nitrogen dioxide). The ozone generated in this mechanism may react with nitrogen monoxide (NO) to reform NO_2, which is a fast reaction. During hours with sunlight and away from combustion sources, a photochemical steady state can be achieved with the amount of ozone being destroyed being equal to the amount of ozone being generated in this way. In the absence of significant ozone formation such as at night-time, the ozone concentration decreases due to reactions with NO and through ozone deposition to the surface such as vegetation.

7.3 Near roads, concentrations of NO are high so the ozone reacts with the NO to form NO_2. Concentrations of ozone next to roads are therefore reduced and are lower than in areas away from pollution sources. We are not aware of any measurements of ozone having been made in the Forest so have to rely on national monitoring data to illustrate this. Measured ozone concentrations at a rural site (Lullington Heath), at a heavily trafficked urban site (London Marylebone Road) and an urban background site in Thurrock are shown in Table 7. Ozone concentrations are highest at the rural site and lowest at the heavily trafficked site in London due to ozone reacting with NO in the polluted areas.

Table 7: Measured Ozone Concentrations (μg/m^3) in 2018

Annual mean (μg/m^3)	**London Marylebone Rd** ***Urban site***	**Lullington Heath** ***Rural site***	**Thurrock** ***Urban background site***
O_3	24	85	43

7.4 Ozone concentrations next to roads in EFSAC will be lower than in areas well away from roads. As the reactions to form ozone from NOx and hydrocarbons are slow, ozone concentrations will not be increased in EFSAC due to the traffic travelling through the Forest. The net effect of the traffic in EFSAC is to reduce ozone concentrations within the Forest.

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7.5 Ozone is not considered to be a pollutant of concern as it will be present in low concentrations in EFSAC due to the high levels of traffic. It will therefore not be considered any further in the air quality assessment.

[14] http://www.efdclocalplan.org/wp-content/uploads/2019/05/ED62-Natural-England-Assessment-of-likely-effects-of-NOx-and-ammonia-including-methodological-issues-.pdf

8. Deposition velocities

8.1 The Inspector, in her Advice letter of 2 August 2019 (ED98), set out the following:

"*14. In relation to air quality, the key issues to address as I see them are set out below. However, in this technical area I must, to some extent, rely upon the experts to refine them if necessary.*

i. Unmitigated growth scenario DS2: This might not account fully for nitrogen deposition because the modelling is based on "dwarf, shrub, heath" rather than tall forest vegetation.

…

15. In respect of how these issues should be addressed, hopefully it is quite straightforward to model for tall rather than short vegetation where appropriate. Where it is found that the Plan would either increase the dose of the relevant pollutants, or would delay the rate at which the pollutants would fall to acceptable levels, then appropriate work should be undertaken to enable the effects of this to be understood at the location/habitat specific level. Whilst participants in the hearing advocated surveying the entire forest to understand its present condition, this would not seem either proportionate or necessary to assess the effects of planned growth. Indeed if mitigation can be secured to reduce the effects of the Plan, then the need for survey work could be reduced accordingly."

8.2 The deposition rate used in the assessment for the 2019 HRA was based on published guidance in the Design Manual for Roads and Bridges (DMRB), Volume 11, Chapter 3, Part 1 Air Quality which was current at the time of the assessment. This guidance was updated in November 2019 and now contains deposition rates for short and tall vegetation.

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8.3 All scenarios will be provided based on both 'heathland' and 'tall vegetation' deposition velocity factors. The data will be presented as contour plots for the main scenarios, with the appropriate deposition velocity used for the appropriate area.

8.4 The deposition rates of NO_2 and NH_3 will be consistent with the Institute of Air Quality Management's (IAQM) June 2019 guidance, "A guide to the assessment of air quality impacts on designated nature conservation sites" (v1.0 June 2019)[15], which has been taken from Air Quality Technical Advisory Group (AQTAG) guidance[16]:

- grassland: NO_2 deposition velocity = 0.0015 m/s;
- forest: NO_2 deposition velocity = 0.003 m/s;
- grassland: NH_3 deposition velocity = 0.02 m/s;
- forest: NH_3 deposition velocity = 0.03 m/s.

8.5 It should be noted that the deposition rates of NO_2 given in Highways England's recently released and updated DMRB guidance for air quality, LA 1051[17], are consistent with those cited in the 2019 IAQM guidance (grassland and similar habitats: 1 $\mu g/m^3$ of NO_2 = 0.14 kg N/ha/year; forests and similar habitats: 1 $\mu g/m^3$ of NO_2 = 0.29 kg N/ha/year). The DMRB guidance does not cite deposition rates for NH_3

15 https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2019.pdf
16 Air Quality Technical Advisory Group, 2014, AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air.
17 http://www.standardsforhighways.co.uk/ha/standards/dmrb/vol11/section3/LA%20105%20Air%20qualityweb.pdf

9. Model scenarios

9.1 In order to assess the impact of the growth proposed in the Local Plan, including changes in the proposed allocations and/or site capacity assumptions arising from the Inspector's advice (ED98) upon air quality, the following model scenarios are proposed:

Scenario 1: 2014 Start of Plan:

Traffic flows will be projected back to 2014. This is to represent the situation at the beginning of the plan period. Vehicle fleet / emission factors will be projected back to 2014 using the ANPR-defined vehicle fleet if feasible, otherwise Defra 2015 fleet and emission factors will be used.

Scenario 2: 2017 Baseline for model verification:

Monitoring data was collected in 2018-19 and will be annualised to 2017. Traffic flows will be based on traffic data collected in 2017, and vehicle fleet / emission factors will use the 2017 ANPR data.

Scenario 3: Projected End of Plan (2033) baseline:

Traffic flows will be based on traffic data collected in 2017, and vehicle fleet / emission factors will be projected to 2030 from 2019 ANPR data. This uses the 2017 Baseline traffic flows from Scenario 2, but uses the composition of the vehicle fleet projected to the end of the Local Plan period. In other words, this is the situation we would expect in 2033 in the absence of any further growth.

Scenario 4. All development to 2033 excluding modal shift and Woodgreen physical highway works (Do Something End of Plan (2033)):

Traffic flows will be projected to 2033 from data collected in 2017 (i.e. including projected traffic growth using Tempro factors) + all development including the updated quantum of development in the EFDC Local Plan, taking account of the Inspector's advice (ED98). The vehicle fleet / emission factors will be projected to 2030 from 2019 ANPR data.

Scenario 5: All development to 2033 with modal shift and Woodgreen Road/Honey Lane physical highway works (Do Something with Mitigation End of Plan (2033)):

Traffic flows will be projected to 2033 from data collected in 2017 (i.e. including projected traffic growth using Tempro factors) + all development including the updated quantum of development in the EFDC Local Plan, taking account of the Inspector's advice (ED98), + modal shift and Woodgreen physical highway works. Vehicle fleet / emission factors will be projected to 2030 from 2019 ANPR data. This is therefore the 2033 situation including all planned growth and with some interventions that will constitute mitigation. Following the completion of the first iteration of modelling further mitigation may need to be modelled, in which case an updated version of this scenario will be modelled.

Scenario 6: All 'in-combination' development plus EFDC development proposed to 2023 with no modal shift or Woodgreen Road/Honey Lane physical highway works (Do Something Interim Year (2023)):

Traffic flows will be projected to 2023 from data collected in 2017 (i.e. including projected traffic growth using Tempro factors) + all development included in the EFDC Local Plan Housing Trajectory for development proposed to be delivered up to 2023. Vehicle fleet / emission factors will be projected to 2023 from 2019 ANPR data.

10. Summary of refinements and updates

10.1 As set out above, the refinements and updates to the EFSAC air quality modelling methodology are as follows:

1. The use of ANPR data to define the vehicle fleet in base and future years with future year projections based on forecasts from a tool within the EFT (Section 2);
2. Queue lengths for the four periods of the day will be used with NOx emission rates based on those at 5 km/hr for queuing vehicles (Section 3);
3. Emissions of ammonia from queuing traffic will not be modelled (Section 3);
4. Queue lengths on some links may increase beyond 500m (Section 3);
5. Emission rates for NOx will be taken from EFT v9 (Section 4);
6. 2017 NAEI emission rates for ammonia will be used for all scenarios, with the change in proportion of vehicle type taken into account (Section 4);
7. Background NOx concentrations and NOx emission rates for 2030 will be used for Scenarios 3-5 and those for 2023 for Scenario 6 (Section 5);
8. Scenarios 3-5 will also be assessed using conservative assumptions, as sensitivity tests (Section 2);
9. Background NH_3 concentrations, background nitrogen deposition rates and NH_3 emission rates will be assumed to remain at current levels for all scenarios assessed. (Section 5);
10. Due to the much greater uncertainty associated with NH_3 predictions and measurements both nationally and locally, EFSAC mitigation will focus primarily on NOx (Section 6);
11. Nitrogen deposition rates will be assessed for both long and short vegetation using AQTAG deposition rates (Section 8).

10.2 The changes to the methodology are summarised in Table 8.

Table 8: Proposed Changes to Methodology

Parameter	**2019 HRA**	**Updated method**
Vehicle fleet mix	Based on national vehicle fleet for outside London	Based on ANPR data obtained on-site and projected to 2023 and 2030
NOx emission rates	Emission factors from EFT v8.0.1 2023 factors for Scenarios 3, 4 & 6 2030 factors for Scenario 5	Emission factors from EFT v9 2023 factors for Scenario 6 2030 factors for Scenarios 3-5 Scenarios 3-5 will also be assessed using conservative assumptions, as sensitivity tests
NH_3 emission rates	2016 factors for rural roads with the proportion of each vehicle type updated for future years.	2017 factors for rural roads with proportion of each vehicle type updated for future years

Consideration of NH_3	Included in all predictions	Included, however, EFSAC mitigation will focus primarily on NOx
Background concentrations	2023 NOx background for Scenarios 3, 4 and 6 2030 NOx background for Scenario 5 2014-2016 NH_3 and N background, decreased for future scenarios	2023 NOx background for Scenario 6 2030 NOx background for Scenarios 3-5 Scenarios 3-5 will also be assessed using conservative assumptions, as sensitivity tests 2015-2017 NH_3 and N background for all scenarios
Queuing vehicles	CERC methodology to calculate emissions with maximum 10 minute average queue length, and 500m truncation	NOx emissions at 5 km/hr and maximum 10 minute average queue length during four modelled time periods, 500m truncation removed
Deposition rates	Short vegetation	Short and tall vegetation

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