



Air Quality Input for Habitats Regulations Assessment: Pevensey Levels

August 2018



Experts in air quality
management & assessment

Document Control

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1 Introduction

- 1.1 This report considers the potential for adverse air quality impacts on the Pevensy Levels Special Area of Conservation (SAC) and Ramsar Site caused by traffic generated by the Wealden Local Plan. The assessment is intended to assist Wealden District Council in meeting its Habitats Regulations duty as relevant to plan making and in particular for the purposes of assessing the proposals contained within the Wealden Local Plan.
- 1.2 Pevensy Levels are designated as a Ramsar site, Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI). The Pevensy Levels are considered to be important due to the fact that the Levels are one of the largest lowland grassland systems in the southeast which supports rare species such as freshwater molluscs, dragonflies, the fen raft spider and a significant grouping of breeding and wintering wildfowl. The SAC is designated because of the presence of *Anisus vorticulus* (Little whirlpool ramshorn snail) for which this is considered to be one of the best areas in the UK.
- 1.3 The main air pollutants of concern related to traffic emissions and the potential for adverse impacts on the Pevensy Levels are nitrogen oxides (NO_x) and ammonia (NH₃) concentrations, and nutrient-nitrogen deposition.
- 1.4 This assessment has been carried out by Air Quality Consultants Ltd on behalf of Wealden District Council. A summary of the professional experience of the staff contributing to this assessment is provided in Appendix A1. The approach is relatively simplistic when compared with work that has been carried out by Air Quality Consultants Ltd. for Ashdown Forest. The key differences are:
 - no local measurements (of air quality, traffic flows, or vegetation characteristics) have been made for this study, meaning that the results will be less robust and less precise than those for Ashdown Forest;
 - the dispersion modelling has only considered a relatively small number of receptor locations, which means that, while maximum concentrations and fluxes can be calculated, and isopleths can be plotted, it has not been possible to present the results in the same level of detail as for Ashdown Forest; and
 - only the roads running through this SAC were included within the transport model, and so the effects of changes in traffic caused by the Local Plan on roads more than 200 m from the SAC have not been considered.

Despite these differences, both studies have used the same general approach to dispersion modelling, emissions calculations, future-year projections, and deposition modelling.

2 Assessment Criteria

Assessment Criteria

- 2.1 Critical levels and critical loads are the ambient concentrations and deposition fluxes below which significant harmful effects to sensitive ecosystems are unlikely to occur. The critical levels relevant to this assessment are set out in Table 1, while the critical loads are provided in Table 2¹.
- 2.2 The critical loads have been defined from the Air Pollution Information System (APIS) for 'Coastal and Floodplain Grazing Marsh' which most closely corresponds to habitats within the Pevensy Levels. APIS does not provide critical loads for water habitats, such as ditches, which form part of the Ramsar designation, nor for the *Anisus vorticulus* species (SAC designation). In addition there are no comparable habitats with an established critical load estimate available for those habitats where the Damselfly, Dragonfly and Invertebrate species occur.

Table 1: Vegetation and Ecosystem Critical Levels^a

Pollutant	Time Period	Critical Level
NO _x (expressed as NO ₂)	Annual Mean ^{a, b}	30 µg/m ³
	24-Hour Mean ^a	75 µg/m ³
Ammonia	Annual Mean	3 µg/m ³

^a The critical levels are defined by the World Health Organisation (WHO, 2000). Ammonia critical level is defined by the Convention on Long-Range Transboundary Air Pollution (CLRTAP)

^b Away from major sources (see Paragraph 2.3), this critical level is set as an objective by the UK Government (Defra, 2007) and a limit value by the European Union (Directive 2008/50/EC of the European Parliament and of the Council, 2008). In the case of Pevensy Levels the objective and limit value do not apply.

Table 2: Vegetation and Ecosystem Critical Loads

Habitat Type	Nutrient Nitrogen (kg-N/ha/yr) ^a
Coastal and Floodplain Grazing Marsh	20

^a Critical loads for nutrient nitrogen taken from the Air Pollution Information System (APIS) website (APIS, 2018), the habitat type for this location was Coastal and Floodplain Grazing Marsh, this was defined using the same process as the Appropriate Assessment completed in 2009 (Scott Wilson, 2009) and most closely corresponds to habitats within the Pevensy Levels. APIS provides a critical load for this location based on a habitat of Low and Medium Altitude Hay Meadows.

¹ There is no critical load available for acid deposition and therefore this has not been included within this assessment.

- 2.3 Objectives for the protection of vegetation and ecosystems have also been set by the UK Government and have the same numerical values as the critical levels that have been used in this assessment. The objectives, however, only apply a) more than 20 km from an agglomeration (about 250,000 people), and b) more than 5 km from Part A industrial sources, motorways and built up areas of more than 5,000 people². The Pevensy Levels are located within 5 km of both Pevensy and Eastbourne and therefore the objectives do not apply within the Pevensy Levels.

Descriptors for Air Quality Impacts and Assessment of Significance

- 2.4 The Environment Agency's Air Emissions Risk Assessment guidance (Environment Agency, 2016) discounts as insignificant any impact on an SAC from an individual permit³ application if the change in annual mean concentration or deposition flux is <1% of a long-term (e.g. annual mean) or 10% of a short-term (e.g. 24-hour mean) environmental standard. This is the case regardless of the existing or predicted future baseline level (i.e. whether or not the critical level or critical load is currently exceeded). The Environment Agency does not suggest that impacts will necessarily be significant above these criteria, merely that there is a potential for significant impacts to occur that should be considered using alternative means. When issuing permits to operate, the Environment Agency also suggests that there is no need for additional assessment if it can be demonstrated that the predicted concentration or flux (with the proposed operation in place) is less than the critical level or critical load.
- 2.5 Despite their origin, these criteria are commonly used as screening criteria when assessing all manner of development schemes, including those that generate road traffic. Because many interested parties are familiar with these screening criteria, they have been used here as one of the ways to present the results. It is not within the scope of this study to appraise whether or not the Environment Agency screening criteria provide an appropriate level of assessment, or protection, with respect to traffic-related impacts from a Local Plan.

² The same concentrations, with the same constraints, have also been set as Limit Values by the European Commission.

³ The Environment Agency issues permits to operate industrial processes in England and Wales and its guidance was developed for this purpose.

3 Assessment Approach

Existing Conditions

- 3.1 Background nitrogen oxide and nitrogen dioxide concentrations across the study area have been defined using the national pollution maps published by Defra (Defra, 2018). These cover the whole country on a 1x1 km grid.
- 3.2 Background nutrient-nitrogen deposition fluxes across the Pevensy Levels have been taken from the APIS website (APIS, 2018). These are based on a three year average, in this case 2014 – 2016.
- 3.3 Background ammonia concentrations are provided by the Centre for Ecology and Hydrology and cover the country on a 5 x 5 km grid. Ammonia concentrations are reported for 2014, which was the latest year for which year-specific data were available when the assessment was carried out

Road Traffic Impacts

- 3.4 Pollutant concentrations have been modelled over a gridded area, covering up to 200 m from the edge of the A259, A27 and B2191, which run through the Pevensy Levels, as shown in Figure 1⁴. In addition, concentrations have been modelled at the automatic monitoring station located along De La Warr Road (A259), in order to verify the modelled results (see Appendix A2 for verification method). This automatic monitoring station is operated by Rother District Council. It is considered suitable for use for this modelling as it is located on the A259 and has a similar layout and characteristics as the study area, as well as a similar traffic flow.

⁴ Concentrations have been predicted at roadside locations and then at 1, 2, 3, 4, 5, 10, 20 m and then every 10 m up to a distance of 200 m from the roadside.

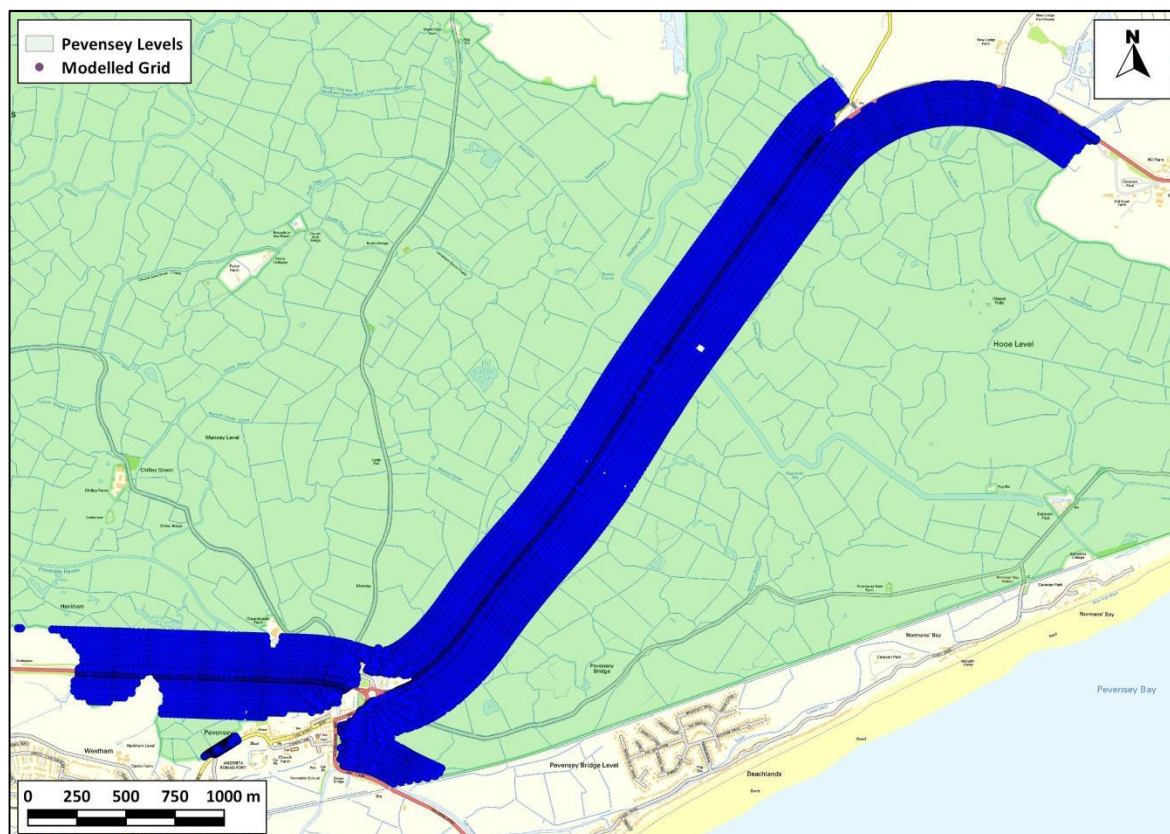


Figure 1: Modelled Grid⁵

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Modelling of Concentrations

- 3.5 For each of the modelled scenarios the maximum predicted concentrations and deposition fluxes within the Pevensey Levels have been presented in the results tables. Where the predicted changes exceed the relevant screening criteria, figures showing the areas of exceedance are shown in Section 6.

Nitrogen Oxides, Nitrogen Dioxide and Ammonia

- 3.6 Concentrations have been predicted using the ADMS-Roads dispersion model. Traffic data for the assessment have been provided by GTA Civils on behalf of Wealden District Council. Details of the traffic data, model inputs, assumptions and the verification are provided in Appendix A2, together with the method used to derive base and future year background concentrations. Where assumptions have been made, a realistic worst-case approach has been adopted.

⁵ The blue area represents each point across the modelled grid explicitly within the Pevensey Levels area.

Modelling of Nitrogen Deposition

- 3.7 A very detailed approach has been taken to calculating deposition fluxes, which goes well beyond the level of detail that would typically be used for an air quality assessment. The approach used is based on an electrical resistance analogy; also known as the 'big-leaf model'. This is the same general approach used by CEH on behalf of Defra in the UK national deposition maps. In order to take account of uncertainty regarding diurnal variations in the rate at which nitrogen dioxide is absorbed through the stomata of plants, two separate deposition models have been used; with results presented for each. These two models are called the 'EA method' and the 'AQC method'. Details of both approaches are set out in Appendix A3.

Uncertainty in Road Traffic Modelling Predictions

- 3.8 There are many components that contribute to the uncertainty of modelling predictions. The road traffic emissions dispersion model used in this assessment is dependent upon the traffic data that have been input, which will have inherent uncertainties associated with them. There are then additional uncertainties, as models are required to simplify real-world conditions into a series of algorithms.
- 3.9 An important stage in the process is model verification, which involves comparing the model output with measured concentrations (see Appendix A2). Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of base year (2015) concentrations.
- 3.10 Predicting pollutant concentrations in a future year will always be subject to greater uncertainty. For obvious reasons, the model cannot be verified in the future, and it is necessary to rely on a series of projections provided by DfT and Defra as to what will happen to traffic volumes, background pollutant concentrations and vehicle emissions.
- 3.11 European type approval ('Euro') standards for vehicle emissions apply to all new vehicles manufactured for sale in Europe. These standards have, over many years, become progressively more stringent and this is one of the factors that has driven reductions in both predicted and measured pollutant concentrations over time.
- 3.12 Historically, the emissions tests used for type approval were carried out within laboratories and were quite simplistic. They were thus insufficiently representative of emissions when driving in the real world. For a time, this resulted in a discrepancy, whereby nitrogen oxides emissions from new diesel vehicles reduced over time when measured within the laboratory, but did not fall in the real world. This, in turn, led to a discrepancy between models (which predicted improvements in nitrogen dioxide concentrations over time) and measurements (which very often showed no improvements year-on-year).
- 3.13 Recognition of these discrepancies has led to changes to the type approval process. Vehicles are now tested using a more complex laboratory drive cycle and also through 'Real Driving Emissions'

(RDE) testing, which involves driving on real roads while measuring exhaust emissions. For Heavy Duty Vehicles (HDVs), the new testing regime has worked very well and NO_x emissions from the latest vehicles (Euro VI⁶) are now very low when compared with those from older models (ICCT, 2017).

- 3.14 For Light Duty Vehicles (LDVs), while the latest (Euro 6) emission standard has been in place since 2015, the new type-approval testing regime only came into force in 2017. Despite this delay, earlier work by AQC (AQC, 2018) showed that Euro 6 diesel cars manufactured prior to 2017 tend to emit significantly less NO_x than previous (Euro 5 and earlier) models. Given the changes to the testing regime, it is reasonable to expect that diesel cars and vans registered for type approval since 2017 will, on average, generate even lower NO_x emissions.
- 3.15 As well as reviewing information on the emissions from modern diesel vehicles in the real world (AQC, 2018), AQC has also reviewed the assumptions contained within Defra's latest Emission Factor Toolkit (EFT) (v8.0.1) (AQC, 2018). One point of note is that the EFT makes a range of assumptions, which appear to be very conservative, regarding the continued use of diesel cars into the future and the relatively slow uptake of non-conventional (e.g. electric) vehicles (AQC, 2018). Thus, despite previous versions of Defra's EFT being over-optimistic regarding future-year predictions, it is not unreasonable to consider that EFT v8.0.1 might under-state the scale of reductions over coming years (i.e. over-predict future-year traffic emissions).
- 3.16 There are, however, assumptions within EFT v8.0.1 regarding the expected performance of diesel cars and vans registered for type approval beyond 2016 that have not been tested, and it is thus sensible to consider the possibility that this future-year technology might be less effective than has been assumed. Modelling using emissions model B assumes that the post-2020 technology fitted to Euro 6 diesel cars and vans does not deliver any benefits. There are also assumptions, within both EFT v8.0.1 and CURED V3A regarding the rate of removal of older vehicles from the fleet which cannot, at this time, be guaranteed. Emissions model A accounts for this uncertainty by assuming that there will be no improvements at all from 2015.
- 3.17 Much less research has been carried out into ammonia emissions from vehicles, and so all projections are more tenuous. A principal issue is that while NO_x emissions are regulated by European legislation, ammonia emissions are not. Furthermore, Selective Catalytic Reduction (SCR) technology, which is often used to help achieve the new NO_x emissions standards, is potentially a major source of ammonia. The way in which the NO_x emissions standards are implemented for light-duty diesel vehicles is to become more stringent by 2020, and it is anticipated that vehicle manufacturers will meet this challenge with more emphasis on SCR technology and, potentially, with higher dosing rates of the reagents which can give rise to ammonia emissions. While this is speculative, it is reasonable to conclude that ammonia

⁶ Euro VI refers to HDVs while Euro 6 refers to LDVs.

emissions per vehicle may increase in the future. This effect is not taken into account within the Calculation of Emissions from Road Transport (COPERT) model (V5.0.1067) which is produced by the European Environment Agency, and is expected to be used by the majority of European member states for reporting to the Commission. The COPERT model predicts that while NO_x emissions from newly-manufactured diesel cars will fall between 2016 and 2020, there will be no associated change in ammonia emissions. Defra's predictions go further, and suggest that ammonia emissions from road traffic will reduce into the future (Defra, 2012).

- 3.18 Despite the greater uncertainty regarding ammonia emissions in the future, with the possibility that emissions per vehicle may increase between 2015 and 2028, there are no suitable models with which to predict these patterns. Ammonia emissions per vehicle have thus only been modelled using one dataset, which represents emissions per vehicle in 2015 (for which the model outputs of annual mean NO_x have been verified against local measurements).

4 Scenario Definition

Traffic Datasets

4.1 Air quality modelling has been carried out using three different traffic datasets:

- 1) existing traffic;
- 2) existing traffic + amended Temprow growth to 2028 but without any growth associated with the Wealden Local Plan; and
- 3) existing traffic + amended Temprow growth to 2028 + the Wealden Local Plan.

4.2 These three sets of traffic data have been used to predict conditions in the following scenarios:

- 'Existing Baseline' (traffic dataset 1);
- '2028 No Growth' (traffic dataset 1);
- '2028 No WDC-Growth' (traffic dataset 2); and
- '2028 With Plan' (traffic dataset 3).

Emissions Datasets

4.3 As explained in Section 3, it is difficult to forecast how traffic emissions will change between 2015 and 2028, and all projections are uncertain. In order to account for some of the uncertainty regarding emissions of NO_x, three separate emissions models have been used:

A) emissions per vehicle are the same as those in 2015 (for which the model has been verified against local measurements);

B) emissions per vehicle fall between 2015 and 2028 in line with the CURED 3A model (AQC, 2018); and

C) emissions per vehicle fall between 2015 and 2028 as predicted in Defra's EFT V8.0.1 (2018).

Deposition Models

4.4 As explained in Paragraph 3.7, deposition fluxes have been calculated using two alternative models. This is principally to take account of uncertainty regarding the stomatal resistance to NO₂, to which the deposition models are particularly sensitive. One method follows an approach published by the Environment Agency (EA method), while the other follows an approach developed for the Ashdown Forest study (AQC method).

Scenario Summary

- 4.5 Table 3 summarises the various models which have been run. For example, for the existing baseline, one NO_x dataset, one NH₃ dataset, and two deposition datasets have been produced. For 2028 With Plan, three NO_x datasets, one NH₃ dataset, and six deposition datasets (i.e. both the EA and AQC methods have been used for each of the NO_x emissions datasets in turn, with each alternative NO_x emissions dataset combined with the same 'A' NH₃ emissions dataset) have been produced.

Table 3: Summary of Dispersion and Deposition Model Scenarios

Feature	Existing Baseline	2028 No Growth			2028 No WDC-Growth			2028 With Plan		
2015 Traffic	Y	Y			Y			Y		
Additional Traffic from Growth Outside Wealden	-	-			Y			Y		
Additional Traffic Caused by Local Plan	-	-			-			Y		
NO _x Emissions Scenarios	A	A	B	C	A	B	C	A	B	C
NH ₃ Emissions Scenarios	A	A	A	A	A	A	A	A	A	A
Deposition Scenarios	EA AQC	EA AQC	EA AQC	EA AQC	EA AQC	EA AQC	EA AQC	EA AQC	EA AQC	EA AQC

Scenario Comparisons

- 4.6 The results from these model scenarios have been compared to show the changes in concentrations and deposition fluxes that the Local Plan will cause, both on its own and in combination with other anticipated changes, as follows.

Changes Caused by the Local Plan Alone

- 4.7 The changes caused by the Local Plan alone have been calculated by subtracting the results for '2028 No WDC-Growth' from those for '2028 With Plan'. In each case this has been done using equivalent emissions and deposition models. This means that the changes associated with the Local Plan alone are presented for three different NO_x emissions scenarios, one NH₃ emissions scenario, and six deposition scenarios as outlined in Table 4. The changes identified are those caused by the increase in traffic associated with the Local Plan, on explicitly-modelled roads.

Table 4: Formulation of Comparisons which Show the Changes Caused by the Local Plan Alone

Feature	Dataset					
Start-point for Traffic	2028 No WDC-Growth					
End-point for traffic	2028 With Plan					
NO _x Emissions Scenarios	A		B		C	
NH ₃ Emissions Scenarios	A		A		A	
Deposition Scenarios	EA	AQC	EA	AQC	EA	AQC

Changes Caused by Local Plan In Combination with Other Predicted Traffic Growth

- 4.8 The changes associated with the Local Plan, in combination with other predicted traffic growth, have been calculated by subtracting the results for '2028 No Growth' from those for '2028 With Plan'. As above, in each case this has been done using equivalent emissions and deposition models. These changes are presented for three different NO_x emissions scenarios, one NH₃ emission scenario, and six deposition scenarios, as outlined in Table 5. The changes identified are those associated with the Local Plan and growth in traffic, on explicitly-modelled roads.

Table 5: Formulation of Comparisons which Show the Changes Caused by the Local Plan In Combination with Other Predicted Traffic Growth

Feature	Dataset					
Start-point for Traffic	2028 No Growth					
End-point for traffic	2028 With Plan					
NO _x Emissions Scenarios	A		B		C	
NH ₃ Emissions Scenarios	A		A		A	
Deposition Scenarios	EA	AQC	EA	AQC	EA	AQC

Changes Caused by Local Plan In Combination with Other Predicted Traffic Growth and International Emissions Projections

- 4.9 The changes associated with the Local Plan in combination with other predicted traffic growth and International Emissions Projections, have been calculated by subtracting the results for '2028 No Growth' from those for '2028 With Plan'; in this case, alternative NO_x emissions have been compared as shown in Table 6. The changes identified are those associated with the Local Plan

and other traffic growth on explicitly-modelled roads; the projected changes in emissions over this time period are, in this case, also included.

Table 6: Formulation of Comparisons which Show the Changes Caused by the Local Plan In Combination with Other Predicted Traffic Growth and International Emissions Projections

Feature	Dataset			
Start-point for Traffic	2028 No Growth			
End-point for traffic	2028 With Plan			
Start-point for NOx Emissions	A			
End-Point for NOx Emissions	B	C		
Start-point for NH ₃ Emissions	A			
End-point for NH ₃ Emissions	A			
Deposition Scenarios	EA	AQC	EA	AQC

5 Existing Baseline Conditions

National Background Maps for NO_x and nitrogen dioxide

- 5.1 Estimated background concentrations of NO_x and nitrogen dioxide in the study area have been determined for 2015 and a future year of 2028⁷ using Defra's background maps (Defra, 2018). The background concentrations are set out in Table 7 and have been derived as described in Appendix A2. The background concentrations of NO_x are well below the critical level.

Table 7: Estimated Annual Mean Background Pollutant Concentrations in 2015 and 2028 (µg/m³)

Year	NO _x	Nitrogen Dioxide ^a
2015	10.9 – 13.3	8.3 – 10.0
Scenario A ^b	10.9 – 13.3	8.3 – 10.0
Scenario B ^c	7.5 – 9.1	5.8 – 7.0
Scenario C ^d	7.1 – 8.4	5.5 – 6.5
Critical Level	30	-

The range of values is for the different 1x1 km grid squares covering the study area.

^a Nitrogen dioxide backgrounds have been used to convert the NO_x model outputs into road nitrogen dioxide for the purposes of calculating the nutrient-nitrogen deposition.

^b Backgrounds have been kept the same as the 2015 baseline.

^c Assuming higher emissions from modern diesel vehicles as described in Appendix A2.

^d In line with Defra's forecasts in 2028.

National Background Ammonia Map

- 5.2 Background ammonia concentrations for 2014⁸ within the Pevensey Levels have been taken from the UK Deposition Data website operated by the Centre for Ecology and Hydrology (CEH, 2018). The background ammonia concentrations are set out in Table 8, and are below the critical level.

Table 8: Estimated Annual Mean Ammonia (µg/m³)

Year	Ammonia
2014	0.8 – 1.0
Critical Level	3

The range of values is for the different 5 x 5 km grid squares covering the study area.

⁷ The Defra background maps include some development profile in the future years.

⁸ 2014 is the latest year that data were available for when the assessment was carried out.

Background Deposition

- 5.3 Background nitrogen deposition fluxes to the Pevensey Levels have been taken from the APIS website (APIS, 2018)⁹. The background nutrient-nitrogen deposition rate is below the critical load in this period (2014-2016).

Table 9: Estimated Annual Mean Background Nitrogen Deposition

Site	Nutrient-Nitrogen Deposition (kg-N/ha/yr)
Grazing Marsh ^a	13.4
Critical Load	20

^a Grazing Marsh has been selected since it is the habitat for which critical loads have been calculated that most closely corresponds to habitats within the Ramsar site. This habitat corresponds with the original Appropriate Assessment completed in 2009 (Scott Wilson, 2009).

Existing Baseline Model Results

- 5.4 The existing baseline concentrations of NO_x, at the location within the Pevensey Levels with the highest predicted concentration, is set out in Table 10. This location is at the kerbside of the A259 on the western side of the road. Annual mean concentrations of NO_x exceed the critical level at this worst-case location within the Pevensey Levels in 2015, and are predicted to exceed the critical level at locations up to 10 m from the roadside of the A259. This occurs along the majority of the modelled road length.

Table 10: Maximum Annual Mean NO_x Concentrations Pevensey Levels

Pollutant	Annual Mean NO _x (mg/m ³)
Maximum Concentration	57.3
Critical Level	30

- 5.5 The existing baseline 24-hour NO_x concentration, at the location within the Pevensey Levels with the highest concentration in 2015, is set out in Table 11. This location is at the kerbside of the A259 on the western side of the road. Baseline 24-hour NO_x concentrations in 2015 are expected to exceed the critical level of 75 µg/m³ across the modelled area, which extends out 200 m from the kerbside.

Table 11: Maximum 24-hour NO_x Concentrations Pevensey Levels

Pollutant	Maximum 24-hour Mean NO _x (mg/m ³)
Maximum Concentration	310.2
Critical Level	75

⁹ The background data which underpin the modelling of total deposition fluxes were the species-specific fluxes described in Appendix A2, rather than these three-year average total values.

- 5.6 The existing baseline concentration of ammonia, at the location within the Pevensey Levels with the highest concentration in 2015, is set out in Table 12. The maximum concentration occurs at the kerbside of the A259 on the western side of the road; however, there are no exceedances of the critical level.

Table 12: Maximum Ammonia Concentrations Pevensey Levels

Pollutant	Annual Mean NH ₃ (mg/m ³)
Maximum Concentration	1.7
Critical Level	3

- 5.7 The existing baseline nutrient-nitrogen deposition rates within the Pevensey Levels in 2015 are set out in Table 13 for the location with the highest deposition flux. The maximum flux in both methods occurs at the kerbside of the A259 on the western side of the road. Following the EA Method (see Appendix A3), baseline nutrient-nitrogen deposition rates are predicted to be above the critical load in 2015. Exceedances are predicted to occur at locations up to 5 m from the roadside; this, though, does not occur along the whole length of the roads modelled. When considering the AQC Method for calculating deposition, baseline nutrient-nitrogen deposition rates are predicted to be below the critical load in 2015.

Table 13: Maximum Baseline Nutrient-Nitrogen Deposition Rates (kg-N/ha/yr)

Method	Nutrient Nitrogen Deposition (kg-N/ha/yr)
Maximum Concentration (EA Method)	25.2
Maximum Concentration (AQC Method)	19.5
Critical Load	20

^a Exceedances of the critical load are shown in bold.

6 No-Growth Model Results

- 6.1 This section sets out the ambient concentrations and nitrogen deposition fluxes predicted to occur in 2028 if traffic volumes in 2028 are no different from those in 2015 (i.e. no growth caused by development in Wealden or elsewhere). Results are presented for emissions scenarios B and C. The 2028 No-Growth model results under emissions Scenario A are identical to those for the existing baseline (since all of the model inputs are identical) and thus these are not presented again. Since only one ammonia emissions scenario was modelled (Scenario A), the results for ammonia are not presented. Results for Scenario A can be found in Chapter 5.

Concentrations of NOx

- 6.2 The maximum annual mean and 24-hour mean NOx concentrations at any location within the Pevensey Levels SAC for the 2028 No-Growth scenario are set out in Table 14. The location is at the kerbside of the A259 on the western side of the road, for both scenarios and averaging periods.

Table 14: Maximum Baseline NOx Concentrations Pevensey Levels in the 2028 No Growth Scenario ^a

Pollutant	Scenario B ^b	Scenario C ^c	Critical Level
Annual Mean NOx (mg/m ³)	32.8	24.6	30
Maximum 24-hour Mean NOx (mg/m ³)	203.3	161.4	75

^a Exceedances of the critical level are shown in bold.

^b Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^c In line with Defra's forecasts for 2028.

- 6.3 Annual mean concentrations of NOx exceed the critical level at this worst-case location within the Pevensey Levels in Scenario B. Annual mean concentrations are predicted to exceed the critical level at the roadside of the A259, east of Pevensey Roundabout. This does not occur along the whole length of the modelled road (applying to approximately 30% of the length of the A259). Assuming vehicle emissions reduce in line with Defra's forecast (Scenario C), there are predicted to be no exceedances of the annual mean critical level at any modelled receptor.
- 6.4 With respect to the 24-hour mean, in Scenario B, exceedances of the critical level have been predicted 200 m from the kerbside close to Pevensey Roundabout (which is the full extent of the modelled area). Away from the roundabout, the area of exceedence is smaller, and limited to 75 m

on either side of the road. In Scenario C, exceedances of the critical level occur up to 50 m on the northern / western side of the A259, and up to 25 m on the southern / eastern side.

Nutrient Nitrogen Deposition

- 6.5 The maximum nutrient-nitrogen deposition rates within the Pevensey Levels in the 2028 No-Growth scenario are set out in Table 15. The maximum flux in both methods, for both scenarios, occurs at the kerbside of the A259 on the western side of the road.

Table 15: Maximum Baseline Nutrient-Nitrogen Deposition Rates (kg-N/ha/yr) in the 2028 No Growth Scenario

Pollutant	Scenario B ^b	Scenario C ^c	Critical Load
Nitrogen Deposition (EA Method) (kg-N/ha/yr)	20.1	18.5	20
Nitrogen Deposition (AQC Method) (kg-N/ha/yr)	16.8	15.9	

^a Exceedances of the critical load are shown in bold.

^b Road traffic modelling has been completed assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^c Road traffic emissions in line with Defra's forecasts for 2028 have been used in the modelling.

- 6.6 Nutrient-nitrogen deposition rates are only predicted to be above the critical load in Scenario B, and using the EA deposition method. The exceedance is limited to two roadside locations on the western side of the A259. There are predicted to be no exceedances of the critical load in either scenario using the AQC method.

7 No WDC-Growth Model Results

- 7.1 This section summarises the ambient concentrations and nitrogen deposition fluxes predicted to occur in 2028 if traffic volumes grow to 2028 in line with the amended Tempro 7.2 reference case (WDC no growth) assumptions but without any growth within Wealden district associated with the Wealden Local Plan. Results are presented for emissions scenarios A, B and C.

Concentrations of NO_x and NH₃

- 7.2 The highest modelled concentrations of NO_x and NH₃ in 2028, for all three emissions scenarios, are set out in Table 16. The maximum concentration in all three scenarios occurs at the kerbside of the A259 on the western side of the road.

Table 16: Maximum Baseline NO_x and NH₃ Concentrations in the 2028 No WDC-Growth Scenario ^a

Pollutant	Scenario A ^b	Scenario B ^c	Scenario C ^d	Critical Level
Annual Mean NO _x (mg/m ³)	66.7	38.1	28.2	30
Maximum 24-hour Mean NO _x (mg/m ³)	345.9	228.5	180.6	75
Annual Mean NH ₃ (mg/m ³)	1.9	n/a	n/a	3

^a Exceedances of the critical level are shown in bold.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

^c Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d In line with Defra's forecasts for 2028.

- 7.3 Annual mean concentrations of NO_x exceed the critical level at this worst-case location within the Pevensey Levels in both Scenarios A and B. Exceedances of the critical level are predicted to occur approximately 10 m from the roadside in Scenario A and up to 2 m from the roadside of the A259 in Scenario B. This does not occur along the whole length of the roads modelled, applying to approximately 75%. Assuming vehicle emissions reduce in line with Defra's forecast (Scenario C), there are predicted to be no exceedances of the annual mean critical level in 2028.
- 7.4 In terms of 24-hour mean NO_x, exceedances of the critical level are predicted to occur in all emissions scenarios. In all cases, exceedances of the critical load occur along the entire road length; in Scenario A, exceedances of the critical level are predicted to occur over the entire modelled area. When considering the CURED predictions (Scenario B), exceedances extend at

least 100 m from the roadside of the A259, whilst when assuming vehicle emissions follow Defra's forecasted reductions (Scenario C), exceedances extend out to 50 m.

- 7.5 Concentrations of ammonia have only been predicted for Scenario A; exceedances of the critical level are not predicted to occur at any modelled receptor in the Pevensey Levels.

Nutrient Nitrogen Deposition

- 7.6 Baseline nutrient-nitrogen deposition rates within the Pevensey Levels in 2028 are set out in Table 17. The maximum concentration in both methods, for all emissions scenarios, occurs at the kerbside of the A259 on the western side of the road.
- 7.7 Following the EA method (see Appendix A3), nutrient-nitrogen deposition rates are predicted to be above the critical load in both Scenarios A and B. When considering the AQC method, nutrient-nitrogen deposition rates are only predicted to exceed the critical load in Scenario A.

Table 17: Maximum Baseline Nutrient-Nitrogen Deposition Rates (kg-N/ha/yr) in the 2028 No WDC-Growth Scenario^a

Pollutant	Scenario A ^b	Scenario B ^c	Scenario C ^d	Critical Load
Nitrogen Deposition (EA Method) (kg-N/ha/yr)	27.9	21.5	19.7	20
Nitrogen Deposition (AQC Method) (kg-N/ha/yr)	20.8	17.9	16.9	

^a Exceedances of the critical load are shown in bold.

^b Road traffic modelling assumes that vehicle emissions are the same the 2015 baseline.

^c Road traffic modelling has been completed assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d Road traffic emissions in line with Defra's forecasts for 2028 have been used in the modelling.

- 7.8 Using the EA method to calculate deposition, exceedances of the critical load are predicted to occur approximately 10 m from the roadside in Scenario A and up to 1 m from the roadside of the A259 in Scenario B. This does not occur along the whole length of the roads modelled.
- 7.9 Following the AQC method, baseline nutrient nitrogen deposition rates are only predicted to exceed the critical load of 20 kg-N/ha/yr in Scenario A at kerbside locations. This, though, does not occur along the whole length of the roads modelled.

8 With Plan Model Results

- 8.1 This section sets out the ambient concentrations and nitrogen deposition fluxes predicted to occur in 2028 with the Wealden Local Plan combined with other traffic growth (TEMPRO 7.2). Results are presented for emissions scenarios A, B and C. This section does not contain comparisons against the model predictions for either the 'no WDC-growth' or the 'no-growth' scenarios. These comparisons are set out in Chapters 9, 10, and 11.

Concentrations of NO_x and NH₃

- 8.2 The maximum predicted total annual mean and 24-hour mean NO_x concentrations at any location within the Pevensey Levels are provided in Table 18. Table 18 also provides the maximum total ammonia concentration for Scenario A. The maximum concentration for all scenarios and pollutants occurs at the kerbside of the A259 on the western side of the road.

Table 18: Maximum Predicted Concentrations across the Pevensey Levels SAC in the 2028 With Local Plan Scenario ^a

Pollutant	Scenario A ^b	Scenario B ^c	Scenario C ^d	Critical Level
Annual Mean NO _x (mg/m ³)	68.6	39.3	29.1	30
Maximum 24-hour Mean NO _x (mg/m ³)	353.0	228.5	184.8	75
Annual Mean NH ₃ (mg/m ³)	1.94	n/a	n/a	3

^a Exceedances of the critical level are shown in bold.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

^c Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d In line with Defra's forecasts for 2028.

Annual Mean NO_x

- 8.3 In Scenario A, which assumes no reduction in emissions between 2015 and 2028, and Scenario B, which uses the CURED 3A model, the total annual mean NO_x concentration with the Local Plan is predicted to be above the critical level. There are no exceedances of the annual mean critical level in 2028 in the scenario which assumes vehicle emissions reduce in line with Defra's forecasts (Scenario C).
- 8.4 In Scenario A, which assumes no reduction in emissions per vehicle or in background concentrations between 2015 and 2028, annual mean NO_x concentrations are predicted to be

above $30 \mu\text{g}/\text{m}^3$ up to approximately 10 m from the roadside of the A259 (See Figure 2). This occurs along the majority of the road length and on both sides of the road for the A259. Exceedances occur up to 10 m from the roadside on the northern side of the A27, but only up to 5 m from the roadside on the southern side. At the boundary of the Pevensey Levels, nearest to the Pevensey Roundabout, annual mean NO_x concentrations are predicted to exceed $30 \mu\text{g}/\text{m}^3$ up to 25 m from the roadside on the northern side, although this is limited to one receptor location.

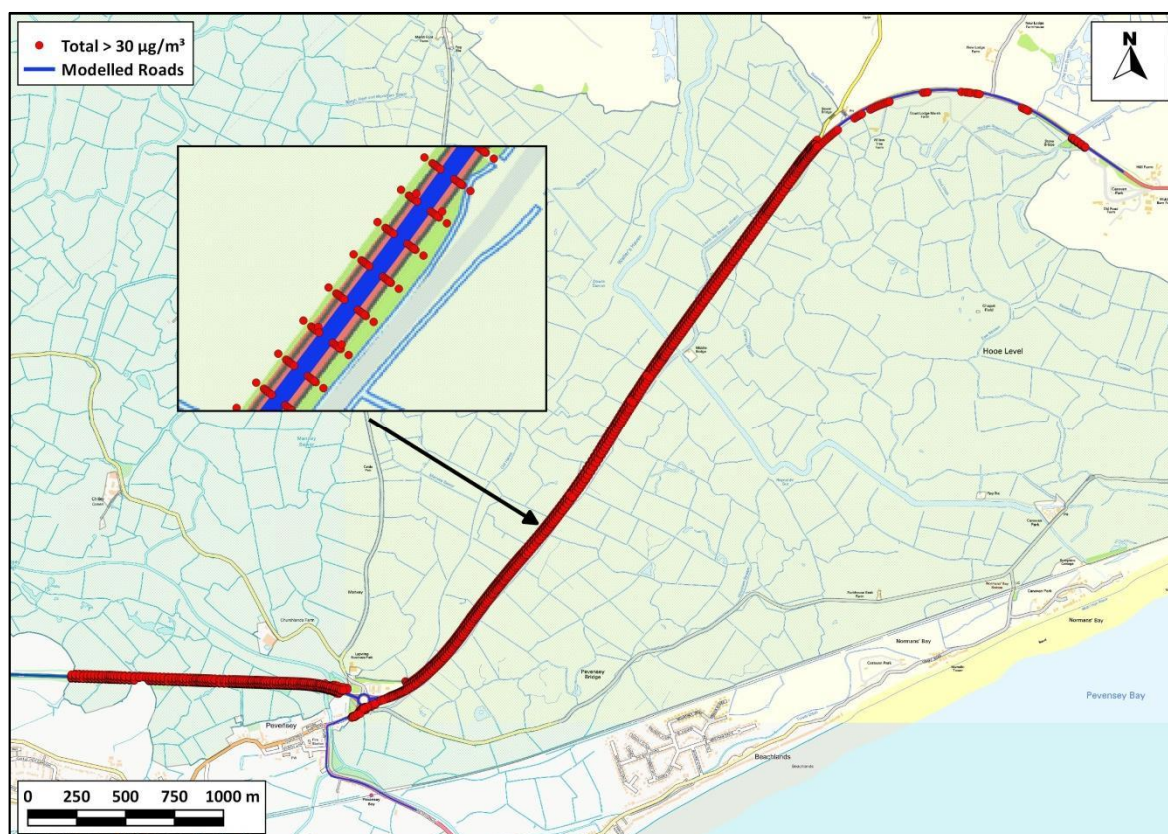


Figure 2: Receptors where Annual Mean NO_x is above $30 \mu\text{g}/\text{m}^3$ in 2028 With Plan, Scenario A

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- 8.5 In Scenario B, annual mean NO_x concentrations are predicted to be above $30 \mu\text{g}/\text{m}^3$ up to 3 m from the roadside of the A259, although this is limited to an approximately 150 m section of road on the northern/western side, to the east of Pevensey Roundabout. Thereafter, predicted annual mean NO_x concentrations are predicted to exceed the critical level up to 1 m from the roadside. This applies to either side of the carriageway (see Figure 3), although not for the entire modelled road length (applying to approximately 60% of the length of the A259). Exceedances on the A27, to the west of Pevensey Roundabout, are predicted at the kerbside of the road, but only on the northern side of the road.

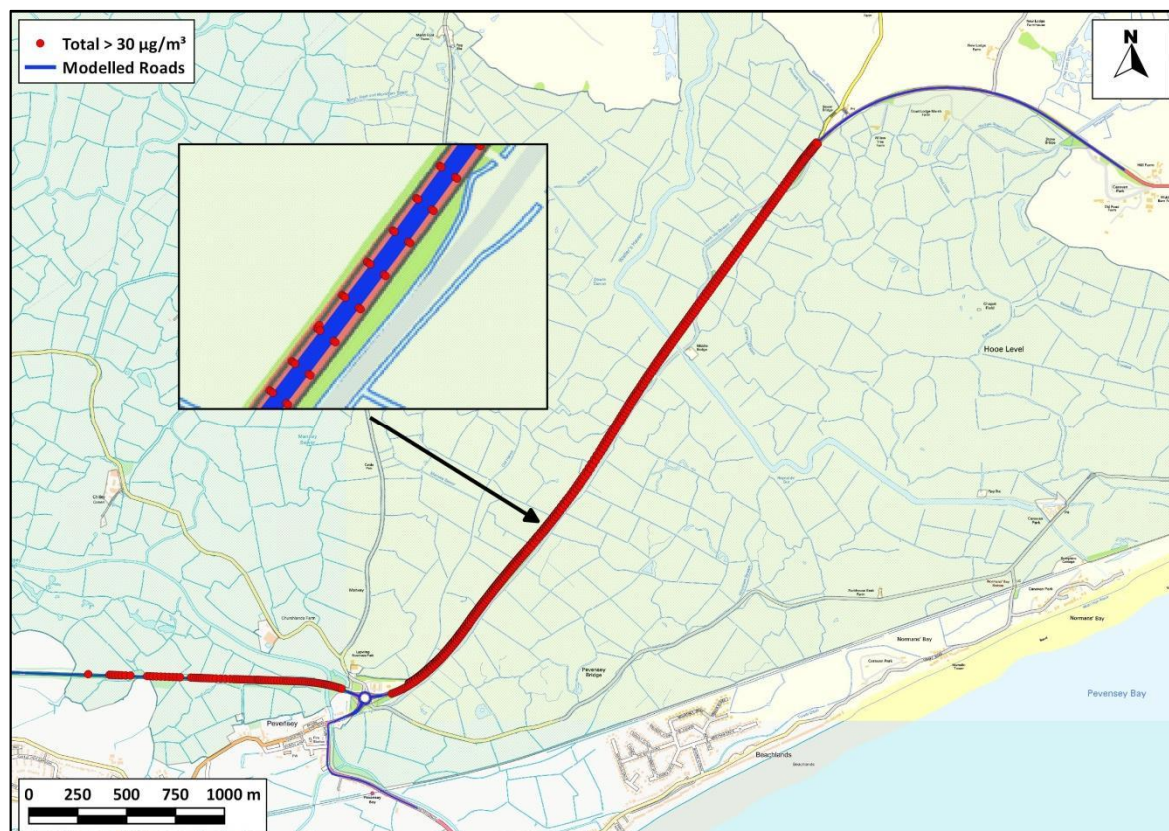


Figure 3: Receptors where Annual Mean NO_x is above 30 µg/m³ in 2028 With Plan, Scenario B

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24-Hour Mean NO_x

- 8.6 Exceedances of the 24-hour mean critical level are predicted to occur in all three modelled scenarios on all modelled roads.
- 8.7 In Scenario A, exceedances of the 24-hour NO_x critical level are predicted at every modelled receptor. In Scenario B, close to Pevensey roundabout, exceedances are predicted to occur out to at least 200 m from the carriageway of the A259 and A27. Away from the roundabout, exceedances are predicted between 75 m and 125 m on both sides of the A259 to the east of the roundabout. Exceedances are also predicted to occur up to 25 m from the northern side of High Street.
- 8.8 In Scenario C, the locations of the exceedances are the same as described for Scenario B, but are more limited in their extent. Close to Pevensey roundabout, exceedances are predicted to occur up to 125 m from the carriageway of the A259. Away from the roundabout, exceedances are predicted up to 50 m on both sides of the road. To the west of Pevensey roundabout,

exceedances are predicted up to 50 m on the northern side of the road, but only up to 25 m on the southern side of the carriageway. South of the roundabout, exceedances are predicted to occur up to 25 m on the northern side of the A259. Exceedances are also predicted to occur up to 25 m from the northern side of High Street.

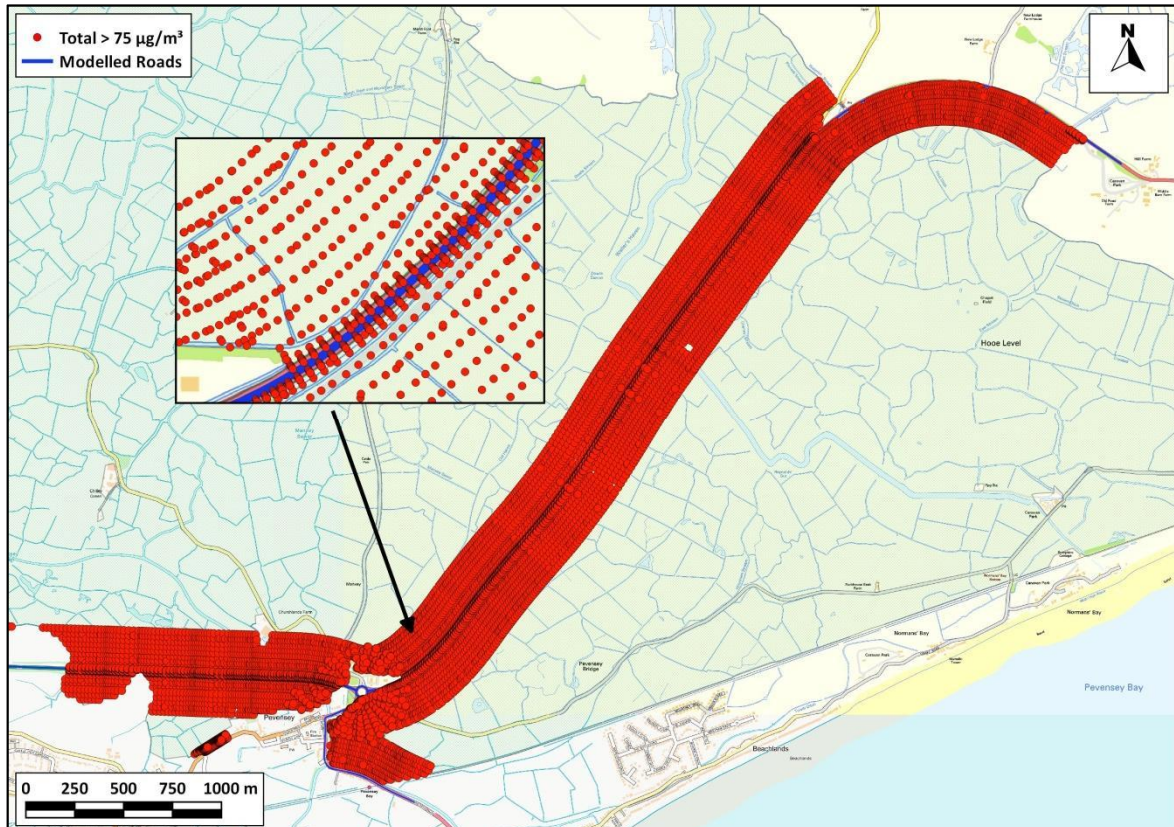


Figure 4: Receptors where 24-Hour NO_x above 75 µg/m³ in 2028 With Plan, Scenario A

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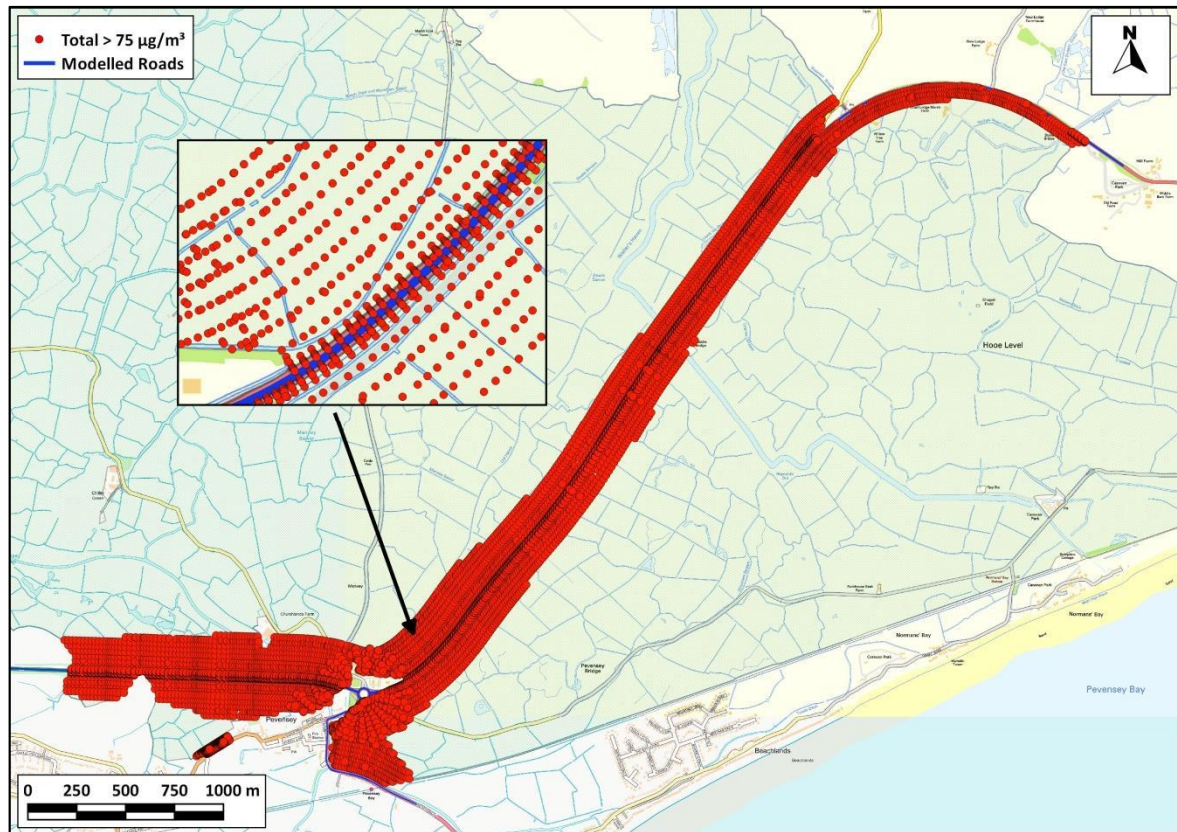


Figure 5: Receptors where 24-Hour NO_x is above 75 µg/m³ in 2028 With Plan, Scenario B

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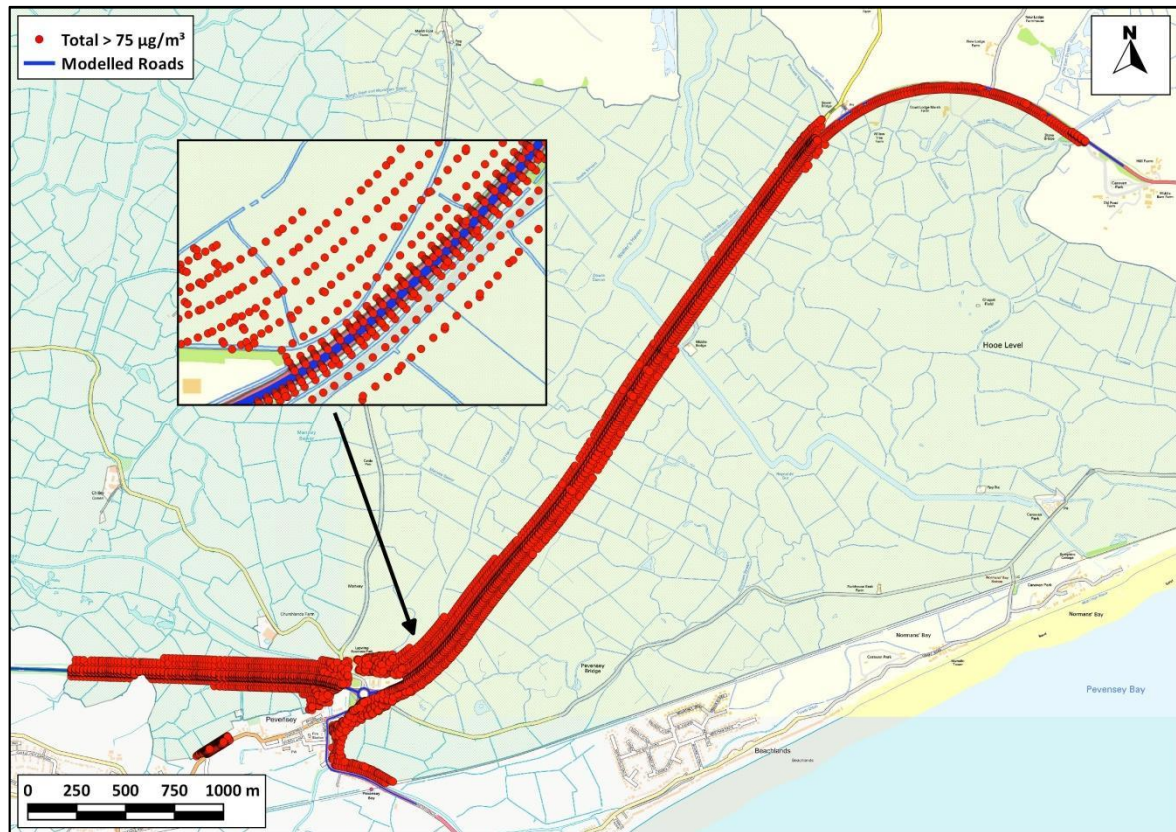


Figure 6: Receptors where 24-Hour NO_x is above 75 µg/m³ in 2028 With Plan, Scenario C

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Ammonia

- 8.9 Concentrations of ammonia have only been predicted for Scenario A. Exceedances of the critical level are not predicted to occur at any modelled receptor in the Pevensey Levels.

Nutrient Nitrogen Deposition

- 8.10 The maximum total nutrient-nitrogen deposition fluxes, following both the EA and AQC methodologies, are provided in Table 19. Following the EA method, there are predicted to be exceedances of the critical load in Scenarios A and B. With the AQC method, exceedances are only predicted in Scenario A.

Table 19: Maximum Predicted Nutrient Nitrogen Deposition Fluxes across the Pevensey Levels SAC in the 2028 With Local Plan Scenario ^a

Pollutant	Scenario A ^b	Scenario B ^c	Scenario C ^d	Critical Load
Nitrogen Deposition (EA Method) (kg-N/ha/yr)	28.4	21.8	19.9	20
Nitrogen Deposition (AQC Method) (kg-N/ha/yr)	21.1	18.1	17.1	

^a Exceedances of the critical level are shown in bold.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

^c Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d In line with Defra's forecasts for 2028.

- 8.11 Following the EA method, in Scenario A, which assumes no reduction in emissions per vehicle or in background concentrations between 2015 and 2028, nutrient-nitrogen deposition fluxes are predicted to be above 20 kg-N/ha/yr up to approximately 10 m from the roadside of the A259 (see Figure 7). This occurs along the majority of the road length and on both sides of the road. On the A27, exceedances are predicted up to 5 m on the northern side of the carriageway, and at the roadside on the southern side. To the south of Pevensey Roundabout, exceedances are also predicted up to 5 m from the roadside on the eastern side of the A259.
- 8.12 In Scenario B, nutrient-nitrogen deposition fluxes are predicted to be greater than 20 kg-N/ha/yr at the roadside of the A259 on either side of the carriageway, however, there are also some discrete locations where exceedances are predicted at 1 m from the roadside (see Figure 8). Exceedances do not occur along the entire length of the A259 (applying to approximately 65% of the length).
- 8.13 There are predicted to be no exceedances of the critical load in 2028 in the scenario which assumes vehicle emissions reduce in line with Defra's forecasts (Scenario C).
- 8.14 Following the AQC method, in Scenario A, nutrient-nitrogen deposition fluxes are predicted to be above 20 kg-N/ha/yr at the roadside of the A259 (see Figure 9). This occurs along 75% of the modelled road length on the southern / eastern side of the road, but only approximately 20% on the northern / western side of the road. There are predicted to be no exceedances of the critical load in 2028 in neither Scenario B nor C.

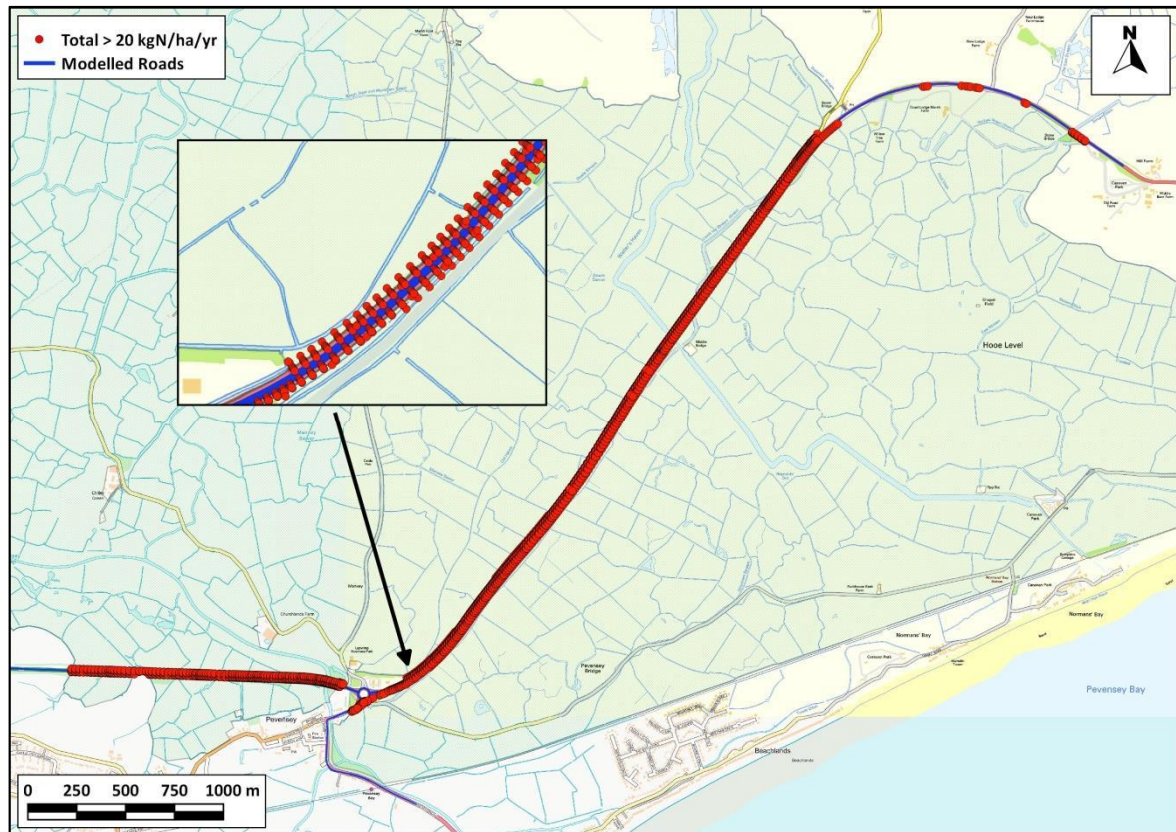


Figure 7: Receptors where Nutrient-Nitrogen Deposition Flux (Following EA Method) are above 20 kg-N/ha/yr in 2028 With Plan, Scenario A

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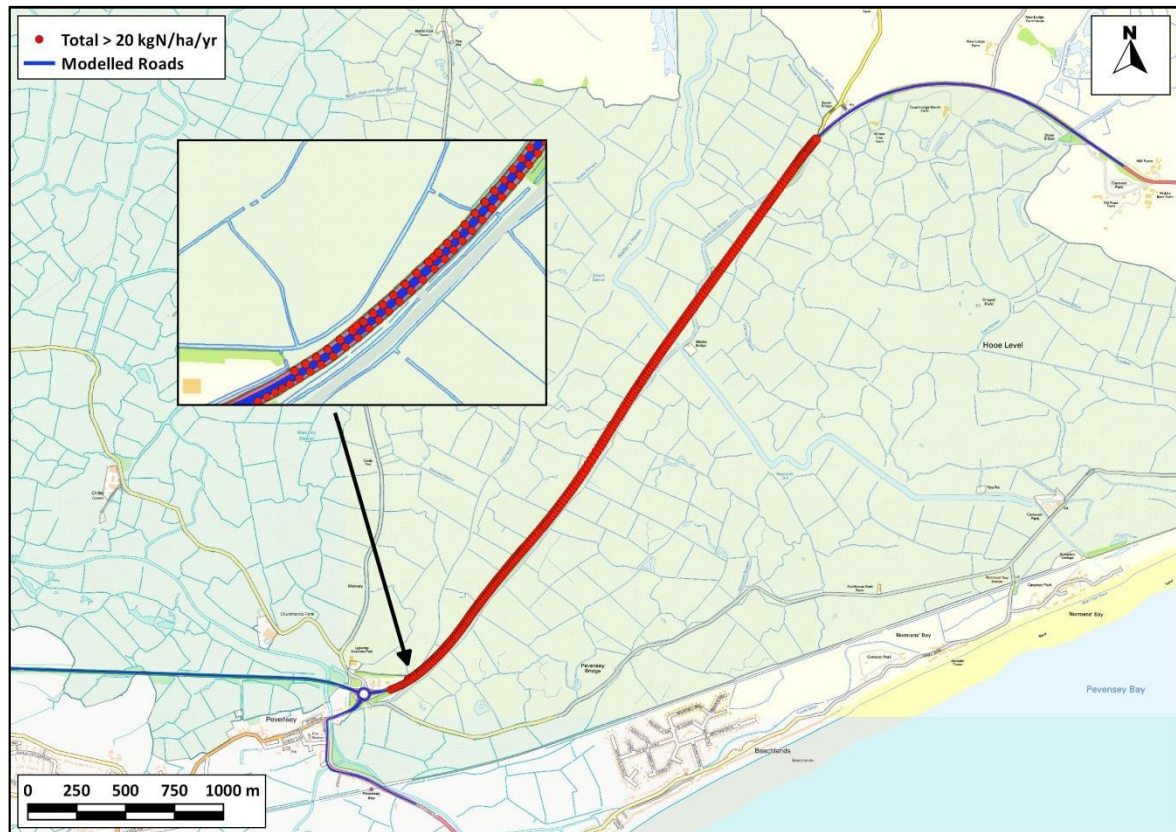


Figure 8: Receptors where Nutrient-Nitrogen Deposition Flux (Following EA Method) are above 20 kg-N/ha/yr in 2028 With Plan, Scenario B

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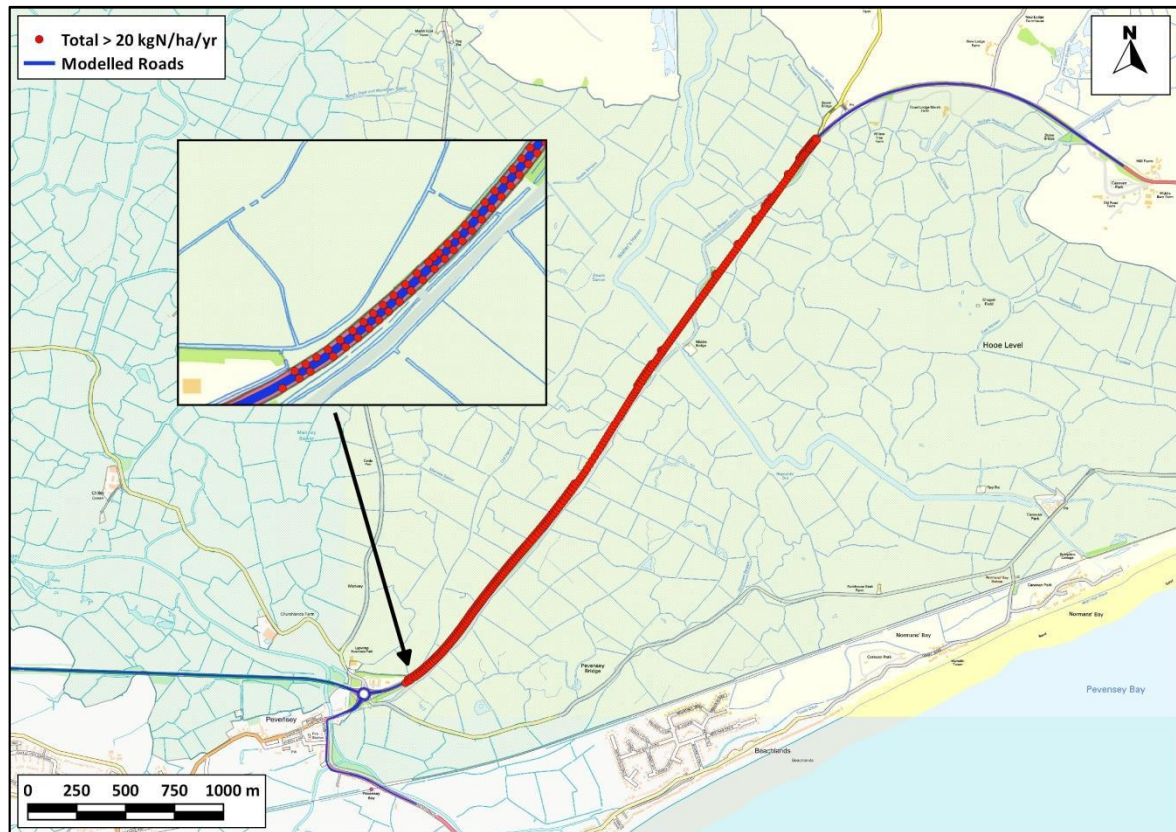


Figure 9: Receptors where Nutrient-Nitrogen Deposition Flux (Following AQC Method) are above 20 kg-N/ha/yr in 2028 With Plan, Scenario A

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9 Impact Assessment – Local Plan Only

- 9.1 This section sets out the predicted changes in concentrations and fluxes that would be caused by the Wealden Local Plan in isolation. These comparisons have been derived by comparing the results of the 'With Plan' scenario against those from the 'No WDC-growth' scenario. Results are presented for emissions scenarios A, B and C.
- 9.2 This part of the assessment identifies changes which are greater than 1% of the long-term critical level or critical load, and greater than 10% of the 24-hour critical level. This should not be taken to suggest that changes greater than 1% (or 10%) will be associated with significant effects, or that changes less than 1% (or 10%) in isolation will be associated with insignificant effects, but it is a useful, and conventional, way of presenting results.
- 9.3 The maximum changes in predicted concentrations for each pollutant in 2028 are set out in Table 20 to Table 22. Each table shows the maximum predicted concentration at any of the modelled receptors within the Pevensey Levels SAC. The absolute changes, compared with the baseline values (2028 No WDC-Growth Scenario), are presented, together with the changes expressed as a percentage of the critical level or load in parentheses. The maximum changes for NO_x are set out in Table 20, for ammonia in Table 21, and for rates of nutrient-nitrogen deposition in Table 22. As described in Paragraph 3.18, only one emissions scenario has been considered for ammonia, based on emission factors from 2015, and therefore, only the results from Scenario A are presented. It should be borne in mind that the location where the maximum change occurs does not necessarily coincide with the location where the maximum concentrations, described in Sections 5 to 8, occur.

Concentrations of NO_x and NH₃

- 9.4 In all model scenarios, the maximum change in annual mean concentrations of NO_x is greater than 1% of the critical level at the worst-case location within the Pevensey Levels SAC, as shown in Table 20. The maximum change in 24-hour mean NO_x concentrations is only less than 10% of the critical level at the worst-case location for Scenario C.

Table 20: Predicted Maximum Changes in NOx Concentrations Caused by the Local Plan in Isolation^a

Receptor	Scenario A ^b	Scenario B ^c	Scenario C ^d
Annual Mean NOx ($\mu\text{g}/\text{m}^3$)	2.8 (9.3%)	1.7 (5.7%)	1.2 (4.0%)
Critical Level (mg/m^3)	30		
24hr-Mean NOx ($\mu\text{g}/\text{m}^3$)	14.5 (19.3%)	10.4 (13.9%)	7.5 (10.0%)
Critical Level ($\mu\text{g}/\text{m}^3$)	75		

^a Absolute changes are presented in $\mu\text{g}/\text{m}^3$ along with the changes as a percentage of the critical level in parenthesis.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

^c Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d In line with Defra's 'official' forecasts for 2028.

- 9.5 The maximum change in ammonia concentration in Scenario A presented in Table 21 is predicted to be greater than 1% of the critical level at the worst-case location.

Table 21: Predicted Maximum Changes in Ammonia Concentrations Caused by the Local Plan in Isolation^a

Receptor	Scenario A ^b
Road Ammonia ($\mu\text{g}/\text{m}^3$)	0.05 (1.7%)
Critical Level ($\mu\text{g}/\text{m}^3$)	3

^a Absolute changes are presented in $\mu\text{g}/\text{m}^3$ along with the changes as a percentage of the critical level in parenthesis.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

Nutrient Nitrogen Deposition

- 9.6 Table 22 provides the changes in nutrient-nitrogen deposition rates; the changes are predicted to be greater than 1% of the critical load in all scenarios, both when considering the EA method and the AQC method.

Table 22: Maximum Changes in Nitrogen Deposition Rates caused by the Local Plan In Isolation ^a

Receptor	Scenario A ^b	Scenario B ^c	Scenario C ^d
Annual Mean Nutrient-Nitrogen Deposition Rate (kg-N/ha/yr) – EA Method	0.61 (3.0%)	0.44 (2.2%)	0.35 (1.8%)
Annual Mean Nutrient-Nitrogen Deposition Rate (kg-N/ha/yr) – AQC Method	0.40 (2.0%)	0.31 (1.5%)	0.26 (1.3%)
Critical Load (kg-N/ha/yr)	20		

^a Absolute changes are presented in kg-N/ha/yr along with the changes as a percentage of the critical load in parenthesis.

^b Road traffic modelling assumes that vehicle emissions are the same as the 2015 baseline.

^c Road traffic modelling has been completed assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d Road traffic emissions in line with Defra's forecasts for 2028 have been used in the modelling.

10 Impact Assessment – Local Plan In Combination with Other Predicted Traffic Growth

- 10.1 This section describes the impacts arising from the Local Plan in combination with other predicted traffic growth. The absolute changes are the difference between the 2028 With Local Plan scenario and the 2028 No Growth scenario, as described in Paragraph 4.8.
- 10.2 This part of the assessment identifies changes which are greater than 1% of the long-term critical level or critical load, and greater than 10% of the 24-hour critical load. This should not be taken to suggest that changes greater than 1% (or 10%) will be associated with significant effects, or that changes less than 1% (or 10%) will be associated with insignificant effects, but it is a useful, and conventional, way of presenting results.
- 10.3 The following tables show the maximum predicted changes in concentration at any of the modelled receptors within the Pevensey Levels. The absolute changes are presented, together with the changes expressed as a percentage of the critical level or load shown in parentheses. The maximum changes in 2028 for NO_x are set out in Table 23, for ammonia in Table 24 and for rates of nutrient-nitrogen deposition in Table 25. As described in Paragraph 3.18, only one emissions scenario has been considered for ammonia. It should be borne in mind that the location where the maximum change occurs does not necessarily coincide with the location where the maximum concentrations, described in Sections 5 to 8, occur.

Concentrations of NO_x and NH₃

- 10.4 The absolute changes and percentage change relative to the critical load for annual mean and 24-hour NO_x are provided in Table 23.

Table 23: Predicted Maximum Changes in NO_x Concentrations Caused by the Local Plan in Combination with Other Predicted Traffic Growth^a

Receptor	Scenario A ^b	Scenario B ^c	Scenario C ^d
Annual Mean NO _x (µg/m ³)	11.2 (37.4%)	6.5 (21.8%)	4.5 (15.0%)
Critical Level (mg/m ³)	30		
24hr-Mean NO _x (µg/m ³)	42.8 (57.0%)	30.7 (41.0%)	23.5 (31.3%)
Critical Level (µg/m ³)	75		

^a Absolute changes are presented in µg/m³ along with the changes as a percentage of the critical level in parenthesis.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

^c Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^d In line with Defra's 'official' forecasts for 2028.

- 10.5 In all model scenarios, the change in annual mean concentrations of NO_x is greater than 1% of the critical level at the worst-case location; however, as explained in Chapter 8, the critical level is only predicted to be exceeded in Scenario A and B.
- 10.6 The changes in 24-hour mean NO_x concentrations exceed 10% of the critical level at the worst-case location in all three modelled scenarios. In Scenario A, which assumes no reduction in emissions per vehicle or in background concentrations between 2015 and 2028, the total 24-hour mean concentrations exceed the critical level at all receptor locations. Changes in 24-hour NO_x concentrations greater than 10% are predicted to occur up to 50 m from the roadside on the eastern/southern side of the A259 this occurs along the entire modelled road length. On the western side of the carriageway, predicted changes greater than 10% are predicted to occur up to 100 m from the roadside for 140 m from the Pevensey Roundabout, and up to 75 m thereafter. On the A27, predicted changes greater than 10% are predicted up to 25 m on the northern side of the carriageway, and to 10 m on the southern side of the road. This occurs along the entire length of modelled road. Predicted changes greater than 10% are also predicted adjacent to High Street, up to 15 m from the roadside, and on the A259, south of the Pevensey Roundabout, on the eastern side of the carriageway, 25 m from the roadside.
- 10.7 In Scenario B, changes in 24-hour NO_x concentrations are predicted to be greater than 10% up to 25 m from the roadside on the eastern/southern side of the A259; this occurs along the entire modelled road length. On the western side of the carriageway, changes greater than 10% of the critical level are predicted to occur up to 50 m from the roadside for 200 m from the Pevensey Roundabout, and up to 25 m thereafter. On the A27, exceedances are predicted up to 25 m on the northern side of the carriageway, and to 10 m on the southern side of the road. This occurs along the entire length of modelled road. Predicted changes greater than 10% are also predicted adjacent to High Street, up to 14 m from the roadside.

- 10.8 When assuming Defra's forecast reductions in vehicle emissions and backgrounds (Scenario C), changes are predicted to be greater than 10% of the critical level up to 25 m from the western side of the A259, and up to 10 m from the eastern side. This occurs for the majority of the modelled road length. On the A27, changes greater than 10% of the critical level are predicted up to 10 m from the northern side of the carriageway, and to 5 m from the southern side of the road. This occurs along the entire length of modelled road. Changes greater than 10% are also predicted adjacent to High Street, up to 5 m from the roadside.
- 10.9 Table 24 presents the maximum change in ammonia concentrations for Scenario A. The change in ammonia concentration is predicted to exceed 1% of the critical level at the worst-case location, but, as explained in Chapter 8, the critical level will not be exceeded.

Table 24: Predicted Maximum Changes in Ammonia Concentrations Caused by the Local Plan in Combination with Other Predicted Traffic Growth^a

Receptor	Scenario A ^b
Road Ammonia ($\mu\text{g}/\text{m}^3$)	0.22 (7.2%)
Critical Level ($\mu\text{g}/\text{m}^3$)	3

^a Absolute changes are presented in $\mu\text{g}/\text{m}^3$ along with the changes as a percentage of the critical level in parenthesis.

^b Background concentrations and vehicle emissions are kept the same as the 2015 baseline.

Nutrient Nitrogen Deposition

- 10.10 Maximum changes in nutrient-nitrogen deposition rates are provided in Table 25; changes are predicted to be greater than 1% of the critical load in all scenarios, both when considering the EA method and the AQC method.

Table 25: Maximum Changes in Nitrogen Deposition Rates Caused by the Local Plan in Combination with Other Predicted Traffic Growth^a

Receptor	Scenario A ^b	Scenario B ^c	Scenario C ^d
Annual Mean Nutrient-Nitrogen Deposition Rate (kg-N/ha/yr) – EA Method	3.2 (15.9%)	1.8 (8.8%)	1.5 (7.3%)
Annual Mean Nutrient-Nitrogen Deposition Rate (kg-N/ha/yr) – AQC Method	1.6 (7.9%)	1.3 (6.3%)	1.1 (5.6%)
Critical Load (kg-N/ha/yr)	20		

^a Absolute changes are presented in kg-N/ha/yr along with the changes as a percentage of the critical load in parenthesis.

^b Road traffic modelling assumes that vehicle emissions are the same as the 2015 baseline.

- ^c Road traffic modelling has been completed assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.
- ^d Road traffic emissions in line with Defra's forecasts for 2028 have been used in the modelling.

- 10.11 As explained in Chapter 8, following the EA method, exceedances of the critical load are only predicted in Scenarios A and B. In Scenario A, which assumes no reduction in emissions per vehicle or in background concentrations between 2015 and 2028, changes in nutrient-nitrogen deposition fluxes are predicted to be above 1% up to approximately 75 m from the roadside of the A259. This occurs along the majority of the road length and on both sides of the road. On the A27, changes greater than 1% are predicted up to 50 m on both sides of the carriageway, and up to 50 m from the roadside on the eastern side of the A259, to the south of Pevensey Roundabout.
- 10.12 In Scenario B, assuming the CURED 3A model, predicted changes in deposition fluxes greater than 1% are predicted up to 50 m from the roadside of the A259, on either side of the carriageway. On the A27, changes greater than 1% of the critical load are predicted to occur up to 25 m from the roadside, on both sides of the road.
- 10.13 Following the AQC method, there are predicted to be no exceedances of the critical load in 2028 in either Scenario B or C. In Scenario A, the locations of changes more than 1% of the critical load are not materially different to those described for Scenario B above.

11 Impact Assessment – Local Plan In Combination with Other Predicted Traffic Growth and National and International Emissions Projections

- 11.1 This section sets out the predicted changes in concentrations and fluxes that would be caused by the Wealden Local Plan in combination with other predicted traffic growth and changes in national and international emissions projections. This includes changes in emissions per vehicle associated with technological improvements, as well as reductions in emissions from many other sectors. These comparisons have been derived by comparing the results of the 'With Plan' scenario using emissions scenarios B and C against those from the 'Existing Baseline' scenario (which uses emissions scenario A). NH_3 is not included in this chapter, because there is only one emission scenario for NH_3 .
- 11.2 For all of the comparisons presented in this chapter, the predicted reductions in emissions driven by new technology and national and international policy are greater than the increases in emissions caused by the additional traffic associated with the Wealden Local Plan and growth outside of the district. This means that if the technological and policy improvements predicted nationally and internationally all deliver their anticipated benefits, then air quality will be better, and nitrogen deposition fluxes will be smaller, than they are at present.
- 11.3 It has already been shown that the Local Plan (see Chapter 9) and the Local Plan in combination with other traffic growth (see Chapter 10) will cause concentrations and fluxes to be higher than would otherwise be the case. Thus, while all of the results in this chapter are presented as benefits, it should be recognised that these benefits would be greater without the traffic associated with the Local Plan. In other words the Local Plan will cancel out some of the benefits that have been predicted due to new technology and national and international policy measures. The precise amount by which the Plan will do this is shown in Chapter 9 for the Plan in isolation and Chapter 10 for the Plan in combination with other traffic growth.
- 11.4 This current report does not seek to interpret the concentration and deposition results in terms of ecological impacts or in terms of compatibility with legislation and policy. This is done elsewhere, in particular in the Habitats Regulations Assessment being prepared for the Local Plan. Despite this distinction, it is nevertheless noted that this chapter was prepared prior to the publication of the Opinion of Advocate General Kokott of the European Court of Justice, delivered on 25th July 2018 which has a clear bearing on the results in this chapter. The results presented in this chapter are still considered to provide useful information, but it has already been shown, in Chapter 8, that the critical levels and critical loads will continue to be exceeded within the SAC in emissions scenarios B and C. In this context, the Advocate General is clear in relation to future-year emissions projections such as these that:

“it is not sufficient, for the purposes of approval of additional nitrogen deposition, if deposition declines overall, but the land in question is still overloaded with nitrogen. (in these circumstances) the expected decrease in nitrogen emissions may not be taken into account in the decision on the approval of additional nitrogen deposition” Para 98 (see also Para 169) ¹⁰.

- 11.5 The maximum changes in predicted concentrations for each pollutant in 2028 are set out in Table 26 and Table 27 for the Local Plan in combination with other predicted traffic growth and international emissions projections scenario. The absolute changes are presented, along with the changes expressed as a percentage of the critical level or load in parentheses. The maximum changes in 2028 for NO_x are set out in Table 26, and for rates of nutrient-nitrogen deposition in Table 27.

Table 26: Predicted Maximum Changes in NO_x Concentrations Caused by the Local Plan in Combination with Other Predicted Traffic Growth and National and International Emissions Projections ^a

Receptor	Scenario B ^b	Scenario C ^c
Annual Mean NO _x (µg/m ³)	-0.3 (-1.0%)	-0.5 (-1.6%)
Critical Level (mg/m ³)	30	
24hr-Mean NO _x (µg/m ³)	-26.8 (-35.7%)	-31.7 (-42.2%)
Critical Level (µg/m ³)	75	

^a Absolute changes are presented in µg/m³ along with the changes as a percentage of the critical level in parenthesis.

^b Assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^c In line with Defra's 'official' forecasts for 2028.

¹⁰ Available at: <http://curia.europa.eu/juris/celex.jsf?celex=62017CC0293&lang1=en&type=TEXT&ancre=>

Table 27: Maximum Changes in Nitrogen Deposition Rates Caused by the Local Plan in Combination with Other Predicted Traffic Growth and National and International Emissions Projections ^a

Receptor	Scenario B ^b	Scenario C ^c
Annual Mean Nutrient-Nitrogen Deposition Rate (kg-N/ha/yr) – EA Method	-1.8 (-9.2%)	-2.2 (-11.2%)
Annual Mean Nutrient-Nitrogen Deposition Rate (kg-N/ha/yr) – AQC Method	-1.1 (-5.3%)	-1.4 (-6.9%)
Critical Load (kg-N/ha/yr)	20	

^a Absolute changes are presented in kg-N/ha/yr along with the changes as a percentage of the critical load in parenthesis.

^b Road traffic modelling has been completed assuming higher emissions from modern diesel vehicles in 2028 as described in Paragraph A2.5 in Appendix A2.

^c Road traffic emissions in line with Defra's forecasts for 2028 have been used in the modelling.

12 Summary of Results

Annual Mean NO_x Concentrations

Existing Baseline

- 12.1 Exceedances of the critical level are currently predicted up to 10 m from the edge of the A259 on both sides of the carriageway, and up to 10 m from the edge of the A27 on the northern side, and 4 m on the southern side.

With Plan

- 12.2 Exceedances of the critical level in Scenario A are predicted up to 10 m from the edge of the A259 on both sides of the road. On the A27, exceedances are predicted to occur up to 10 m from the roadside of the northern side of the A27, and up to 5 m on the southern side. In Scenario B, exceedances are predicted up to 3 m from the roadside of the A259 for a small section of the road, but up to 1 m from the roadside in most other locations. Exceedances are only predicted at the kerbside of the A27. No exceedances are predicted under emissions scenario C.

Impacts of Local Plan Alone

- 12.3 In terms of annual mean NO_x concentrations, there is an area (up to 10 m from the edge of the A259 and A27 in Scenario A and up to 3 m from the edge of the A259 in Scenario B) where both the critical level will be exceeded, and where the change in concentrations caused by the plan will be greater than 1% of the critical level. No exceedances are predicted under emissions scenario C.

Impacts of Local Plan In-Combination with Other Predicted Traffic Growth

- 12.4 The same areas, extending up to 10 m from the edge of the A259 and A27 in Scenario A, and up to 3 m from the edge of the A259 in Scenario B, are predicted to experience both an exceedance of the critical level and a change greater than 1% of the critical level as a result of the Plan in combination with other predicted traffic growth under emissions scenarios A and B. No exceedances are predicted under emissions scenario C.

Impacts of Local Plan In-Combination with Other Predicted Traffic Growth and International Emissions Projections

- 12.5 Annual mean NO_x concentrations are predicted to be lower in 2028 with the Plan using emissions Scenarios B and C than they are at present. This is because changes in emissions from road traffic, and other sectors, are predicted to result in a reduction in NO_x. These changes are not predicted to be sufficient to remove the current exceedances of the critical level in Scenario B.

Improvement would however be greater if growth proposed within the Local Plan combined with other predicted traffic growth did not take place.

24-Hour NO_x Concentrations

Existing Baseline

- 12.6 Exceedances of the critical level are currently predicted at all receptors that have been modelled.

With Plan

- 12.7 Exceedances of the critical level are predicted at every modelled receptor in Scenario A. In Scenario B, exceedances are predicted to occur up to 200 m from the carriageway of the A259 near to Pevensy Roundabout, and up to between 75 m and 125 m away from the roundabout, as well as up to 25 m from the northern side of High Street. In Scenario C, the locations of the exceedances are the same as described for Scenario B, but are more limited in their extent.

Impacts of Local Plan Alone

- 12.8 The critical level will be exceeded across the study area in all emissions scenarios, but changes greater than 10% of the critical load will only occur in Scenarios A and B. In Scenario A, the critical level will be exceeded at all receptors that have been modelled, whilst in Scenario B, exceedances are predicted to occur up to 200 m from the carriageway of the A259 near to Pevensy Roundabout, and up to between 75 m and 125 m away from the roundabout, as well as up to 25 m from the northern side of High Street. The percentage change is only greater than 10% adjacent to High Street, up to 15 m from the roadside in Scenario A and up to 5 m from the roadside in Scenario B.

Impacts of Local Plan In-Combination with Other Predicted Traffic Growth

- 12.9 The areas of the exceedances of the critical level are the same as described above, however, the percentage changes with respect to the critical level also exceed 10% in Scenario C. In Scenario C, exceedances of the critical level are predicted to occur up to 125 m from the A259 close to Pevensy Roundabout, and up to 50 m further away. In Scenario A, changes greater than 10% of the critical level occur up to between 50 m and 100 m from the edge of the A259 for the entire modelled length. In Scenario B, the changes in critical level exceed 10% between 25 m and 50 m from the edge of the A259 for the entire modelled length. In Scenario C, changes greater than 10% are predicted up to 25 m on the western side of the 259, and up to 10 m on the eastern side, as well as up to 10 m from the northern carriageway of the A27, and 5 m on the southern side.

Impacts of Local Plan In-Combination with Other Predicted Traffic Growth and International Emissions Projections

- 12.10 24-hour mean NO_x concentrations are predicted to be lower in 2028 with the Plan using emissions Scenarios B and C than they are at present. Nonetheless, these changes are not predicted to be sufficient to remove the current exceedances of the critical level. The predicted improvement would also be greater if growth proposed within the Local Plan combined with other predicted traffic growth did not take place.

Ammonia Concentrations

Existing Baseline

- 12.11 There are not predicted to be any exceedances of the critical level at any location within the study area in 2015.

With Plan

- 12.12 There will be no exceedances of the critical level at any location within the Pevensy Levels.

Impacts of Local Plan

- 12.13 In both Local Plan assessments (Alone and In-Combination with Other Predicted Traffic Growth), the percentage changes in ammonia concentrations are predicted to be more than 1% of the critical level, however, there will be no exceedances of the critical level at any location within the Pevensy Levels.

Nitrogen Deposition

Existing Baseline

- 12.14 Following the EA Method baseline nutrient-nitrogen deposition rates are predicted to be above the critical load in 2015, with exceedances up to 5 m from the roadside on both the A259 and A27. When considering the AQC Method for calculating deposition, baseline nutrient-nitrogen deposition rates are predicted to be below the critical load in 2015.

With Plan

- 12.15 Following the EA deposition method, in Scenario A, the exceedance of the critical load extends to 10 m from the roadside of the A259, and 5 m from the northern side of the A27. In Scenario B, the exceedances of the critical load predominantly occur at the roadside of the A259, but also at 1 m in some discrete locations. No exceedances of the critical load are predicted in Scenario C.
- 12.16 Following the AQC method, exceedances of the critical load are only predicted at the roadside of the A259 in Scenario A. No exceedances of the critical load are predicted in Scenarios B or C.

Impacts of Local Plan Alone

- 12.17 In terms of nitrogen deposition, when using the EA deposition method, there are predicted to be exceedances of the critical load in Scenarios A and B. In Scenario A, the exceedance of the critical load extends to 10 m from the roadside of the A259, and 5 m from the northern side of the A27. However, percentage changes only exceed 1% 5 m from the roadside of the A259 and up to 3 m from the A27. In Scenario B, the exceedances of the critical load, and changes greater than 1%, predominantly occur at the roadside of the A259, but also at 1 m in some discrete locations.
- 12.18 Following the AQC method, exceedances of the critical load and percentage changes greater than 1% are only predicted at the roadside of the A259 in Scenario A. No exceedances of the critical load are predicted in Scenarios B or C.

Impacts of Local Plan In-Combination with Other Predicted Traffic Growth

- 12.19 Applying the EA deposition method, the areas of exceedance are the same in Scenario B as those described for the Local Plan Alone. In Scenario A, the percentage changes exceed 1% along both the A259 (up to 10 m from the roadside) and the A27 (up to 5 m from the roadside).
- 12.20 Applying the AQC method, the areas of exceedance are the same as those described for the Local Plan Alone.

Impacts of Local Plan In-Combination with Other Predicted Traffic Growth and International Emissions Projections

- 12.21 Nutrient-nitrogen deposition fluxes are predicted to reduce between 2015 and 2028 for Scenarios B and C, and following both methodologies. The reductions would be greater without growth proposed in the Local Plan and in combination with other predicted traffic growth. Nitrogen deposition is predicted to remain above the critical load even with the predicted improvements.

Outcome

- 12.22 The next step will be for Wealden District Council to carry out an analysis of whether the habitats within the areas defined in this report are affected by nitrogen oxides and/or ammonia, and whether the changes in concentrations and deposition rates predicted have the potential to adversely affect the integrity of the SAC/Ramsar.

13 References

- APIS (2018) *APIS*, [Online], Available: www.apis.ac.uk.
- AQC (2018) *Development of the CURED v3A Emissions Model*, [Online], Available: <http://www.aqconsultants.co.uk/Resources/Download-Reports.aspx>.
- AQC (2018a) *Adjusting Background NO2 Maps for CURED v3A*, [Online], Available: <http://www.aqconsultants.co.uk/Resources/Download-Reports.aspx>.
- CEH (2018) *UK Deposition Data*, [Online], Available: <http://www.pollutantdeposition.ceh.ac.uk/data>.
- Defra (2007) *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*, Defra.
- Defra (2012) *UK Emission Projections of Air Quality Pollutants to 2030*, [Online], Available: http://naei.defra.gov.uk/reports/reports?report_id=721.
- Defra (2018) *Local Air Quality Management (LAQM) Support Website*, [Online], Available: <http://laqm.defra.gov.uk/>.
- DfT (2015) *DfT Automatic traffic Counters Table TRA0305-0307*, [Online], Available: <https://www.gov.uk/government/statistical-data-sets/tra03-motor-vehicle-flow>.
- Directive 2008/50/EC of the European Parliament and of the Council* (2008).
- Environment Agency (2008) *Calculation of near-field critical load exceedence from generating stations*.
- Environment Agency (2008a) *Review of modelling methods of near-field acid deposition*, ISBN: 978-1-84432-905-2.
- Environment Agency (2016) *Air emissions risk assessment for your environmental permit*, [Online], Available: <https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit>.
- Erismann and Draaijers (1995) *Atmospheric deposition in relation to acidification and eutrophication*, Studies in Environmental Sciences No 63. ISBN 0-444-82247-X.
- Fowler, Fletchard, Skiba, Coyle and Cape., a. (1998) *The atmospheric budget of oxidised nitrogen and its role in ozone formation and deposition*, New Phytologist. 139, 11-23.
- Highways England (2018) *Highways England Webtris*, [Online], Available: <http://webtris.highwaysengland.co.uk/#>.
- ICCT (2017) *NOx emissions from heavy-duty and light-duty diesel vehicles in the EU: Comparison of real-world performance and current type-approval requirements*, [Online], Available: <http://www.theicct.org/nox-europe-hdv-ldv-comparison-jan2017>.
- Marner and Harrison (2004) *A spatially refined monitoring based study of atmospheric nitrogen deposition*, Atmospheric Environment 38, 5045 - 5056.

Massman (1998) *A review of the molecular diffusivities of H₂O, CO₂, CH₄, CO, O₃, SO₂, NH₃, N₂O, NO and NO₂ in Air, O₂, and N₂ Near STP*, Atmospheric Environment 32 - 1111-1127.

Scott Wilson (2009) *Appropriate Assessment and Air Quality Local to the Pevensy Levels Ramsar Site*.

Smith, Fowler, Sutton, Fletchard and Coyle (2000) *Regional estimation of pollutant gas dry deposition in the UK: model description, sensitivity analyses and outputs.*, Atmospheric Environment 34 - 3757-3777.

Wehr, Commane, Munger, McManus, Nelson, Zahniser and Wofsy, S.a. (2017) *Dynamics of canopy stomatal conductance, transpiration, and evaporation in a temperate deciduous forest, validated by carbonyl sulfide uptake*, Biogeosciences, 14,389-401.

WHO (2000) *Air Quality Guidelines for Europe; 2nd Edition*.
http://www.euro.who.int/_data/assets/pdf_file/0005/74732/E71922.pdf.

14 Glossary

AADT	Annual Average Daily Traffic
ADMS-Roads	Atmospheric Dispersion Modelling System model for Roads
AQC	Air Quality Consultants
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
Exceedance	A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure
HDV	Heavy Duty Vehicles (> 3.5 tonnes)
IAQM	Institute of Air Quality Management
LAQM	Local Air Quality Management
µg/m³	Microgrammes per cubic metre
NO	Nitric oxide
NO₂	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO ₂ + NO)
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
PC	Process Contribution
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal

15 Appendices

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A1 Professional Experience

Prof. Duncan Laxen, BSc (Hons) MSc PhD MEnvSc FIAQM

Prof Laxen is an Associate of Air Quality Consultants, a company which he founded in 1993. He has over forty years' experience in environmental sciences and has been a member of Defra's Air Quality Expert Group and the Department of Health's Committee on the Medical Effects of Air Pollution. He has been involved in major studies of air quality, including nitrogen dioxide, lead, dust, acid rain, PM₁₀, PM_{2.5} and ozone and was responsible for setting up the UK's urban air quality monitoring network. Prof Laxen has been responsible for appraisals of all local authorities' air quality Review & Assessment reports and for providing guidance and support to local authorities carrying out their local air quality management duties. He has carried out air quality assessments for power stations; road schemes; ports; airports; railways; mineral and landfill sites; and residential/commercial developments. He has also been involved in numerous investigations into industrial emissions; ambient air quality; indoor air quality; nuisance dust and transport emissions. Prof Laxen has prepared specialist reviews on air quality topics and contributed to the development of air quality management in the UK. He has been an expert witness at numerous Public Inquiries, published over 70 scientific papers and given numerous presentations at conferences. He is a Fellow of the Institute of Air Quality Management.

Dr Ben Marner, BSc (Hons) PhD CSci MEnvSc MIAQM

Dr Marner is a Technical Director with AQC and has seventeen years' experience in the field of air quality. He has been responsible for air quality and greenhouse gas assessments of road schemes, rail schemes, airports, power stations, waste incinerators, commercial developments and residential developments in the UK and abroad. He has been an expert witness at several public inquiries, where he has presented evidence on health-related air quality impacts, the impacts of air quality on sensitive ecosystems, and greenhouse gas impacts. He has extensive experience of using detailed dispersion models, as well as contributing to the development of modelling best practices. Dr Marner has arranged and overseen air quality monitoring surveys, as well as contributing to Defra guidance on harmonising monitoring methods. He has been responsible for air quality review and assessments on behalf of numerous local authorities. He has also developed methods to predict nitrogen deposition fluxes on behalf of the Environment Agency, provided support and advice to the UK Government's air quality review and assessment helpdesk, Transport Scotland, Transport for London, and numerous local authorities. He is a Member of the Institute of Air Quality Management and a Chartered Scientist.

Caroline Odbert, BA (Hons) MSc CSci MEnvSc MIAQM

Ms Odbert is a Senior Consultant with AQC, with over eight years' relevant experience. She is involved in the preparation of air quality assessments for a range of development projects. She has been responsible for a wide range of air quality projects covering impact assessments for new residential and commercial developments, local air quality management, ambient air quality monitoring of nitrogen dioxide and sulphur dioxide and the assessment of nuisance odours. She has extensive modeling experience for road traffic and has worked with a variety of clients to provide expert air quality services and advice, including local authorities, planners, developers and process operators. She is a Member of the Institute of Air Quality Management and is a Chartered Scientist.

Dr Frances Marshall, MSci PhD

Dr Marshall is a Consultant with AQC, having joined the company in September 2016. She is currently gaining experience of undertaking air quality assessments, including the use of dispersion modelling. Prior to joining AQC, Frances spent four years carrying out postgraduate research into atmospheric aerosols at the University of Bristol.

Full CVs are available at www.aqconsultants.co.uk.

A2 Modelling Methodology

Road Traffic Inputs

- A2.1 Predictions have been carried out using the ADMS-Roads dispersion model (v4.1). The model requires the user to provide various input data, including emissions from each section of road, and the road characteristics (including road width). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the EFT (Version 8.0.1) published by Defra (Defra, 2018).
- A2.2 AADT flows and vehicle fleet composition data have been provided by GTA Civils, who have undertaken the transport assessment for the local plan proposals in Wealden. Traffic speeds have been estimated based on professional judgement, taking account of the road layout, speed limits and the proximity to a junction. The traffic data used in this assessment are summarised in Table A2.1.

Table A2.1: Summary of Traffic Data used in the Assessment (AADT Flows)

Road Link	2015		2028 (Without Scheme)		2028 (With Scheme)		Speed (KPH) ^a
	AADT	%HDV	AADT	%HDV	AADT	%HDV	
A259 Pevensey Levels	18,070	3.5	22,300	3.3	23,217	3.2	96
A259 West of Roundabout	14,270	1.7	15,832	1.7	16,509	1.6	48
A259 Towards E'bourne	11,430	1.4	12,936	1.4	14,575	1.2	48
A27 North of Pevensey	15,430	3.5	18,403	3.3	18,969	3.2	96
B2191	5,760	1.8	6,339	1.8	8,139	1.4	48

^a Speeds have been reduced to 20 KPH on the approach to the roundabout and at junctions.

- A2.3 Diurnal flow profiles for the traffic have been derived from the national diurnal profiles published by DfT (2015).
- A2.4 Figure A2.1 shows the road network included within the model and defines the study area.

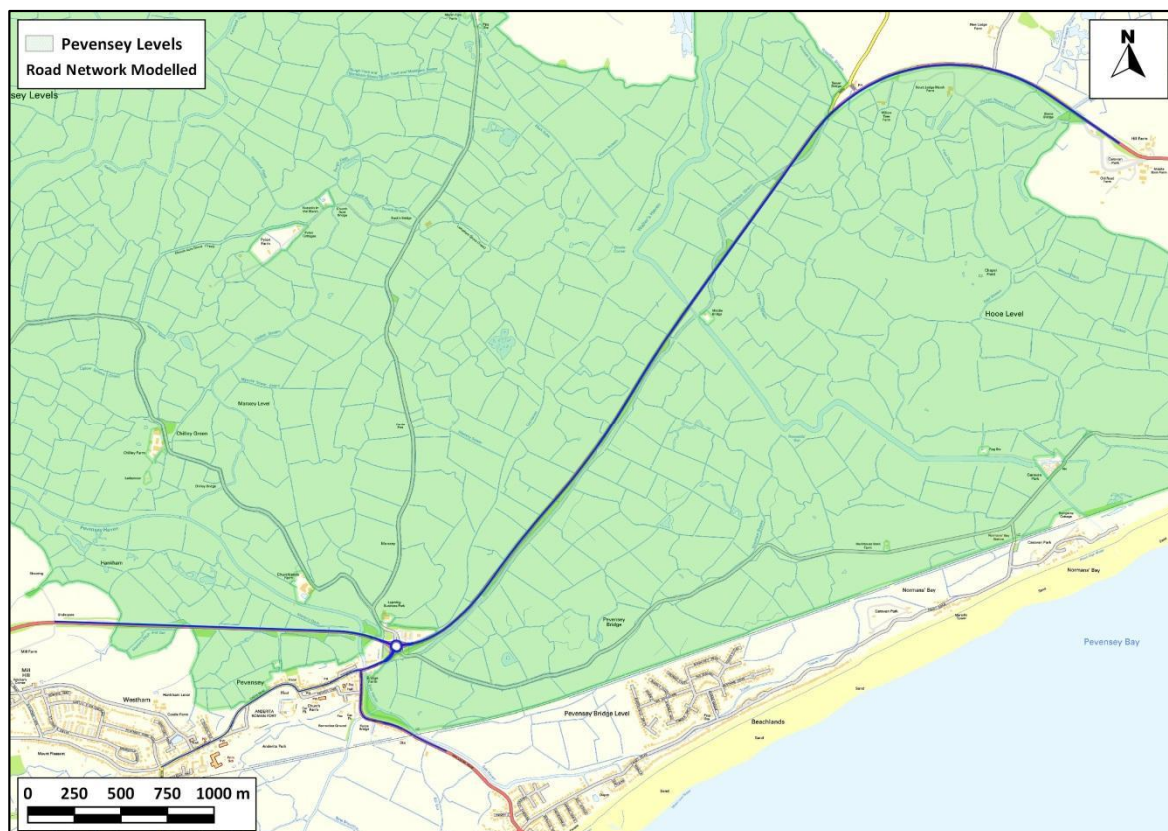


Figure A2.1: Modelled Road Network

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CURED 3A Model for NO_x and Nitrogen Dioxide

- A2.5 As explained in Section 3, AQC has carried out a detailed analysis which showed that, whereas previous standards had had limited on-road success in reducing nitrogen oxides emissions from diesel vehicles, the 'Euro VI' and 'Euro 6' standards are delivering real on-road improvements (AQC, 2018). Defra's EFT v8.0.1 takes account of these observed improvements, but also makes additional assumptions regarding the performance of diesel cars and vans that will be produced in the future. In particular, it assumes that diesel cars and vans registered for type approval after 2020 will, on average, emit significantly less NO_x than earlier models. A sensitivity test has been carried out using AQC's CURED v3A model (AQC, 2018), which assumes that this post-2020 technology does not deliver any benefits (as a worst-case assumption). Further details of CURED v3A are provided in the supporting report prepared by AQC (AQC, 2018).
- A2.6 Results are thus presented for three scenarios: first the 'Scenario A' which assumes that road traffic emissions are held constant at 2015 levels, the second 'Scenario B', which applies adjustments to certain diesel vehicles, and the third 'Scenario C', which uses the EFT with no

adjustment. The results from Scenarios A and B are likely to over-predict emissions from vehicles in the future.

Meteorological Data

- A2.7 Hourly meteorological data from Gatwick Airport have been used in the model. The Gatwick Airport meteorological monitoring station is located at approximately 65 km to the northwest of the Pevensey Levels.
- A2.8 For consistency with the work on Ashdown Forest, the meteorological file covers a 2-year period from 07/08/14 to 09/08/16. This meteorological file has model has been split into a number of subsets to facilitate the deposition calculations and this is explained in Appendix A3.

Background Concentrations

- A2.9 The background nitrogen dioxide and nitrogen oxide concentrations across the study area have been defined using the national pollution maps published by Defra (Defra, 2018). These cover the whole country on a 1x1 km grid and are published for each year from 2013 until 2030. The background maps for 2015 have been calibrated against concurrent measurements from national monitoring sites. The calibration factor calculated has also been applied to future year backgrounds. This has resulted in slightly higher predicted concentrations for the future assessment year than that derived from the Defra maps (Defra, 2018).
- A2.10 The background ammonia concentrations across the study area have been taken from UK Deposition data provided by the Centre for Ecology and Hydrology (CEH, 2018). These cover the whole country on a 5 x 5 km grid, and are published yearly from 2004 until 2014. Since data for 2015 are unavailable, the data for 2014 have been used throughout the entire assessment. No suitable models are available to predict how ammonia concentrations may change in the future; the 2015 background concentrations have, therefore, not been projected forward to 2028 for the assessment.

Background Concentrations for Emissions Model A

- A2.11 The values used for emissions model A are those for 2015.

Background Concentrations for Emissions Models B and C

NO₂ and NO_x Concentrations

- A2.12 For emissions model B, the road-traffic components of NO_x and nitrogen dioxide in the background maps have been uplifted in order to derive future year background nitrogen dioxide and NO_x concentrations. Details of the approach are provided in the report prepared by AQC (2018a).

- A2.13 For emissions model C, background NO₂ and NO_x concentrations were taken from Defra's maps, adjusted as described in Paragraph A2.12.

HNO₃ and particulate NO₃⁻ and NO₂⁻

- A2.14 Trends in concentrations of HNO₃ and particulate NO₃⁻ and NO₂⁻ are likely to follow those in NO_x. Predicting background concentrations of these pollutants thus follows a similar approach to that for NO_x, but because these species form over greater distances, the model domain has been expanded, and traffic emissions have not been removed. First, Defra's maps of ambient background NO_x concentrations in 2015 and 2028 (Defra, 2018) for the 24,000 1 km x 1 km grid squares that make up the southeast of England have been obtained. For emissions model B, the road-traffic components of NO_x have been uplifted in line with the CURED model (AQC, 2018). For emissions model C, the background maps have been used directly.
- A2.15 The ratios of the 2028 prediction to the 2015 prediction at each square have then been calculated. On average, the predictions for models B and C are 70% and 65% respectively of those for model A. The measured concentrations of HNO₃ and particulate NO₃⁻ and NO₂⁻ have thus been multiplied by 0.701 and 0.653 to estimate future-year values.

NH₃ and Particulate NH₄⁺

- A2.16 There are no emissions models B or C for NH₃ from local traffic, but in order to provide robust estimates of total nitrogen deposition under models B and C, background NH₃ and particulate NH₄⁺ in the future have been scaled using national-level projections.
- A2.17 Whilst it would be preferable to calculate source-specific emissions in 2015 and use detailed process information to model year-by-year changes in emissions from each source individually, such an approach would require resources well beyond the scope of this study. A best estimate has been calculated by multiplying existing annual mean background concentrations by the expected change in national ammonia emissions between 2015 and 2028. Given other sources of uncertainty, this approach is considered to be appropriate; although, in particular, it is noted that the published national-level projections do not take account of recent commitments and proposals at both European and UK levels to reduce NH₃ emissions and so the future-year background projections may prove precautionary. Defra has calculated the UK total NH₃ emissions in 2015 to be 272.11 kt, and predicted that the emissions in the future will be 283.82 kt in 2020, 288.93 kt in 2025, and 294.33 kt in 2030 (Defra, 2012). Interpolating between the 2025 and 2030 values gives an estimate for 2028 of 292.17 kt. The existing (model A) background NH₃ and particulate NH₄⁺ concentrations have thus been multiplied by 292.17 / 272.11. This clearly over-simplifies what is likely to happen (for example, changes in the emissions of acidic gases over this period will change the behaviour of NH₃) but it nevertheless provides a useful estimate.

Model Verification

- A2.18 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements.
- A2.19 The model has been verified using meteorological data covering the time period between 2014 and 2016. As such, background concentrations used in the verification process also represent the average from the years 2014 to 2016. These have been derived from the national maps, having been calculated using the same approach as described in Paragraph A2.9. The background concentrations for the verification site, for each year, and the average, are presented in Table A2.2.

Table A2.2: Background Concentration used in the Verification

Year	NO ₂
2014	11.5
2015	11.3
2016	11.0
Average	11.3
Objective	40

Traffic Data

- A2.20 AADT flows, and the proportions of HDVs, for the A259 adjacent to the monitoring site, have been determined from the interactive web-based map Webtris provided by the Highways England (Highways England, 2018). For consistency with the meteorological time period used in the verification, the average of the AADT flows, and proportions of HDVs, between 2014 and 2016 along the A259 adjacent to the monitoring site have been used. Traffic data for each year, and that used in the model verification are presented in Table A2.3.

Table A2.3: AADT Traffic Data for the A259 used in the Model Verification

Year	AADT	% HDV
2014	23,691	4.9
2015	24,787	3.9
2016	20,506	3.2
Average	22,995	4.0

Nitrogen Dioxide

- A2.21 Most nitrogen dioxide (NO₂) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of NO_x (NO_x = NO + NO₂). The model has been run to predict the annual mean NO_x

concentrations during 2015 at the De La Warr Road automatic monitoring site. Concentrations have been modelled at 2.02 m, the height of the monitor.

A2.22 The model output of road-NO_x (i.e. the component of total NO_x coming from road traffic) has been compared with the 'measured' road-NO_x. Measured road-NO_x has been calculated from the measured NO₂ concentration and the predicted background NO₂ concentration using the NO_x from NO₂ calculator (Version 6.1) available on the Defra LAQM Support website (Defra, 2018).

A2.23 An adjustment factor has been determined as the ratio of the 'measured' road contribution and the model derived road contribution. This factor has then been applied to the modelled road- NO_x concentration for each receptor to provide adjusted modelled road- NO_x concentrations. The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road- NO_x concentrations with the predicted background NO₂ concentration within the NO_x to NO₂ calculator (Defra, 2018).

A2.24 For consistency with the meteorological time period used in the verification, the average measured concentration at the De La Warr monitoring site between the years 2014 and 2016 has been used. The measured concentrations for each year are presented in Table A2.4, along with the average concentration used to verify the model.

Table A2.4: Measured Concentrations used in the Model Verification

Year	Measured Concentration (µg/m ³)
2014	21.9
2015	18.4
2016	25.1
Average	22.9

A2.25 The data used to calculate the adjustment factor are provided below:

- Measured NO₂ : 22.9 µg/m³
- Background NO₂ : 11.3 µg/m³
- 'Measured' road- NO_x (using NO_x from NO₂ calculator): 22.5 µg/m³
- Modelled road- NO_x = 14.2 µg/m³
- Road- NO_x adjustment factor: $22.5/14.2 = 1.577^{11}$

A2.26 The factor implies that the unadjusted model is under-predicting the road- NO_x contribution. This is a common experience with this and most other road traffic emissions dispersion models.

¹¹ Based on un-rounded values.

Model Post-processing

Road Traffic

NO_x and nitrogen dioxide

- A2.27 The model predicts road- NO_x concentrations at each receptor location. These concentrations have been adjusted using the adjustment factor set out above, which, along with the background NO₂, has been processed through the NO_x to NO₂ calculator available on the Defra LAQM Support website (Defra, 2018). The traffic mix within the calculator has been set to "All UK traffic", which is considered suitable for the study area. The calculator predicts the component of NO₂ based on the adjusted road- NO_x and the background NO₂.

24-hour NO_x

- A2.28 The dispersion model has not been used to calculate 24-hour mean NO_x concentrations. Instead, the relationship between annual mean and maximum 24-hour mean NO_x concentrations discussed in the Ashdown Forest report has been applied to Pevensey Levels. This relationship is based on measured annual mean and maximum 24-hour mean NO_x concentrations measured at 135 AURN monitoring sites between 2014 and 2016.

- A2.29 The maximum 24-hour mean NO_x concentrations have thus been predicted as:

$$\text{Maximum 24-hour Mean NO}_x = \text{EXP} (2.7924 \times (\ln(\text{Annual Mean NO}_x))^{0.5149})$$

A3 Deposition Model

- A3.1 Dry deposition is driven by a concentration gradient caused by surface depletion. This is quantified as a deposition velocity (V_d), which is the ratio between deposition flux and atmospheric concentration.

$$\text{Eq 1.} \quad V_d(z) = -F/C(z)$$

and therefore:

$$\text{Eq 2.} \quad F = V_d C$$

where F is the deposition flux, and atmospheric concentration (C) and V_d are both referenced to a height (z) above the ground. In principle, these terms refer to instantaneous values, but more commonly, time-averaged data are used.

- A3.2 A very detailed approach has been taken to calculating deposition fluxes, which goes well beyond the level of detail that would typically be used for an air quality assessment. Very often, air quality assessments multiply annual average concentrations by annual average deposition velocities, but it is well-established that there are diurnal and seasonal differences in deposition velocities, as well as diurnal and seasonal differences in concentrations. The highest NO_2 concentrations, for example, often occur after dark in the winter, but these are largely irrelevant for deposition since deposition of NO_2 largely stops at this time (since the principal route of NO_2 deposition is via plant's stomata and these are inactive after dark in the winter). Applying annual average deposition velocities to annual average concentrations smooths over this, and other, details, and while this simplification is probably appropriate for basic assessments, it is associated with potentially significant error. Modelling carried out on behalf of Defra (Smith et al. (2000)) and the Environment Agency (Environment Agency, 2008) has taken a more detailed approach of using temporally-variable concentrations and temporally-variable deposition velocities. For consistency with other work being carried out by Wealden District Council, it was considered appropriate to apply a more detailed approach to the deposition modelling than that of using annual average deposition velocities.

- A3.3 The approach used is based on an electrical resistance analogy; also known as the 'big-leaf model'. This is the same general approach used by CEH on behalf of Defra in the UK national deposition maps. The approach treats the various forces which resist deposition separately. The first of these forces is termed the 'aerodynamic resistance' (r_a). This is the resistance to transport between the atmosphere and a shallow (ca. 1 mm) layer near to the surface. Transport here is due to turbulent diffusion. r_a is dependent on height, and is therefore given for a reference height (z). Second is laminar boundary layer resistance (r_b). This is the resistance to transport through the quasi-laminar layer to the surface. Transport of gases through this layer is due to molecular diffusion. Transport of particles may be the result of Brownian motion or sedimentation. Third is

surface resistance (r_c). This is the receptiveness of the surface to depositing material and depends on properties of both. Equation Eq 3 shows how the deposition velocity (V_d) is calculated from these three resistances Smith et al. (2000).

$$\text{Eq 3.} \quad V_d = \left(\frac{1}{r_a + r_b + r_c} \right)$$

A3.4 Two separate deposition models have been run; providing two alternative sets of outputs. The reason for this is uncertainty in the surface resistance (r_c) for NO_2 ; to which the model is particularly sensitive. One method “the EA method”, follows an approach for calculating r_c published by the Environment Agency (2008). The second method has been developed by the authors of this report, but relies very heavily on work by CEH in producing the national UK deposition maps Smith et al. (2000). Since it was not appropriate to follow CEH’s method exactly, this is termed the “AQC method”. It should be noted that while the terms “EA method” and “AQC method” are used here, for convenience, to describe the entire deposition calculations, these names are more precisely related to the different descriptions of the parameter $r_c(\text{NO}_2)$, between the two methods. In the following section, the approach used for the EA method is set out first, and then the additional features of the AQC method are described.

EA Deposition Method

A3.5 A separate value of V_d has been calculated for each surface type and for each hour of the meteorological dataset running from 7th August 2014 to 9th August 2016¹². These V_d values have then been averaged over each of the following time periods: summer day, summer night, winter day, and winter night¹³. It has not been practical to apply hour-by-hour deposition velocities to hour-by-hour concentrations.

Deposition of Gases (NO_2 , NO , NH_3 , and HNO_3)

Calculating r_a and r_b

A3.6 The approach largely follows that described by Smith et al. (2000), which is used in Defra’s national deposition maps. r_a and r_b are calculated as follows:

$$\text{Eq 4.} \quad r_a = \frac{u(z)}{u_*^2}$$

$$\text{Eq 5.} \quad r_b = \frac{2}{ku_*} \left(\frac{Sc}{Pr} \right)^{2/3}$$

¹² Excluding those hours when the Gatwick meteorological station did not record any data.

¹³ In the case of NO , $r_a+r_b+r_c$ was averaged, rather than averaging V_d since V_d NO is dependent on the ambient concentration.

where $u(z)$ is the wind speed at reference height (z), k is von Karman's constant, Sc is the Schmidt number for the gas, Pr is the Prandtl number for air, and u_* is the friction velocity.

- A3.7 The Prandtl number has been calculated using Sutherland's law, taking account of the average recorded temperature at the Gatwick meteorological office station during each time period. The Schmidt number has been calculated using Equation Eq 6, applying the molecular diffusion coefficients calculated by Massman (1998), adjusted to each period-specific temperature.

$$\text{Eq 6.} \quad Sc = \frac{\nu}{k_c}$$

where ν is the kinematic viscosity of air, and k_c is the molecular diffusion coefficient of each gas in air.

- A3.8 In common with the approach given by Smith et al (2000), the following relationship between canopy height (h), wind speed (u), aerodynamic roughness length (z_0), zero plane displacement (d), and friction velocity has been assumed:

$$\text{Eq 7.} \quad z_0 = 0.1h$$

$$\text{Eq 8.} \quad d = 0.7h$$

$$\text{Eq 9.} \quad u_* = \frac{u(z)k}{\log_e((z-d)/z_0)}$$

- A3.9 The Gatwick meteorological office station records wind speed at a height of 10 m above the ground. The calculations set out above require the wind speed above the canopy. This has been calculated using equation Eq 10. Each hourly wind speed has been treated separately (along with the concurrent recorded temperature). The meteorological station records wind speeds <0.25 m/s as 0 m/s. These have been manually set to 0.125 m/s.

$$\text{Eq 10.} \quad \frac{u(z)}{u(z_{ref})} = \frac{\ln\left(\frac{z-d}{z_0}\right)}{\ln\left(\frac{z_{ref}-d}{z_0}\right)}$$

where z is the height above the canopy from which deposition is calculated and z_{ref} is the height at which the wind speed has been measured.

- A3.10 Canopy height has been set to be consistent with the assumed canopy heights for grassland and woodland in the Ashdown Forest modelling study. Concentrations have been modelled at a height of 1.5 m above ground. The reference height has been set to 1.5 m for those canopies less than 1.5 m and set to 0.5 m above the woodland canopy.

Estimating $r_c(\text{NH}_3)$

- A3.11 Defra's national model takes different forms depending on the land use category. NH_3 deposition to moorland and forest uses a fixed r_c of 20 s/m, reflecting the dominance of uptake on cuticular surfaces in these ecosystems¹⁴. For arable and grassland a bi-directional flux is introduced, but this detail has not been included here. A fixed $r_c(\text{NH}_3)$ value of 20 s/m has been used.

Estimating $r_c(\text{HNO}_3)$

- A3.12 In common with Defra's national model, $r_c(\text{HNO}_3)$ has been assumed to be zero (i.e. $r_c(\text{HNO}_3) = 0$ s/m).

Estimating $r_c(\text{NO}_2)$

- A3.13 The approach for $r_c(\text{NO}_2)$ follows that given by the Environment Agency (Environment Agency, 2008) as set out in equation Eq 11.

$$\text{Eq 11.} \quad \frac{1}{r_c} = \frac{1}{r_{\text{stomata}}} + \frac{1}{r_{\text{soil}}} + \frac{1}{r_{\text{surface}}}$$

- A3.14 The Environment Agency (Environment Agency, 2008) values of r_{stomata} in Table A3.1, and values of $r_{\text{soil}} + r_{\text{surface}}$ in Table A3.2 have been used in the model.

Table A3.1: Values of Stomatal Resistance (r_{stomata}) (s/m) Taken from the Environment Agency (Environment Agency, 2008)

Habitat	Summer day	Summer night	Winter day	Winter night
Deciduous forest	75	9,999	9,999	9,999
Grassland	50	9,999	9,999	9,999

Table A3.2: Values of Surface Resistance and Soil Resistance ($r_{\text{surface}} + r_{\text{soil}}$) Taken from the Environment Agency (Environment Agency, 2008)

Habitat	Summer day	Summer night	Winter day	Winter night
Deciduous forest	1,000	2,000	2,000	2,000
Grassland	1,000	2,000	2,000	2,000

Deposition of NO

- A3.15 Deposition of NO is slow compared with the other species considered and, in any event, only occurs where NO concentrations are elevated (elsewhere, the soil is a net source of NO). The

¹⁴ Resistances are expressed in s/m, since deposition velocities are expressed in m/s.

Environment Agency (2008a), following on from work by Fowler et al. (1998), used the following generalisation to calculate deposition of NO (Eq 12).

$$\text{Eq 12.} \quad \text{NOFlux} = \frac{C_{\text{air}} - C_{\text{soil}}}{r_a + r_b + r_{\text{soil}}}$$

Where C_{air} is the concentration in the air and C_{soil} is the concentration in the soil. Fixed values of $20 \mu\text{g}/\text{Nm}^3$ for C_{soil} and $1,000 \text{ s/m}$ for r_{soil} have been used, which are those used by both Fowler et al. (1998) and the Environment Agency (2008a).

- A3.16 Equation Eq 12 shows that at ambient concentrations above C_{soil} ($20 \mu\text{g}/\text{Nm}^3$), NO is deposited, while at ambient concentrations below this, it is emitted. Since period-average values of C_{air} have been used, the instantaneous nature of this process has been lost. Where NO deposition is calculated to be positive, it has been added to the total deposition flux, however, negative fluxes have not been included in the model. While this approach is simplistic, the slow and localised nature of NO deposition will mean that it introduces relatively little error.

Application to Habitats in the SAC

- A3.17 Table A3.3 sets out the canopy heights and land-use categories used in the deposition modelling.

Table A3.3: Assumed Canopy Heights (m) and Categories from Table A3.1 and Table A3.2

Surface Type	Summer	Winter	Equivalent Category from Table A3.1 and Table A3.2
Grassland	0.5	0.2	Grassland
Semi-natural woodland	10	10	Deciduous forest

Deposition of Particles

- A3.18 Marner and Harrison (2004) used equation Eq 13 to calculate mass-weighted particle deposition velocities.

$$\text{Eq 13.} \quad V_d = \frac{\sum_{i=1}^{i=6} V_{di} C_i}{\sum_{i=1}^{i=6} C_i}$$

where V_{di} is the V_d of fraction i , and C_i is the mass concentration of analyte in size fraction i . The same authors also measured typical particle size distributions of the species of interest to this study (Figure A3.1) and calculated deposition velocities (Table A3.3). These have been used for this study, assuming arable-based velocities to bracken and heath, grassland-based velocities to

grassland and bare ground, and forest and water-based velocities to woodland and water respectively.

Table A3.4: Particle Deposition Velocities (after Marner and Harrison (2004)) (cm/s)

Particle Sizes	Deposition Velocities (V_d) for Different Land Uses			
	Water	Grassland	Arable	Forest
dp 8 – 20 μm	2.00	1.8	3.25	na
dp 4 – 8 μm	0.60	0.35	0.55	na
dp 2 – 4 μm	0.25	0.1	0.15	na
dp 1 – 2 μm	0.15	0.04	0.08	na
dp 0.5 – 1 μm	0.07	0.021	0.045	na
dp < 0.5 μm	0.01	0.018	0.023	na
Overall Aerosol NO_3^-	0.23	0.15	0.26	1.78
Overall Aerosol NH_4^+	0.11	0.06	0.10	1.02

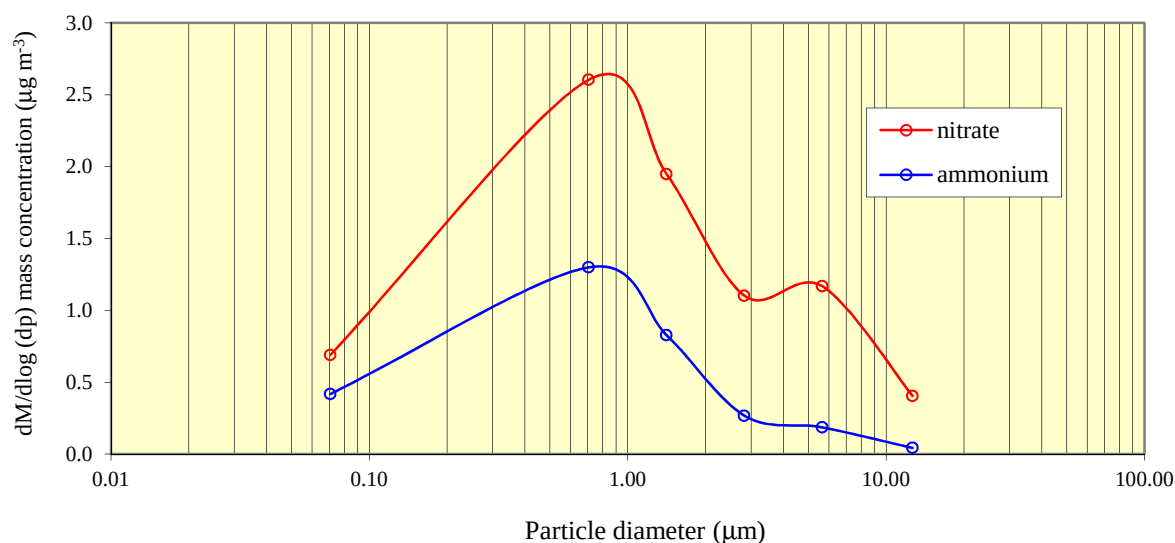


Figure A3.1: Mean Particle Size Distribution (after Marner and Harrison (2004))

Wet Deposition

Emissions Scenario A

A3.19 The contribution from wet deposition has been taken from the national deposition maps for 2014, which is the most recent year of available data (CEH, 2018). The 2014 fluxes have been assumed to represent the existing baseline scenario. These are presented on a 5 km x 5 km grid across the

UK. Values across the SAC have been derived by interpolating the coarse gridded data using triangulation with linear interpolation (taking all of the values within 35 km of the SAC and assuming each value represents the centre of each grid point).

- A3.20 It has not been possible to take account of the influence that traffic associated with the Local Plan will have on wet deposition. This is because the contribution to wet deposition of emissions from individual roads cannot be determined. The influence of roads within the Transport Model on wet deposition to the SAC is expected to be negligible.

Emissions Scenarios B and C

- A3.21 There is a non-linear relationship between total emissions and total deposition and this makes it extremely difficult to predict baseline deposition fluxes in 2028 taking account of national-scale predicted changes in emissions. In order to provide an estimate of wet deposition under emissions models B and C, a linear relationship between emissions and deposition has been assumed; which will inevitably introduce error.
- A3.22 In order to estimate wet deposition of reduced nitrogen in 2028 under emissions scenarios B and C, the interpolated 2014-specific fluxes have been multiplied by the ratio of Defra's predicted UK total NH_3 emissions in 2028 (292.17 kt) to those in 2015 (272.11 kt) (Defra, 2012). This is an over-simplification but nevertheless provides a useful estimate.
- A3.23 In order to predict wet deposition of oxidised nitrogen in 2028 under Emissions Scenario B and C, the same approach as described for projecting future-year HNO_3 and particulate NO_3^- concentrations has been used. Defra's maps of ambient background NO_x concentrations in 2015 and 2028 (Defra, 2018) for the 24,000 1 km x 1 km grid squares that make up the southeast of England have been used. For emissions model B, the road-traffic components of NO_x have been uplifted in line with the CURED model (AQC, 2018). For emissions model C, the background maps have been used directly. The ratios of the 2028 prediction to the 2015 prediction at each square has then been calculated. On average, the predictions for models B and C are 70.1% and 65.3% respectively of those for model A. Oxidised wet deposition has thus been multiplied by 0.701 and 0.653 to estimate future-year values for models B and C respectively.

AQC Deposition Method

Estimating r_a and r_b

- A3.24 The approach used in the AQC method for parameters r_a and r_b , is identical to that used in the EA deposition method as described above.

Estimating $r_c(\text{NO}_2)$

- A3.25 Values of r_c were calculated using equation Eq 11:

$$\text{Eq 14.} \quad \frac{1}{r_c} = \frac{1}{r_{stomata}} + \frac{1}{r_{surface}}.$$

Estimating $r_{stomata}$ (NO_2)

A3.26 The calculations followed the method provided by Smith *et al* (2000), but whereas that model calculates deposition velocities for each hour of a single day within each month (i.e. $24 \times 12 = 288$ separate values of r_c for each habitat), the current study began by calculating a separate deposition velocity for each individual hour of a 2-year meteorological file (i.e. 17,597 valid values in total). Smith *et al* (2000) provided ranges for certain parameters used in their model, and the approach used here has been to interpolate across these ranges using other published measurements as described below.

A3.27 The value of $r_{stomata}$ is dependent on the amount of incoming solar radiation, which was estimated for each hour in the dataset as follows. Direct (R_{beam}) and diffuse ($R_{diffuse}$) radiation were determined separately, using the following equations (taken from Smith *et al* (2000)):

$$\text{Eq 15.} \quad R_{beam} = 600 \text{ Wm}^{-2} * e^{-0.185(P/P_0)/\cos(\theta)} \cos(\theta)$$

and

$$\text{Eq 16.} \quad R_{diffuse} = 0.4(600 \text{ Wm}^{-2} - R_{beam}) \cos(\theta)$$

where θ is the zenith angle of the sun and

$$\text{Eq 17.} \quad \frac{P}{P_0} = \left(1 - \frac{0.0065a}{288.16}\right)^{5.25611}$$

is the ratio of actual to sea level pressure. Here a is the altitude. The value of 600 Wm^{-2} is the irradiance of visible light at the top of the atmosphere, assumed to be 45% of the 1320 Wm^{-2} solar radiation Smith *et al* (2000).

A3.28 These parameters were then adjusted to give a maximum value for clear skies and a minimum value for overcast skies. As noted above, the model of Smith *et al* (2000) focused on a single day within each month, and differentiated between clear and overcast skies based on a 1985 analysis of solar radiation measurements. For the current study, whether the sky was clear or overcast was determined for each separate hour of the meteorological dataset using cloud cover measurements made at Gatwick Airport. It was assumed that cloud cover readings of 0-4 oktas indicated clear sky, while readings of 5-8 oktas indicated overcast sky. Following the approach of Smith *et al* (2000), the actual visible direct and diffuse radiation S_{beam} and $S_{diffuse}$ was set to a maximum as:

$$\text{Eq 18.} \quad S_{beam} = 0.9R_{beam}$$

and

$$\text{Eq 19.} \quad S_{diffuse} = 0.9R_{diffuse}$$

for clear skies; and was set to a minimum as

$$\text{Eq 20.} \quad S_{beam} = 0$$

and

$$\text{Eq 21.} \quad S_{diffuse} = 0.2(R_{beam} + R_{diffuse})$$

for overcast skies.

A3.29 The average values for direct and diffuse visible radiation falling on a leaf surface, assuming a spherical leaf angle distribution, were calculated by:

$$\text{Eq 22.} \quad S_{beam}(leaf) = \frac{S_{beam}}{2 \cos(\theta)}$$

and

$$\text{Eq 23.} \quad S_{diffuse}(leaf) = \frac{S_{diffuse}}{2}$$

with the appropriate values of S_{beam} and $S_{diffuse}$ used depending on cloud cover.

A3.30 The stomatal resistance for NO_2 was then calculated for sunlit leaves as:

$$\text{Eq 24.} \quad r_{sunlit} = \frac{r_{stomata(min)}}{f_T} \left(1 + \frac{b}{S_{beam}(leaf) + S_{diffuse}(leaf)} \right) DVR_{NO2}$$

and for shaded leaves as:

$$\text{Eq 25.} \quad r_{shaded} = \frac{r_{stomata(min)}}{f_T} \left(1 + \frac{b}{S_{diffuse}(leaf)} \right) DVR_{NO2}$$

where $r_{stomata(min)}$ is the minimum stomatal resistance for water vapour, b is the light response coefficient (see Table A3.5), DVR_{NO2} is the molecular diffusion correction and f_T is the temperature correction. DVR_{NO2} is given by:

$$\text{Eq 26.} \quad DVR_{NO2} = \frac{dv(H_2O)}{dv(NO_2)}$$

where $dv(X)$ is the molecular diffusivity of gas X . The temperature correction f_T takes in account that the rate stomatal exchange is highest at an optimum temperature $T_{opt} = 15^\circ\text{C}$ and falls to zero above a maximum temperature $T_{max} = 25^\circ\text{C}$ and below a minimum temperature T_{min} that is dependent on the land use (see Table A3.5), and is defined as

$$\text{Eq 27.} \quad f_T = \frac{T - T_{\min}}{T_{\text{opt}} - T_{\min}} \frac{T_{\max} - T}{T_{\max} - T_{\text{opt}}} \frac{T_{\max} - T_{\text{opt}}}{T_{\text{opt}} - T_{\min}}$$

where T is the temperature during a given hour. For temperatures outside the range for which stomatal exchange would occur, f_T was set to 0.0001 as an arbitrarily low number to avoid dividing by zero later in the model. This was sufficient to make the stomatal pathway for deposition negligible.

A3.31 The area indices of leaves which are exposed to radiation, LAI_{lit} , were calculated from the Leaf Area Index (LAI) (see paragraph A3.36 below) using the equation:

$$\text{Eq 28.} \quad LAI_{lit} = 1.95(1 - e^{-0.7LAI})$$

which for clear skies were then split into indices for direct and diffuse radiation, approximated by:

$$\text{Eq 29.} \quad LAI_{sunlit} = 2 \left(1 - e^{-\frac{LAI}{2 \cos(\theta)}} \right) \cos(\theta)$$

and

$$\text{Eq 30.} \quad LAI_{shaded} = LAI_{lit} - LAI_{sunlit}$$

respectively. The stomatal resistance was then calculated, for each individual hour of the meteorological dataset, as:

$$\text{Eq 31.} \quad r_{stomata}(clear) = \frac{1}{LAI_{sunlit}/r_{sunlit} + LAI_{shaded}/r_{shaded}}$$

for clear skies and

$$\text{Eq 32.} \quad r_{stomata}(overcast) = \frac{r_{shaded}}{LAI_{lit}}$$

for overcast skies. These were calculated for each hour in the dataset using hourly temperature and cloud data.

A3.32 Table A3.6 shows how the values presented in Table A3.5 have been applied to the habitat types used in this current study.

Table A3.5: Constants used to Calculate $r_c(\text{NO}_2)$, taken from Smith *et al* (2000)

Land Use Category	Min $r_{stomata}(\text{min})$	Max $r_{stomata}(\text{min})$	Min LAI	Max LAI	$b \text{ (W/m}^2\text{)}$	Tmin (°C)
Grassland	80	300	2	4	40	4
Forest	140	350	6	6	25	0

Table A3.6: Assumed Equivalence of Land Use Categories

Surface Type	Equivalent Category from Table A3.5
Grassland	Grassland
Semi-natural woodland	Forest

A3.33 Except for the difference that values were calculated for each hour of the 2-year dataset, rather than for one day per month, the calculations set out above follow those presented by Smith *et al* (2000). Where it was necessary to develop a bespoke method was in order to estimate temporal variation in values of $r_{stomata(min)}$ and LAI. In both cases, Smith *et al* (2000) provided the ranges of their values for each land use category (see Table A3.5) and it was necessary to interpolate between these values in order to generate a profile across the year, and across the growing season.

Interpolating $r_{stomata(min)}$

A3.34 In order to interpolate hour-specific values of $r_{stomata(min)}$, recent work by Wehr *et al* (Wehr *et al.*, 2017) was used. While this work is not specific to the UK, within the context in which it has been used here, it is considered to be appropriate. Wehr *et al* (Wehr *et al.*, 2017) measured carbonyl sulphide (OCS) uptake in plants over the growing season, which they found to be a good indicator of stomatal conductance. In order to interpolate between the values in Table A3.5, it was assumed that, over the course of a year $r_{stomata(min)}$ would be proportional to the inverse of the rate of carbonyl sulphide (OCS) uptake (R_{OCS}) and that the maximum value of R_{OCS} would correspond to the minimum value of $r_{stomata(min)}$ and vice versa. The measured values of R_{OCS} are shown in Table A3.7. The values of $r_{stomata(min)}$ corresponding to values of R_{OCS} between the minimum and maximum were calculated using Equation Eq 33:

$$\text{Eq 33.} \quad r_{stomata(min)} = \frac{A}{R_{OCS}} + C$$

A3.35 where A and C are constants calculated for each land use category. For days between those for which R_{OCS} was given, the value corresponding to the most recent day for which there was a measurement was used. For days outside the period of measurement the maximum value of $r_{stomata(min)}$ was used.

Interpolating Leaf Area Index

A3.36 Maximum and minimum values of Leaf Area Index (LAI) were, again, taken from the values reported by Smith *et al* (2000) (see Table A3.5), and this time it was assumed that LAI is proportional to the gross primary production (GPP) measured by Wehr *et al* (Wehr *et al.*, 2017) (Table A3.7). LAI was then calculated similarly to $r_{stomata(min)}$, with the differences that: it was assumed the maximum and minimum values of LAI corresponded with the maximum and minimum values of GPP; that values of LAI corresponding to values of GPP between the maximum and

minimum were calculated using an Equation Eq 34; and that the minimum value of LAI was used for days outside the period of measurement.

$$\text{Eq 34.} \quad r_{\text{stomata}(\min)} = AR_{\text{OCS}} + C$$

Table A3.7: Values of R_{OCS} and GPP taken from Wehr *et al* (Wehr *et al.*, 2017)

Julian Day	R_{OCS} ($\mu\text{mol m}^{-2} \text{ s}^{-1}$)	GPP ($\mu\text{mol m}^{-2} \text{ s}^{-1}$)
141	29	14
155	30	17
169	37	25
183	42	23
197	38	20
211	34	22
225	26	22
239	32	20
253	29	14
267	30	15
281	25	14
295	9	6

Estimating $r_{\text{surface}}(\text{NO}_2)$

A3.37 Smith *et al* (2000) did not include $r_{\text{surface}}(\text{NO}_2)$ within their model, since this route of uptake is considered to be so slow when compared with stomatal uptake that it can be safely ignored. However, given that this route of uptake was included by the Environment Agency (2008), and thus in the EA method, it was considered that, for the sake of completeness, it should also be included here. Erisman and Draaijers (1995) (Table 4.5) estimated values of r_c to wet and dry soil surfaces, with this resistance being either 2,000 s/m to wet soil or 1,000 s/m to dry soil.

A3.38 Values of r_{surface} were thus assigned to each hour of the meteorological file as follows:

- if rain fell in the current hour $r_{\text{surface}} = 2,000 \text{ s/m}$;
- in winter, if rain fell in the previous two hours $r_{\text{surface}} = 2,000 \text{ s/m}$;
- for hours between midnight (GMT) and sunrise $r_{\text{surface}} = 2,000 \text{ s/m}$; and
- for all other hours, $r_{\text{surface}} = 1,000 \text{ s/m}$.

These rules were based on judgement, but are unlikely to introduce significant error.

Averaging V_d NO_2

- A3.39 As with the EA method, the deposition velocity (V_d) of NO_2 was calculated for each hour of the 2-year meteorological dataset, using hour-specific values of r_a , r_b , and r_c . The values of V_d were then averaged over representative periods. These averaging periods are those for which ambient concentrations were predicted by the dispersion model, and thus deposition fluxes were calculated for each individual averaging period (e.g. winter night etc.), rather than for each individual hour. While it would have been preferable to apply hour-specific deposition velocities to hour-specific predicted concentrations, this was not possible given the size of the dataset.
- A3.40 For the EA method, defining the averaging periods was relatively straightforward, since NO_2 deposition is known to vary most significantly between day and night and between summer and winter. The added level of detail used in the AQC method resulted in significant variance in V_d over the daytime periods and it did not, therefore, seem appropriate to average across these values. More refined and representative daytime averaging periods were thus identified.
- A3.41 It is noted that there is no requirement for the averaging periods to be chronologically-contiguous (i.e. leading on from one another). In practice, those hours which the AQC deposition model predicts were associated with the highest rates of deposition occurred at many different times of the day. Furthermore, since dry, sunny, conditions are usually associated with higher deposition velocities, but very high temperatures are associated with some of the lowest velocities (i.e. where T_{max} is exceeded), this means that deposition can, within the model, turn from very high to very low from one hour to the next.
- A3.42 In order to account for these patterns, the AQC method has thus grouped the daylight meteorological hours according to their calculated deposition velocities. For this exercise, and for consistency with the Ashdown Forest study, the land use selected was Heath, although this selection is unlikely to significantly affect the outcomes of the study. Figure A3.2 shows all of the hourly values of V_d NO_2 to heath during summer daytime hours, as well as a series of 'break points'. These 'break points' were defined subjectively and are simply intended to separate the range of deposition velocities into workable groups for averaging. Figure A3.3 shows these groupings in a different way, and shows how the deposition velocities have then been averaged. For example, all hours that gave rise to one of the deposition velocities in Set 5 in Figure A3.3 were modelled using the average value for that set. In this way, the daytime meteorological hours were grouped according to their deposition velocities and not according to their chronological order.
- A3.43 Because the dispersion model was run to predict the average concentration within each of these meteorological groups, the effect of this approach is that the correct meteorological conditions are paired with the correct deposition velocities and, while detail will still be lost by using average values, this effect will be much smaller than would be the case if the daytime period not been split up.

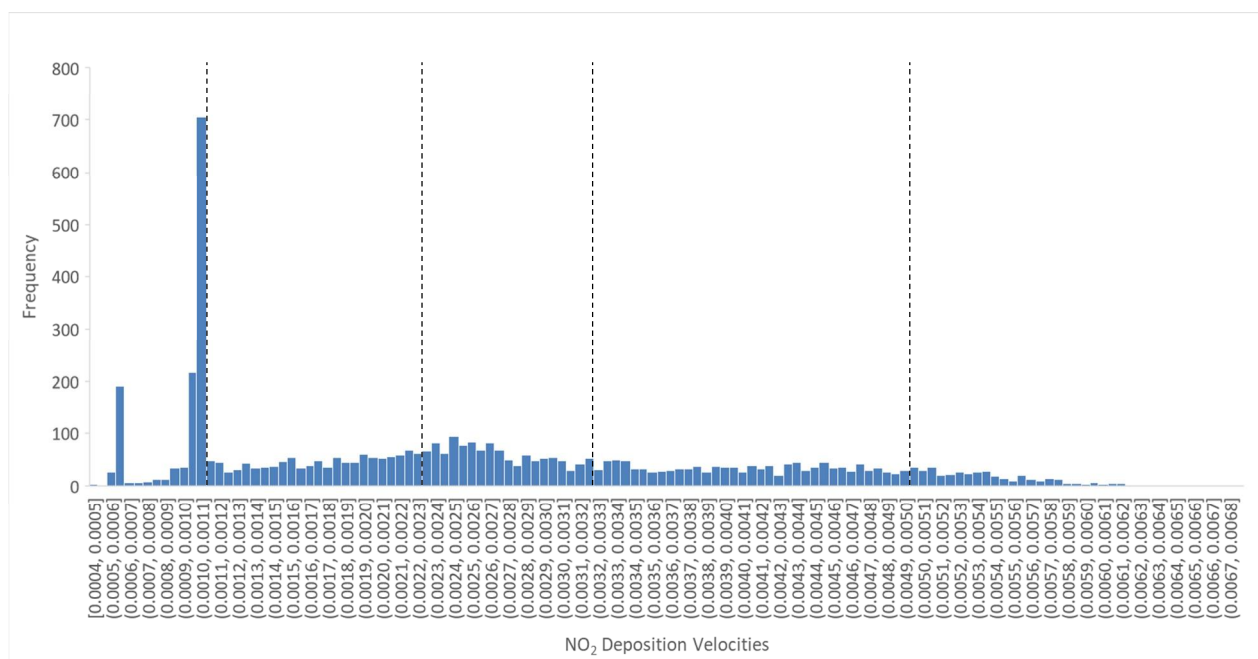


Figure A3.2: Frequency of Summer Daytime Hourly Values of V_d NO_2 to Heath

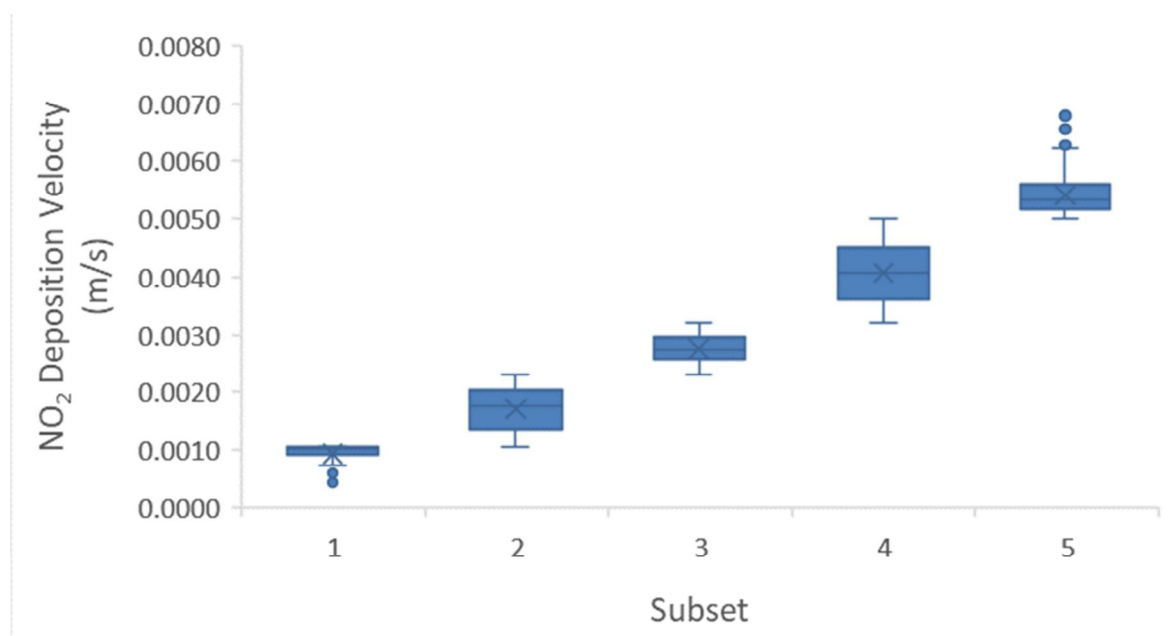


Figure A3.3: Hourly Values of V_d (NO_2) to Heath During Summer Daytime, separated into Five Subsets

A3.44 The degree of variability in the winter daytime deposition velocities was less significant than that for summer daytime and thus a smaller number of groups was judged to be required. Winter daytime meteorological hours were thus separated into three sets as shown in Figure A3.4. It was not considered necessary to further subdivide the night-time datasets for the AQC method, and these periods are thus the same for both the AQC and EA methods.

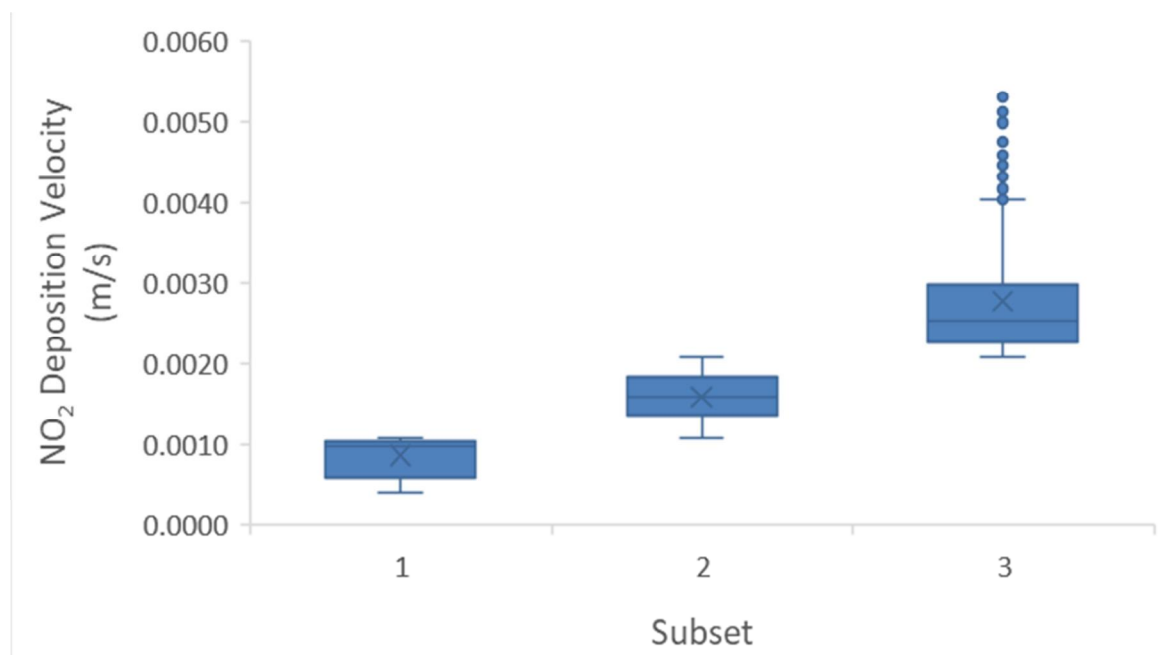


Figure A3.4: Hourly Values of V_d (NO_2) to Heath During Winter Daytime, separated into Three Subsets

A3.45 The meteorological datasets have been defined according to deposition to heath, but have then been used with other land cover types (see Figure A3.5). The values for other land cover types in Figure A3.5 overlap across the different averaging periods, whereas those in Figure A3.3 for heath do not. These overlaps mean that the meteorological groupings defined for heath are imperfect for the other habitat types, but overall the overlaps are relatively small and these meteorological subsets are thus considered to be appropriate. The meteorological datasets used for the AQC method are summarised in Table A3.8.

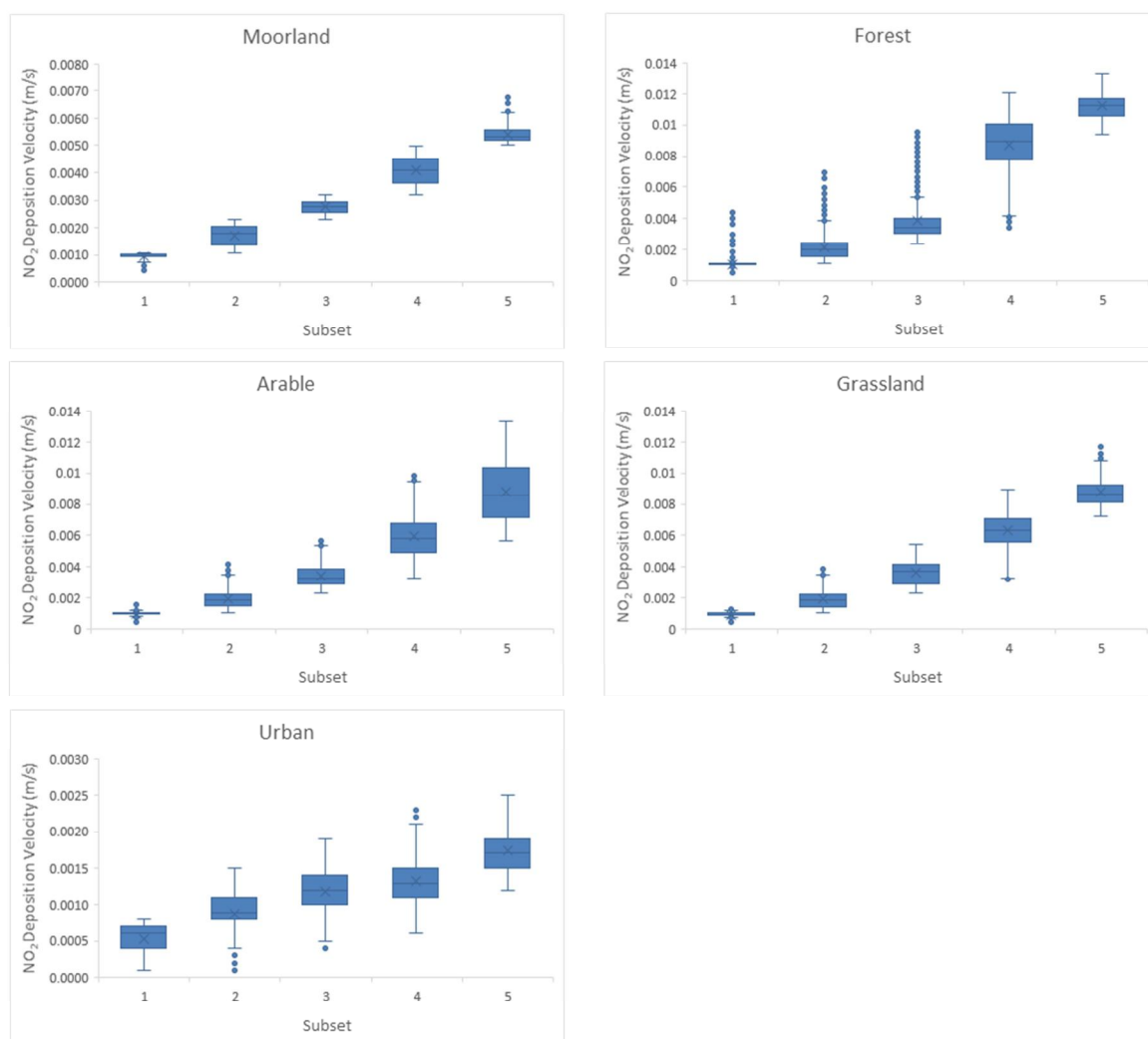


Figure A3.5: Hourly Values of V_d (NO_2) to Other Land Cover Types During Summer Daytime separated into the Five Subsets defined for Heath

Table A3.8: Number of Hours in Each Meteorological Dataset used in the AQC Deposition Method

Period	Number of Meteorological Hours
Winter Night	5,602
Winter Day 1	764
Winter Day 2	1,632
Winter Day 3	738
Summer Night	3,753
Summer Day 1	1,117
Summer Day 2	1,016
Summer Day 3	1,456
Summer Day 4	1,185

AQC method for Vd NO

- A3.46 In the AQC method, deposition of NO, was assumed to be zero. While the EA method assumed that, at very high ($>20 \mu\text{g}/\text{m}^3$) ambient NO concentrations, NO will deposit, it is considered that this relationship should take account of the duration of the exposure; and the effect of this on soil nitrogen concentrations. Thus, while a brand new emission source (e.g. a new road) which caused NO concentrations to exceed $20 \mu\text{g}/\text{m}^3$ would probably cause net deposition, this may not be the case for an existing road, where the environment will have experienced elevated nitrogenous inputs for some considerable time (and thus may have higher soil nitrogen concentrations). For this reason, and to provide a sensitivity test to the assumptions in the EA method, deposition of NO has been excluded from the AQC method. In practice, even within the EA method, deposition of NO only makes up an extremely small fraction of the total flux (see Chapter 9) and so this methodological difference has little effect.

AQC Deposition Method for other Pollutants

- A3.47 As noted above, the AQC method uses identical parameters for r_a and r_b as the EA method. It also uses the same values of r_c for HNO_3 and NH_3 and the same particle deposition velocities and wet deposition fluxes. This means that all of the fluxes of HNO_3 , particle deposition and wet deposition predicted using the two methods are the same. For NH_3 , however, the use of different averaging periods introduces some small differences. Even though these averaging periods were defined for NO_2 deposition, it is considered appropriate to retain them for the NH_3 deposition calculations (i.e. they simply add a finer degree of temporal resolution and cannot introduce additional error). The NH_3 deposition fluxes are thus marginally different between the EA and AQC methods.