

Ammonia Assessment
Castle Farm, Bilstone

Client: JG and CA Bayley

Reference: 9105-1r1

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Report Issue

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1.0 INTRODUCTION

1.1 Background

1.1.1 Redmore Environmental Ltd was commissioned by JG and CA Bayley to undertake an Ammonia Assessment in support of extensions to three existing livestock sheds and the construction of one new livestock building on land at Castle Farm, Bilstone.

1.1.2 The proposals have the potential to cause changes in pollution levels at sensitive ecological locations as a result of ammonia (NH₃) emissions associated with the development. An Ammonia Assessment was therefore undertaken in order to consider potential effects.

1.2 Site Location and Context

1.2.1 The proposed development is located on land at Castle Farm, Bilstone, at approximate National Grid Reference (NGR): 436361, 306152. Reference should be made to Figure 1 for a site location plan.

1.2.2 Castle Farm features an established dairy production unit. It is proposed to extend three existing livestock sheds to provide space to accommodate up to 50 additional dairy cows all year round. It is also proposed to construct a new livestock shed to provide housing for up to 100 dairy heifers and calves for six months of the year.

1.2.3 A planning application for the proposal was submitted to Hinckley and Bosworth Borough Council (reference: 24/00853/OUT). A response from Natural England (NE)¹ was received requesting a Simple Calculation of Atmospheric Impact Limits (SCAIL) Assessment be provided to evaluate potential effects on sensitive habitats as a result of the development. A SCAIL Assessment² was submitted in February 2025, which quantified air quality impacts on ecological designations as a result of NH₃ releases from the extended and new livestock buildings. A subsequent consultation response on the 7th of April 2025 from NE³ indicated residual concerns relating to potential effects on the following sites:

¹ 488836, NE, 2024.

² 9105r1 - SCAIL Assessment - Castle Farm, Bilstone, Redmore Environmental Ltd, 2025.

³ 504172, NE, 2025.

- Ashby Canal SSSI (Site of Special Scientific Interest); and,
- Newton Burgoland Marshes SSSI.

1.2.4 An Ammonia Assessment was therefore undertaken in order to assess the likely effects and determine whether adverse impacts on site integrity can be ruled out. This is provided in the following report.

2.0 METHODOLOGY

2.1 Introduction

2.1.1 The proposals have the potential to cause changes in pollution levels at sensitive ecological locations as a result of NH₃ emissions associated with the development. An assessment was therefore undertaken in order to determine baseline conditions and assess potential effects. The associated methodology is outlined in the following Sections.

2.2 Guidance

2.2.1 The following guidance was utilised throughout the assessment:

- Air quality risk assessment interim guidance, NE, 2022;
- Intensive farming risk assessment for your environmental permit, Environment Agency (EA), 2018;
- Natural England's approach to advising competent authorities on the assessment of road traffic emissions under the Habitats Regulations, NE, 2018; and,
- Habitats regulations assessments: protecting a European site, Department for Environment, Food and Rural Affairs (DEFRA), NE, Welsh Government and Natural Resources Wales, 2021.

2.3 Assessment Stages

2.3.1 The assessment was undertaken in accordance with the stages outlined within the Habitat Regulations Assessment (HRA) guidance⁴ produced by DEFRA. This is summarised as follows, though it should be noted that completion of all elements is not always necessary, depending on the findings of each stage:

- Stage 1 - Screening: Plans or projects with no likely significant effect on an ecological designation can be 'screened out' of the need for further assessment;

⁴ Habitats regulations assessments: protecting a European site, DEFRA, NE, Welsh Government and Natural Resources Wales, 2021.

- Stage 2 - Appropriate Assessment: Detailed assessment to consider the likely significant effects of the proposal in more detail and identify ways to avoid or minimise any effects; and,
- Stage 3 - Derogation: To assess the likely significant effects of the proposal in more detail and identify ways to avoid or minimise any effects.

2.3.2 The methodology adopted for each stage is summarised in the following Sections.

2.3.3 It should be noted that although the HRA methodology only applies to European sites, the approach has also been adopted when considering effects on SSSIs in lieu of alternative guidance.

Stage 1: Screening

2.3.4 Stage 1: Screening utilised the following steps, as derived from relevant guidance⁵ ⁶ and information provided within consultation responses from NE on similar projects:

- Step 1: Does the proposal give rise to emissions which are likely to reach an international or national site? If there are no designations within the vicinity of the project, then a screening conclusion of no likely significant effect can be reached with regard to air quality;
- Step 2: Are the qualifying features of the designation sensitive to air pollution? If there are no sensitive qualifying features, then a screening conclusion of no likely significant effect on the site can be reached with regard to air quality;
- Step 3: Could the sensitive qualifying features of the site be exposed to emissions? If the qualifying features could not be exposed to emissions, then a screening conclusion of no likely significant effect on the site can be reached with regard to air quality;
- Step 4: Application of the following screening thresholds to determine potential risk of effects alone and in-combination with emissions from other plans and projects:
 - 4a) Alone: Risk of significant effect if a Predicted Concentration (PC) is 1% of the critical load or level or greater as a result of the proposal in isolation; and,

⁵ Natural England's approach to advising competent authorities on the assessment of road traffic emissions under the Habitats Regulations, NE, 2018.

⁶ Air quality risk assessment interim guidance, NE, 2022.

- 4b) In-combination: Risk of significant effect if a PC is 1% of the critical load or level or greater as a result of the proposal in-combination with other relevant plans or projects.
- If the above criteria are not exceeded, then a screening conclusion of no likely significant effect on the site can be reached with regard to air quality.

2.3.5 If the above steps indicate a screening conclusion of no likely significant effects on the relevant designations can be reached with regard to air quality, then the assessment can be concluded. If potential effects cannot be screened out, then the assessment should proceed to Stage 2: Detailed Assessment.

Stage 2: Detailed Assessment

2.3.6 Having identified a risk of a significant effect from a plan or project either alone or in-combination, the purpose of Stage 2: Detailed Assessment is to more precisely assess the likely effects and to inform a conclusion as to whether an adverse effect on site integrity can be ruled out. It should be noted that in relation to HRA, the assessment should be 'appropriate' in terms of its scope, content, length and complexity to the plan or project under assessment. This was reiterated by the Supreme Court⁷, which clarified:

"'Appropriate' is not a technical term. It indicates no more than that the assessment should be appropriate to the task in hand: that task being to satisfy the authority that the project will not adversely affect the integrity of the site concerned."

2.3.7 It should not be assumed that an Appropriate or Detailed Assessment will necessarily involve detailed and complex monitoring or modelling work. Whilst this may be necessary in fully understanding what will happen to a site if the plan or project goes ahead, it is equally possible that a fairly concise and straightforward assessment might be entirely 'appropriate'.

⁷ Champion v North Norfolk DC, UK Supreme Court, 2015.

2.3.8 A number of factors are identified in the NE guidance⁸ for further consideration during an Appropriate Assessment. These are summarised as follows:

- Consider whether the sensitive qualifying features of the site would be exposed to emissions;
- Consider the European Site's Conservation Objectives;
- Consider background pollution;
- Consider the designated site in its national context;
- Consider the best available evidence on small incremental impacts from nitrogen deposition;
- Consider the spatial scale and duration of the predicted impact and the ecological functionality of the affected area;
- Consider site survey information;
- Consider national, regional and local initiatives or measures which can be relied upon to reduce background levels at the site;
- Consider measures to avoid or reduce the harmful effects of the plan or project on site integrity; and,
- Consider any likely in-combination effects with other live plans and projects from other sectors.

2.3.9 It should be noted that in accordance with the above definition of an Appropriate Assessment, not all factors may be relevant to a specific plan or project and only those which aid in forming a conclusion as to whether an adverse effect on site integrity can be ruled out need to be considered.

⁸ Natural England's approach to advising competent authorities on the assessment of road traffic emissions under the Habitats Regulations, NE, 2018.

3.0 STAGE 1: SCREENING

3.1 Introduction

3.1.1 A Stage1: Screening Assessment of potential effects on sensitive ecological designations as result of emissions from the development was undertaken in accordance with the stages outlined in Section 2.3. The results are provided in the following Sections.

3.2 Step 1

3.2.1 The following ecological designations were considered in the assessment, as requested by NE⁹:

- Ashby Canal SSSI; and,
- Newton Burgoland Marshes SSSI.

3.2.2 As shown above, two designations were identified that may be affected by emissions associated with the development. As such, the assessment proceeded to Step 2.

3.3 Step 2

3.3.1 In order to identify whether the designations are sensitive to air pollution, the critical loads and levels for the qualifying features were obtained from the Air Pollution Information System (APIS)¹⁰ website. The relevant data is summarised in Appendix 1.

3.3.2 A review of the relevant data indicated critical levels for NH₃ concentrations and critical loads for nitrogen and acid deposition have been identified for the qualifying features of the designations identified in Step 1. As such, these are considered sensitive to air pollution and the assessment proceeded to Step 3.

⁹ 504172, NE, 2025.

¹⁰ APIS, www.apis.ac.uk.

3.4 Step 3

- 3.4.1 For the purpose of Stage 1: Screening and in order to provide a worst-case assessment, it was assumed that the most sensitive feature of each designation is located at the boundary closest to the development as this is the area where impacts are most likely. Discrete receptors were subsequently defined to represent these locations. The relevant positions are shown in Table 1.

Table 1 Discrete Receptor Locations

Receptor		NGR (m)	
		X	Y
E1	Ashby Canal SSSI	435555.6	307373.9
E2	Ashby Canal SSSI	436703.5	307188.5
E3	Ashby Canal SSSI	437623.7	306713.2
E4	Ashby Canal SSSI	437555.7	305939.7
E5	Ashby Canal SSSI	437174.1	305522.2
E6	Newton Burgoland Marshes SSSI	438008.2	308283.9

- 3.4.2 The relevant features and critical levels for NH₃ at the identified receptors are summarised in Table 2.

Table 2 Features and Critical Levels for NH₃

Receptor		Feature	Annual Mean Critical Level for NH ₃ (µg/m ³)
E1	Ashby Canal SSSI	Standing waters	3
E2	Ashby Canal SSSI	Standing waters	3
E3	Ashby Canal SSSI	Standing waters	3
E4	Ashby Canal SSSI	Standing waters	3
E5	Ashby Canal SSSI	Standing waters	3
E6	Newton Burgoland Marches SSSI	Alopecurus pratensis - Sanguisorba officinalis Grassland	3

3.4.3 The relevant features and nitrogen deposition critical loads at the identified receptors are presented in Table 3.

Table 3 Features and Critical Loads for Nitrogen Deposition

Receptor		Feature	Relevant Nitrogen Critical Load Class	Critical Load (kgN/ha/yr)	
				Low	High
E1	Ashby Canal SSSI	Standing waters	No comparable habitat with established critical load estimate available	-(a)	-(a)
E2	Ashby Canal SSSI	Standing waters	No comparable habitat with established critical load estimate available	-(a)	-(a)
E3	Ashby Canal SSSI	Standing waters	No comparable habitat with established critical load estimate available	-(a)	-(a)
E4	Ashby Canal SSSI	Standing waters	No comparable habitat with established critical load estimate available	-(a)	-(a)
E5	Ashby Canal SSSI	Standing waters	No comparable habitat with established critical load estimate available	-(a)	-(a)
E6	Newton Burgoland Marches SSSI	Alopecurus pratensis - Sanguisorba officinalis Grassland	Low and medium altitude hay meadows	10	20

Note: (a) No critical load assigned for the feature on APIS.

3.4.4 The relevant features and acid deposition critical loads at the identified receptors are presented in Table 4.

Table 4 Features and Critical Loads for Acid Deposition

Receptor		Feature	Relevant Acid Critical Load Class	Critical Load (keq/ha/yr)		
				CLMin N	CLMax S	CLMax N
E1	Ashby Canal SSSI	Standing waters	Freshwater	-(a)	-(a)	-(a)
E2	Ashby Canal SSSI	Standing waters	Freshwater	-(a)	-(a)	-(a)
E3	Ashby Canal SSSI	Standing waters	Freshwater	-(a)	-(a)	-(a)

Receptor		Feature	Relevant Acid Critical Load Class	Critical Load (keq/ha/yr)		
				CLMin N	CLMax S	CLMax N
E4	Ashby Canal SSSI	Standing waters	Freshwater	-(a)	-(a)	-(a)
E5	Ashby Canal SSSI	Standing waters	Freshwater	-(a)	-(a)	-(a)
E6	Newton Burgoland Marches SSSI	Alopecurus pratensis - Sanguisorba officinalis Grassland	Calcareous grassland (using base cation)	0.8560	4.0000	4.8560

Note: (a) Critical load not assigned for the feature on APIS.

3.4.5 Reference should be made to Figure 2 for a map of the discrete receptor locations.

3.4.6 A review of the relevant data indicated the qualifying features within the identified designations could be exposed to emissions. As such, a screening conclusion of no likely significant effects on the sites could not be reached with regard to air quality and the assessment proceeded to Step 4.

3.5 **Step 4a**

3.5.1 Dispersion modelling was undertaken in order to quantify the predicted PC as a result of emissions from the development alone as a proportion of the relevant critical load or level at the identified receptors with subsequent comparison against the screening threshold. Reference should be made to Appendix 2 for the dispersion modelling inputs.

3.5.2 Predicted annual mean NH₃ concentrations are summarised in Table 5.

Table 5 Predicted Annual Mean NH₃ Concentrations - Development Alone

Receptor		Predicted Annual Mean NH ₃ PC (µg/m ³)	PC as Prop. of CL (%)
E1	Ashby Canal SSSI	0.0060	0.20
E2	Ashby Canal SSSI	0.0232	0.77
E3	Ashby Canal SSSI	0.0138	0.46
E4	Ashby Canal SSSI	0.0173	0.58

Receptor		Predicted Annual Mean NH ₃ PC (µg/m ³)	PC as Prop. of CL (%)
E5	Ashby Canal SSSI	0.0146	0.49
E6	Newton Burgoland Marches SSSI	0.0046	0.15

3.5.3 As shown in Table 5, the predicted PC as a result of emissions from the development alone was below 1% of the relevant critical level at all receptors. As such, a screening conclusion of no likely significant effect as a result of the development alone can be reached with regard to annual mean NH₃ concentrations.

3.5.4 Predicted annual nitrogen deposition rates are summarised in Table 6.

Table 6 Predicted Annual Nitrogen Deposition - Development Alone

Receptor		Predicted Annual Nitrogen Deposition PC (kgN/ha/yr)	PC as Prop. of CL (%)
E1	Ashby Canal SSSI	0.0313	-
E2	Ashby Canal SSSI	0.1205	-
E3	Ashby Canal SSSI	0.0719	-
E4	Ashby Canal SSSI	0.0897	-
E5	Ashby Canal SSSI	0.0757	-
E6	Newton Burgoland Marches SSSI	0.0240	0.24

3.5.5 As shown in Table 6, the predicted PC as a result of emissions from the development alone was below 1% of the relevant critical load at all receptors. As such, a screening conclusion of no likely significant effect as a result of the development alone can be reached with regard to nitrogen deposition.

3.5.6 Predicted annual acid deposition rates are summarised in Table 7.

Table 7 Predicted Annual Acid Deposition - Development Alone

Receptor		Predicted Annual Acid Deposition PC (keq/ha/yr)	PC as Prop. of CL (%)
E1	Ashby Canal SSSI	0.0022	-
E2	Ashby Canal SSSI	0.0086	-
E3	Ashby Canal SSSI	0.0051	-
E4	Ashby Canal SSSI	0.0064	-
E5	Ashby Canal SSSI	0.0054	-
E6	Newton Burgoland Marches SSSI	0.0017	0.04

3.5.7 As shown in Table 7, the predicted PC as a result of emissions from the development alone was below 1% of the relevant critical load at all receptors. As such, a screening conclusion of no likely significant effect as a result of the development alone can be reached with regard to acid deposition.

3.6 **Step 4b**

3.6.1 Step 4b required consideration of potential effects in-combination with other plans or projects. A review of the following information sources was therefore undertaken in order to identify any schemes that may act in-combination, as required by NE guidance¹¹:

- Planning Portals to locate applications awaiting permissions;
- Environmental Permits Register of Applications and Register of Issued Permits; and,
- Local Plans (including brownfield registers with permission in principle) and any allocations not yet permitted.

3.6.2 A review of planning applications submitted since 2021 was undertaken to identify the following projects within 10km of the site:

- Any agricultural proposals; and,

¹¹ Natural England's approach to advising competent authorities on the assessment of road traffic emissions under the Habitats Regulations, NE, 2018.

- Any industrial proposals with associated NH₃ emissions.

3.6.3 A review of the Environmental Permit register¹² was also undertaken in order to identify the following projects within 10km of the site which had received an Environmental Permit or Variation since 2021:

- Any intensive agricultural proposals; and,
- Any industrial proposals with associated NH₃ emissions.

3.6.4 Additionally, review of the site allocations in the relevant Local Plan was undertaken in order to identify any further proposals potentially coming forward within the relevant plan period.

3.6.5 A review period of 2021 onwards was selected to correlate with the latest background pollution data information available from APIS, as well as the expiration timescale for any planning consents that had not been implemented.

3.6.6 It should be noted that any projects identified during the review that did not have a SCAL Assessment or Ammonia Assessment were not considered further. This approach has been agreed with NE for similar schemes throughout the UK.

3.6.7 A review of the above information sources identified no relevant plans or projects for consideration of in-combination effects with the proposed development. As such, a screening conclusion of no likely significant effect as a result of the development in-combination could be reached with regard to annual mean NH₃ concentrations and nitrogen and acid deposition on the ecological designations.

3.7 Summary

3.7.1 The results of Stage 1: Screening can be summarised as follows:

- Two ecological designations were identified that may be affected by emissions from the development;

¹² <https://environment.data.gov.uk/public-register/view/index>.

- Of the identified designations, both have features that are considered sensitive to air pollution. As such, these sites were progressed through the assessment;
- Dispersion modelling was used to determine PCs as a result of the development alone at discrete receptor positions within the designations;
- No relevant plans or projects were identified for consideration of in-combination effects with the development; and,
- The results indicated that a screening conclusion of no likely significant effect as a result of the development alone and in-combination could be reached with regard to NH₃ concentrations and nitrogen and acid deposition on all ecological designations.

3.7.2 As shown above, a screening conclusion of no likely significant effect as a result of the development both alone and in-combination could be reached for all designations. As such, a Stage 2: Detailed Assessment was not required.

4.0 CONCLUSION

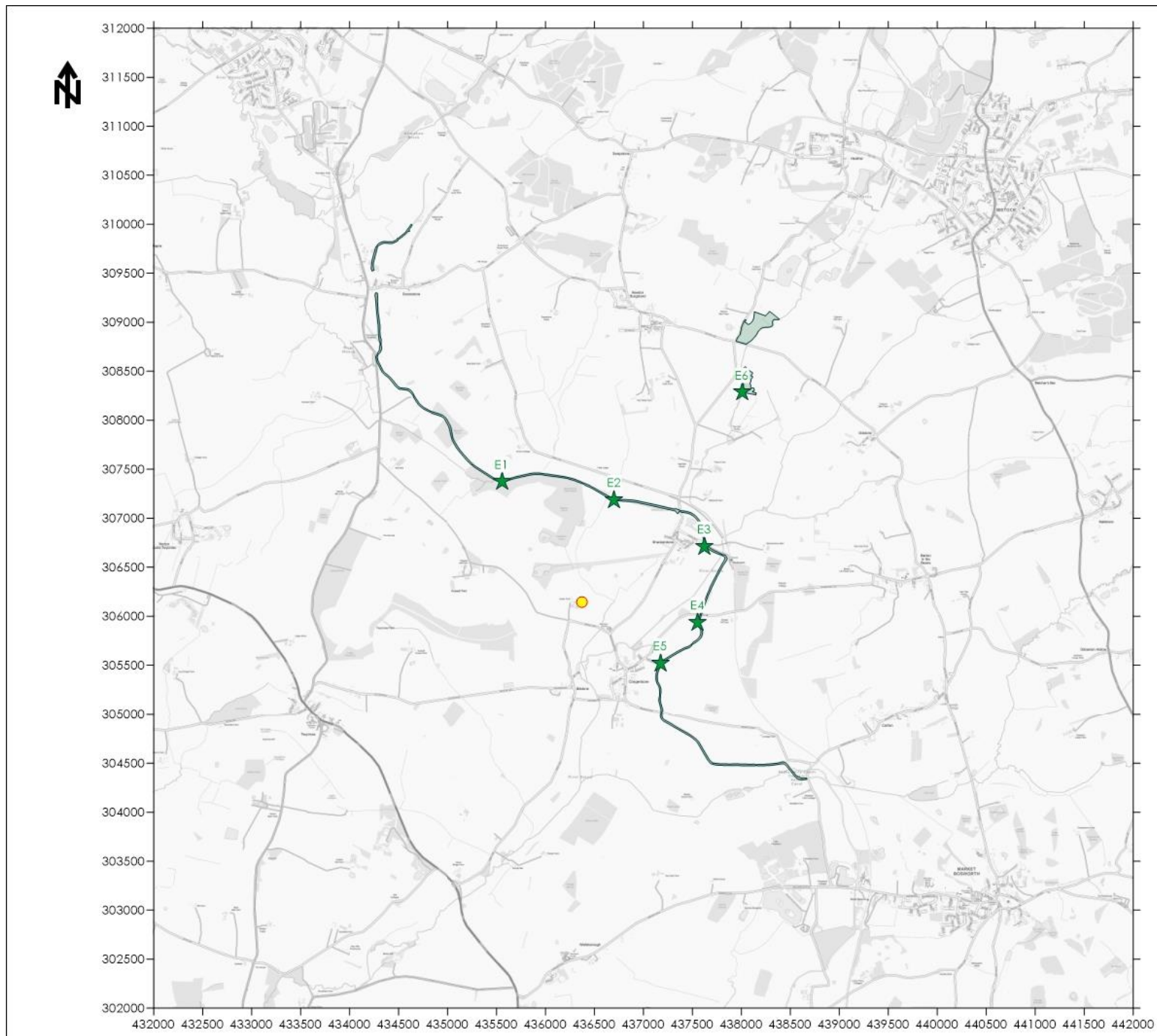
- 4.1.1 Redmore Environmental Ltd was commissioned by JG and CA Bayley to undertake an Ammonia Assessment in support of extensions to three existing livestock sheds and the construction of one new livestock building on land at Castle Farm, Bilstone.
- 4.1.2 The proposals have the potential to cause changes in pollution levels at sensitive ecological locations as a result of NH₃ emissions associated with the development. An Ammonia Assessment was therefore undertaken in order to determine baseline conditions and assess potential effects.
- 4.1.3 A staged assessment was undertaken with reference to relevant NE guidance. This considered emissions from the development alone and in-combination with other plans and projects.
- 4.1.4 The results of the assessment indicated a screening conclusion of no likely significant effect as a result of the development in relation to annual mean NH₃ concentrations and nitrogen and acid deposition both alone and in-combination could be reached for the identified ecological designations. As such, a Stage 2: Detailed Assessment was not required.

5.0 **ABBREVIATIONS**

APIS	Air Pollution Information System
CERC	Cambridge Environmental Research Consultants
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
HRA	Habitats Regulations Assessment
LU	Livestock Unit
NE	Natural England
NGR	National Grid Reference
NH ₃	Ammonia
PC	Predicted Concentration
SCAIL	Simple Calculation of Atmospheric Impact Limits
SSSI	Site of Special Scientific Interest
Z ₀	Surface Roughness

Figures





Legend

- Site Location
- ★ Receptor
- Ecological Designations

Title

Figure 2 - Discrete Receptor Positions

Project

Ammonia Assessment
Castle Farm, Bilstone

Project Reference

9105-1

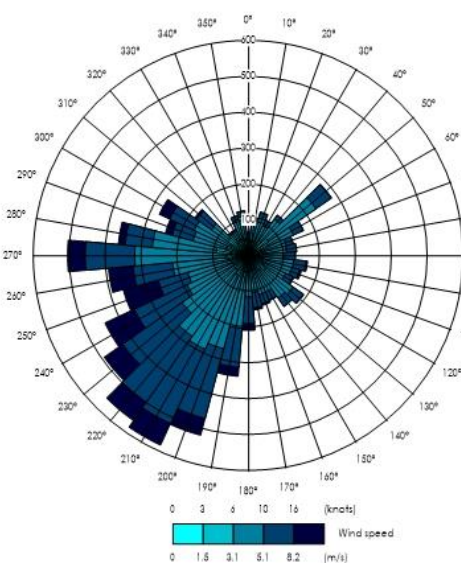
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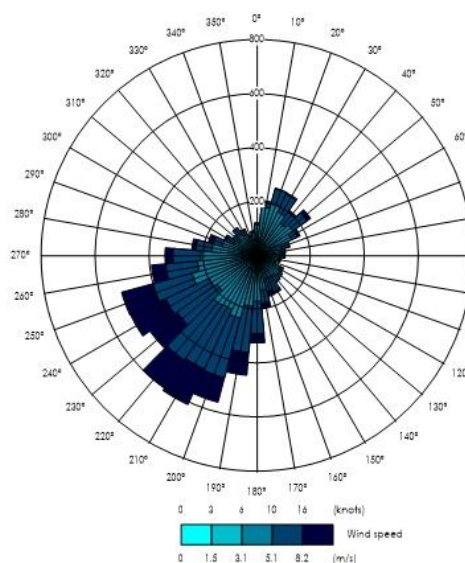
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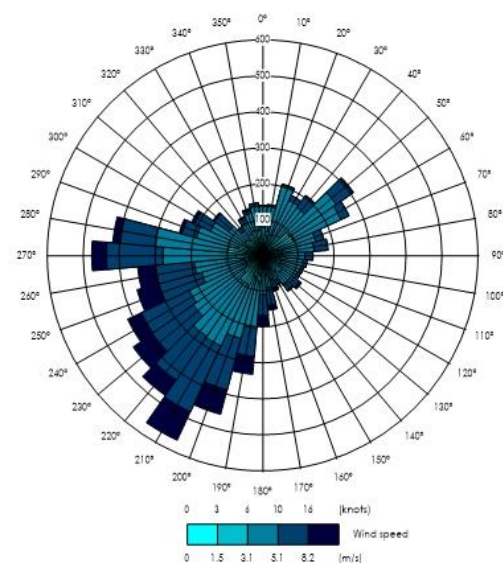
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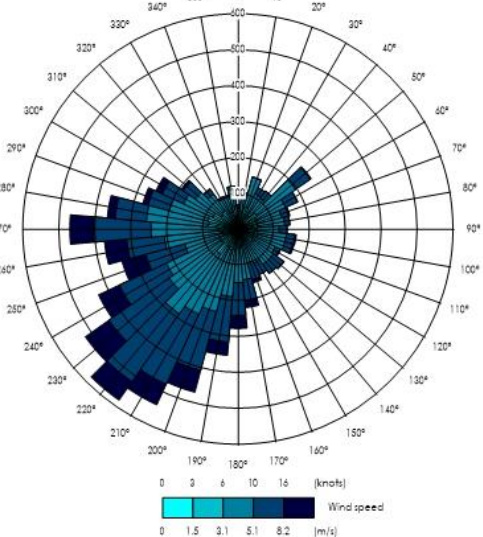
2019 Meteorological Data



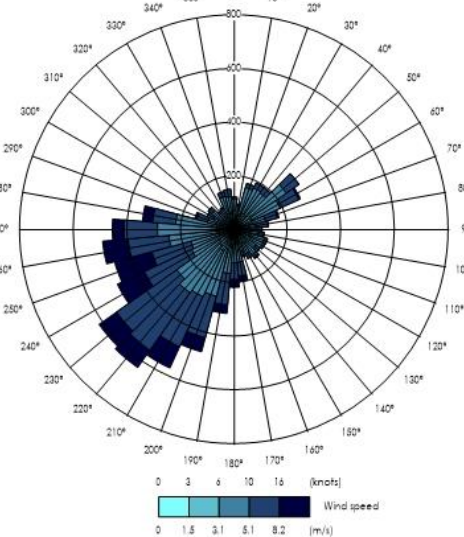
2020 Meteorological Data



2021 Meteorological Data



2022 Meteorological Data



2023 Meteorological Data

Legend

Title
Figure 3 - Wind Roses of 2019 to 2023
East Midlands Airport Meteorological
Data

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Castle Farm, Bilstone

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Appendix 1 - Critical Loads and Levels

Critical Levels

The NH₃ critical levels for Ashby Canal SSSI are presented in Table A1.1.

Table A1.1 NH₃ Critical Level - Ashby Canal SSSI

Habitat	Are Bryophytes Integral for this Habitat?	Are Lichens Integral for this Habitat?	Annual Mean NH ₃ Critical Level (µg/m ³)
Standing waters	No	No	3
Standing Water	-(a)	-(a)	-(a)

Note: (a) No critical level assigned for the feature on APIS.

The NH₃ critical levels for Newton Burgoland Marshes SSSI are presented in Table A1.2.

Table A1.2 NH₃ Critical Level - Newton Burgoland Marshes SSSI

Habitat	Are Bryophytes Integral for this Habitat?	Are Lichens Integral for this Habitat?	Annual Mean NH ₃ Critical Level (µg/m ³)
Alopecurus pratensis - Sanguisorba officinalis Grassland	No	No	3

Nitrogen Critical Loads

The nitrogen critical loads for Ashby Canal SSSI are presented in Table A1.3.

Table A1.3 Nitrogen Critical Loads - Ashby Canal SSSI

Feature Name	Is the Feature Sensitive to Nitrogen?	Nitrogen Critical Load Class	Nitrogen Critical Load (kgN/ha/yr)	
			Low	High
Standing waters	Yes	No comparable habitat with established critical load estimate available	-(a)	-(a)
Standing Water	Site specific	No critical load assigned for the feature on APIS	-(a)	-(a)

Note: (a) No critical load assigned for the feature on APIS.

The nitrogen critical loads for Newton Burgoland Marshes SSSI are presented in Table A1.4.

Table A1.4 Nitrogen Critical Loads - Newton Burgoland Marshes SSSI

Feature Name	Is the Feature Sensitive to Nitrogen?	Nitrogen Critical Load Class	Nitrogen Critical Load (kgN/ha/yr)	
			Low	High
Alopecurus pratensis - Sanguisorba officinalis Grassland	Yes	Low and medium altitude hay meadows	10	20

Acid Critical Loads

The acid critical loads for Ashby Canal SSSI are presented in Table A1.5.

Table A1.5 Acid Critical Loads - Ashby Canal SSSI

Feature Name	Is the Feature Sensitive to Acidity?	Relevant Acid Critical Load Class	Acid Critical Load (keq/ha/yr)		
			CLMinN	CLMaxS	CLMaxN
Standing Water	Site specific	No critical load assigned for the feature on APIS	-(a)	-(a)	-(a)
Standing waters	No	Freshwater	-(a)	-(a)	-(a)

Note: (a) No critical load assigned for the feature on APIS.

The acid critical loads for Newton Burgoland Marshes SSSI are presented in Table A1.6.

Table A1.6 Acid Critical Loads - Newton Burgoland Marshes SSSI

Feature Name	Is the Feature Sensitive to Acidity?	Relevant Acid Critical Load Class	Acid Critical Load (keq/ha/yr)		
			CLMinN	CLMaxS	CLMaxN
Alopecurus pratensis - Sanguisorba officinalis Grassland	Yes	Calcareous grassland (using base cation)	0.856	4.000	4.856

Appendix 2 - Dispersion Model Input Data

Dispersion Model

Dispersion modelling was undertaken using ADMS-6.0 (v6.0.2.0). ADMS-6 is developed by Cambridge Environmental Research Consultants (CERC) and is routinely used throughout the world for the prediction of pollutant dispersion from agricultural sources. Modelling predictions from this software package are accepted within the UK by the EA and DEFRA.

Baseline Pollution Levels

Baseline annual mean NH₃ concentrations and nitrogen and acid deposition rates were obtained from APIS¹³. The relevant values are summarised in Table A2.1.

Table A2.1 Baseline Pollution Levels

Receptor		Annual Mean NH ₃ Conc. (µg/m ³)	Annual Nitrogen Deposition Rate (kgN/ha/yr)	Annual Acid Deposition Rate (keq/ha/yr)
E1	Ashby Canal SSSI	1.70	15.17	1.10
E2	Ashby Canal SSSI	1.75	15.34	1.11
E3	Ashby Canal SSSI	1.76	15.49	1.13
E4	Ashby Canal SSSI	1.72	15.46	1.12
E5	Ashby Canal SSSI	1.72	15.46	1.12
E6	Newton Burgoland Marches SSSI	1.70	15.51	1.14

Model Inputs - Development Alone

Releases from the proposed shed extensions and new livestock building were derived from the relevant emission rate provided within the DEFRA document 'Inventory of Ammonia Emissions from UK Agriculture'¹⁴, as well as information provided by the Applicant. The relevant model inputs for the proposed livestock housing are summarised in Table A2.2.

¹³ APIS, www.apis.ac.uk.

¹⁴ Inventory of Ammonia Emissions from UK Agriculture, DEFRA, 2021.

Table A2.2 Model Inputs - Livestock Housing

Parameter	Unit	Livestock Shed 1 Extension	Livestock Shed 2 Extension	Livestock Shed 3 Extension	New Livestock Shed
Source type	-	Volume	Volume	Volume	Volume
Source area	m ²	131.5	200.7	626.9	836.5
Source height	m	4.67	5.62	5.70	5.95
Source volume	m ³	614.1	1,127.8	3,573.5	4,976.9
Livestock type	-	Dairy Cows	Dairy Cows	Dairy Cows	Dairy calves/heifers
Number of livestock	-	7	10	33	100
Livestock weight	kg	600	600	600	350
Housing system	-	Slurry	Slurry	Slurry	Straw
NH ₃ -N emission rate	g/Livestock Unit (LU) ^(a) /day	34.3	34.3	34.3	23.1
Volume specific NH ₃ emission rate	g/m ³ /s	0.0000066	0.0000051	0.0000053	0.0000023

Note: (a) One LU is equal to 500kg of liveweight.

Emissions from the extensions and new livestock sheds were assumed to be constant over the relevant housing periods.

Reference should be made to Figure 1 for a map of the proposed emission source locations.

Terrain Data

Ordnance Survey OS Terrain 50 data was included in the model for the site and surrounding area in order to take account of the specific flow field produced by variations in ground height throughout the assessment extents. This was pre-processed using the method suggested by CERC¹⁵.

¹⁵ Note 105: Setting up Terrain Data for Input to CERC Models, CERC, 2016.

Meteorological Data

Meteorological data used in the assessment was taken from East Midlands Airport meteorological station over the period 1st January 2019 to 31st December 2023 (inclusive). East Midlands Airport meteorological station is located at NGR: 446277, 325799, which is approximately 22.4km north-east of the site. It is anticipated that conditions would be reasonably similar over a distance of this magnitude. The data was therefore considered suitable for an assessment of this nature.

All meteorological files used in the assessment were provided by Atmospheric Dispersion Modelling Ltd, which is an established distributor of data within the UK. Reference should be made to Figure 3 for wind roses of the utilised meteorological records.

Roughness Length

The surface roughness (z_0) is a modelling parameter applied to allow consideration of surface height roughness elements. A z_0 of 0.3m was used to describe the modelling extents. This is considered appropriate for the morphology of the area and is suggested within ADMS-6 as being suitable for 'agricultural areas (max)'.

A z_0 0.2m was used to describe the meteorological site. This is considered appropriate for the morphology of the area and is suggested within ADMS-6 as being suitable for 'agricultural areas (min)'.

Monin-Obukhov Length

The Monin-Obukhov length provides a measure of the stability of the atmosphere. A minimum Monin-Obukhov length of 1m was used to describe the modelling extents. This is considered appropriate for the nature of the area and is suggested within ADMS-6 as being suitable for 'rural areas'.

A minimum Monin-Obukhov length of 10m was used to describe the meteorological site. This is considered appropriate for the nature of the area and is suggested within ADMS-6 as being suitable for 'small towns <50,000'.

Deposition

Nitrogen deposition rates were calculated using the conversion factors provided within EA document 'Technical Guidance on Detailed Modelling approach for an Appropriate Assessment for Emissions to Air AQTAG 06'¹⁶. Predicted pollutant concentrations were multiplied by the relevant deposition velocity and conversion factor to calculate the speciated dry deposition flux. The conversion factors used for the determination of nitrogen deposition are presented within Table A2.3.

Table A2.3 Conversion Factors to Determine Dry Deposition Flux for Nitrogen Deposition

Pollutant	Deposition Velocity (m/s)		Conversion Factor ($\mu\text{g}/\text{m}^2/\text{s}$ to $\text{kg}/\text{ha}/\text{yr}$ of pollutant species)
	Grassland	Forest	
NH ₃	0.02	0.03	260

The relevant deposition velocity for each ecological receptor was selected from Table A2.3 based on the vegetation type of the qualifying feature.

Predicted ground level NH₃ concentrations were converted to kilo-equivalent ion depositions ($\text{keq}/\text{ha}/\text{yr}$) for comparison with the critical load for acid deposition at each of the identified ecological receptors. The conversion to units of equivalents, a measure of the potential acidifying effect of a species, was undertaken using the standard conversion factors shown in Table A2.4.

Table A2.4 Conversion Factors to Determine Dry Deposition Flux for Acid Deposition

Pollutant	Deposition Velocity (m/s)		Conversion Factor ($\mu\text{g}/\text{m}^2/\text{s}$ to $\text{keq}/\text{ha}/\text{yr}$ of pollutant species)
	Grassland	Forest	
NH ₃	0.02	0.03	18.5

The following formula was used to calculate predicted PCs as a proportion of the critical load function:

¹⁶ Technical Guidance on Detailed Modelling approach for an Appropriate Assessment for Emissions to Air AQTAG 06, EA, 2014.

$$\text{PC as \%CL function} = ((\text{PC of N deposition}) / \text{CLmaxN}) \times 100$$

The above formula was obtained from APIS¹⁷.

Scientific literature suggests that the dry deposition velocity of NH₃ is concentration dependent and is significantly reduced at high concentrations, i.e. from 0.02m/s to 0.03m/s at ambient concentration down to approximately 0.003m/s at a long-term average over 80µg/m³^{18 19}. When the concentration dependence of the deposition velocity is considered, the reported cumulative depletion ratio (the ratio of NH₃ deposited to the total emitted) was about 10% at 500m to 1,000m downwind^{20 21}.

In order to represent the above within the model, the variable concentration dependent deposition velocity function within ADMS-6 was engaged, as outlined within EA guidance²². This utilised predicted annual mean NH₃ concentrations to determine location specific deposition velocities throughout the assessment extents for inclusion within the final model.

¹⁷ <http://www.apis.ac.uk/>.

¹⁸ Walker J, Spence P, Kimbrough S and Robarge W, 2008. Inferential model estimates of ammonia dry deposition in the vicinity of a swine production facility. *Atmospheric Environment* 42, 3407-3418.

¹⁹ Cape JN, Jones MR, Leith ID, Sheppard LJ, van Dijk N, Sutton MA, Fowler D, Estimate of annual NH₃ dry deposition to a fumigated ombrotrophic bog using concentration-dependant deposition velocities. *Atmospheric Environment* 42 (2008) 6637-6646.

²⁰ Walker J, Spence P, Kimbrough S and Robarge W, 2008. Inferential model estimates of ammonia dry deposition in the vicinity of a swine production facility. *Atmospheric Environment* 42, 3407-3418.

²¹ Cape JN, Jones MR, Leith ID, Sheppard LJ, van Dijk N, Sutton MA, Fowler D, Estimate of annual NH₃ dry deposition to a fumigated ombrotrophic bog using concentration-dependant deposition velocities. *Atmospheric Environment* 42 (2008) 6637-6646.

²² Guidance on Modelling the Concentration and Deposition of Ammonia Emitted from Intensive Farming, EA, 2010.
