

# A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Broiler Chicken Rearing Houses and Manure Storage Building at Middleton Stoney Poultry Unit, Forest Lodge Farm, Middleton Park, Middleton Stoney, near Bicester in Oxfordshire

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# Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Stephen Raasch, on behalf of Mr. Sam Drummond of Brackley Farms Ltd., to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses and manure storage building at Middleton Stoney Poultry Unit, Forest Lodge Farm, Middleton Park, Middleton Stoney, Bicester, Oxfordshire. OX25 4AJ.

Ammonia emission rates from the proposed poultry houses and manure storage building have been assessed and quantified based upon the Environment Agency’s standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

The primary purpose of the modelling study is to investigate and understand the effects of extending the existing poultry houses, increasing stocking numbers, adding a manure storage building and replacing the existing side mounted ventilation fans with modern high speed ridge mounted fans, each with a short chimney, on ammonia concentrations and nitrogen deposition rates at nearby areas of Ancient Woodland (AW). However, for completeness, the impacts at all statutory wildlife sites within 10 km have also been assessed.

This report is arranged in the following manner:

* Section 2 provides relevant details of the farm and potentially sensitive receptors in the area.
* Section 3 provides some general information on ammonia; details of the method used to estimate ammonia emissions, relevant guidelines and legislation on exposure limits and where relevant, details of likely background levels of ammonia.
* Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling procedure.
* Section 5 contains the results of the modelling.
* Section 6 provides a discussion of the results and conclusions.

# Background Details

The site of the poultry rearing houses at Middleton Stoney Poultry Unit is in a rural area, approximately 1.4 km to the west-south-west of Middleton Stoney in Oxfordshire. The surrounding land is used largely for arable farming, but there are areas of woodland and parkland nearby. The site is at an altitude of around 91 m, with the land rising towards slightly higher ground to the north and falling towards the River Ray/River Cherwell valley to the south.

There are eight poultry houses at Middleton Stoney Poultry Unit which are permitted to stock up to 243,999 broiler chickens. The existing houses are ventilated via side mounted fans. Manure and spent litter collects within the housing throughout the crop and is cleared and removed from the site at the end of each crop cycle.

It is proposed that the existing poultry houses be extended and modernized, which would include replacing the existing side fans with modern high speed ridge mounted fans, each with a short chimney. The extended and modernized poultry houses would provide accommodation for up to 364,999 broiler chickens. Manure and spent litter would collect within the housing throughout the crop and would be cleared and removed from the site at the end of each crop cycle.

There are seven areas of woodland designated as Ancient Woodland (AW) and a candidate Local Wildlife Site (cLWS) within 2km (the normal screening distance for non-statutory sites) of the farm. There are eighteen Sites of Special Scientific Interest (SSSIs) within 10 km (the normal screening distance for statutory sites) of the farm. There are no internationally designated wildlife sites within 10 km of the farm. Some further details of the SSSIs are provided below:

* **Ardley Trackways SSSI** - Approximately 2.5 km to the north-east - Geological.
* **Weston Fen SSSI** - Approximately 2.1 km to the south-south-west - A small, species-rich, calcareous fen bordering a fast-flowing stream, together with adjacent willow carr, hazel woodland, limestone grassland and marshy grassland habitats.
* **Kirtlington Quarry SSSI** - Approximately 3.7 km to the south-west - Geological.
* **Ardley Cutting and Quarry SSSI** - Approximately 4.1 km to the north-east - The limestone grassland on the steep banks of the railway cutting and the adjacent quarry forms the main biological interest. It is one of the largest limestone grassland sites in the Oxfordshire Cotswolds where unimproved grassland is now very rate. The invertebrate fauna is particularly rich along the railway cutting, with large populations of calcareous grassland butterflies.
* **Wendlebury Meads and Mansmoor Closes** SSSI - Approximately 4.9 km to the south-east - A series of traditionally-managed unimproved neutral meadows supporting a complex variety of plant communities that have developed in response to varying management, drainage and soils. The meadows are amongst the few surviving examples of calcareous clay pasture communities which are now rare owing to agricultural improvement and urbanisation.
* **Shipton-on-Cherwell & Whitehill Farm Quarries SSSI** - Approximately 5.8 km to the south-west - Geological.
* **Sheep's Banks SSSI** - Approximately 8.3 km to the west - An isolated fragment of species-rich grassland situated in an area now largely converted to arable and reseeded pasture. The site represents the eastern-most example of traditionally managed Cotswold grassland.
* **Rushy Meadows SSSI** - Approximately 8.8 km to the south-west - A series of unimproved alluvial grasslands alongside the Oxford Canal, in which low-intensity, traditional management has produced rich meadow and fen communities containing several uncommon species.
* **Blenheim Park SSSI** - Approximately 9.8 km to the south-west - One of the finest areas of ancient oak-dominated pasture woodland in the country and is descended from a twelfth century deer park and Anglo-Saxon chase. Noted for sixteen species of epiphytic lichens.
* **Woodeaton Quarry SSSI** - Approximately 9.4 km to the south - Geological.
* **Otmoor SSSI** - Approximately 8.3 km to the south-south-east - The site contains a wide range of habitats with many species of nationally uncommon plants and animals. Approximately half of the site is herb-rich damp grassland which grades into wet sedge and coarse grassland. A woodland block forms part of the eastern boundary of the site and several dense hedges are present throughout the site and most date back to the enclosure of Otmoor in the mid-nineteenth century. Standing water habitats are well represented. The blackthorn thickets contain large populations of the nationally restricted black hairstreak and brown hairstreak butterflies. This site has the only colony of marsh fritillary butterfly currently known in Oxfordshire and represents the second most easterly station for this butterfly in Britain.
* **Murcott Meadows SSSI** - Approximately 9.9 km to the south-east - A series of unimproved neutral meadows which are traditionally managed for hay. A small block of woodland and scrub is present on the site and is of special interest for a rare species of butterfly.
* **Whitecross Green and Oriel Woods SSSI** - Approximately 9.9 km to the south-east - A tract of ancient woodland, extremely rich in plant and animal life, encompassing parts of two former royal forests, Shotover and Bernwood. The twenty-four butterflies recorded to date include particularly strong colonies of wood white *Leptidea sinapis*, white admiral *Ladoga camilla* and the nationally rare black hairstreak *Strymonidia pruni*, as well as purple emperor *Apatura iris*.
* **Arncott Bridge Meadows SSSI** - Approximately 8.6 km to the east-south-east - The meadows exhibit medieval ridge-and-furrow features indicating that parts, at least, have remained unploughed for many centuries. They are managed as hay meadow and pasture and accordingly support a wide range of plant species.
* **Stratton Audley Quarries SSSI** - Approximately 7.7 km to the east-north-east - Geological.
* **Bestmoor SSSI** - Approximately 8.1 km to the north-north-west - A semi-improved floodplain meadow adjacent to the middle reaches of the River Cherwell. The main interest of the meadow is that it contains one of the largest known British populations (estimated at over 30,000) of narrow-leaved water-dropwort *Oenanthe silaifolia*.
* **Horsehay Quarries SSSI** - Approximately 8.6 km to the north-west - A Geological.
* **Middle Barton Fen SSSI** - Approximately 9.1 km to the north-west - A Calcareous fen-meadow bordering a small tributary of the River Glyme, together with adjacent limestone grassland and hedgerows. The site is the most extensive example of calcareous fen-meadow currently known in Oxfordshire.

Maps of the surrounding area showing the positions of the proposed poultry houses and the nearby wildlife sites are provided in Figures 1a and 1b. In the figures, the AWs are shaded in olive, the cLWS is shaded in yellow, the SSSIs are shaded in green and the positions of the proposed poultry houses are outlined in blue.

*Figure 1a. The area surrounding Middleton Stoney Poultry Unit, with circles radii at 2.0 km (olive), 5.0 km (green) and 10.0 km (purple)*

Diagram

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*Figure 1b. The area surrounding Middleton Stoney Poultry Unit - a closer view*

Map

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# Ammonia, Background Levels, Critical Levels & Loads & Emission Rates

## 3.1 Ammonia concentration and nitrogen and acid deposition

When assessing potential impact on ecological receptors, ammonia concentration is usually expressed in terms of micrograms of ammonia per metre cubed of air (µg-NH3/m3) as an annual mean. Ammonia in the air may exert direct effects on the vegetation, or indirectly affect the ecosystem through deposition which causes both hyper-eutrophication (excess nitrogen enrichment) and acidification of soils. Nitrogen deposition, specifically in this case the nitrogen load due to ammonia deposition/absorption, is usually expressed in kilograms of nitrogen per hectare per year (kg-N/ha/y). Acid deposition is expressed in terms of kilograms equivalent (of H+ ions) per hectare per year (keq/ha/y).

## 3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around the site of the poultry unit and the wildlife sites is 2.61 µg-NH3/m3. The background nitrogen deposition rate to woodland is 37.24 kg-N/ha/y and to short vegetation is 21.00 kg-N/ha/y. The background acid deposition rate to woodland is 2.70 keq/ha/y and to short vegetation is 1.52 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, March 2022).

## 3.3 Critical Levels & Critical Loads

Critical Levels and Critical Loads are a benchmark for assessing the risk of air pollution impacts to ecosystems. It is important to distinguish between a Critical Level and a Critical Load. The **Critical Level** is the gaseous **concentration** of a pollutant in the air, whereas the **Critical Load** relates to the quantity of pollutant **deposited** from air to the ground.

Critical Levels are defined as, "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur according to present knowledge" (UNECE).

Critical Loads are defined as, "a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (UNECE).

For ammonia concentration in air, the Critical Level for higher plants is 3.0 µg-NH3/m3 as an annual mean. For sites where there are sensitive lichens and bryophytes present, or where lichens and bryophytes are an integral part of the ecosystem, the Critical Level is 1.0 µg-NH3/m3 as an annual mean.

Critical Loads for nutrient nitrogen are set under the Convention on Long-Range Transboundary Air Pollution. They are based on empirical evidence, mainly observations from experiments and gradient studies. Critical Loads are given as ranges (e.g. 10-20 kg-N/ha/y); these ranges reflect variation in ecosystem response across Europe.

The Critical Levels and Critical Loads at the wildlife sites assumed in this study are provided in Table 1. N.B. Where the Critical Level of 1.0 µg-NH3/m3 is assumed, it is usually unnecessary to consider the Critical Load as the Critical Level provides the stricter test.

*Table 1. Critical Levels and Critical Loads at the wildlife sites*

|  |  |  |  |
| --- | --- | --- | --- |
| Site | Critical Level  (µg-NH3/m3) | Critical Load Nitrogen Deposition  (kg-N/ha/y) | Critical Load  Acid Deposition  (keq/ha/y) |
| AWs and cLWS | 1.0 1 | - | - |
| Weston Fen SSSI | 1.0 1 & 2 | 10.0 2 & 3 | - |
| Whitecross Green and Oriel Woods SSSI | 1.0 1 & 2 | 15.0 2 & 3 | - |
| Ardley Trackways SSSI, Kirtlington Quarry SSSI, Shipton-on-Cherwell & Whitehill Farm Quarries SSSI, Woodeaton Quarry SSSI, Stratton Audley Quarries SSSI and Horsehay Quarries SSSI | n/a 4 | n/a 4 | - |
| Ardley Cutting and Quarry SSSI, Sheep's Banks SSSI, Rushy Meadows SSSI and Middle Barton Fen SSSI | 3.0 2 | 15.0 2 & 3 |  |
| Wendlebury Meads and Mansmoor Closes SSSI, Otmoor SSSI and Arncott Bridge Meadows SSSI | 3.0 2 | 20.0 2 & 3 | - |
| Bestmoor SSSI | 3.0 2 | n/a 5 | - |

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to sensitive lichens and/or bryophytes.
2. Based upon the citation for the site and information listed on APIS (March 2022).
3. The lower bound of the range of Critical Loads for the site/species, obtained from APIS (March 2022).
4. Designated for geological features.
5. No Critical Load information available.

## 3.4 Guidance on the significance of ammonia emissions

### 3.4.1 Environment Agency Criteria

The Environment Agency web-page titled “Intensive farming risk assessment for your environmental permit”, contains a set of criteria, with thresholds defined by percentages of the Critical Level or Critical Load, for: internationally designated wildlife sites (Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites); Sites of Special Scientific Interest (SSSIs) and other non-statutory wildlife sites. The lower and upper thresholds are: 4% and 20% for SACs, SPAs and Ramsar sites; 20% and 50% for SSSIs and 100% and 100% for non-statutory wildlife sites. If the predicted process contributions to Critical Level or Critical Load are below the lower threshold percentage, the impact is usually deemed acceptable.

If the predicted process contributions to Critical Level or Critical Load are in the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsar sites; 20% to 50% for SSSIs and 100% to 100% for other non-statutory wildlife sites, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. In making their decision, the Environment Agency will consider whether other farming installations might act in-combination with the farm and the sensitivities of the wildlife sites. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in-combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

### 3.4.2 Natural England advisory criterion

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% of Critical Level or Critical Load at a SSSI, SAC, SPA or Ramsar site, then the local authority should consider whether other farming installations1 might act in-combination or cumulatively with the farm and the sensitivities of the wildlife sites. This advice is based primarily upon the Habitats Directive, EIA Directive and the Countryside and Rights of Way Act.

1. The process contribution from most farming installations is already included in the background ammonia concentrations and nitrogen and acid deposition rates. Therefore, it is normally only necessary to consider new installations and installations with extant planning permission and proposed developments when understanding the additional impact of a proposal upon nearby ecologies. However, established farms in close proximity may need to be considered given the background concentrations and deposition rates are derived as an average for a 5 km by 5 km grid.

### 3.4.3 Joint Nature Conservancy Committee - Guidance on Decision-making Thresholds for Air Pollution

In December 2021, the Joint Nature Conservancy Committee (JNCC) published a report titled, “Guidance on Decision-making Thresholds for Air Pollution” This report provides decision-making criteria to inform the assessment of air quality impacts on designated conservation sites. The criteria are intended to be applied to individual sources to identify those for which a decision can be taken without the need for further assessment effort.

The Decision-making thresholds (DMT) for on-site emission sources provided in the JNCC report are reproduced below:

* For lichens and bryophytes - 0.08%, 0.20%, 0.34% and 0.75% of the Critical Level for high, medium, low and very low development density areas, respectively.
* For higher plants - 0.08%, 0.20%, 0.34% and 0.75% of the Critical Level for high, medium, low and very low development density areas, respectively.
* For nitrogen deposition to woodland (Critical Load 10 kg-N/ha/y) - 0.13%, 0.34%, 0.57% and 1.30% of the Critical Level for high, medium, low and very low development density areas, respectively.
* For nitrogen deposition to grassland (Critical Load 10 kg-N/ha/y) 0.09%, 0.24%, 0.40% and 0.88% of the Critical Level for high, medium, low and very low development density areas, respectively.

Note that ‘development density’ is defined as, the assumed number of additional new sources below the DMT within 5 km of the proposed development over 13 years: very low density being 1 development; low 5 developments; medium 10 developments and high 30 developments.

Subject to some exceptions, where the process contribution from an on-site source is below the DMT, no further assessment is required. Where the process contribution exceeds the DMT there are two possible outcomes:

* Where site-relevant thresholds have been derived these can be applied to see if it is possible to avoid further assessment effort on the basis of site-specific circumstances.
* If site-relevant thresholds have not yet been derived, further assessment in combination with other plans and projects is required.

## 3.5 Quantification of ammonia emissions

Ammonia emission rates from poultry houses depend on many factors and are likely to be highly variable. However, the benchmarks for assessing impacts of ammonia and nitrogen deposition are framed in terms of an annual mean ammonia concentration and annual nitrogen deposition rates. To obtain relatively robust figures for these statistics it is not necessary to model short term temporal variations and a steady continuous emission rate can be assumed. In fact, modelling short term temporal variations might introduce rather more uncertainty than modelling continuous emissions.

The Environment Agency provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For broiler chickens, the Environment Agency figure is 0.034 kg-NH3/bird place/year. For poultry manure, the Environment Agency figure is 1.74 kg-NH3/tonne/year; however, in this case, the combustion air for the biomass boiler would be drawn from the manures store (with ammonia then being thermally oxidised) and therefore, manure store would be under negative pressure, therefore this figure has been reduced by 50%. Details of the poultry numbers and types, manure storage and emission factors used and calculated ammonia emission rates are provided in Table 2.

*Table 2. Details of poultry numbers and ammonia emission rates*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | Animal numbers/Tonnage |  | Type or weight | Emission factor  (kg-NH3/place/y) or (kg-NH3/tonne/y) | Emission rate  (g-NH3/s) |
| Proposed poultry houses | 364,999 |  | Broiler Chickens | 0.034 | 0.393248 |
| Manure store | 300 |  | Poultry litter/manure | 1.74 x 50% | 0.008271 |

# The Atmospheric Dispersion Modelling System (ADMS) and Model Parameters

The Atmospheric Dispersion Modelling System (ADMS) ADMS 5 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters; the boundary layer depth and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution (shown by validation studies to be a better representation than a symmetrical Gaussian expression).

ADMS has a number of model options that include: dry and wet deposition; NOx chemistry; impacts of hills; variable roughness; buildings and coastlines; puffs; fluctuations; odours; radioactivity decay (and γ-ray dose); condensed plume visibility; time varying sources and inclusion of background concentrations.

ADMS has an in-built meteorological pre-processor that allows flexible input of meteorological data both standard and more specialist. Hourly sequential and statistical data can be processed and all input and output meteorological variables are written to a file after processing.

The user defines the pollutant, the averaging time (which may be an annual average or a shorter period), which percentiles and exceedance values to calculate, whether a rolling average is required or not and the output units. The output options are designed to be flexible to cater for the variety of air quality limits which can vary from country to country and are subject to revision.

## 4.1 Meteorological data

Computer modelling of dispersion requires hourly sequential meteorological data and to provide robust statistics the record should be of a suitable length; preferably four years or longer.

The meteorological data used in this study is obtained from assimilation and short term forecast fields of the Numerical Weather Prediction (NWP) system known as the Global Forecast System (GFS)1.

The GFS is a spectral model: the physics/dynamics model has an equivalent resolution of approximately 9 km (latterly 6 km) over the UK. Terrain is understood to be resolved at a resolution of approximately 2 km, with sub-9/6 km terrain effects parameterised. Site specific data may be extrapolated from nearby archive grid points, or a most representative grid point chosen. The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR2). The use of NWP data has advantages over traditional meteorological records because:

* Calm periods in traditional observational records may be over represented, this is because the instrumentation used may not record wind speeds below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.
* Traditional records may include very local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled; these deviations are difficult to identify and remove from a meteorological record. Conversely, local effects at the site being modelled are relatively easy to impose on the broad-scale flow and provided horizontal resolution is not too great, the meteorological records from NWP data may be expected to represent well the broad-scale flow.
* Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a. Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the location of the poultry houses at Middleton Stoney Poultry Unit is shown in Figure 2b. The resolution of the wind field in terrain runs is approximately 340 m. Please also note that FLOWSTAR2 is used to obtain a local flow field, not to explicitly model dispersion in complex terrain as defined in the ADMS User Guide; therefore, the ADMS default value for minimum turbulence length has been amended3.

1. The GFS data used is derived from the high resolution operational GFS datasets, the data is not obtained from the lower resolution (0.5 degree) long-term archive.
2. Note that FLOWSTAR requirements are for meteorological data representative of the upwind flow over the modelling domain and that single site meteorological data (observational or from high resolution modelled data) that is representative of the application site is not generally suitable (personal correspondence: CERC 2019 and UK Met O 2015). If data are deemed representative of a particular application site, either wholly or partially, then these data cannot also be representative of the upstream flow over the modelling domain. Furthermore, it would be extremely poor practice to use such data as the boundary conditions for a flow-solver, such as FLOWSTAR.
3. When modelling complex terrain with ADMS, by default, the minimum turbulence length has 0.1 m added to the flat terrain value (calculated from the Monin-Obukhov length). Whilst this might be appropriate over hill/mountain tops in terrain with slopes > 1:10 (and quite possibly only in certain wind directions) in lesser terrain it introduces model behaviour that is not desirable where FLOWSTAR is simply being used to modify the upwind flow. Specifically, the parameter sigma z of the Gaussian plume model is overly constrained, which for elevated point sources emissions, may on occasion cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013), conversely for low level emission sources, this will cause gross under prediction. Note that this becomes particularly important overnight and if calm and light wind conditions are not being ignored, as they often are when using traditional observational meteorological datasets. To reduce this behaviour, where terrain is modelled, AS Modelling & Data Ltd. have set a minimum turbulence length of 0.025 m in ADMS. This approximates the normal behaviour of ADMS with flat terrain.

*Figure 2a. The wind rose. Raw GFS derived data for 51.894 N, 1.233W, 2018 - 2021*

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*Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 452750, 222050, 2018-2021*

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## 4.2 Emission sources

Emissions from the chimneys of the uncapped high speed roof fans are represented by three point sources per house within ADMS (H1\_ to H5 1, 2 & 3). Details of the point source parameters are shown in Table 2a. The positions of the point sources may be seen in Figure 3 (marked by green circles).

Fugitive emissions from the proposed manure storage building represented by a single volume source within ADMS (MANURE). Details of the volume source parameters are shown in Table 2b. The positions of the point sources may be seen in Figure 3 (the source occupies the same footprint as the building marked MANURE).

*Table 2a. Point source parameters*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source ID | Height (m) | Diameter (m) | Efflux velocity (m/s) | Emission temperature (˚C) | Emission rate per source  (g-NH3/s) |
| H1 and H5 1, 2 & 3 | 5.0 | 0.8 | 11.0 | 22.0 | 0.014565 |
| H2, H3, H4, H6, H7 & H8 1, 2 & 3 | 5.0 | 0.8 | 11.0 | 22.0 | 0.016992 |

*Table 2b. Volume source parameters*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source ID | Length (m) | Width  (m) | Depth (m) | Base height  (m) | Emission temperature (°C) | Emission rate  (g-NH3/s) |
| MANURE | 27.4 | 14.0 | 2.0 | 2.0 | Ambient | 0.008271 |

## 4.3 Modelled buildings

The structure of the poultry houses may affect the plumes from the point sources. Therefore, the buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3 (marked by grey rectangles).

## 4.4 Discrete receptors

Thirty-four discrete receptors have been defined at the statutory and non-statutory wildlife sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4a and 4b (marked by enumerated pink rectangles).

## 4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition velocity field, a regular Cartesian grid has been defined within ADMS. The grid receptors are defined at ground level within ADMS. The position of the nested Cartesian grid receptors may be seen in Figures 4a and 4b (marked by grey lines).

## 4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 22.0 km x 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 340 m.

## 4.7 Roughness Length

In this case, a spatially varying roughness length file has been defined, this is based upon the UK Centre for Ecology and Hydrology 25m land use database, with permission1. The GFS meteorological data is assumed to have a roughness length of 0.3 m. The sample of the central area of the spatially varying roughness length field is shown in Figure 5.

1. Morton, R.D. ; Marston, C.G.; O’Neil, A.W.; Rowland, C.S. (2021). Land Cover Map 2020 (25m rasterised land parcels, GB). NERC EDS Environmental Information Centre. https://doi.org/10.5285/6c22cf6e-b224-414e-aa85-900325baed

*Figure 3. The positions of the modelled buildings and sources*

Map

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*Figure 4a. The discrete receptors and regular Cartesian grid*

*Diagram

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*Figure 4b. The discrete receptors and regular Cartesian grid - a closer view*

*Map

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*Figure 5. The spatially varying surface roughness field*

Map

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## 4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based primarily upon Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004-2013). AS Modelling & Data Ltd. has restricted deposition over arable farmland and heavily grazed and fertilised pasture; this is to compensate for possible saturation effects due to fertilizer application and to allow for periods when fields are clear of crops (Sutton), the deposition is also restricted over areas with little or no vegetation and the deposition velocity is set to 0.002 m/s where grid points are over the poultry housing and 0.010 m/s to 0.015 m/s over heavily grazed grassland. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used. Land usage is based upon the UK Centre for Ecology and Hydrology 25m land use database, with permission 1.

In summary, the method is as follows:

* A preliminary run of the model without deposition is used to provide an ammonia concentration field.
* The preliminary ammonia concentration field, along with land usage, has been used to define a deposition velocity field. The deposition velocities used are provided in Table 3.

*Table 3. Deposition velocities*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NH3 concentration  (PC + background) (µg/m3) | < 10 | 10 - 20 | 20 - 30 | 30 - 80 | > 80 |
| Deposition velocity - woodland  (m/s) | 0.03 | 0.015 | 0.01 | 0.005 | 0.003 |
| Deposition velocity - short vegetation  (m/s) | 0.02 (0.010 to 0.015 over heavily grazed grassland) | 0.015 | 0.01 | 0.005 | 0.003 |
| Deposition velocity - arable farmland/rye grass  (m/s) | 0.005 | 0.005 | 0.005 | 0.005 | 0.003 |

* The model is then rerun with the spatially varying deposition module.

A contour plot of the spatially varying deposition field is provided in Figure 6.

Please note that, outside of the central grid, a fixed deposition at 0.005 m/s is applied and similarly to not modelling deposition at all, the predicted ammonia concentrations (and nitrogen and acid deposition rates) are always equal to, or higher than if spatially varying deposition were modelled explicitly, particularly where there is some distance between the source and a receptor.

1. Morton, R.D. ; Marston, C.G.; O’Neil, A.W.; Rowland, C.S. (2021). Land Cover Map 2020 (25m rasterised land parcels, GB). NERC EDS Environmental Information Centre. https://doi.org/10.5285/6c22cf6e-b224-414e-aa85-900325baedbd

*Figure 6. The spatially varying deposition field*

*Map

Description automatically generated*

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# Details of the Model Runs and Results

## 5.1 Preliminary modelling and model sensitivity tests

ADMS was effectively run a totalof sixteen times, once for each year of the meteorological record and in the following four modes:

* In basic mode without calms, or terrain - GFS data.
* With calms and without terrain - GFS data.
* Without calms and with terrain and surface roughness - GFS data.
* Without calms, with terrain and surface roughness and a fixed deposition at 0.003 m/s - GFS data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled.

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 4. In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Environment Agency’s upper percentage threshold of the relevant Critical Level or Critical Load for the site (50% for a SSSI and 100% for a non-statutory site) are coloured red. Predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in the range between the Environment Agency’s upper threshold and lower threshold percentages (20% and 50% for a SSSI and 100% and 100% for a non-statutory site) are coloured blue. Additionally, predicted ammonia concentrations (or concentrations equivalent to nitrogen deposition rates) that exceed 1% of the relevant Critical Level or Critical Load at a statutory wildlife site are highlighted with bold text. For convenience, cells referring to the AW are shaded olive, cells referring to the cLWS are shaded yellow and cells referring to the SSSIs are shaded green.

*Table 4. Preliminary ammonia concentration predictions*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Receptor number | X(m) | Y(m) | Designation | Maximum annual mean ammonia concentration - (µg/m3) | | | |
| Proposed | | | |
| GFS No Calms No Terrain | GFS Calms No Terrain | GFS No Calms Terrain | GFS No Calms Terrain Fixed Dep 0.003 m/s |
| 1 | 452517 | 222250 | AW | 0.654 | 0.702 | 0.706 | 0.650 |
| 2 | 452212 | 222270 | AW | 0.252 | 0.272 | 0.262 | 0.227 |
| 3 | 451828 | 222101 | AW | 0.147 | 0.157 | 0.152 | 0.123 |
| 4 | 451271 | 222295 | AW | 0.072 | 0.077 | 0.077 | 0.057 |
| 5 | 450946 | 222778 | AW | 0.049 | 0.052 | 0.051 | 0.036 |
| 6 | 450970 | 221524 | AW | 0.071 | 0.074 | 0.072 | 0.051 |
| 7 | 453867 | 223654 | AW | 0.109 | 0.113 | 0.109 | 0.090 |
| 8 | 451517 | 220468 | cLWS | 0.083 | 0.087 | 0.080 | 0.062 |
| 9 | 453754 | 224511 | Ardley Trackways SSSI | 0.061 | 0.064 | 0.065 | 0.049 |
| 10 | 453740 | 225179 | Ardley Trackways SSSI | 0.047 | 0.048 | 0.050 | 0.036 |
| 11 | 454506 | 224900 | Ardley Trackways SSSI | 0.047 | 0.049 | 0.047 | 0.036 |
| 12 | 452401 | 219887 | Weston Fen SSSI | **0.056** | **0.060** | **0.055** | **0.041** |
| 13 | 452658 | 219177 | Weston Fen SSSI | **0.036** | **0.039** | **0.036** | **0.025** |
| 14 | 449474 | 219977 | Kirtlington Quarry SSSI | 0.033 | 0.034 | 0.034 | 0.022 |
| 15 | 455902 | 225017 | Ardley Cutting and Quarry SSSI | **0.037** | **0.038** | **0.038** | 0.028 |
| 16 | 454710 | 226043 | Ardley Cutting and Quarry SSSI | **0.029** | **0.030** | **0.029** | 0.021 |
| 17 | 453638 | 227130 | Ardley Cutting and Quarry SSSI | 0.025 | 0.026 | 0.026 | 0.016 |
| 18 | 451493 | 228941 | Ardley Cutting and Quarry SSSI | 0.013 | 0.014 | 0.013 | 0.007 |
| 19 | 455449 | 217884 | Wendlebury Meads and Mansmoor Closes SSSI | 0.023 | 0.024 | 0.028 | 0.016 |
| 20 | 456432 | 217024 | Wendlebury Meads and Mansmoor Closes SSSI | 0.019 | 0.020 | 0.024 | 0.012 |
| 21 | 447808 | 218670 | Shipton-on-Cherwell & Whitehill Farm Quarries SSSI | 0.018 | 0.019 | 0.020 | 0.012 |
| 22 | 448053 | 217515 | Shipton-on-Cherwell & Whitehill Farm Quarries SSSI | 0.017 | 0.018 | 0.017 | 0.011 |
| 23 | 444343 | 220980 | Sheep's Banks SSSI | 0.008 | 0.008 | 0.009 | 0.004 |
| 24 | 448053 | 214468 | Rushy Meadows SSSI | 0.011 | 0.012 | 0.012 | 0.006 |
| 25 | 444171 | 216925 | Blenheim Park SSSI | 0.009 | 0.010 | 0.010 | 0.005 |
| 26 | 453263 | 212429 | Woodeaton Quarry SSSI | 0.009 | 0.010 | 0.008 | 0.004 |
| 27 | 457194 | 214837 | Otmoor SSSI | 0.012 | 0.012 | 0.015 | 0.007 |
| 28 | 458988 | 214247 | Murcott Meadows SSSI | 0.011 | 0.012 | 0.013 | 0.006 |
| 29 | 459676 | 214911 | Whitecross Green and Oriel Woods SSSI | **0.012** | **0.012** | **0.013** | 0.006 |
| 30 | 460658 | 218572 | Arncott Bridge Meadows SSSI | 0.013 | 0.014 | 0.012 | 0.007 |
| 31 | 460020 | 224960 | Stratton Audley Quarries SSSI | 0.020 | 0.021 | 0.020 | 0.012 |
| 32 | 449405 | 229506 | Bestmoor SSSI | 0.011 | 0.012 | 0.012 | 0.006 |
| 33 | 445842 | 227245 | Horsehay Quarries SSSI | 0.008 | 0.008 | 0.008 | 0.003 |
| 34 | 444442 | 226262 | Middle Barton Fen SSSI | 0.007 | 0.007 | 0.007 | 0.000 |

## 5.2 Detailed deposition modelling

Detailed modelling has been carried out over a domain around the proposed poultry houses at Middleton Stoney Poultry Unit, nearby AWs and Weston Fen SSSI. Outside of this domain, a fixed deposition velocity of 0.005 m/s is assumed.

The predicted process contribution to maximum annual mean ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 5. In the Table, predicted ammonia concentrations and deposition rates that are in excess of 1% of the relevant Critical Level/Load are highlighted in bold text.

Contour plots of the predicted process contributions to ground level maximum annual mean ammonia concentrations and nitrogen deposition rates are shown in: Figures 7a and 7b.

*Table 5. Predicted process contribution to maximum annual mean ammonia and nitrogen deposition at the discrete receptors*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Receptor number | X(m) | Y(m) | Name | Site Parameters | | | Maximum annual ammonia concentration | | Maximum annual nitrogen deposition rate | |
| Deposition Velocity | Critical Level (µg/m3) | Critical Load (kg/ha) | Process Contribution (µg/m3) | %age of Critical Level | Process Contribution (kg/ha) | %age of Critical Load |
| 1 | 452517 | 222250 | AW | 0.03 | 1.0 | 10.0 | 0.620 | 61.98 | 4.829 | 48.29 |
| 2 | 452212 | 222270 | AW | 0.03 | 1.0 | 10.0 | 0.187 | 18.65 | 1.453 | 14.53 |
| 3 | 451828 | 222101 | AW | 0.03 | 1.0 | 10.0 | 0.114 | 11.38 | 0.886 | 8.86 |
| 4 | 451271 | 222295 | AW | 0.03 | 1.0 | 10.0 | 0.052 | 5.24 | 0.409 | 4.09 |
| 5 | 450946 | 222778 | AW | 0.03 | 1.0 | 10.0 | 0.032 | 3.21 | 0.250 | 2.50 |
| 6 | 450970 | 221524 | AW | 0.03 | 1.0 | 10.0 | 0.045 | 4.52 | 0.352 | 3.52 |
| 7 | 453867 | 223654 | AW | 0.03 | 1.0 | 10.0 | 0.080 | 8.01 | 0.624 | 6.24 |
| 8 | 451517 | 220468 | cLWS | 0.02 | 1.0 | 10.0 | 0.054 | 5.44 | 0.282 | 2.82 |
| 9 | 453754 | 224511 | Ardley Trackways SSSI | 0.02 | n/a | n/a | 0.044 | - | 0.227 | - |
| 10 | 453740 | 225179 | Ardley Trackways SSSI | 0.02 | n/a | n/a | 0.031 | - | 0.161 | - |
| 11 | 454506 | 224900 | Ardley Trackways SSSI | 0.02 | n/a | n/a | 0.031 | - | 0.163 | - |
| 12 | 452401 | 219887 | Weston Fen SSSI | 0.02 | 1.0 | 10.0 | 0.030 | **3.01** | 0.156 | **1.56** |
| 13 | 452658 | 219177 | Weston Fen SSSI | 0.02 | 1.0 | 10.0 | 0.018 | **1.80** | 0.094 | 0.94 |
| 14 | 449474 | 219977 | Kirtlington Quarry SSSI | 0.03 | n/a | n/a | 0.019 | - | 0.150 | - |
| 15 | 455902 | 225017 | Ardley Cutting and Quarry SSSI | 0.02 | 3.0 | 15.0 | 0.024 | 0.81 | 0.126 | 0.84 |
| 16 | 454710 | 226043 | Ardley Cutting and Quarry SSSI | 0.02 | 3.0 | 15.0 | 0.018 | 0.62 | 0.096 | 0.64 |
| 17 | 453638 | 227130 | Ardley Cutting and Quarry SSSI | 0.02 | 3.0 | 15.0 | 0.014 | 0.46 | 0.072 | 0.48 |
| 18 | 451493 | 228941 | Ardley Cutting and Quarry SSSI | 0.02 | 3.0 | 15.0 | 0.006 | 0.21 | 0.032 | 0.22 |
| 19 | 455449 | 217884 | Wendlebury Meads and Mansmoor Closes SSSI | 0.02 | 3.0 | 20.0 | 0.013 | 0.44 | 0.068 | 0.34 |
| 20 | 456432 | 217024 | Wendlebury Meads and Mansmoor Closes SSSI | 0.02 | 3.0 | 20.0 | 0.010 | 0.34 | 0.052 | 0.26 |
| 21 | 447808 | 218670 | Shipton-on-Cherwell & Whitehill Farm Quarries SSSI | 0.03 | n/a | n/a | 0.010 | - | 0.081 | - |
| 22 | 448053 | 217515 | Shipton-on-Cherwell & Whitehill Farm Quarries SSSI | 0.03 | n/a | n/a | 0.009 | - | 0.071 | - |
| 23 | 444343 | 220980 | Sheep's Banks SSSI | 0.02 | 3.0 | 15.0 | 0.004 | 0.12 | 0.019 | 0.13 |
| 24 | 448053 | 214468 | Rushy Meadows SSSI | 0.02 | 3.0 | 15.0 | 0.005 | 0.17 | 0.027 | 0.18 |
| 25 | 444171 | 216925 | Blenheim Park SSSI | 0.03 | 1.0 | 15.0 | 0.004 | 0.45 | 0.035 | 0.23 |
| 26 | 453263 | 212429 | Woodeaton Quarry SSSI | 0.03 | n/a | n/a | 0.004 | - | 0.028 | - |
| 27 | 457194 | 214837 | Otmoor SSSI | 0.02 | 3.0 | 20.0 | 0.006 | 0.19 | 0.030 | 0.15 |
| 28 | 458988 | 214247 | Murcott Meadows SSSI | 0.02 | 3.0 | 20.0 | 0.005 | 0.16 | 0.025 | 0.13 |
| 29 | 459676 | 214911 | Whitecross Green and Oriel Woods SSSI | 0.03 | 1.0 | 15.0 | 0.005 | 0.48 | 0.038 | 0.25 |
| 30 | 460658 | 218572 | Arncott Bridge Meadows SSSI | 0.02 | 3.0 | 20.0 | 0.005 | 0.18 | 0.028 | 0.14 |
| 31 | 460020 | 224960 | Stratton Audley Quarries SSSI | 0.03 | n/a | n/a | 0.010 | - | 0.076 | - |
| 32 | 449405 | 229506 | Bestmoor SSSI | 0.02 | 3.0 | n/a | 0.005 | 0.17 | 0.027 | - |
| 33 | 445842 | 227245 | Horsehay Quarries SSSI | 0.03 | n/a | n/a | 0.003 | - | 0.021 | - |
| 34 | 444442 | 226262 | Middle Barton Fen SSSI | 0.02 | 3.0 | 15.0 | 0.003 | 0.09 | 0.013 | 0.09 |

*Figure 7a. Predicted process contribution to maximum annual mean ammonia concentration*

Diagram

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*Figure 7b. Predicted process contribution to maximum annual nitrogen deposition rates*

Map

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# Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Stephen Raasch, on behalf of Mr. Sam Drummond of Brackley Farms Ltd., to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses and manure storage building at Middleton Stoney Poultry Unit, Forest Lodge Farm, Middleton Park, Middleton Stoney, Bicester, Oxfordshire. OX25 4AJ.

Ammonia emission rates from the proposed poultry houses and manure storage building have been assessed and quantified based upon the Environment Agency’s standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

The primary purpose of the modelling study is to investigate and understand the effects of extending the existing poultry houses, increasing stocking numbers, adding a manure storage building and replacing the existing side mounted ventilation fans with modern high speed ridge mounted fans, each with a short chimney, on ammonia concentrations and nitrogen deposition rates at nearby areas of Ancient Woodland (AW). However, for completeness, the impacts at all statutory wildlife sites within 10 km have also been assessed.

The modelling predicts that:

* At all of the SSSIs, the process contribution to annual mean ammonia concentrations and nitrogen deposition rates would be below the Environment Agency’s lower threshold percentages (20% for a SSSI) of the relevant Critical Level/Load for the site.
* Process contributions would exceed 1% of the Critical Level/Load at Weston Fen SSSI. At all other SSSIs, process contributions would be below 1% of the Critical Level/Load.
* At all of the AWs and the cLWS, the process contribution to annual mean ammonia concentrations and nitrogen deposition rates would be below the Environment Agency’s lower threshold percentages (100% for a non-statutory site) of the precautionary Critical Level of 1.0 µg-NH3/m3.

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