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# A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Broiler Chicken Rearing Houses at Gailey Farm, Gailey Lea Lane, Gailey in Staffordshire

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# Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Ian Pick of Ian Pick Associates Ltd., on behalf of Abbey Foods Ltd., to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Gailey Farm, Gailey Lea Lane, Gailey in Staffordshire. ST19 5PT.

Ammonia emission rates from the proposed poultry rearing houses 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.

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 proposed broiler rearing houses at Gailey Farm is in a rural area adjacent to Gailey Lower Reservoir used for leisure activities, whilst the surrounding land is used primarily for arable farming. The site is at an altitude of around 105 m, with the land falling gently to the north-west and rising toward higher ground over Cannock to the east.

It is proposed that two broiler rearing houses be constructed at Gailey Farm. The houses would provide accommodation for up to 67,000 broiler chickens in total and would be ventilated primarily by uncapped high speed ridge mounted fans, each with a short chimney. There would also be gable end fans which would provide supplementary ventilation only in hot weather conditions. The chickens would be reared from day old chicks to up to around 38 days old and there would be approximately 7.6 flocks per annum.

There are five Local Wildlife Sites (LWSs) and two Ancient Woodlands (AWs) within 2 km (the normal screening distance for non-statutory sites) of the proposed poultry houses. There are eight areas designated as Sites of Special Scientific Interest (SSSIs) within 10 km (the normal screening distance for SSSIs) of the farm, three of which are also designated as Special Areas of Conservation (SACs). There are no other internationally designated sites within 10 km of the site. Some further details of the SSSIs are provided below:

* **Stowe Pool and Walk Mill Clay Pit SSSI** - approximately 4.5 km to the south-east. Waterbodies supporting large populations of native white-clawed crayfish. Limited marginal vegetation.
* **Four Ashes Pit SSSI** - approximately 3.2 km to the south-west. Geological.
* **Belvide Reservoir SSSI** - approximately 6.5 km to the west. Well vegetated canal feeder reservoir of ornithological interest.
* **Big Hyde Rough SSSI** - approximately 7.1 km to the west-south-west. Ancient woodland dominated by alder, oak and ash.
* **Chasewater and the Southern Staffordshire Coalfield Heaths SSSI** - approximately 6.9 km to the east-north-east (closest point). Nationally important wet and dry lowland heath, including mires, swamps and oligotrophic standing open water habitats.
* **Cannock Chase SSSI/SAC** - approximately 6.3 km to the north-east (closest point). A large diverse area of seminatural vegetation including ancient woodland, scrub and extensive heathland.
* **Cannock Extension Canal SSSI/SAC** - approximately 6.3 km to the north-east (closest point). A side branch of the Wyrley and Essington Canal with high water quality and low boat traffic. Nationally scarce floating water plantain of major importance.
* **Mottley Meadows SSSI/SAC** - approximately 6.3 km to the north-east (closest point). Mesotrophic grassland with alluvial flood meadow.

A map of the surrounding area showing the positions of the proposed poultry houses at Gailey Farm, the LWSs, AWs, SSSIs and SACs is provided in Figure 1. In the figure, the LWSs are shaded in yellow with a brown outline, the AWs are shaded in olive, the SSSIs are shaded in green, the SACs are shaded in purple and the positions of the proposed poultry houses are outlined in red.

*Figure 1. The area surrounding Gailey Farm – concentric circles radii 2.0 km (olive) and 10.0 km (purple)*

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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 source of the background figures is the Air Pollution Information System (APIS, February 2024). It should be noted that the 1 km APIS database background levels are extrapolated from 5 km modelled data. Ammonia levels may vary markedly over relatively short distances and the APIS website itself notes that, the background values should be used only to assist the user in obtaining a broad indication of the likely pollutant impact at a specific location andcannot be considered representative of any particular location within the 5 km grid square; extrapolation to a 1 km grid does not alter this.

The APIS figures for background ammonia concentration in the area around Gailey Farm is 2.3 µg‑NH3/m3. The background nitrogen deposition rate to woodland is 31.8 kg-N/ha/y and to short vegetation is 18.22 kg-N/ha/y. The background acid deposition rate to woodland is 2.35 keq/ha/y and to short vegetation is 1.36 keq/ha/y.

The APIS background figures are subject to revision and appear to change fairly frequently, the latest figures can be obtained at <https://www.apis.ac.uk/search-location>.

## 3.3 Critical Levels and 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. Normally, the Critical Load for nitrogen deposition provides a stricter test than the Critical Load for acid deposition.

*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) |
| Gailey Reservoirs LWS | 3.0 1 | - | - |
| Other LWSs and AWs | 1.0 2 | - | - |
| Stowe Pool and Walk Mill Clay Pit SSSI and Belvide Reservoir SSSI | 3.0 3 | - | - |
| Big Hyde Rough SSSI | 1.0 2&3 | - | - |
| Chasewater and the Southern Staffordshire Coalfield Heaths SSSI, Cannock Chase SSSI/SAC, Cannock Extension Canal SSSI/SAC and Mottey Meadows SSSI/SAC | 1.0 2&3 | 5.0 2 & 4 | - |
| Four Ashes Pit SSSI | n/a 5 | n/a 5 | n/a 5 |

1. A recent site visit confirmed that no sensitive lichens or bryophytes are likely to be present.
2. A precautionary figure, used where details of the site are unavailable, or citations/APIS indicate that sensitive lichens and bryophytes may be present.
3. Based upon the citation for the site.
4. The lower bound of the range of Critical Loads for the site.
5. Designated features are not sensitive to ammonia emissions/nitrogen deposition – geological.

## 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 criteria

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% (or lower in some circumstances) 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.

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 are derived from an average for a 5 km by 5 km grid.

### 3.4.3 Environment Agency and Natural England May 2022 Air Quality Risk Assessment Interim Guidance

Although it seems important to include a reference to this document, it appears to be primarily a discussion document about internal Environment Agency screening models and the SCAIL model and AS Modelling & Data Ltd. have been unable to draw any conclusions from the document as to what thresholds may or may not apply, nor in what circumstances the threshold may or may not apply.

### 3.4.4 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

### 3.5.1 General information

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 normally 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. Details of the poultry numbers and types 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 | Type or weight | Emission factor  (kg-NH3/place/y) | Emission rate  (g-NH3/s) |
| Proposed Poultry Houses | 67,000 | Broiler Chickens | 0.034 | 0.072185 |

### 3.5.2 Further details of the emission modelling

For the proposed houses, it is assumed for modelling purposes that 50% of the emissions are from the gable end fans when temperatures exceed 30 Celsius; ridge fans emissions are reduced by 50% when this occurs. These estimates are based on a detailed emission model that calculates ventilation requirements (available upon request).

# The Atmospheric Dispersion Modelling System (ADMS) and model parameters

The Atmospheric Dispersion Modelling System (ADMS) ADMS 6 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.

Prior to April 2019 the GFS was a spectral model, post April 2019 the physics are discrete. The physics/dynamics model has a resolution or had an equivalent resolution of approximately 7 km over the UK; terrain is understood to be resolved at a resolution of approximately 2 km, with sub-7 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 site is shown in Figure 2b. Although there is little modification in this case, elsewhere in the modelling domain wind roses may differ more markedly, reflecting the local flow in that part of the domain. 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 amended 3.

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 52.696 N, 2.095 W, 2020-2023*

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*Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 393575, 310900, 2020-2023*

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## 4.2 Emission sources

Emissions from the chimneys of the uncapped high speed ridge fans that are/would be used for the primary ventilation of the proposed poultry houses are represented by three point sources per house within ADMS (H1 1, 2 & 3 and H2 1, 2 & 3).

Emissions from the gable end fans that would be used to supplement the primary ventilation have been represented by three volume sources within ADMS (H1\_GAB and H2\_GAB).

The emissions from the gable end fans are assumed to be zero unless the ambient temperature equals or exceeds 30 Celsius. Once this threshold has been reached, 50% of the total house emissions are assigned to the high speed ridge fans and 50% are assigned to the gable end fans.

Details of the point source parameters are shown in Table 3a and details of the volume source parameters are shown in Table 3b. The positions of the point sources used are shown in Figure 3 (point sources are marked by green circles and the volume sources are marked by red shaded rectangles).

*Table 3a. Point source parameters*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source ID | Height  (m) | Diameter (m) | Efflux velocity (m/s) | Emission temperature  (˚C) | Emission rate per source  (g/s) |
| H1 & H2; 1, 2 & 3 | 6.5 | 0.8 | 11.0 | Variable 1 | 0.012031 3 |

*Table 3b. Volume source parameters*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Source ID | Length (m) | Width  (m) | Depth  (m) | Base height  (m) | Emission temperature (°C) | Emission rate  (g/s) |
| H1\_GAB & H2\_GAB | 20.42 | 10.0 | 3.0 | 0.5 | Ambient | 0.036093 2 |

1. Dependent on ambient temperature.
2. 50% of emissions emitted only when ambient temperature equals or exceeds 30 Celsius.
3. Reduced by 50% when ambient temperature equals or exceeds 30 Celsius.

## 4.3 Modelled buildings

The structure of the proposed poultry houses and other large farm buildings may affect the plumes from the point sources. Therefore, these 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-three discrete receptors have been defined at the LWSs, AWs, SSSIs and SACs. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4 (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 individual grid receptors are defined at ground level within ADMS. The position of the Cartesian grid may be seen in Figure 4 (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 by 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the modelling. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field for the terrain runs 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 Defra Living Landscapes land use database. The GFS meteorological data is assumed to have a roughness length of 0.317 m (arithmetic average of the spatially varying roughness over the modelling domain). The sample of the central area of the spatially varying roughness length field is shown in Figure 5.

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

A map of a farm

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*Figure 4. The discrete receptors and Cartesian grid*

A map with a grid and dots

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*Figure 5. The spatially varying surface roughness field (central area)*

A map of land with roads and roads

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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.

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 4.

*Table 4. 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.

*Figure 6. The spatially varying deposition field*

A close-up of a map

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# Details of the Model Runs and Results

## 5.1 Preliminary modelling and model sensitivity tests

ADMS was 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 - GFS data.
* Without calms with terrain and 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 process contribution from the proposed poultry houses to annual mean ammonia concentrations at each receptor are provided in Table 5. There are no predicted exceedances of the Environment Agency’s upper or lower percentage threshold of the relevant Critical Level or Critical Load for the site (100% and 100% for a non-statutory site, 50% and 20% for a SSSI and 20% and 4% for an SAC). Additionally, there are no process contributions that exceed 1% of the relevant Critical Level or Critical Load for the statutory sites.

*Table 5. Predicted maximum annual mean ammonia concentration at the discrete receptors*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Receptor number | X(m) | Y(m) | Designation and Site Name | Maximum annual mean ammonia concentration - (µg/m3) | | | |
| GFS No Calms No Terrain | GFS Calms No Terrain | GFS No Calms Terrain | GFS Calms Correction Terrain Fixed depo 0.003 m/s |
| 1 | 393451 | 310706 | Gailey Reservoirs LWS | 0.123 | 0.122 | 0.143 | 0.136 |
| 2 | 393606 | 310619 | Gailey Reservoirs LWS | 0.085 | 0.085 | 0.131 | 0.118 |
| 3 | 393815 | 310484 | Gailey Reservoirs LWS | 0.100 | 0.099 | 0.137 | 0.121 |
| 4 | 394112 | 310219 | Gailey Reservoirs LWS | 0.053 | 0.053 | 0.076 | 0.062 |
| 5 | 393193 | 310445 | Gailey Reservoirs LWS | 0.047 | 0.047 | 0.058 | 0.054 |
| 6 | 393635 | 310067 | Gailey Reservoirs LWS | 0.022 | 0.022 | 0.040 | 0.031 |
| 7 | 393914 | 309975 | Gailey Reservoirs LWS | 0.030 | 0.030 | 0.047 | 0.037 |
| 8 | 392955 | 310183 | Gailey Reservoirs LWS | 0.025 | 0.025 | 0.031 | 0.027 |
| 9 | 393716 | 311115 | Fullmoor Wood LWS | 0.807 | 0.798 | 0.814 | 0.796 |
| 10 | 394039 | 310951 | Fullmoor Wood LWS | 0.141 | 0.140 | 0.168 | 0.155 |
| 11 | 392796 | 311614 | Rodbaston College LWS | 0.018 | 0.018 | 0.027 | 0.022 |
| 12 | 393166 | 311830 | Staffs and Worcs Canal, Penkridge LWS | 0.025 | 0.025 | 0.031 | 0.026 |
| 13 | 393585 | 312175 | Otherton Marsh, Penkridge LWS | 0.028 | 0.028 | 0.037 | 0.032 |
| 14 | 394342 | 310992 | Fullmoor Wood AW | 0.067 | 0.066 | 0.079 | 0.069 |
| 15 | 394273 | 311801 | Mansty Wood AW | 0.044 | 0.044 | 0.049 | 0.043 |
| 16 | 394683 | 311549 | Mansty Wood AW | 0.036 | 0.036 | 0.035 | 0.030 |
| 17 | 395096 | 312037 | Mansty Wood AW | 0.020 | 0.019 | 0.019 | 0.016 |
| 18 | 397373 | 308330 | Stowe Pool and Walk Mill Clay Pit SSSI | 0.007 | 0.007 | 0.008 | 0.004 |
| 19 | 391567 | 308343 | Four Ashes Pit SSSI | 0.004 | 0.004 | 0.005 | 0.004 |
| 20 | 387079 | 309894 | Belvide Reservoir SSSI | 0.003 | 0.003 | 0.003 | 0.002 |
| 21 | 386777 | 308357 | Big Hyde Rough SSSI | 0.002 | 0.002 | 0.002 | 0.001 |
| 22 | 400368 | 312201 | Chasewater and the Southern Staffordshire Coalfield Heaths SSSI | 0.003 | 0.003 | 0.002 | 0.001 |
| 23 | 402018 | 309887 | Chasewater and the Southern Staffordshire Coalfield Heaths SSSI | 0.003 | 0.003 | 0.002 | 0.001 |
| 24 | 402591 | 308576 | Chasewater and the Southern Staffordshire Coalfield Heaths SSSI | 0.002 | 0.002 | 0.002 | 0.001 |
| 25 | 400625 | 316940 | Cannock Chase SSSI | 0.002 | 0.002 | 0.001 | 0.001 |
| 26 | 399022 | 314305 | Cannock Chase SSSI/SAC | 0.003 | 0.003 | 0.002 | 0.001 |
| 27 | 398019 | 315999 | Cannock Chase SSSI/SAC | 0.003 | 0.003 | 0.002 | 0.001 |
| 8 | 397344 | 317849 | Cannock Chase SSSI/SAC | 0.002 | 0.002 | 0.002 | 0.001 |
| 29 | 401359 | 314838 | Cannock Chase SSSI/SAC | 0.002 | 0.002 | 0.002 | 0.001 |
| 30 | 399775 | 317300 | Cannock Chase SSSI/SAC | 0.002 | 0.002 | 0.001 | 0.001 |
| 31 | 402013 | 306889 | Cannock Extension Canal SSSI/SAC | 0.003 | 0.003 | 0.002 | 0.001 |
| 32 | 384241 | 313360 | Mottey Meadows SSSI/SAC | 0.001 | 0.001 | 0.002 | 0.001 |
| 33 | 383897 | 312376 | Mottey Meadows SSSI/SAC | 0.001 | 0.001 | 0.002 | 0.001 |

## 5.2 Detailed modelling

In this case there are no exceedances at any of the wildlife sites, detailed modelling has been carried out over a high resolution 5.0 km by 5.0 km domain to determine the magnitude of deposition of ammonia and consequent plume depletion. Outside of the 5.0 km by 5.0 km domain a fixed deposition velocity of 0.005 m/s is assumed (with appropriate deposition velocities applied post-modelling at the discrete receptors).

The detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition; therefore, calms have not been included in the detailed modelling; however, the results of the preliminary modelling runs indicate that the effects of calms are insignificant in this case.

The predicted process contributions from the proposed poultry houses to maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 6.

Contour plots of the predicted process contributions from the proposed poultry houses to ground level maximum annual mean ammonia concentration and maximum annual nitrogen deposition rate are shown in Figures 7a and 7b.

*Table 6. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Receptor number | X(m) | Y(m) | Designation | 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 | 393451 | 310706 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.131 | 4.4 | 0.681 | - |
| 2 | 393606 | 310619 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.113 | 3.8 | 0.589 | - |
| 3 | 393815 | 310484 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.104 | 3.5 | 0.540 | - |
| 4 | 394112 | 310219 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.058 | 1.9 | 0.303 | - |
| 5 | 393193 | 310445 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.044 | 1.5 | 0.228 | - |
| 6 | 393635 | 310067 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.025 | 0.8 | 0.130 | - |
| 7 | 393914 | 309975 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.028 | 0.9 | 0.147 | - |
| 8 | 392955 | 310183 | Gailey Reservoirs LWS | 0.020 | 3.0 | - | 0.023 | 0.8 | 0.117 | - |
| 9 | 393716 | 311115 | Fullmoor Wood LWS | 0.030 | 1.0 | 10.0 | 0.785 | 78.5 | 6.115 | 61.15 |
| 10 | 394039 | 310951 | Fullmoor Wood LWS | 0.030 | 1.0 | 10.0 | 0.129 | 12.9 | 1.002 | 10.02 |
| 11 | 392796 | 311614 | Rodbaston College LWS | 0.030 | 1.0 | 10.0 | 0.017 | 1.7 | 0.129 | 1.29 |
| 12 | 393166 | 311830 | Staffs and Worcs Canal, Penkridge LWS | 0.030 | 1.0 | 10.0 | 0.020 | 2.0 | 0.157 | 1.57 |
| 13 | 393585 | 312175 | Otherton Marsh, Penkridge LWS | 0.030 | 1.0 | 10.0 | 0.025 | 2.5 | 0.197 | 1.97 |
| 14 | 394342 | 310992 | Fullmoor Wood AW | 0.030 | 1.0 | 10.0 | 0.056 | 5.6 | 0.436 | 4.36 |
| 15 | 394273 | 311801 | Mansty Wood AW | 0.030 | 1.0 | 10.0 | 0.036 | 3.6 | 0.280 | 2.80 |
| 16 | 394683 | 311549 | Mansty Wood AW | 0.030 | 1.0 | 10.0 | 0.025 | 2.5 | 0.197 | 1.97 |
| 17 | 395096 | 312037 | Mansty Wood AW | 0.030 | 1.0 | 10.0 | 0.012 | 1.2 | 0.090 | 0.90 |
| 18 | 397373 | 308330 | Stowe Pool and Walk Mill Clay Pit SSSI | 0.020 | 3.0 | - | 0.004 | 0.12 | 0.018 | - |
| 19 | 391567 | 308343 | Four Ashes Pit SSSI | 0.020 | - | - | 0.003 | - | 0.015 | - |
| 20 | 387079 | 309894 | Belvide Reservoir SSSI | 0.020 | 3.0 | - | 0.001 | 0.05 | 0.007 | - |
| 21 | 386777 | 308357 | Big Hyde Rough SSSI | 0.030 | 1.0 | 10.0 | 0.001 | 0.11 | 0.008 | 0.08 |
| 22 | 400368 | 312201 | Chasewater and the Southern Staffordshire Coalfield Heaths SSSI | 0.020 | 1.0 | 5.0 | 0.001 | 0.12 | 0.006 | 0.12 |
| 23 | 402018 | 309887 | Chasewater and the Southern Staffordshire Coalfield Heaths SSSI | 0.020 | 1.0 | 5.0 | 0.001 | 0.09 | 0.005 | 0.10 |
| 24 | 402591 | 308576 | Chasewater and the Southern Staffordshire Coalfield Heaths SSSI | 0.020 | 1.0 | 5.0 | 0.001 | 0.09 | 0.004 | 0.09 |
| 25 | 400625 | 316940 | Cannock Chase SSSI | 0.020 | 1.0 | 5.0 | 0.001 | 0.08 | 0.004 | 0.08 |
| 26 | 399022 | 314305 | Cannock Chase SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.13 | 0.007 | 0.13 |
| 27 | 398019 | 315999 | Cannock Chase SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.12 | 0.006 | 0.13 |
| 28 | 397344 | 317849 | Cannock Chase SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.11 | 0.006 | 0.12 |
| 29 | 401359 | 314838 | Cannock Chase SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.08 | 0.004 | 0.08 |
| 30 | 399775 | 317300 | Cannock Chase SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.08 | 0.004 | 0.08 |
| 31 | 402013 | 306889 | Cannock Extension Canal SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.10 | 0.005 | 0.10 |
| 32 | 384241 | 313360 | Mottey Meadows SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.06 | 0.003 | 0.07 |
| 33 | 383897 | 312376 | Mottey Meadows SSSI/SAC | 0.020 | 1.0 | 5.0 | 0.001 | 0.07 | 0.003 | 0.07 |

*Figure 7a. Maximum annual ammonia concentration*

A map of a large area

Description automatically generated with medium confidence

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*Figure 7b. Maximum annual nitrogen deposition rates*

A map of land with different colored areas

Description automatically generated

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# Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Ian Pick of Ian Pick Associates Ltd., on behalf of Abbey Foods Ltd., to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Gailey Farm, Gailey Lea Lane, Gailey in Staffordshire. ST19 5PT.

Ammonia emission rates from the proposed poultry rearing houses 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 modelling predicts that:

* At all the wildlife sites which have been considered, the process contribution to ammonia concentration and nitrogen deposition rate is below the Environment Agency lower threshold percentage of the relevant Critical Level and Critical Load.
* At all of the SSSIs and the SAC sites which have been considered, the process contribution to ammonia concentration and nitrogen deposition rate is below the 1% of the relevant Critical Level and Critical Load.

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