

# A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Turkey Rearing Houses at Deepdale Farm, near Chetwyn Heath, in Shropshire

# AS Modelling & Data Ltd.

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# Introduction

AS Modelling & Data Ltd. has been instructed by Mr Steve Raasch, on behalf of A & C Turkeys Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed turkey rearing houses at Deepdale Farm, Chetwynd Heath, Newport, Shropshire. TF10 8BH.

Ammonia emission rates from the existing and proposed turkey rearing houses have been estimated based upon the Environment Agency’s standard ammonia emission factors and figures obtained from the UK Ammonia Emissions Inventory (UKAEI). 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

Deepdale Farm is in a rural area approximately 900 m to the south of the village of Sambrook, in Shropshire. The surrounding land is used primarily for arable farming although there are some meadows and areas of woodland nearby. The site is at an altitude of around 80 m, with the land falling gently towards the River Meese to the north and east and rising towards slightly higher ground to the south.

There are four turkey rearing houses at Deepdale Farm, which currently accommodate up to 35,000 male turkeys. The turkeys are brought on to the site at around 35 days old, weighing approximately 1.5 kg and are reared for around 100 days, to a weight of approximately 17.5 kg and there are approximately 3 flocks per annum. The houses are ventilated using uncapped high velocity ridge mounted fans.

Under the proposals, the stocking of turkeys at Deepdale Farm would change; 50,000 mixed sex turkeys would be brought on to the farm as day old chicks, a third of the female turkeys would be removed after 60 days, a further third after 77 days, with all remaining females removed after 100 days, at a weight of around 8 kg. The male turkeys would be reared for 135 days with no thinning, to a weight of around 17.5 kg.

There is one Local Wildlife Site (LWS), namely Sambrook Mill Pond LWS, within 2 km of the turkey rearing houses at Deepdale Farm and one Site of Special Scientific Interest (SSSI), namely Newport Canal SSSI, within 5 km. There are a further five SSSIs within 10 km of the farm. Parts of Aqualate Mere, which is the largest of the Midland Meres & Mosses Phase 2 Ramsars and is also designated as a SSSI, are within 5 km of Deepdale Farm; there are no other internationally designated wildlife sites within 10 km of the farm. Some further details of Newport Canal SSSI and the Aqualate Mere SSSI/Midland Meres & Mosses Phase 2 Ramsar site are provided below:

* **Newport Canal SSSI** - Approximately 4.6 km to the south-south-east at its closest point – A 2 km length of disused canal that provides habitat for aquatic plants, a narrow fringe of marginal swamp and some fen. Noted for submerged aquatic flora, floating plant communities and in the margins swamp flora.
* **Aqualate Mere SSSI/Midland Meres & Mosses Phase 2 Ramsar** - Approximately 5.0 km to the south-east at its closest point – a complex of open water, fen, grassland and woodland with an extensive reedswamp community, which is well developed and up to 40 m wide in places. The site has an outstanding assemblage of beetles, moths and sawflies and is an important site for breeding herons and other birds.

A map of the surrounding area showing the positions of the turkey rearing houses, the LWS, the SSSIs and the SSSI/Ramsar site is provided in Figure 1. In this figure, the LWS is shaded in olive, the SSSI is shaded in green, the Ramsar site is shaded blue and the site of the turkey rearing houses is outlined in blue.

*Figure 1. The area surrounding Deepdale Farm, with circle radii at 2.0 km (olive), 5.0 km (green) and 10.0 km (purple)*

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 source of these background figures is the Air Pollution Information System (APIS, October 2022). It should be noted that the APIS background levels are an average over a 5 km grid square (they are also modelled values, they are not measured in any way and no particular farms are included explicitly in the sources attribution data). Ammonia levels vary markedly over relatively short distances and the APIS website itself notes that the background values cannot be considered representative on any particular location within the 5 km grid square. The background ammonia concentration (annual mean) in the area around Deepdale Farm is 2.88 µg-NH3/m3. The background nitrogen deposition rate to woodland is 37.94 kg-N/ha/y and to short vegetation is 21.56 kg-N/ha/y. The background acid deposition rate to woodland is 2.72 keq/ha/y and to short vegetation is 1.53 keq/ha/y.

## 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. Note, the citation for Tyrley Canal Cutting SSSI indicate that the reason for this designation is due to geology; therefore, this site has not been considered further. 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) |
| Sambrook Mill Pond LWS | 1.0 1 | 10.0 1 | - |
| Newport Canal SSSI | 1.0 2 | - | - |
| Loynton Moss SSSI, Hodnet Heath SSSI, Doley Common SSSI and Aqualate Mere SSSI/Midland Meres & Mosses Phase 2 Ramsar | 1.0 2 | 10.0 2 & 3 | - |
| Muxton Marsh SSSI | 3.0 2 | 20.0 2 & 3 | - |

1. A precautionary figure used where no details of the ecology of the site are available.
2. Based upon the citation for the site and information listed on APIS (October 2022).
3. The lower bound of the range of Critical Loads for the site/species, obtained from APIS (October 2022).

## 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% (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 and deposition rates are derived as an average for a 5 km by 5 km grid.

### 3.4.3 Shropshire Council Guidance

In April 2018, Shropshire Council published Interim Guidance Note GN2 (Version 1, April 2018), “Assessing the impact of ammonia and nitrogen on designated sites and Natural Assets from new and expanding livestock units (LSUs)”.

AS Modelling & Data Ltd. are currently assessing this guidance; however, in summary, it appears that the following criteria are applicable:

If the sum of the Process Contribution from the application site and other nearby livestock units is less than 1% of the relevant Critical Level or Critical Load (at a wildlife site) then:

* The application can be determined providing avoidance and mitigation measures can be conditioned. It should be noted that it is extremely unlikely that this condition could ever be achieved.
* If the Process Contribution from the application site and other nearby livestock units is greater than 1% of the relevant Critical Level or Critical Load (at a wildlife site) then;
* If the modelled Process Contribution, including BAT (Best Available Techniques) or other avoidance/mitigation measures leads to either; no additional nitrogen deposition or a reduction in background nitrogen deposition (it is assumed this also means no increase in ammonia concentration, or a reduction in concentration), then the application can be determined providing avoidance and mitigation measures can be conditioned. Furthermore, the guidance states that a) new sites would have to be nitrogen neutral (please note that, without some form of nitrogen offset elsewhere, this is not possible) and b) extensions to existing sites would need to add no extra nitrogen deposition or, ideally, achieve a reduction in the nitrogen background level, by use of Best Available Techniques (BAT) or other mitigation measures.
* If the modelled Process Contribution, including BAT, or other avoidance/mitigation measures is not neutral or do not lead to a reduction in nitrogen deposition (it is assumed this also means ammonia concentration), then if the Predicted Environmental Concentration (sum of process contribution and background levels/loads) leads to an exceedance of the relevant Critical Level or Load at a receptor, then, assessments will be made on a case by case basis.
* In the case of nationally, or internationally designated wildlife sites: If the Predicted Environmental Concentration can be reduced to avoid the exceedance, or it can be demonstrated that there would be no adverse effect on an international site, or no damage to the scientific interest of a national site, then the application can be potentially approved with conditioned control measures; otherwise, the application will be potentially refused when all avenues to reduce the contributions are exhausted and it cannot be shown that damage to the sensitive receptors will not occur.
* In the case of a locally designated site, if control measures are available that can reduce the Predicted Environmental Concentration to avoid exceedance of the ammonia Critical Level or nitrogen Critical Load or it can be demonstrated that there would be no adverse effects then: the application can be potentially approved with conditioned control measures; otherwise, a balanced planning decision will be taken based on the information provided, other material considerations and planning policy.

### 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

Ammonia emission rates from livestock housing depend on many factors and may be rather 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 annual statistics it is not usually 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 provided an Intensive farming guidance note which lists standard ammonia emission factors for a variety of livestock, including turkeys. However, it is understood that the Environment agency’s figures for male and female turkeys assume that they are reared from day old chicks until they are fully grown and at Deepdale Farm this would not be the case. Therefore, AS Modelling and Data Ltd. has calculated emission factors specifically for the turkeys reared, or proposed, at Deepdale Farm. The UKAEI has been used, which defines a figure of 64 g-N/livestock-unit/day (a livestock-unit is 500 kg) for turkeys, which equates to an emission factor of 0.05677 g-NH3/kg-live-weight/y.

Currently, male turkeys arrive at the farm at around 36 days old at a weight of approximately 1.5 kg and are reared to around 135 days old when they may weigh up to 17.5 kg. Assuming industry standard growth rates, the average weight of the turkeys (assuming numbers as initially stocked) is 8.507 kg. Assuming the housing is empty and clean for approximately fourteen days between crops, the figure obtained for the site specific emission factor for the existing flock of male turkeys is 0.423632 kg-NH3/bird-place/y.

Under the proposals, male and female turkeys would arrive on the farm as day old chicks. The female turkeys would be thinned by a third on or around day 60 and a further third on or around day 77, before finishing on or around day 100, at a weight of around 8 kg. The male turkeys would be reared from day old chicks for 135 days, to a finishing weight of around 17.5 kg. Again, assuming industry standard growth rates, the average weight of the turkeys (assuming numbers as initially stocked) is 3.602 kg and, also assuming that the housing is empty and clean for fourteen days between crops, the figure obtained for the site specific emission factor for the proposed male and female turkeys is 0.225694 kg-NH3/bird-place/y.

For comparison, the Environment Agency figures are 0.45 kg-NH3/place/y for male turkeys and 0.23 kg-NH3/place/y for female turkeys; it is understood that the Environment Agency figures are also derived using the figure of 64 g-N/livestock-unit/day from the UKAEI. Details of the turkey numbers and weights, emission factors used and calculated ammonia emission rates are provided in Table 2.

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source | Animal numbers | Type or weight | Emission factor  (kg-NH3/place/y) | Emission rate  (g-NH3/s) |
| Existing housing | 35,000 | Male turkeys ~ 1.5 kg to ~17.5 kg | 0.423632 | 0.469843 |
| Proposed housing | 50,000 | Males to ~ 17.5 kg and Females to ~ 8 kg | 0.225694 | 0.357591 |

# 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.

Prior to April 2019 the GFS1 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 GFS1 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 Deepdale Farm 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 52.808 N, -2.424 W, 2018-2021*

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*Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 371400, 323550, 2018-2021*

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## 4.2 Emission sources

Emissions from the uncapped chimneys of the ridge mounted fans that are/would be used to ventilate the turkey houses are represented by three point sources per house within ADMS (PH1 1, 2 & 3 to PH4 1, 2 & 3). It is expected that the ventilation rate would always be such that fugitive emissions from elsewhere on the houses, inlet vents for example, would be minimal.

Details of the point source parameters are shown in Table 3. The positions of the sources may be seen in Figure 3.

*Table 3. Point source parameters*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source ID | Height  (m) | Diameter (m) | Efflux velocity (m/s) | Emission temperature (°C) | Emission rate per source  (g-NH3/s) |
| PH1 to PH4 1, 2 & 3 | 5.4 | 0.8 | 11 | 18.0 | 0.029799 1 |

1. Based on 50,000 mixed turkeys. The results of the modelling have been scaled by a factor of 1.314 to derive the impacts from the existing turkey flock.

*Figure 3. The positions of the modelled sources*

Diagram

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## 4.3 Modelled buildings

The structure of the proposed turkey houses and other nearby farm buildings may affect the plumes from the point sources. Therefore, 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

Eighteen discrete receptors have been defined: three at the LWS (1 to 3); nine at the SSSIs (4 to 12) and six at the Ramsar site (13 to 18). 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 grid receptors are defined at ground level within ADMS. The position of the nested Cartesian grid receptors may be seen in Figure 4 (marked by grey gridlines).

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

*Map

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## 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. The resolution of FLOWSTAR is 64 by 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 25 m land use database, with permission1. The GFS meteorological data is assumed to have a roughness length of 0.25 m (the average over the modelling domain). 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 5. The spatially varying surface roughness field (central area)*

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.

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, with the 4.0 km by 4.0 km deposition field is bounded by a purple rectangle.

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.

*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 thirty-two times, once for each year of the meteorological record, for the existing and proposed turkey rearing houses 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.
* 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 for preliminary modelling runs are provided in Table 5. 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 (20% for a Ramsar 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 (4% and 20% for a Ramsar site, 20% and 50% for a SSSI and 100% and 100% for a non-statutory site) are coloured blue. For convenience, cells referring to the LWSs are shaded olive, cells referring to the SSSIs are shaded green and cells referring to the Ramsar site are shaded blue.

*Table 5. Predicted maximum annual mean ammonia concentration - preliminary modelling – existing and proposed turkey rearing houses*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Receptor number | X(m) | Y(m) | Site | Maximum annual mean ammonia concentration (µg/m3) | | | | | | | |
| Existing 35,000 male turkeys | | | | Proposed 50,000 female/male turkeys | | | |
| GFS No Calms No terrain | GFS Calms No Terrain | GFS No Calms  Terrain | GFS No Calms  Terrain Fixed deposition velocity of 0.003 m/s | GFS No Calms No terrain | GFS Calms No Terrain | GFS No Calms  Terrain | GFS No Calms  Terrain Fixed deposition velocity of 0.003 m/s |
| 1 | 371311 | 324971 | Sambrook Mill Pond LWS | 0.191 | 0.189 | 0.205 | 0.175 | 0.145 | 0.143 | 0.156 | 0.133 |
| 2 | 371294 | 325249 | Sambrook Mill Pond LWS | 0.147 | 0.145 | 0.156 | 0.131 | 0.112 | 0.110 | 0.119 | 0.100 |
| 3 | 371210 | 325494 | Sambrook Mill Pond LWS | 0.119 | 0.117 | 0.123 | 0.102 | 0.090 | 0.089 | 0.094 | 0.078 |
| 4 | 373409 | 319218 | Newport Canal SSSI | 0.054 | 0.054 | 0.057 | 0.035 | 0.041 | 0.041 | 0.044 | 0.027 |
| 5 | 373830 | 319429 | Newport Canal SSSI | 0.058 | 0.057 | 0.059 | 0.036 | 0.044 | 0.043 | 0.045 | 0.028 |
| 6 | 374227 | 319364 | Newport Canal SSSI | 0.053 | 0.052 | 0.054 | 0.032 | 0.040 | 0.040 | 0.041 | 0.024 |
| 7 | 375078 | 319955 | Newport Canal SSSI | 0.042 | 0.041 | 0.041 | 0.023 | 0.032 | 0.032 | 0.032 | 0.017 |
| 8 | 378575 | 324441 | Loynton Moss SSSI | 0.023 | 0.023 | 0.025 | 0.014 | 0.017 | 0.018 | 0.019 | 0.010 |
| 9 | 369894 | 330289 | Tyrley Canal Cutting SSSI | 0.020 | 0.020 | 0.018 | 0.011 | 0.015 | 0.015 | 0.014 | 0.008 |
| 10 | 362348 | 326011 | Hodnet Heath SSSI | 0.011 | 0.012 | 0.014 | 0.007 | 0.009 | 0.009 | 0.010 | 0.005 |
| 11 | 381349 | 321923 | Doley Common SSSI | 0.015 | 0.015 | 0.016 | 0.007 | 0.011 | 0.011 | 0.012 | 0.006 |
| 12 | 371583 | 313691 | Muxton Marsh SSSI | 0.010 | 0.011 | 0.012 | 0.006 | 0.008 | 0.008 | 0.009 | 0.004 |
| 13 | 375702 | 320985 | Aqualate Mere Ramsar | 0.036 | 0.036 | 0.038 | 0.021 | 0.028 | 0.027 | 0.029 | 0.016 |
| 14 | 376091 | 320158 | Aqualate Mere Ramsar | 0.032 | 0.031 | 0.033 | 0.017 | 0.024 | 0.024 | 0.025 | 0.013 |
| 15 | 376805 | 320969 | Aqualate Mere Ramsar | 0.028 | 0.028 | 0.032 | 0.017 | 0.022 | 0.022 | 0.024 | 0.013 |
| 16 | 377145 | 319882 | Aqualate Mere Ramsar | 0.025 | 0.025 | 0.027 | 0.014 | 0.019 | 0.019 | 0.021 | 0.010 |
| 17 | 377720 | 320709 | Aqualate Mere Ramsar | 0.024 | 0.024 | 0.027 | 0.014 | 0.018 | 0.018 | 0.021 | 0.010 |
| 18 | 378806 | 320182 | Aqualate Mere Ramsar | 0.019 | 0.019 | 0.022 | 0.011 | 0.015 | 0.015 | 0.017 | 0.008 |

## 5.2 Detailed deposition modelling

In this case, detailed modelling has been carried out over a high resolution (100 m) domain that extends 4.0 km by 4.0 km and covers the turkey rearing houses at Deepdale Farm, Sambrook Mill Pond LWS and the countryside around the farm. The primary purpose is to determine the magnitude of deposition of ammonia and consequent plume depletion close to the sources where it is of the greatest importance. Outside of the 4.0 km x 4.0 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 predicted process contribution to maximum annual mean ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 6 for the existing and proposed turkey rearing houses. In the Table, predicted ammonia concentrations or nitrogen deposition rates as a percentage of the Critical Level or Critical Load that are in excess of the Environment Agency’s upper threshold for the site (20% for a Ramsar site, 50% for a SSSI and 100% for a non-statutory site) are coloured red. Percentages that are in the range between the Environment Agency’s upper threshold and lower threshold of the Critical Level or Critical Load for the site (4% and 20% for a Ramsar site, 20% and 50% for a SSSI and 100% and 100% for a non-statutory site) are coloured blue. For convenience, cells referring to the LWS are shaded olive, cells referring to the SSSIs are shaded green and cells referring to the Ramsar site are shaded blue.

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 for the existing turkey rearing houses and in Figures 8a and 8b for the proposed turkey rearing houses.

*Table 6. Predicted process contribution to maximum annual mean ammonia and nitrogen deposition at the discrete receptors*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Receptor number | X(m) | Y(m) | Site | Site parameters | | | Maximum annual mean ammonia concentration at ground level | | | | Maximum annual deposition rate | | | |
| Existing 35,000 male turkeys | | Proposed 50,000 female/male turkeys | | Existing 35,000 male turkeys | | Proposed 50,000 female/male turkeys | |
| Critical Level (µg/m³) | Critical Load (kg/ha) | Deposition velocity (m/s) | Process Contribution (µg/m3) | %age of Critical Level | Process Contribution (µg/m3) | %age of Critical Level | Process Contribution (kg/ha) | %age of Critical Load | Process Contribution (kg/ha) | %age of Critical Load |
| 1 | 371311 | 324971 | Sambrook Mill Pond LWS | 1.0 | 10.0 | 0.03 | 0.129 | 12.9 | 0.098 | 9.8 | 1.002 | 10.0 | 0.763 | 7.6 |
| 2 | 371294 | 325249 | Sambrook Mill Pond LWS | 1.0 | 10.0 | 0.03 | 0.095 | 9.5 | 0.072 | 7.2 | 0.736 | 7.4 | 0.560 | 5.6 |
| 3 | 371210 | 325494 | Sambrook Mill Pond LWS | 1.0 | 10.0 | 0.03 | 0.079 | 7.9 | 0.060 | 6.0 | 0.616 | 6.2 | 0.469 | 4.7 |
| 4 | 373409 | 319218 | Newport Canal SSSI | 1.0 | - | 0.02 | 0.029 | 2.9 | 0.022 | 2.2 | 0.151 | - | 0.115 | - |
| 5 | 373830 | 319429 | Newport Canal SSSI | 1.0 | - | 0.02 | 0.030 | 3.0 | 0.023 | 2.3 | 0.158 | - | 0.120 | - |
| 6 | 374227 | 319364 | Newport Canal SSSI | 1.0 | - | 0.02 | 0.027 | 2.7 | 0.020 | 2.0 | 0.140 | - | 0.106 | - |
| 7 | 375078 | 319955 | Newport Canal SSSI | 1.0 | - | 0.02 | 0.020 | 2.0 | 0.015 | 1.5 | 0.102 | - | 0.077 | - |
| 8 | 378575 | 324441 | Loynton Moss SSSI | 1.0 | 10.0 | 0.03 | 0.012 | 1.2 | 0.009 | 0.9 | 0.094 | 0.9 | 0.071 | 0.7 |
| 9 | 369894 | 330289 | Tyrley Canal Cutting SSSI | - | - | - | 0.009 | - | 0.007 | - | - | - | - | - |
| 10 | 362348 | 326011 | Hodnet Heath SSSI | 1.0 | 10.0 | 0.02 | 0.006 | 0.6 | 0.004 | 0.4 | 0.030 | 0.3 | 0.023 | 0.2 |
| 11 | 381349 | 321923 | Doley Common SSSI | 1.0 | 10.0 | 0.02 | 0.007 | 0.7 | 0.005 | 0.5 | 0.034 | 0.3 | 0.026 | 0.3 |
| 12 | 371583 | 313691 | Muxton Marsh SSSI | 3.0 | 20.0 | 0.02 | 0.005 | 0.2 | 0.003 | 0.1 | 0.024 | 0.1 | 0.018 | 0.1 |
| 13 | 375702 | 320985 | Aqualate Mere Ramsar | 1.0 | 10.0 | 0.03 | 0.019 | 1.9 | 0.014 | 1.4 | 0.146 | 1.5 | 0.111 | 1.1 |
| 14 | 376091 | 320158 | Aqualate Mere Ramsar | 1.0 | 10.0 | 0.03 | 0.015 | 1.5 | 0.012 | 1.2 | 0.120 | 1.2 | 0.091 | 0.9 |
| 15 | 376805 | 320969 | Aqualate Mere Ramsar | 1.0 | 10.0 | 0.03 | 0.015 | 1.5 | 0.011 | 1.1 | 0.115 | 1.2 | 0.088 | 0.9 |
| 16 | 377145 | 319882 | Aqualate Mere Ramsar | 1.0 | 10.0 | 0.03 | 0.012 | 1.2 | 0.009 | 0.9 | 0.095 | 0.9 | 0.072 | 0.7 |
| 17 | 377720 | 320709 | Aqualate Mere Ramsar | 1.0 | 10.0 | 0.03 | 0.012 | 1.2 | 0.009 | 0.9 | 0.094 | 0.9 | 0.071 | 0.7 |
| 18 | 378806 | 320182 | Aqualate Mere Ramsar | 1.0 | 10.0 | 0.03 | 0.009 | 0.9 | 0.007 | 0.7 | 0.073 | 0.7 | 0.056 | 0.6 |

*Figure 7a. Predicted process contribution to maximum annual mean ammonia concentration – existing turkey rearing houses*

A picture containing chart

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*Figure 7b. Predicted process contribution to maximum annual nitrogen deposition rates - existing turkey rearing houses*

Map

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*Figure 8a. Predicted process contribution to maximum annual mean ammonia concentration – proposed turkey rearing houses*

Chart

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*Figure 8b. Predicted process contribution to maximum annual nitrogen deposition rates - proposed turkey rearing houses*

Map

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# Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr Steve Raasch, on behalf of A & C Turkeys Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed turkey rearing houses at Deepdale Farm, Chetwynd Heath, Newport, Shropshire. TF10 8BH.

Ammonia emission rates from the existing and proposed turkey rearing houses have been estimated based upon the Environment Agency’s standard ammonia emission factors and figures obtained from the UK Ammonia Emissions Inventory. 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 wildlife site considered, the process contributions to annual ammonia concentration and nitrogen deposition rate are and would be below the Environment Agency lower threshold percentage of Critical level and Critical load (4% for a Ramsar site, 20% for a SSSI and 100% for an AW/LWS).
* Should the proposed changes to the rearing of turkeys at Deepdale Farm proceed, there would be a reduction in process contributions to ammonia concentrations and nitrogen deposition rates at all of the local wildlife sites considered.

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