A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Broiler Chicken Rearing Houses at Cefnau Bach, near Llangadfan, Welshpool in Powys

Prepared by Sally Howse

AS Modelling & Data Ltd.

Email: sally@asmodata.co.uk

Telephone: 01952 462500

27th July 2017

1. Introduction

AS Modelling & Data Ltd. has been instructed by John Ward, on behalf of the applicant Mills Poultry Ltd. to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Cefnau Bach, near Llangadfan, Welshpool, in Powys.

Ammonia emission rates from the proposed poultry 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 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.

2. Background Details

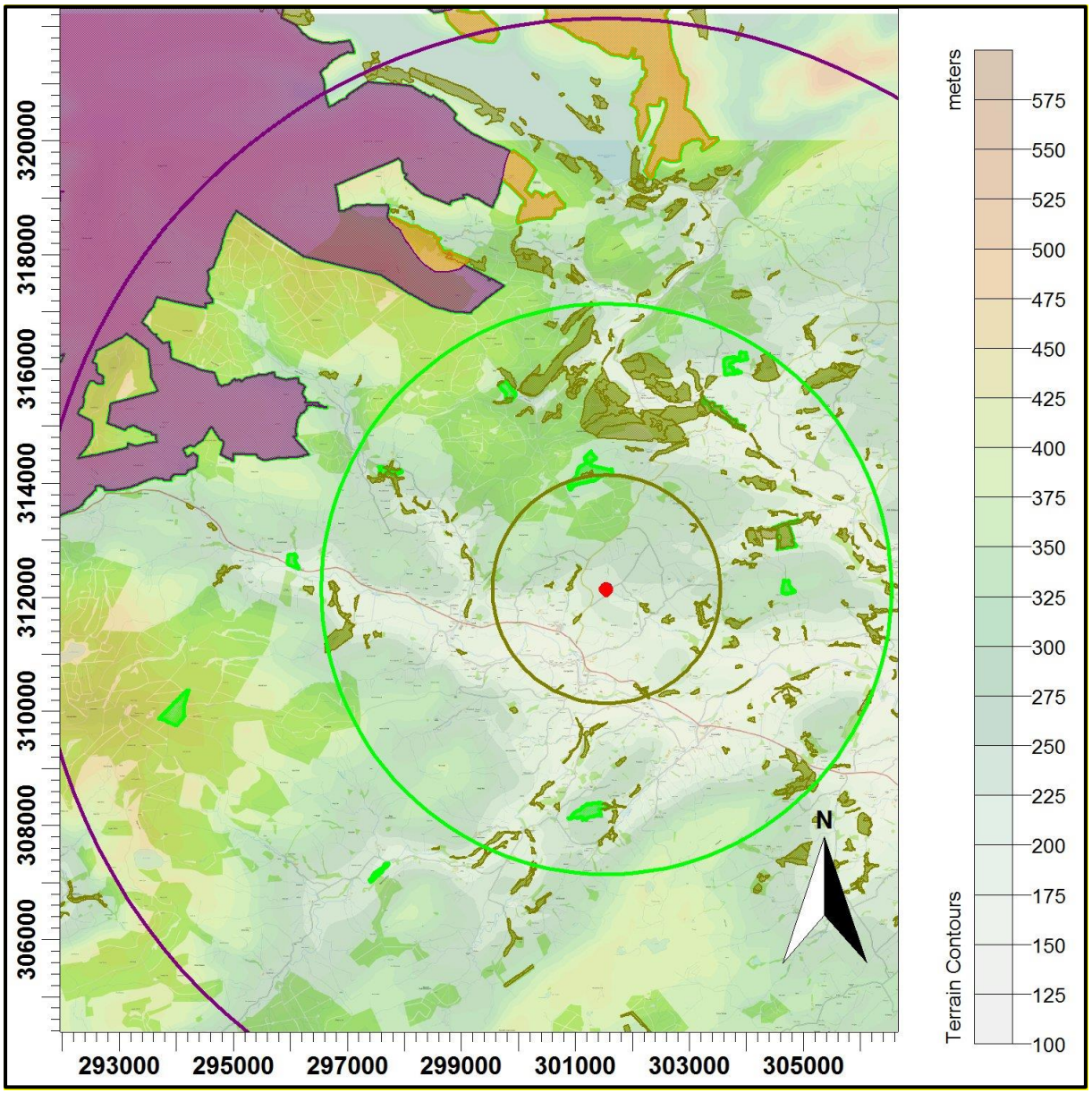
It is proposed that a new broiler chicken rearing unit be constructed on a green field site at Cefnau Bach, a rural area north of the village of Llangadfan, near Welshpool in Powys. The surrounding land is largely agricultural, although there are some wooded areas nearby. The site is located in a hilly area as the land rises above the Afon Banwy valley, at an elevation of around 230 m.

The proposal involves the construction of four poultry houses which would be used to rear up to 250,000 broiler chickens. These poultry houses would be ventilated using uncapped high velocity ridge or roof fans with side inlets.

There are a number of areas designated as Ancient Woodlands (AWs), or Local Wildlife Sites (LWSs), within 2 km of the proposed new poultry unit and several Sites of Special Scientific Interest (SSSIs) within 5 km. Additionally, Berwyn And South Clwyd Mountains, designated as a Special Area of Conservation (SAC), Specially Protected Area (SPA), and Site of Special Scientific Interest (SSSI) in part, is within 10 km of the site.

A map of the surrounding area showing the positions of the poultry unit, the AWs/LWSs, the SSSIs, the SPA and the SAC is provided in Figure 1. In this figure, the AWs/LWSs are shaded in olive, the SSSI is shaded in green, the SAC is shaded in purple, the SPA is shaded orange, and the site of the proposed new poultry unit at Cefnau Bach is indicated by a red dot.

Figure 1. The area surrounding Cefnau Bach – concentric circles radii 2 km (olive), 5 km (green) and 10 km (purple)



3. 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-NH_3/m^3) 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).

3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around Cefnau Bach and the wildlife sites is 1.10 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 30.94 kg-N/ha/y and to short vegetation is 21.70 kg-N/ha/y. The background acid deposition rate to woodland is 2.48 keq/ha/y and to short vegetation is 1.79 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS).

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-NH_3/m^3 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-NH_3/m^3 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-NH_3/m^3 is assumed, it is usually unnecessary to consider the Critical Load as the Critical Level provides the stricter test, especially for woodlands. However, where a Critical Load of 5.0 kg-N/ha/yr is appropriate, it may be necessary to consider the Critical Load for nitrogen deposition. 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-NH_3/m^3)	Critical Load - Nitrogen Deposition (kg-N/ha/y)
AWs and LWSs	1.0 [1]	-
Cors Llyn Coethlyn SSSI	1.0 [1]	5.0 [2]
Cors Lawnt SSSI	1.0 [1]	5.0 [2]
Coed Y Lawnt A Coed Oli SSSI	1.0 [1]	5.0 [2]
Coed Copi'r Graig SSSI	1.0 [1]	5.0 [2]
Fachwen Isaf SSSI	1.0 [1]	5.0 [2]
Gweunydd Dyfnant SSSI	1.0 [1]	5.0 [2]
Gweunydd Pen-Y-Coed SSSI	1.0 [1]	8.0 [2]
Bryn Coch SSSI	1.0 [1]	5.0 [2]
Berwyn and South Clwyd Mountains (SAC) / Berwyn (SPA/SSSI)	1.0 [1]	5.0 [2]

1. A precautionary figure, used where details of the site are unavailable, or citations indicate that sensitive lichens and bryophytes may be present.
2. The lower bound of the range of Critical Loads for the site, obtained from APIS.

3.4 Guidance on the significance of ammonia emissions

In March 2017, Natural Resources Wales (Regulation and Permitting Department, EPP) published Operational Guidance Note 41 (OGN 41), "Assessment of ammonia and nitrogen impacts from livestock units when applying for an Environmental Permit or Planning Permission". This guidance was intended to update the way Natural Resources Wales (NRW) assessed emissions, in particular by changing the thresholds of insignificance and the upper threshold process contributions for designated sites. These designated sites include European sites, such as Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar sites as well as Sites of Special Scientific Interest (SSSIs).

Table 1 in OGN 41 describes the revised screening distance and thresholds for livestock developments; the threshold of insignificant percentage of the designated site Critical Level or Load is given as 1%; the upper threshold percentage of the designated site Critical Level or Load is given as 8%.

Table 2 in OGN 41 describes the possible outcomes of assessment and for detailed modelling of the application alone, where process contributions, considered in isolation, are up to 1% of the designated site Critical Level or Load, then it should be determined that there is no significant environmental effect/no likely significant effect/damage to scientific interest.

Where process contributions, considered in isolation, are between 1% and 8% of the designated site Critical Level or Load, an in-combination assessment is required. Should the in-combination process contributions be between 1% and 8% of the designated site Critical Level or Load then it should be determined that the application would cause no significant environmental effect/likely significant effect/damage to scientific interest.

When considering process contributions, in isolation or in-combination, if they exceed 8% of the designated site Critical Level or Load it is necessary to consider background concentrations and whether the designated site Critical Level or Load is breached and whether additional controls may be necessary. The application will then be determined based on whether there will be significant environmental effect/adverse effect/damage to scientific interest.

Please note that as far as AS Modelling & Data Ltd. is aware, currently, there is no publicly available ledger or database of sites with extant planning permission, or other proposed sites in planning, that would provide sufficient information to make an in-combination modelling assessment. Therefore, if Natural Resources Wales, or the Local Authority concerned do not consider the details of the modelling of ammonia emissions from this site provided by this study as sufficient information to fulfil the requirements of their appropriate assessment, then in most cases, it would not be possible for AS Modelling & Data Ltd. to provide this information.

For Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and Ancient Woodlands (AWs), the current assessment procedure usually applied is based on the Environment Agency's horizontal guidance, H1 Environmental Risks Assessment, H1 Annex B - Intensive Farming. The following are taken from this document.

"An emission is insignificant where Process Contribution (PC) is <50% for local and national nature reserves (LNRs & NNRs), ancient woodland and local wildlife sites." And "Where modelling predicts a process contribution >100% at a NNR, LNR, ancient woodland or local wildlife site, your proposal may not be considered acceptable. In such cases, your assessment should include proposals to reduce ammonia emissions."

This document was withdrawn February 1st 2016 and replaced with a web-page titled "Intensive farming risk assessment for your environmental permit", which contains essentially the same criteria. It is assumed that the upper threshold and lower threshold on the web-page refers to the levels that were previously referred to as levels of insignificance and acceptability in Annex B– Intensive Farming.

Within the range between the lower and upper thresholds, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. N.B. 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%).

3.5 IAQM Position Statement on the use of the 1% criterion

A Position Statement issued by the Institute of Air Quality Management (IAQM) in January 2016 further clarifies the use of the 1% criterion for the determination of an '*insignificant*' effect of air quality impacts on sensitive habitats. The Position Statement states: "*the use of a criterion of 1% of an environmental standard or assessment level in the context of habitats should be used only to screen out impacts that will have an insignificant effect. It should not be used as a threshold above which damage is implied.*" Furthermore, if the impacts are plainly above 1% then this should be regarded as potentially significant; where impacts are just slightly greater than 1% then a degree of professional judgement should be applied with regards to the theoretical risk.

3.6 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 provided an Intensive farming guidance note which lists standard ammonia emission factors for a variety of livestock, including broiler chickens. The emission factor for broiler chickens is 0.034 kg-NH_3/bird place/y; this figure is used as the basis to calculate the emissions from the existing and proposed poultry houses.

Details of the poultry numbers and types, 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-NH_3/place/y)	Emission rate (g-NH_3/s)
Cefnau Bach Housing	250,000	Broiler Chickens	0.034	0.269349

4. 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 including: dry and wet deposition; NO_x 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). Data from the meteorological recording stations at Lake Vrynwy, Shobdon, Shawbury and Trawscoed has also been used.

The GFS is a spectral model and data are archived at a horizontal resolution of 0.25 degrees, which is approximately 25 km over the UK (formerly 0.5 degrees, or approximately 50 km). 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 (FLOWSTAR). 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.

The closest meteorological recording station that records all the parameters required for atmospheric dispersion modelling is at Lake Vrynwy, approximately 8 km to the north of Cefnau Bach. Data from the meteorological recording stations at Shobdon, Shawbury and Trawscoed has also been considered; these stations are all approximately equidistant from Cefnau Bach. However, neither Lake Vyrnwy, Shobdon, Shawbury, nor Trawscoed has an aspect that in any way could be considered similar to Cefnau Bach; therefore, it should be noted that the frequency of winds from a particular direction in the Lake Vyrnwy, Shobdon, Shawbury, or Trawscoed data may be either high or low in comparison to what might occur at Cefnau Bach, which means mean concentrations downwind may be either over or under predicted. Additionally, periods of light winds and calms cannot be properly modelled. Therefore, it is the opinion of AS Modelling & Data Ltd. that the results obtained using the GFS data, particularly when modified by using FLOWSTAR, should be given considerably more weight when interpreting the results of the modelling than should the results obtained using Lake Vyrnwy, Shobdon, Shawbury, or Trawscoed meteorological data, the use of which are rather more likely to produce gross errors.

The wind rose for the raw GFS data at the site of Cefnau Bach is shown in Figure 2a.

The raw GFS wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling wind speeds and directions will be further modified. The terrain and roughness length modified wind rose for the site of Cefnau Bach is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ more markedly and that the resolution of the wind field in terrain runs is approximately 600 m.

The wind roses for Lake Vyrnwy, Shobdon, Shawbury and Trawscoed are shown in Figures 2c, 2d, 2e, and 2f respectively.

Figure 2a. The wind rose. Raw GFS derived data, for 52.697 N, 3.459 W, 2012 – 2015

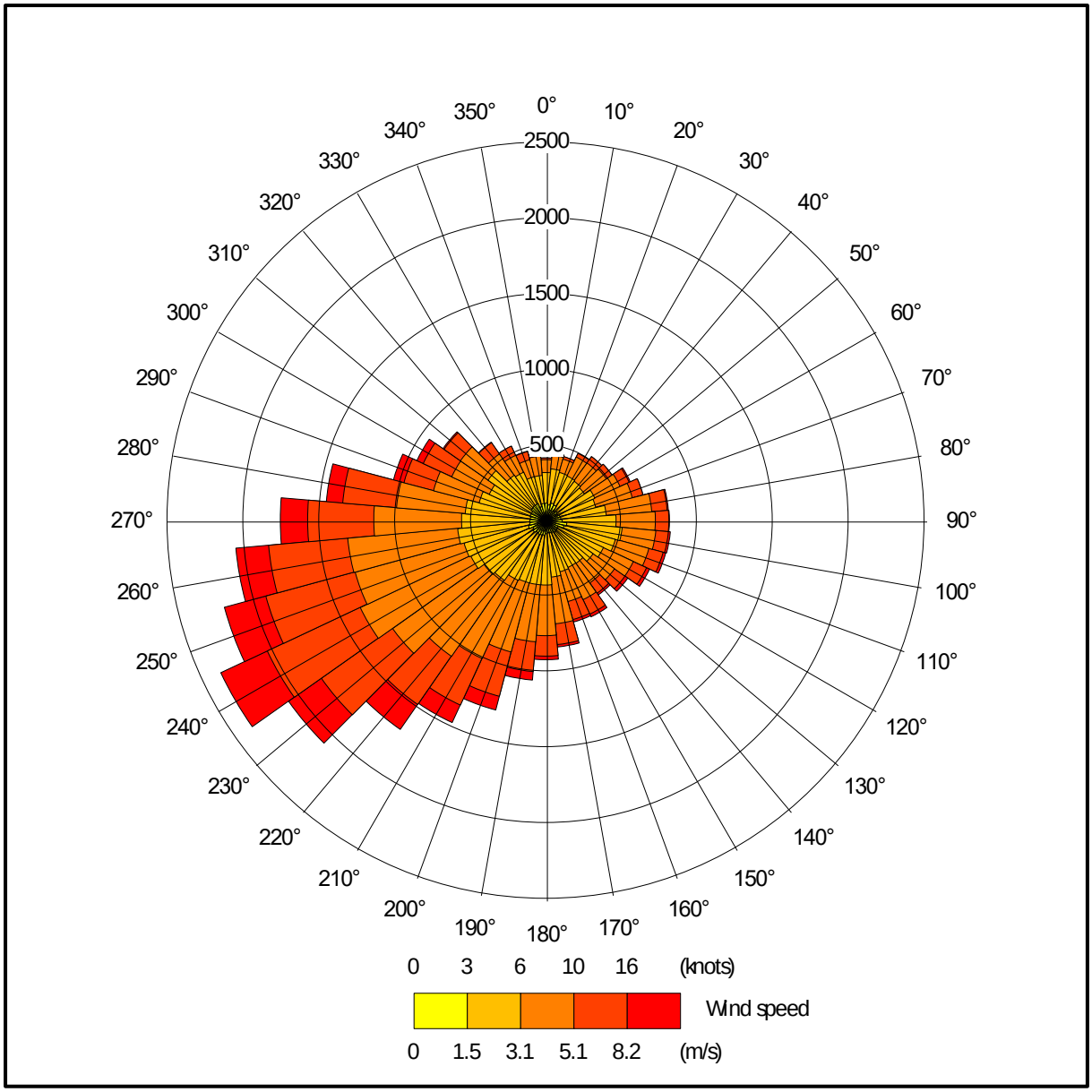


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for 52.697 N, 3.459 W, 2012 – 2015

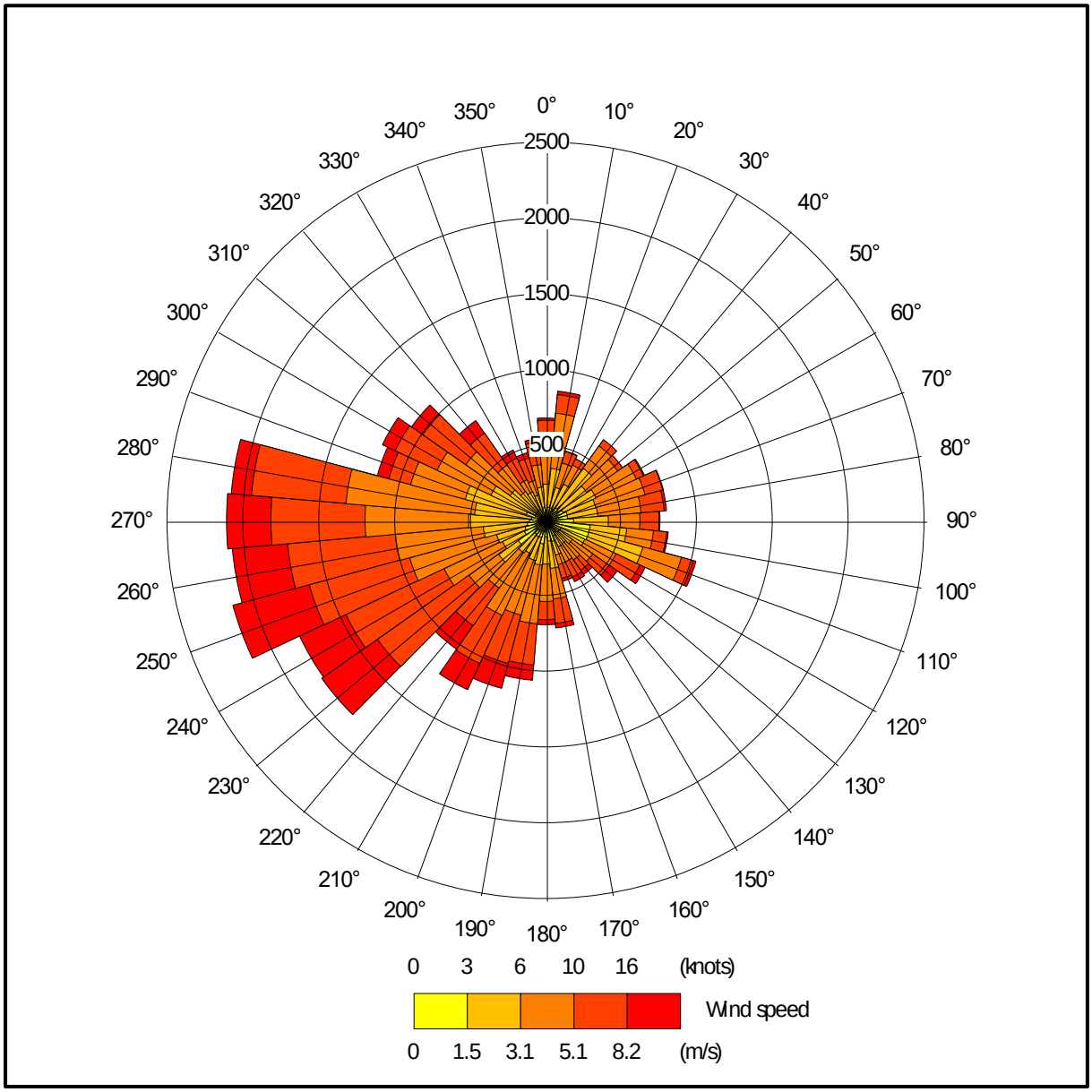


Figure 2c. Recorded meteorological data at Lake Vyrnwy, 2012-2015

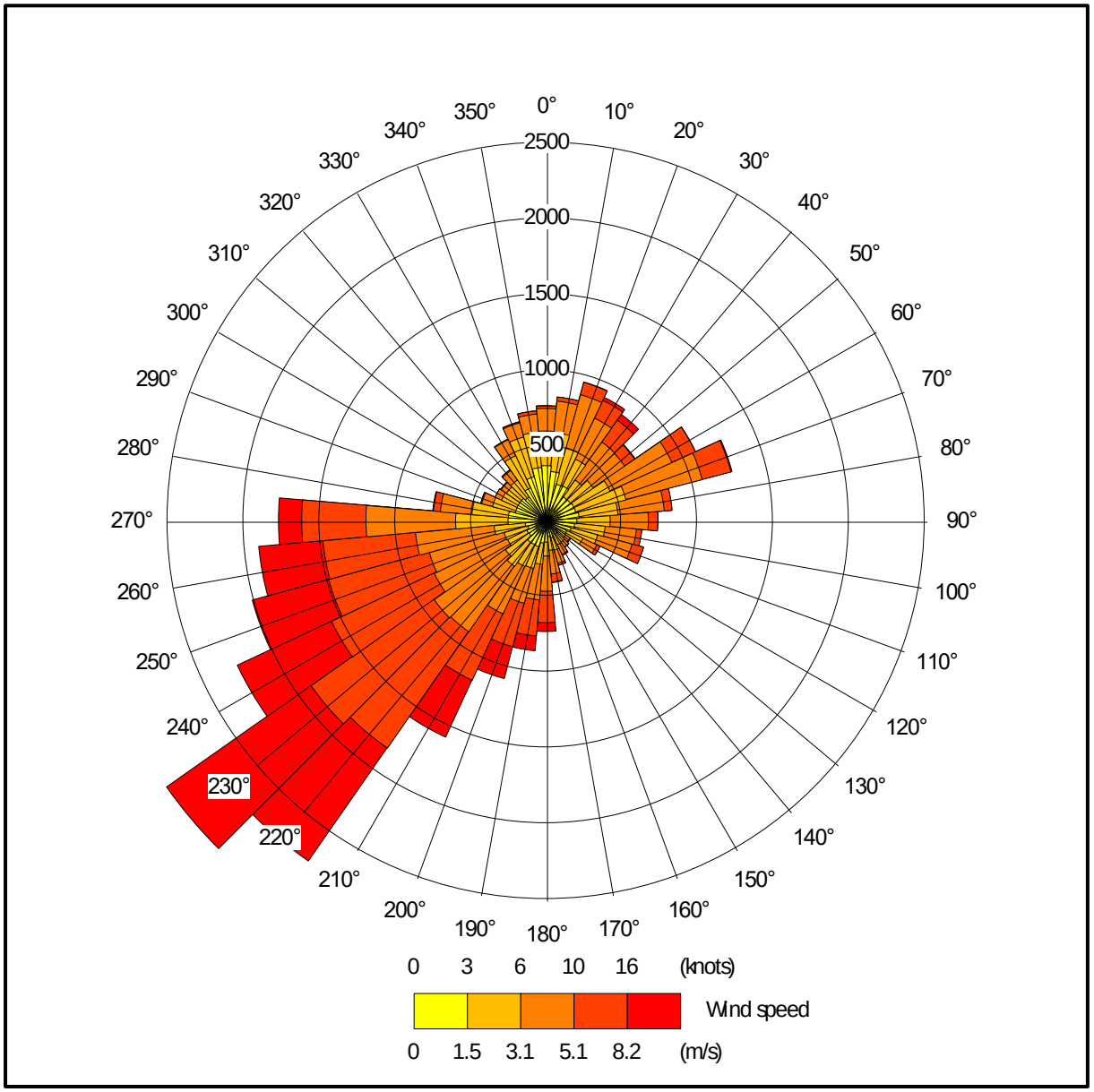


Figure 2d. Recorded meteorological data at Shobdon, 2012-2015

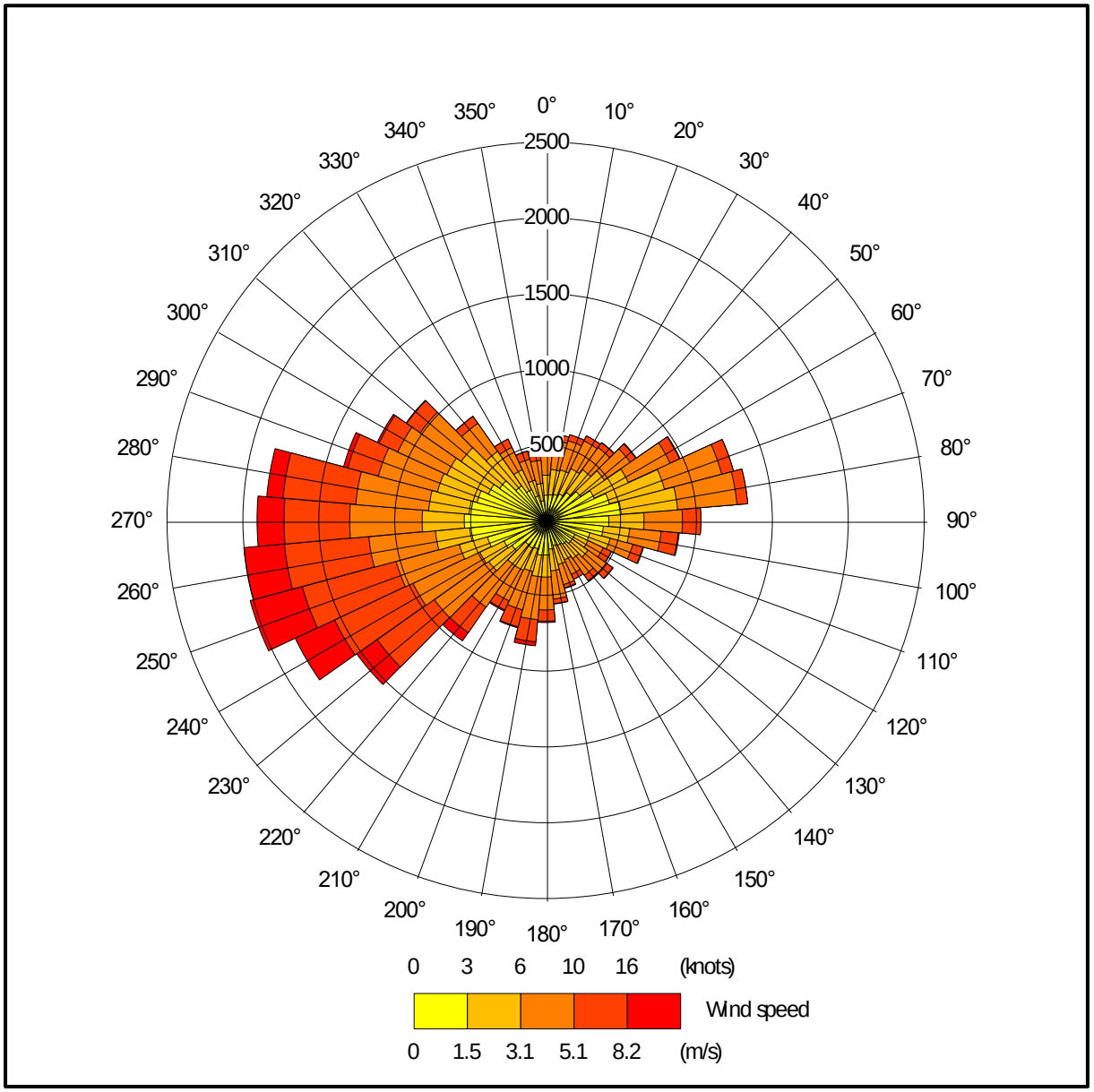


Figure 2e. Recorded meteorological data at Shawbury, 2012-2015

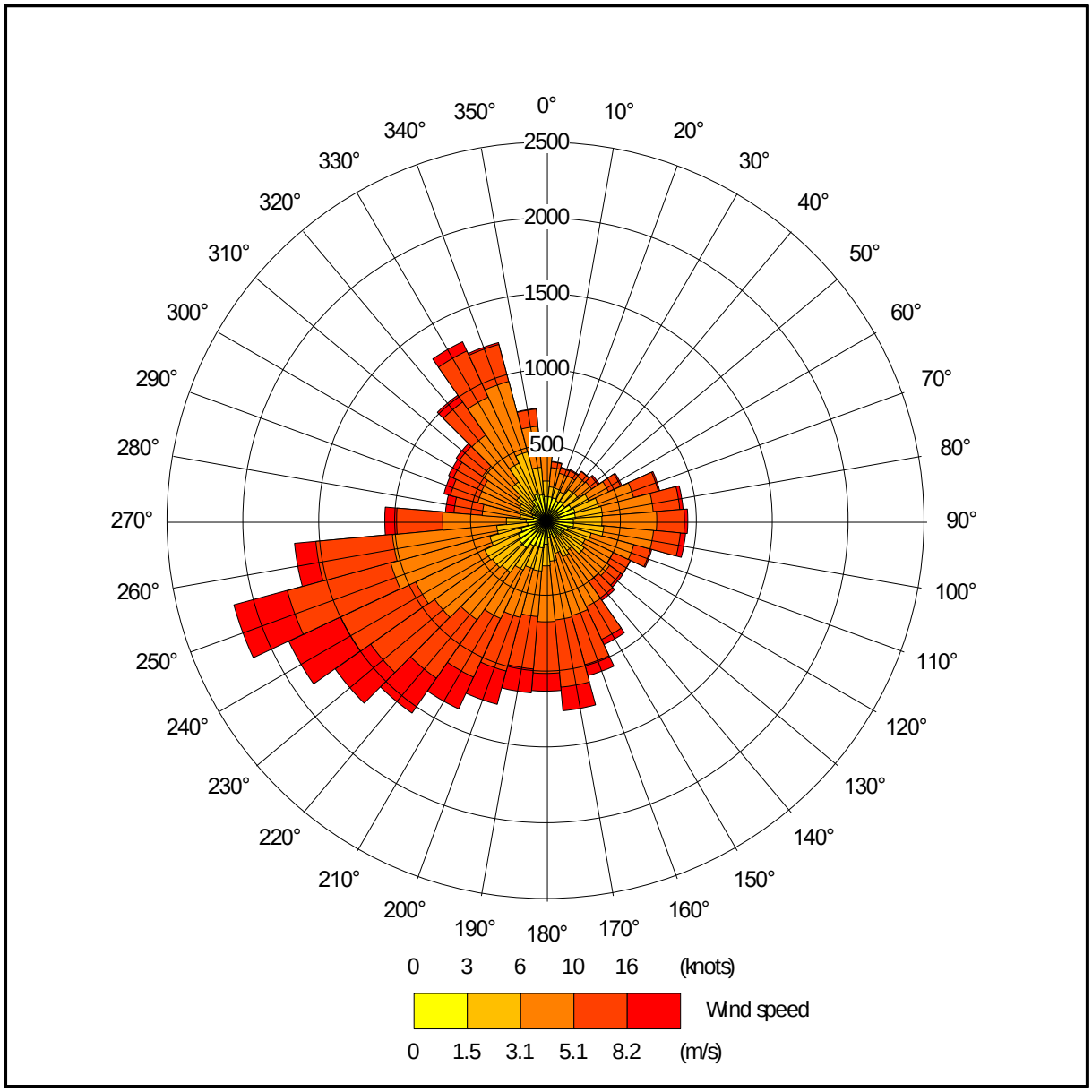
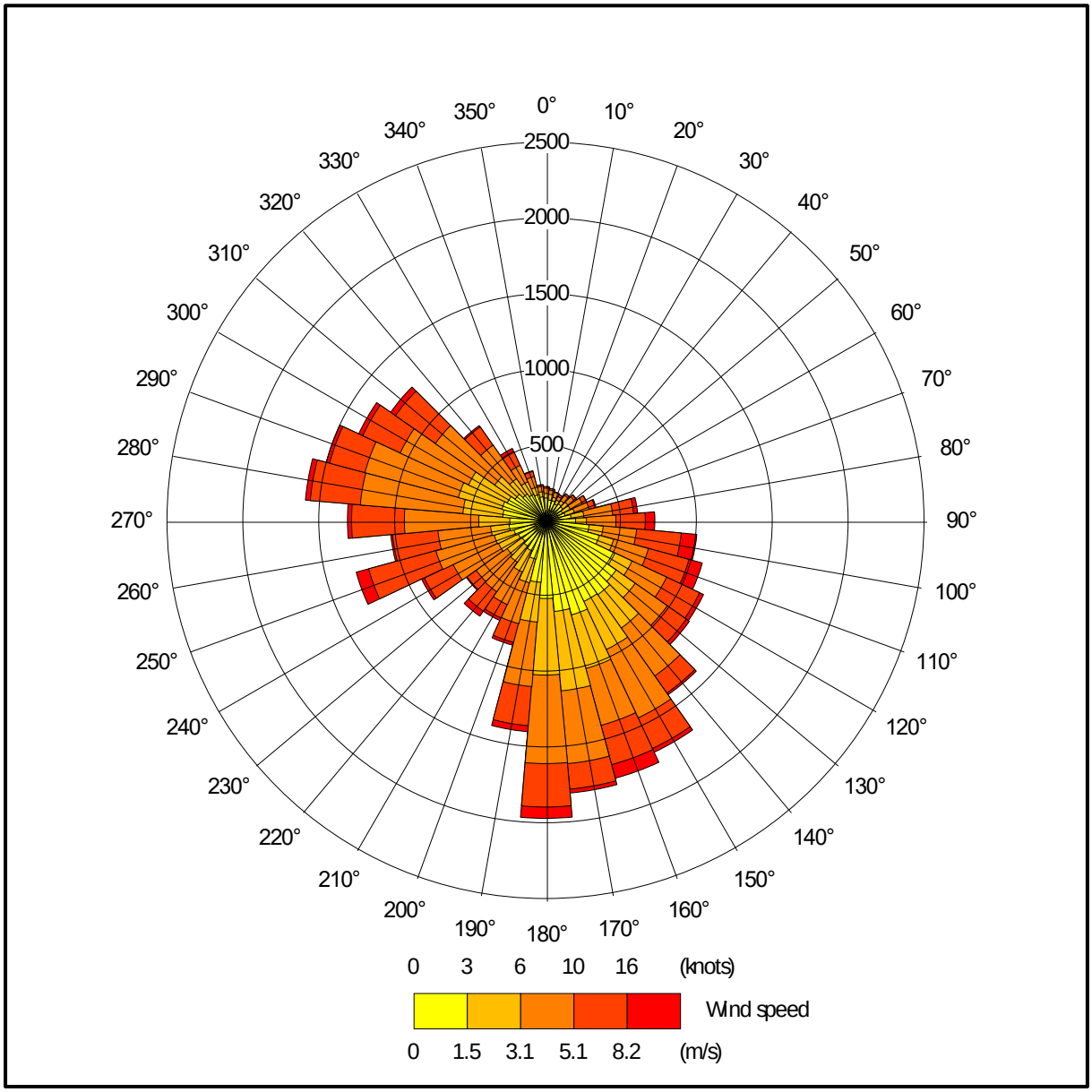


Figure 2f. Recorded meteorological data at Trawscoed, 2012-2015



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed fans that would be used to ventilate the proposed poultry houses are represented by three point sources per house within ADMS (PR1-4; 1, 2 & 3).

Details of these point source parameters are shown in Table 2. The positions of the point sources used are shown in Figure 3, where they are marked by red star symbols.

Table 2. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 1, 2 & 3	6.5	0.8	10.0	22.0	0.022446
PR2 1, 2 & 3	6.5	0.8	10.0	22.0	0.022446
PR3 1, 2 & 3	6.5	0.8	10.0	22.0	0.022446
PR4 1, 2 & 3	6.5	0.8	10.0	22.0	0.022446

Figure 3. The positions of modelled buildings & sources

4.3 Modelled buildings

The structure of the proposed new poultry houses and other nearby 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 4, where they are marked by grey rectangles.

4.4 Discrete receptors

Twenty-six discrete receptors have been defined: fourteen at the AWs/LWSs (1 to 14); nine at the SSSIs (15 to 23); two at the SAC (24 and 25) and one at the SPA (26). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4, where they are 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 field used in the detailed modelling, two regular Cartesian grids have been defined within ADMS at high and low resolution. The individual grid receptors are defined at ground level within ADMS. The positions of the Cartesian grids may be seen in Figure 4b, where they are marked by grey lines.

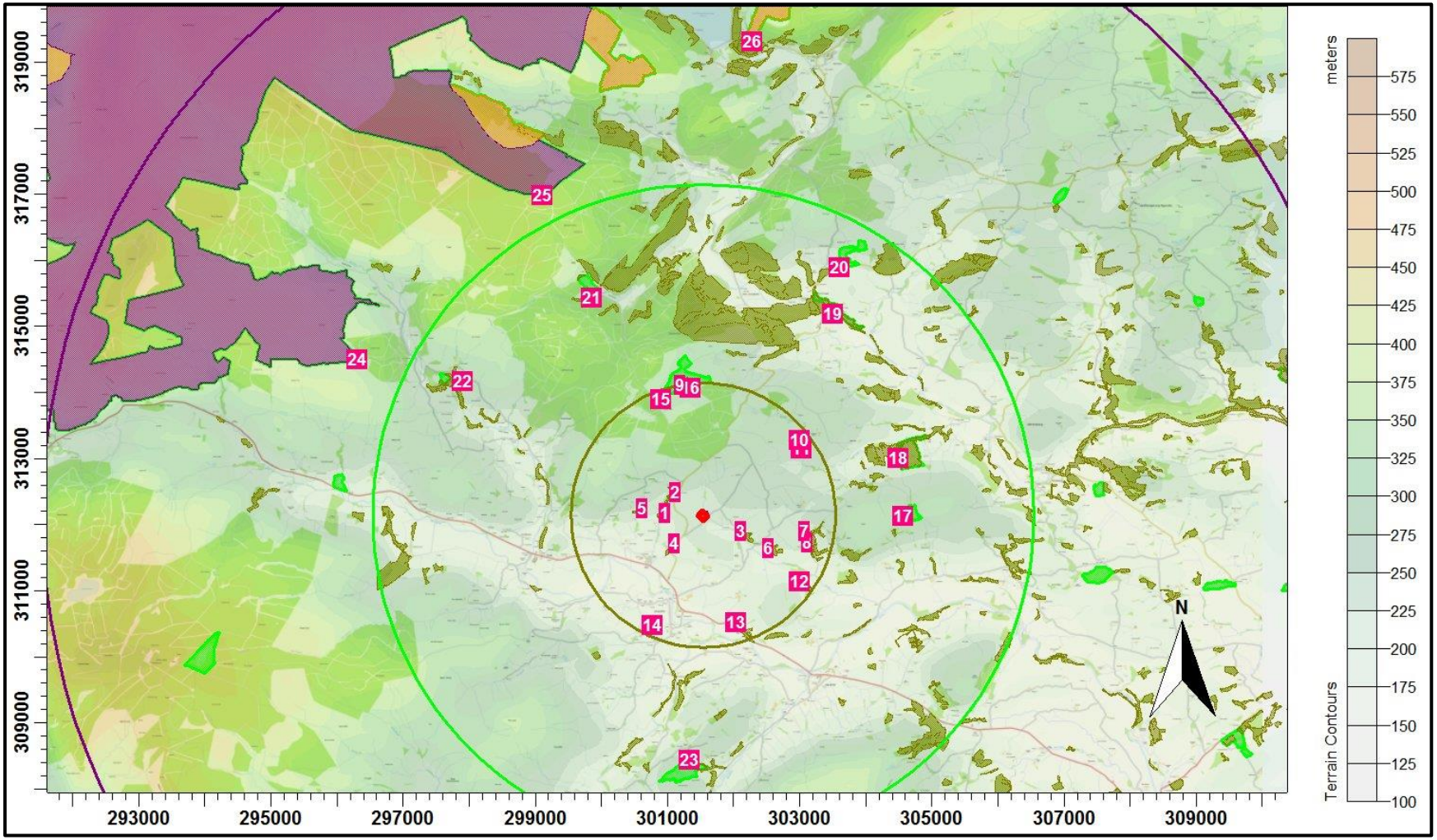
4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 20.0 km x 20.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 32 x 32 grid points; therefore, the effective resolution of the wind field is approximately 600 m.

4.7 Roughness Length

A fixed surface roughness length of 0.25 m has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.225 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations. The Lake Vyrnwy, Shobdon, RAF Shawbury and Trawscoed data is assumed to have a roughness length of 0.25 m.

Figure 4. The discrete receptors



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based on a document titled "Guidance on modelling the concentration and deposition of ammonia emitted from intensive farming" from the Environment Agency's Air Quality Modelling and Assessment Unit, 22 November 2010. N.B. 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 0.015 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 two deposition velocity fields. The deposition velocities used are provided in Table 4.

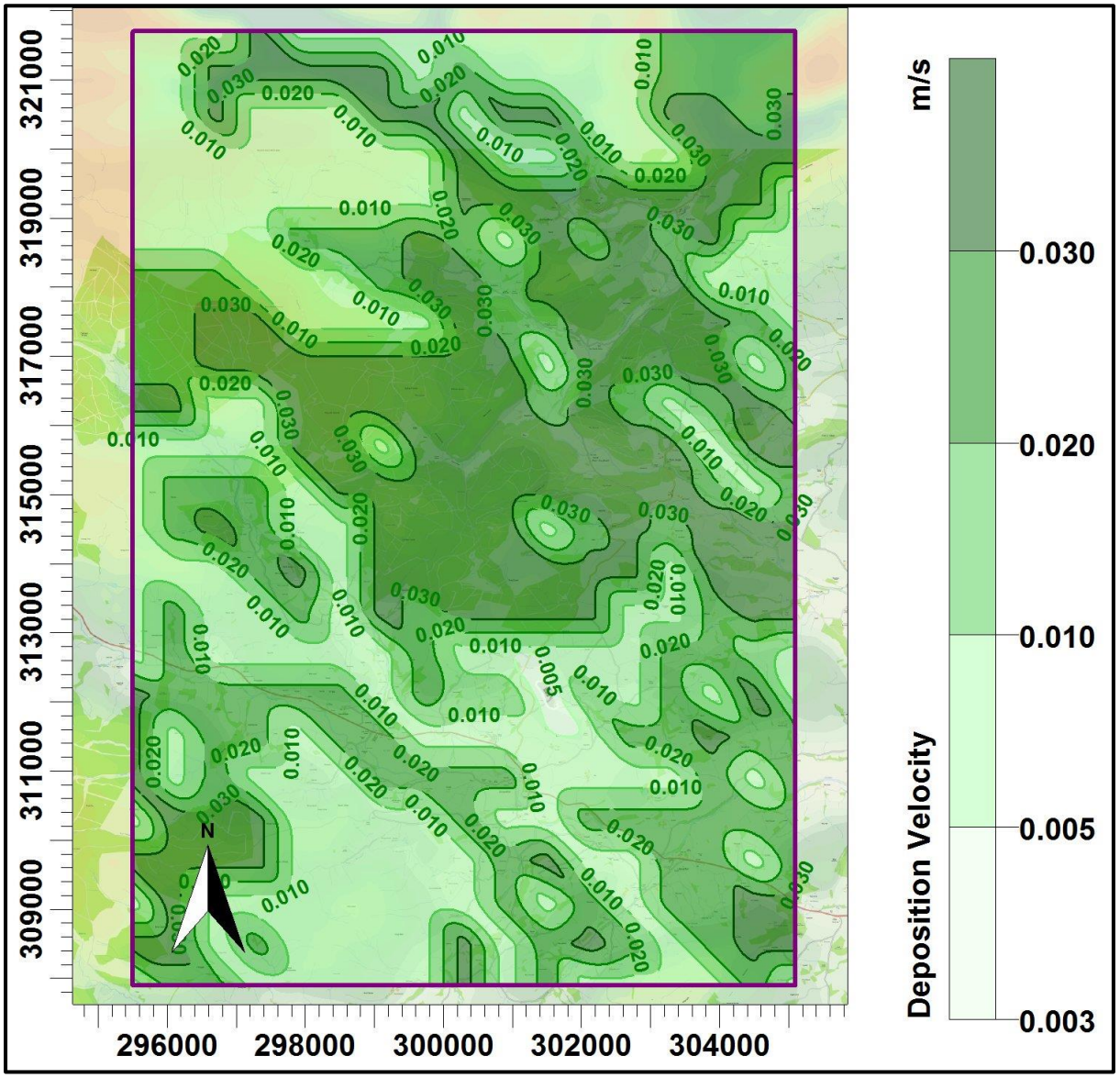
Table 4. Deposition velocities

NH3 concentration (PC + background) (µg/m^3)	< 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 (0.015 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 5.

Figure 5. The spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of twenty-eight times, once for each year of the meteorological record, in the following six modes:

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- In basic mode without calms, or terrain – Lake Vyrnwy data
- In basic mode without calms, or terrain – Shobdon data
- In basic mode without calms, or terrain – Shawbury data
- In basic mode without calms, or terrain – Trawscoed 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 5. In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of the Environment Agency's upper threshold (8% of Critical Level or Load for a SAC/SPA/SSSI and 100% of Critical Level or Load for a non-statutory wildlife site) are coloured red. Concentrations (or concentrations equivalent to deposition rates) in the range between the Environment Agency's lower and upper threshold (1% and 8% for a SAC/SPA/SSSI and 50% and 100% for a non-statutory wildlife site) are coloured blue. For convenience, cells referring to the AWs are shaded olive, cells referring to the SSSIs are shaded green, cells referring to the SAC are shaded purple and cells referring to the SPA are shaded orange.

Table 5. Predicted maximum annual mean ammonia concentration and nitrogen deposition rate at the discrete receptors

Receptor number	X(m)	Y(m)	Site	Maximum annual mean ammonia concentration (µg/m^3)						
				GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vyrnwy No Calms No terrain	Shobdon No Calms No terrain	Shawbury No Calms No terrain	Trawscoed No Calms No terrain
1	300964	312166	Unnamed AW/LWS	0.368	0.363	0.325	0.267	0.392	0.343	0.290
2	301121	312481	Unnamed AW/LWS	0.314	0.311	0.191	0.129	0.224	0.254	0.424
3	302119	311896	Unnamed AW/LWS	0.281	0.275	0.402	0.170	0.385	0.173	0.391
4	301110	311709	Unnamed AW/LWS	0.190	0.188	0.271	0.313	0.257	0.127	0.058
5	300616	312230	Unnamed AW/LWS	0.180	0.177	0.128	0.120	0.167	0.161	0.148
6	302535	311635	Unnamed AW/LWS	0.119	0.118	0.186	0.084	0.198	0.074	0.177
7	303083	311890	Unnamed AW/LWS	0.108	0.106	0.157	0.099	0.163	0.048	0.110
8	303114	311711	Unnamed AW/LWS	0.091	0.089	0.141	0.074	0.147	0.043	0.112
9	301204	314102	Unnamed AW/LWS	0.067	0.066	0.034	0.028	0.043	0.051	0.158
10	303016	313265	Unnamed AW/LWS	0.104	0.102	0.099	0.095	0.078	0.094	0.055
11	303036	313136	Unnamed AW/LWS	0.114	0.112	0.106	0.097	0.088	0.098	0.061
12	303019	311125	Unnamed AW/LWS	0.071	0.071	0.097	0.056	0.121	0.042	0.094
13	302054	310505	Cann Office - east of AW/LWS	0.048	0.048	0.037	0.100	0.047	0.088	0.028
14	300780	310474	Unnamed AW/LWS	0.045	0.045	0.036	0.087	0.058	0.030	0.014
15	300914	313883	Cors Llyn Coethlyn SSSI	**0.058**	**0.058**	**0.029**	**0.026**	**0.041**	**0.056**	**0.158**
16	301364	314053	Cors Llyn Coethlyn SSSI	**0.072**	**0.071**	**0.039**	**0.032**	**0.050**	**0.057**	**0.163**
17	304583	312126	Cors Lawnt SSSI	**0.051**	**0.050**	**0.053**	**0.060**	**0.088**	**0.028**	**0.041**
18	304500	312992	Coed Y Lawnt A Coed Oli SSSI	**0.055**	**0.054**	**0.046**	**0.052**	**0.072**	**0.047**	**0.038**
19	303516	315173	Coed Copi'r Graig SSSI	**0.035**	**0.034**	**0.049**	**0.035**	**0.027**	**0.038**	**0.028**
20	303611	315884	Fachwen Isaf SSSI	**0.027**	**0.026**	**0.039**	**0.026**	**0.023**	**0.028**	**0.024**
21	299865	315422	Gweunydd Dyfnant SSSI	**0.024**	**0.024**	**0.010**	**0.011**	**0.019**	**0.023**	**0.075**
22	297921	314153	Gweunydd Pen-Y-Coed SSSI	**0.028**	**0.028**	0.010	**0.016**	**0.020**	**0.018**	**0.037**
23	301347	308428	Bryn Coch SSSI	**0.025**	**0.025**	0.008	**0.051**	**0.022**	**0.019**	**0.011**
24	296326	314494	Berwyn and South Clwyd Mountains (SAC)	**0.021**	**0.021**	0.007	**0.014**	**0.016**	**0.014**	**0.026**
25	299127	316975	Berwyn and South Clwyd Mountains (SAC)	**0.016**	**0.016**	0.005	0.007	**0.012**	**0.014**	**0.051**
26	302301	319295	Berwyn (SPA/SSSI)	**0.013**	**0.013**	0.009	0.009	**0.014**	**0.015**	**0.031**

5.2 Detailed deposition modelling

The detailed modelling was carried out over a restricted domain where the preliminary modelling indicated that annual mean ammonia concentrations (or nitrogen deposition rates) could potentially exceed the relevant lower threshold percentage of the Critical Level or Critical Load. The domain covers the proposed poultry houses at Cefnau Bach, all of the SSSIs, the Berwyn and South Clwyd Mountains SAC and the Berwyn SPA. At all other receptors considered, the preliminary modelling indicated that ammonia levels (and nitrogen and acid deposition rates) would be below the Natural Resources Wales/Environment Agency lower threshold percentage of Critical Level/Load for the designation of the site.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors within the detailed modelling domain are shown in Table 6. In the table, predicted ammonia concentrations or nitrogen deposition rates that are in excess of the Natural Resources Wales' upper threshold (8% of Critical Level or Load for a SPA/SAC/SSSI and 100% of Critical Level or Load for an AW) are coloured red. Concentrations that are in the range between the Natural Resources Wales' lower and upper threshold (1% to 8% for a SPA/SAC/SSSI and 50% to 100% for an AW) are coloured blue.

The contour plot of the predicted ground level maximum annual mean ammonia concentration and maximum nitrogen deposition rates are shown in Figures 6a and 6b respectively.

Table 6. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual mean ammonia concentration at ground level		Maximum annual deposition rate	
				Critical Level (µg/m³)	Critical Level (kg/ha)	Deposition Velocity (m/s)	Process Contribution (µg/m³)	%age of Cle	Process Contribution (kg/ha)	%age of Clo
15	300914	313883	Cors Llyn Coethlyn SSSI	1.0	5.0	0.03	0.014	**1.4**	0.11	**2.2**
16	301364	314053	Cors Llyn Coethlyn SSSI	1.0	5.0	0.03	0.020	**2.0**	0.16	**3.2**
17	304583	312126	Cors Lawnt SSSI	1.0	5.0	0.03	0.029	**2.9**	0.22	**4.5**
18	304500	312992	Coed Y Lawnt A Coed Oli SSSI	1.0	5.0	0.03	0.027	**2.7**	0.21	**4.3**
19	303516	315173	Coed Copi'r Graig SSSI	1.0	5.0	0.03	0.022	**2.2**	0.17	**3.4**
20	303611	315884	Fachwen Isaf SSSI	1.0	5.0	0.03	0.014	**1.4**	0.11	**2.2**
21	299865	315422	Gweunydd Dyfnant SSSI	1.0	5.0	0.03	0.005	0.5	0.04	0.8
22	297921	314153	Gweunydd Pen-Y-Coed SSSI	1.0	8.0	0.03	0.006	0.6	0.04	0.5
23	301347	308428	Bryn Coch SSSI	1.0	5.0	0.03	0.004	0.4	0.03	0.6
24	296326	314494	Berwyn and South Clwyd Mountains (SAC)	1.0	5.0	0.02	0.003	0.3	0.02	0.4
25	299127	316975	Berwyn and South Clwyd Mountains (SAC)	1.0	5.0	0.01	0.002	0.2	0.00	0.1
26	302301	319295	Berwyn (SPA/SSSI)	1.0	5.0	0.03	0.003	0.3	0.02	0.5

Figure 6a. Maximum annual ammonia concentration

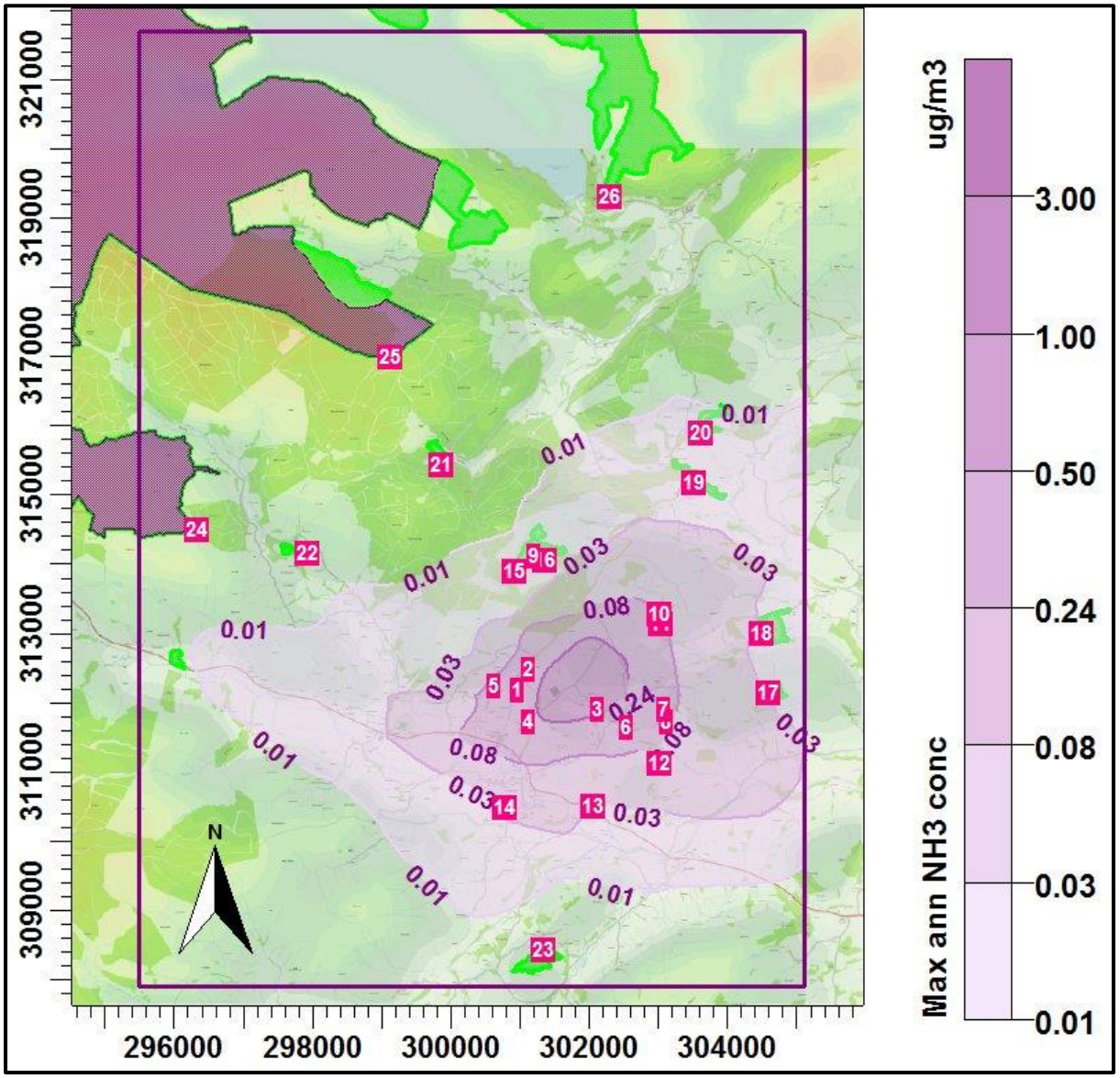
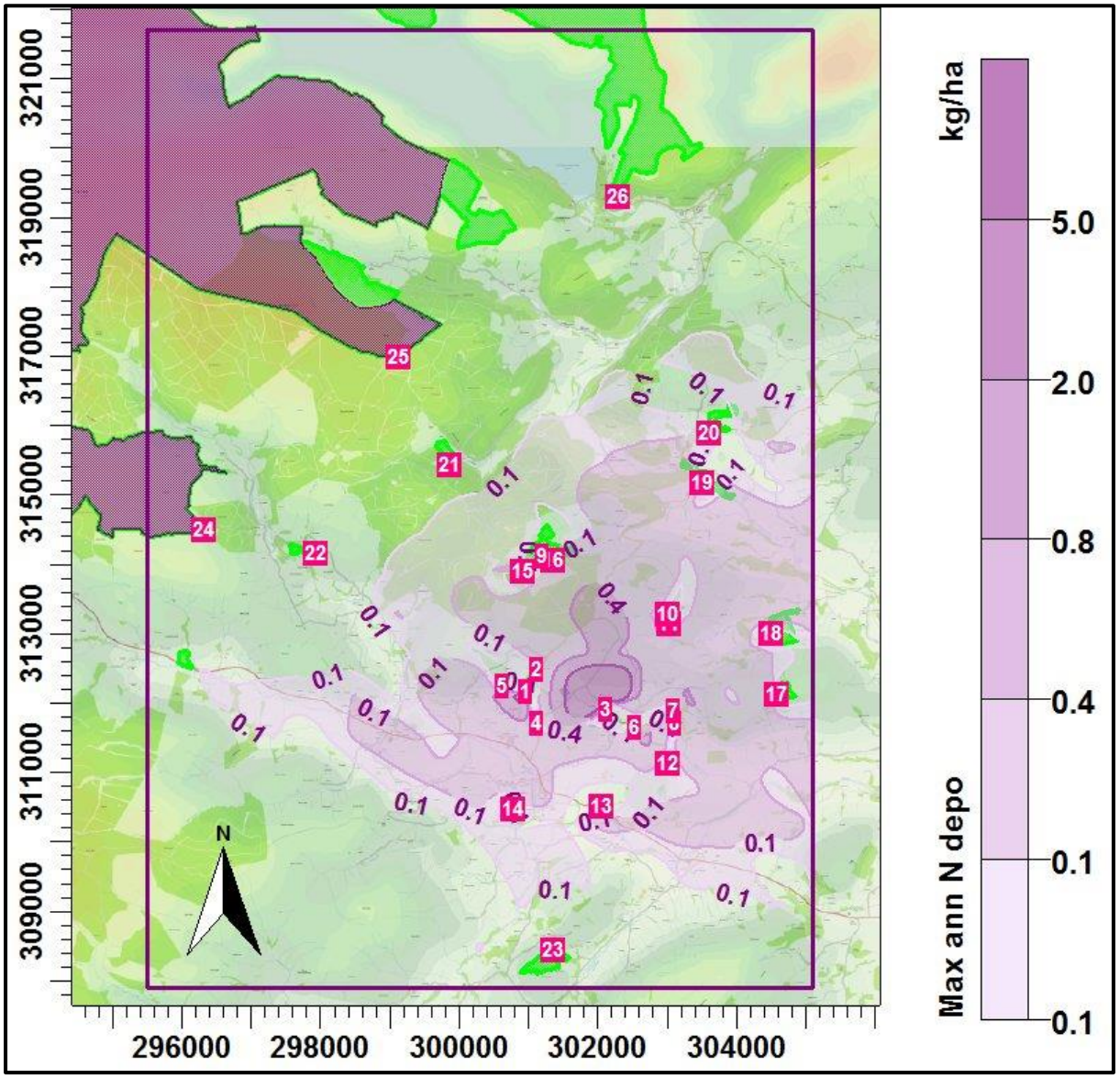


Figure 6b. Maximum annual nitrogen deposition rates



1. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by John Ward, on behalf of the applicant Mills Poultry Ltd. to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Cefnau Bach, near Llangadfan, Welshpool, in Powys.

Ammonia emission rates from the proposed poultry 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 deposition rates in the surrounding area.

Preliminary modelling

The preliminary modelling predicts that the process contribution to ammonia concentrations and nitrogen deposition rates at nearby SSSIs, the Berwyn and South Clwd Mountains SAC and Berwyn SPA would potentially exceed the Natural Resources Wales lower threshold (1% for non-statutory sites) of the Critical Level of 1.0 µg/m³ and the Critical Load of 5.0 kg/ha.

At all other sites considered, the preliminary modelling predicts that the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below the Natural Resources Wales/Environment Agency lower threshold percentage of Critical Level or Critical Load for the site (100% for non-statutory sites).

Detailed deposition modelling

The detailed modelling predicts that the process contribution to ammonia concentrations and nitrogen deposition rates would exceed the Natural Resources Wales lower threshold (1% for SAC/SPA/SSSI) of the Critical Level of 1.0 µg/m³ and the Critical Load of 5.0 kg/ha at Cors Llyn Coethlyn SSSI, Cors Lawnt SSSI, Coed Y Lawnt A Coed Oli SSSI, Coed Copi'r Graig SSSI and Fachwen Isaf SSSI. Please note that both the Critical Level of 1.0 µg/m³ and the Critical Load of 5.0 kg/ha used for this assessment may be precautionary for these sites and that if the higher Critical Load of a higher Critical Load is applicable, the magnitude of any exceedances would be smaller.

At all other sites considered, the detailed modelling predicts that the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below the Natural Resources Wales/Environment Agency lower threshold percentage of Critical Level or Critical Load for the site (1% for a SAC/SPA/SSSI and 100% for non-statutory sites).

Mitigation

Where there is a predicted exceedance of the Natural Resources Wales Lower threshold percentage of Critical Level or Critical Load at a SSSI, but the upper threshold in not exceeded, the proposal may or may not be deemed acceptable, depending on the presence, or not, of other installations that may have in-combination effects, background ammonia concentrations and the sensitivity of the wildlife sites involved.

2. References

Cambridge Environmental Research Consultants (CERC) (website).
http://www.cerc.co.uk/environmental-software/ADMS-model.html

Environment Agency H1 Risk Assessment (website).
https://www.gov.uk/government/collections/risk-assessments-for-specific-activities-environmental-permits

M. A. Sutton *et al*. Measurement and modelling of ammonia exchange over arable croplands.
https://enviro.doe.gov.my/lib/digital/1386301476-1-s2.0-S0166111606802748-main.pdf

Misselbrook. *et al*. Inventory of Ammonia Emissions from UK Agriculture 2011
http://uk-air.defra.gov.uk/assets/documents/reports/cat07/1211291427_nh3inv2011_261112_FINAL_corrected.pdf

United Nations Economic Commission for Europe (UNECE) (website).
http://www.unece.org/env/lrtap/WorkingGroups/wge/definitions.htm

UK Air Pollution Information System (APIS) (website).
http://www.apis.ac.uk/