A Report on the Modelling of the Dispersion of Ammonia from the Proposed Broiler Chicken Rearing Houses at Penpound, near Newbridge-on-Wye, Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Steve Raasch, on behalf of the applicant Raymond Powell, to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Penpound, near Newbridge-on-Wye, Powys. LD1 6HR.

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 two broiler chicken rearing houses be constructed on a green field site at Penpound, near Newbridge-on-Wye in Powys. The surrounding land is largely used for livestock rearing/grazing, although there are some wooded areas and areas of semi-natural grassland nearby. The site is in the River Wye/River Ithon Valley, with the land falling confluence of the two rivers to the south, falling towards the River Wye to the west, falling towards the River Ithon to the east and rising towards hills to the north.

The proposal involves the construction of two poultry houses which would be used to rear up to 100,000 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) within 2 km of the proposed new poultry unit. There are also six Sites of Special Scientific Interest (SSSIs) within 2 km: the Aberithon and Bedw Turbaries SSSI, approximately 330 m to the west-north-west; Rhos Dwfnant SSSI, approximately 460 m to the north-north-west; Dwfnant Pastures approximately 840 m to the north-east; The River Wye (upper Wye) SSSI, approximately 820 m to the west; The River Ithon SSSI, approximately 1.1 km to the east and Rhos Penrhiw SSSI, approximately 1.7 km to the east-south-east. The River Wye (upper Wye) SSSI and The River Ithon SSSI, are both also designated as part of the River Wye Special Area of Conservation (SAC). There are nine other areas designated as SSSIs within 5 km of the site and apart from the River Wye SAC, there are two other SACs and a Special Protection Area (SPA), namely Elenydd SAC, the Elan Valley Woodlands SAC and the Elenydd Mallaen SPA, that are within 10 km of the site.

Maps of the surrounding area showing the positions of the poultry unit, the AWs, the SSSIs, the SACs and the SPA are provided in Figures 1a and 1b. In these figures, the AWs are shaded in olive, the SSSIs is shaded in green, the SACs are shaded in purple, the SPA is shaded orange and the site of the proposed new poultry houses at Penpound is outlined in blue.

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

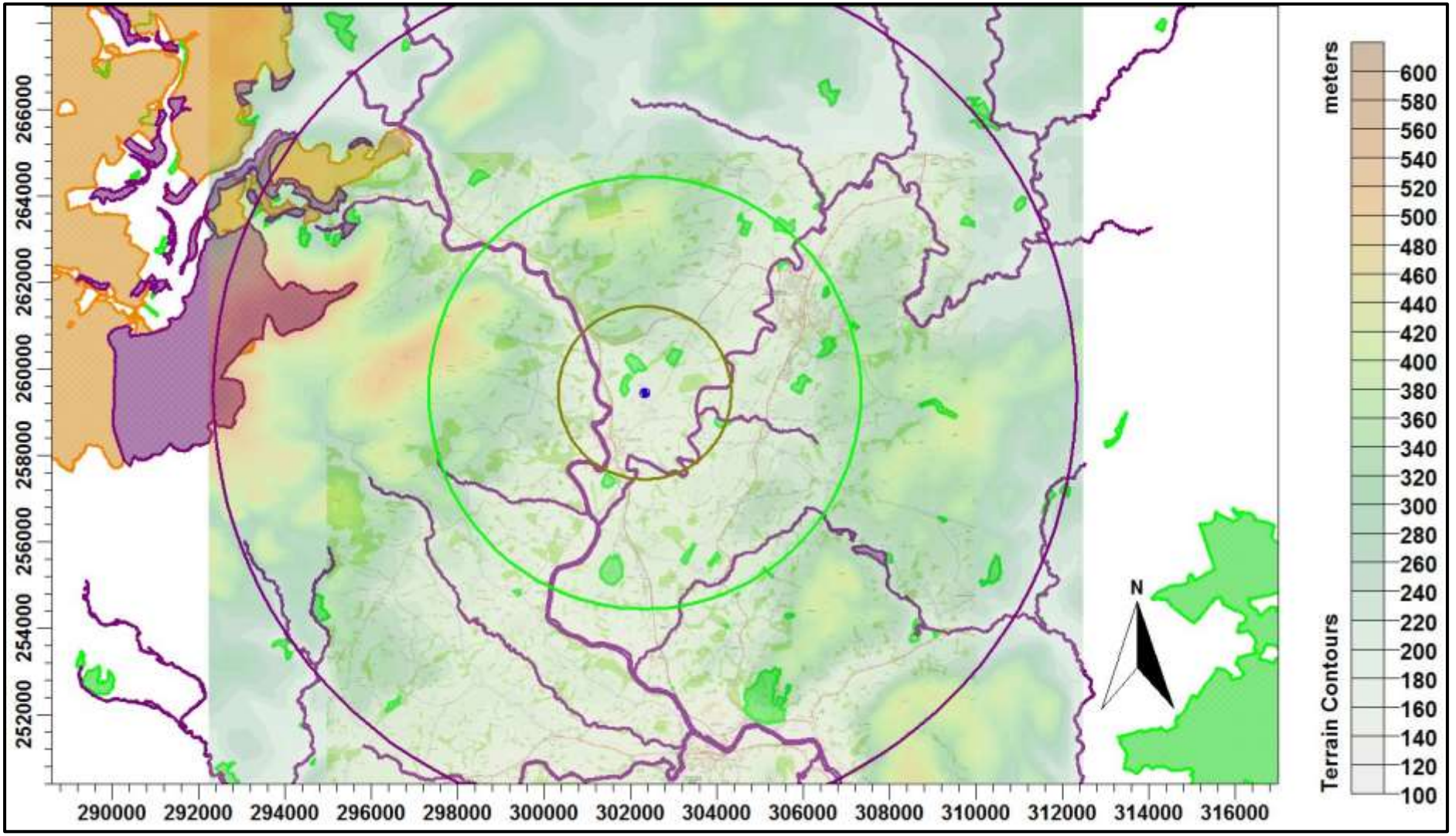
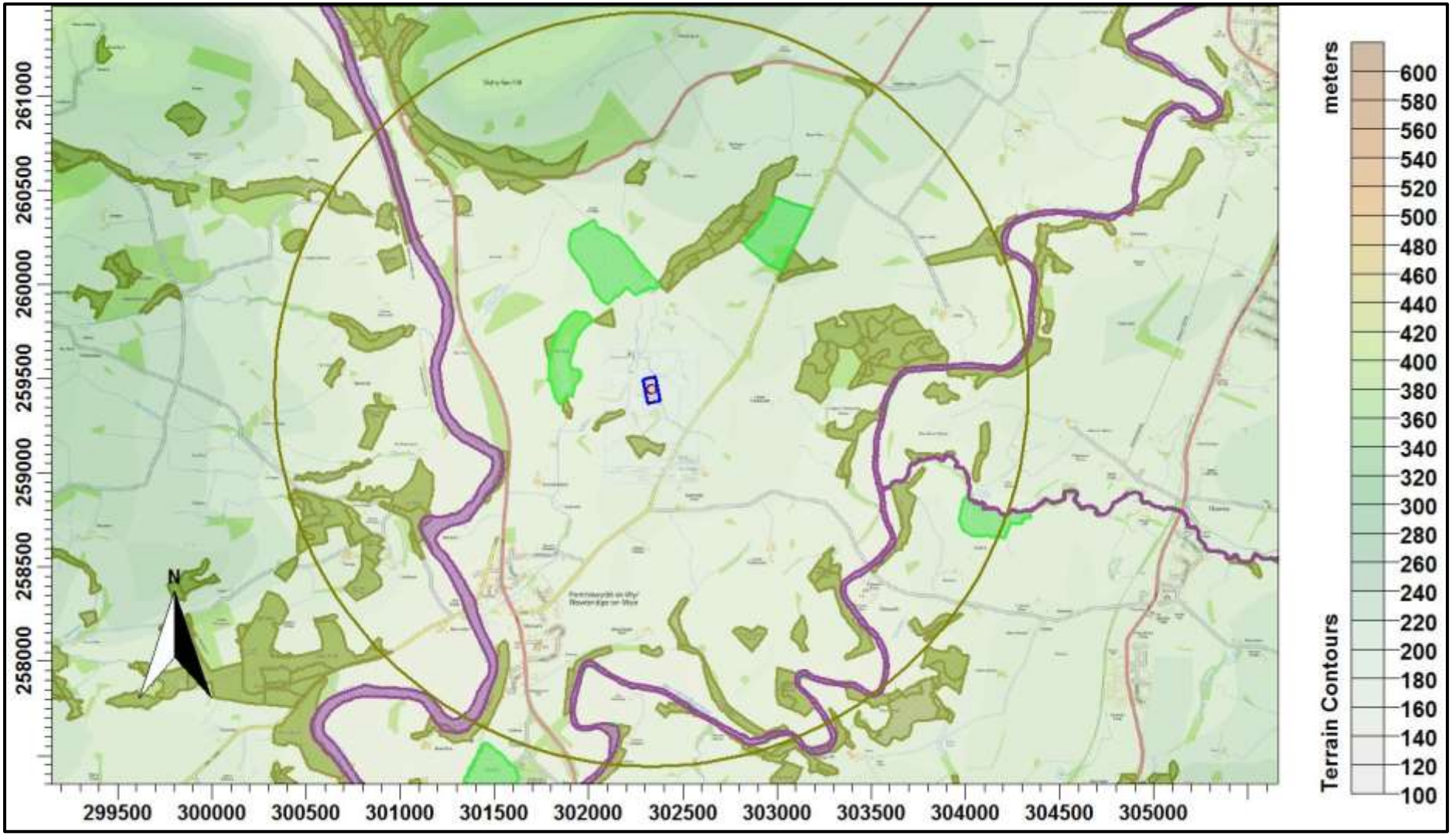


Figure 1b. The area surrounding Penpound – a closer view



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 ($\mu g\text{-}NH_3/m^3$) 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 Glangwden and the wildlife sites is 1.20 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 24.64 kg-N/ha/y and to short vegetation is 16.38 kg-N/ha/y. The background acid deposition rate to woodland is 1.95 keq/ha/y and to short vegetation is 1.34 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 $\mu g\text{-}NH_3/m^3$ 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 $\mu g\text{-}NH_3/m^3$ 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. 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 (kg-N/ha/y)	Critical Load Acid (keq/ha/y)
AWs	1.0 [1]	-	-
SSSIs	1.0 [1]	-	-
SACs/SPAs	1.0 [1]	10.0 [2]	

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to lichens or bryophytes.
2. The lower bound of the range of Critical Loads, obtained from APIS.

3.4 Guidance on the significance of ammonia emissions

The following are obtained from the Environment Agency's horizontal guidance, H1 Environmental Risks Assessment, H1 Annex B - Intensive Farming.

"An emission is insignificant where Process Contribution (PC) is <4% of Critical Levels for SACs, SPAs and Ramsars, <20% for SSSIs, and <50% for local and national nature reserves (LNRs & NNRs), ancient woodland and local wildlife sites."

"Where modelling predicts a process contribution >20% of the Critical Level/Load at a SAC, SPA or Ramsar, >50% at a SSSI or >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. It is understood that Natural Resources Wales used the same criteria as the Environment Agency Annex B – Intensive Farming and therefore it is assumed that they now use the same criteria as defined in the Environment Agency's web-page "Intensive farming risk assessment for your environmental permit".

Within the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsars; 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. 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 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 Environment Agency emission factor for broiler chickens is 0.034 kg-NH_3/bird place/y; this figure has been used to calculate the ammonia emissions from the proposed broiler chicken rearing houses used in the modelling study. 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

Ammonia source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Proposed Housing	100,000	Broiler Chickens	0.034	0.107739

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 Sennybridge, Shobdon 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.

Data from the meteorological recording stations at Sennybridge, Shobdon and Trawscoed has also been considered; these stations are all approximately equidistant from Penpound. However, neither Sennybridge, Shobdon nor Trawscoed has an aspect that in any way could be considered similar to Penpound; therefore, it should be noted that the frequency of winds from a particular direction in the Lake Vyrnwy, Sennybridge, Shobdon and Trawscoed data may be either high or low in comparison to what might occur at Penpound, which means mean concentrations downwind may be either over or under predicted. Additionally, periods of light winds and calms cannot be properly modelled, which means that predictions may, in some circumstances, be somewhat lower than would be obtained if calm conditions were considered. 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 more weight when interpreting the results of the modelling.

The wind rose for the raw GFS data at Penpound 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 Penpound 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 660 m in the preliminary modelling and approximately 300 m in the detailed modelling.

The wind roses for Sennybridge, Shobdon and Trawscoed are shown in Figures 2c, 2d and 2e, respectively.

Figure 2a. The wind rose. Raw GFS derived data for 52.224 N, 3.430 W, 2012 – 2015

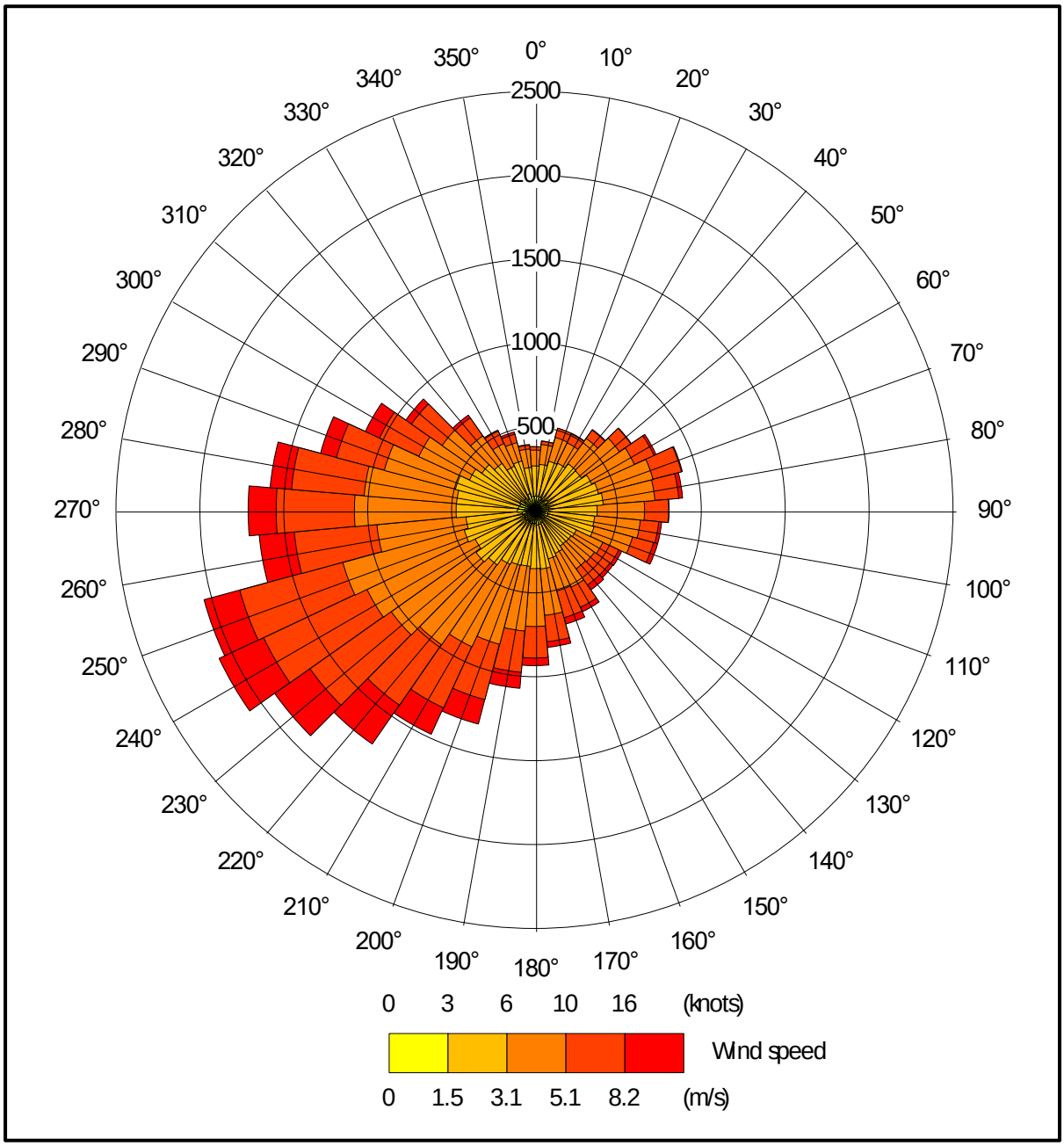


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for 52.224 N, 3.430 W, 2012 – 2015

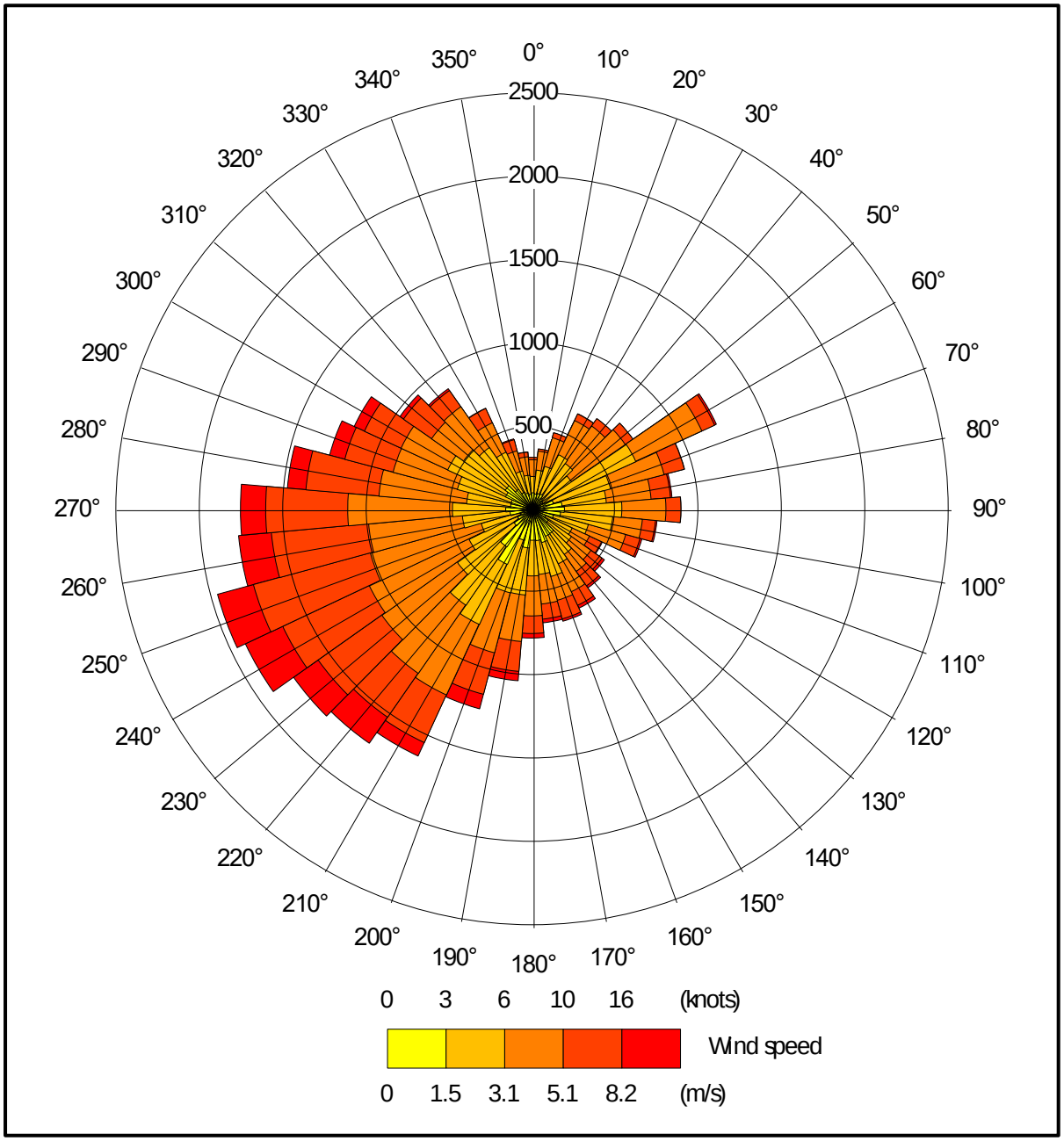


Figure 2c. Recorded meteorological data at Sennybridge, 2012-2015

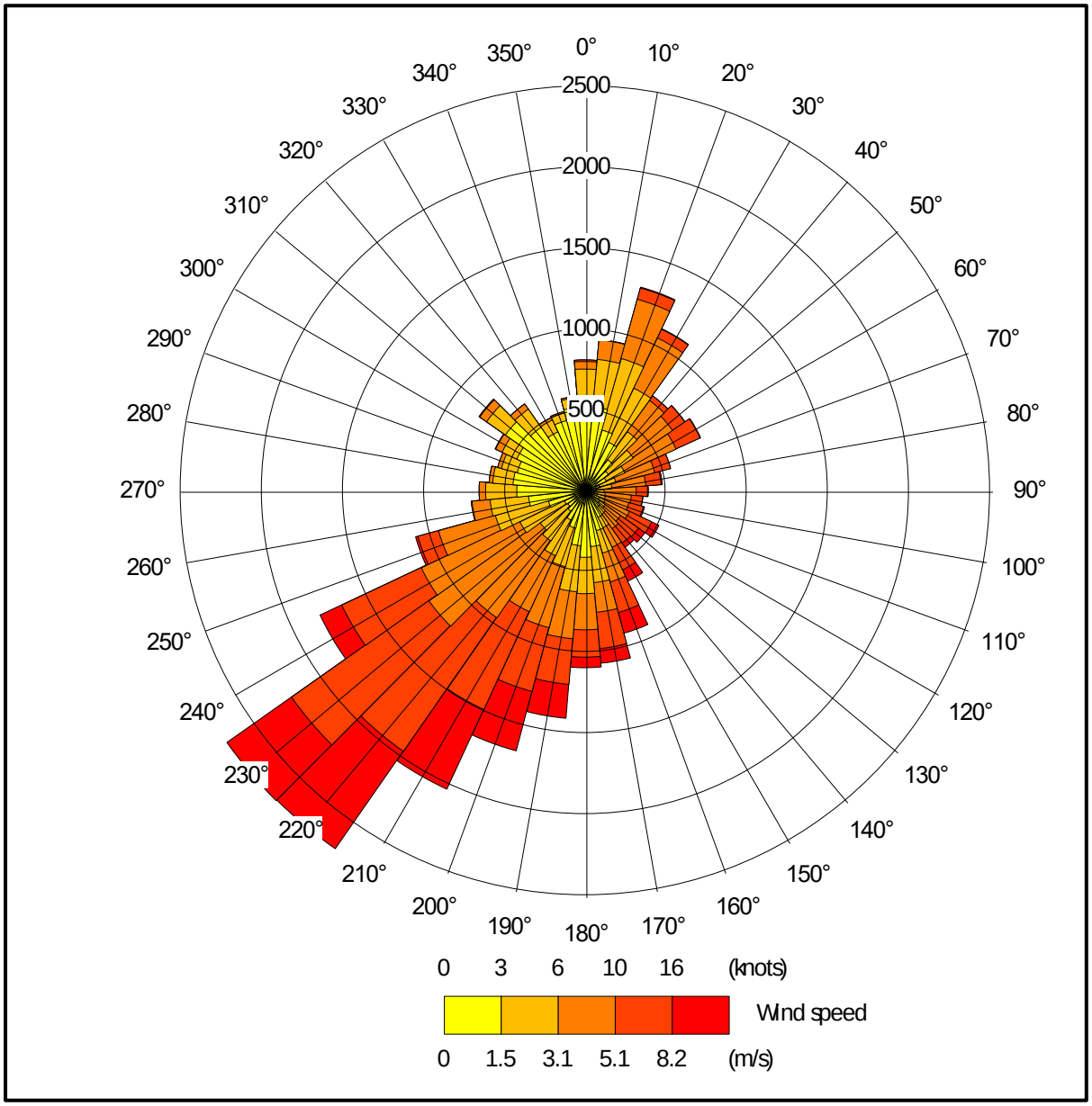


Figure 2d. Recorded meteorological data at Shobdon, 2012-2015

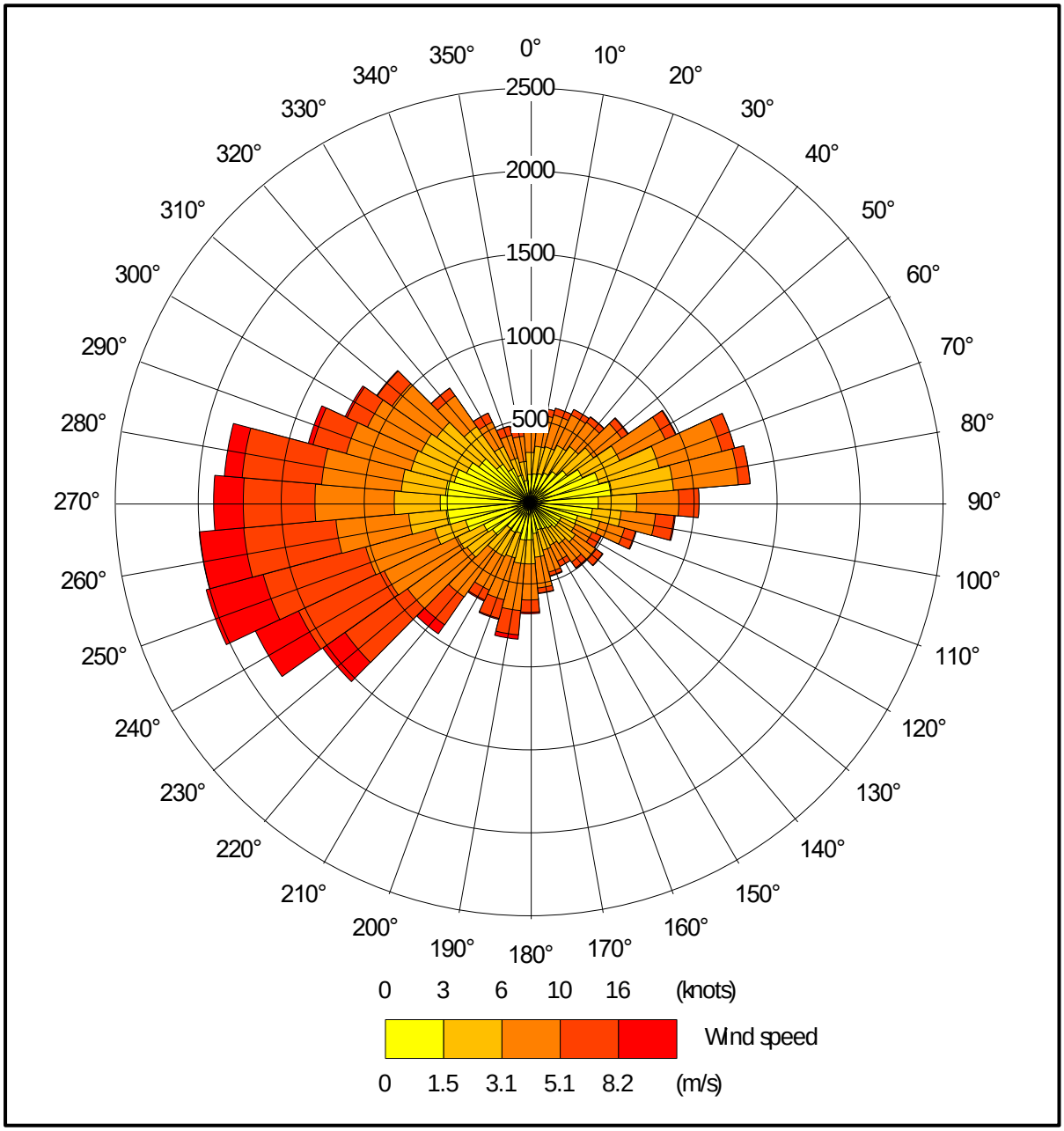
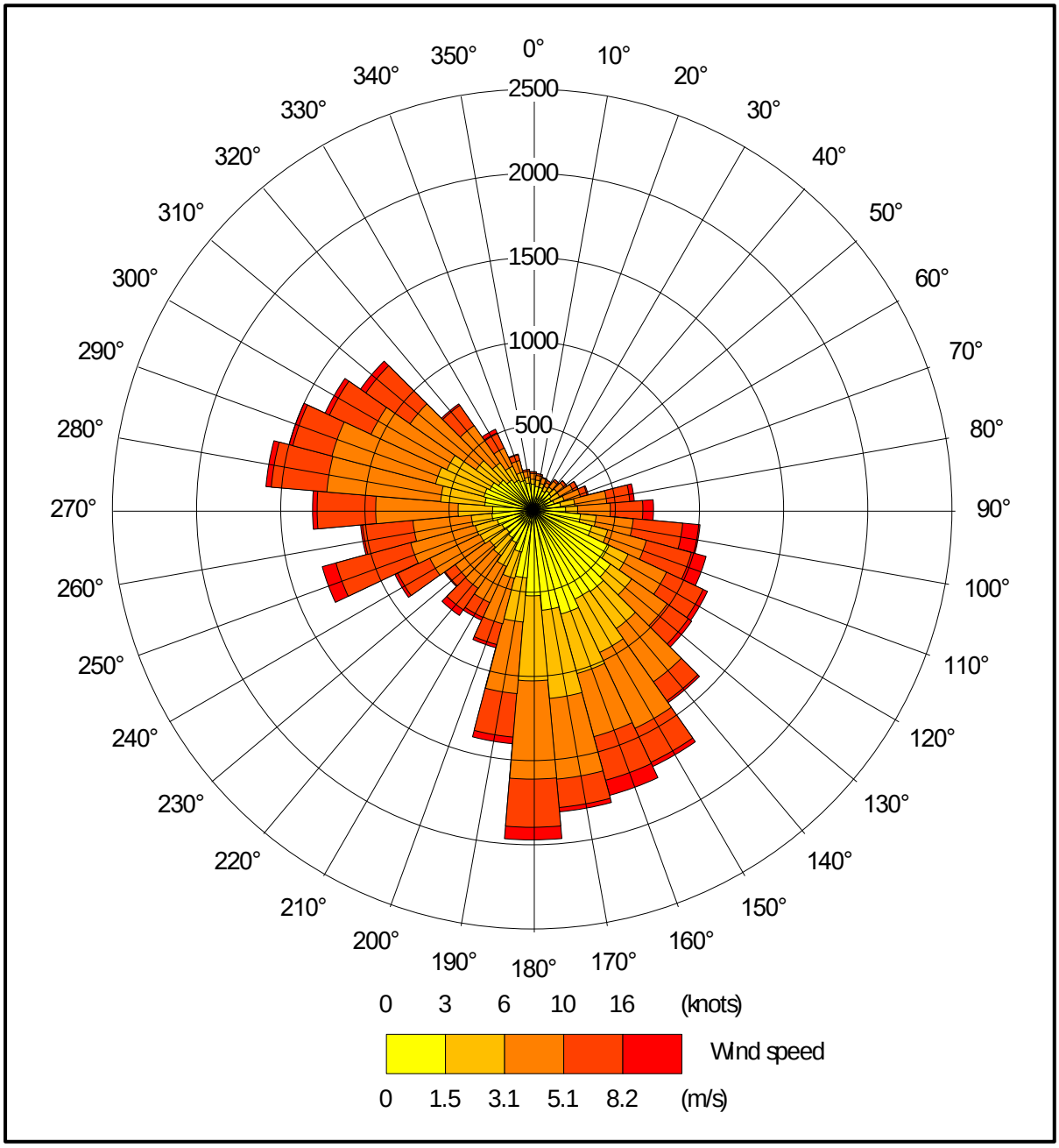


Figure 2e. Recorded meteorological data at Trawscoed, 2012-2015



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed fans that would be used to ventilate the proposed new poultry houses are represented by three point sources per house within ADMS (PR1 a, b & c and PR2 a, b & c).

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

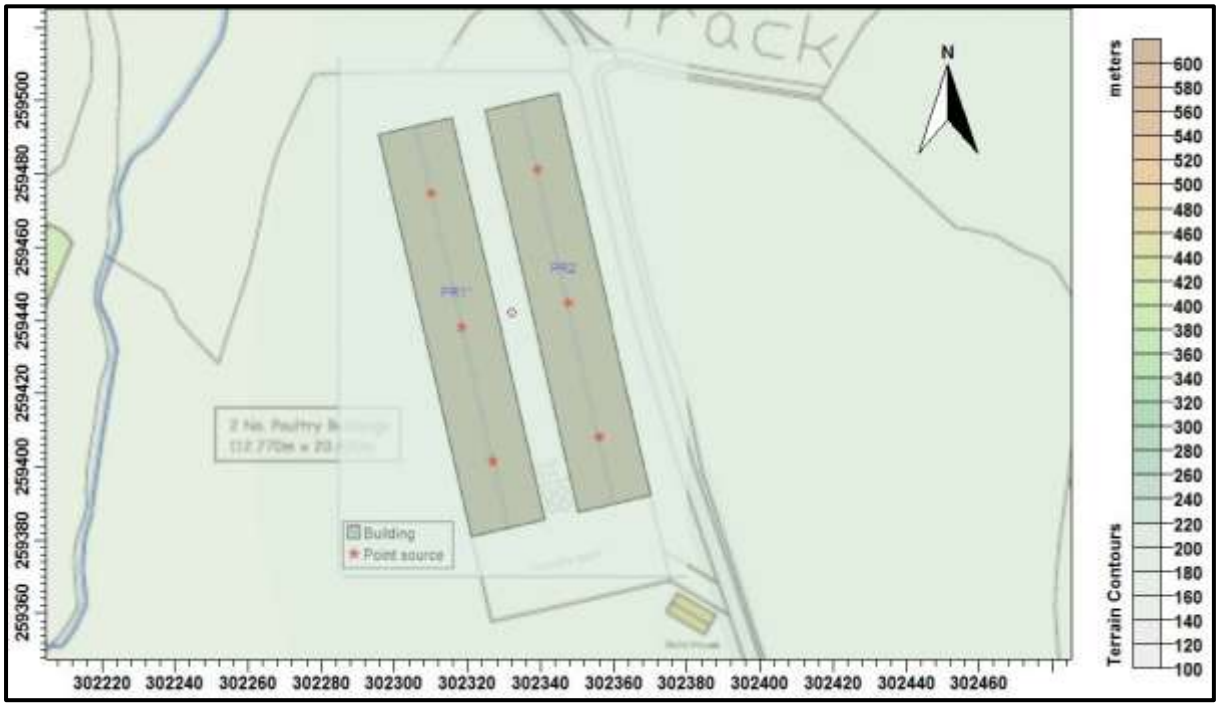
Table 3. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 a, b & c	5.5	0.8	11.0	21.0	0.017957
PR2 a, b & c	5.5	0.8	11.0	21.0	0.017957

4.3 Modelled buildings

The structure of the proposed new poultry houses may affect the plumes from the point sources; therefore, the buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3, where they are marked by grey rectangles.

Figure 3. The positions of modelled buildings & sources



4.4 Discrete receptors

One hundred and sixteen discrete receptors have been defined: thirty-seven at the AWs (1 to 37); twenty-one at the SSSIs (38 to 58); fifty-six at the SACs (59 to 114) and two at the SPA (115 and 116). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4a and 4b, 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 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 4b, where it is marked by grey lines.

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 22.0 km x 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS in the preliminary modelling and a 10.0 km x 10.0 km domain has been resampled at 100 m horizontal resolution for use in the detailed deposition modelling. N.B. The resolution of FLOWSTAR is 32 x 32 grid points; therefore, the effective resolution of the wind field is approximately 660 m in the preliminary modelling and approximately 300 m in the detailed modelling.

4.7 Roughness Length

A fixed surface roughness length of 0.3 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 0.275 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 Sennybridge, Shobdon and Trawscoed data is assumed to have a roughness length of 0.3 m.

Figure 4a. The discrete receptors - a broad-scale view

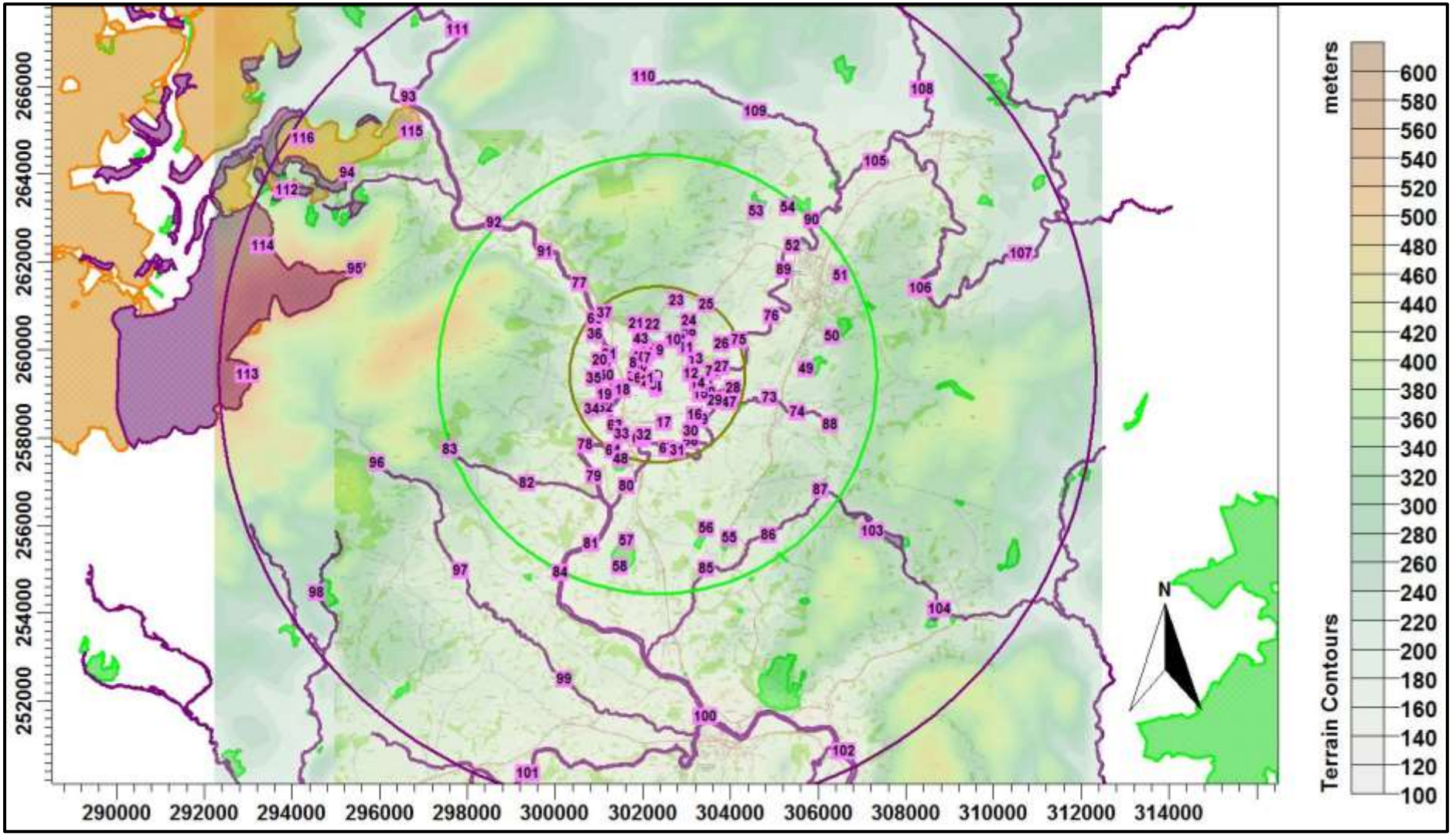
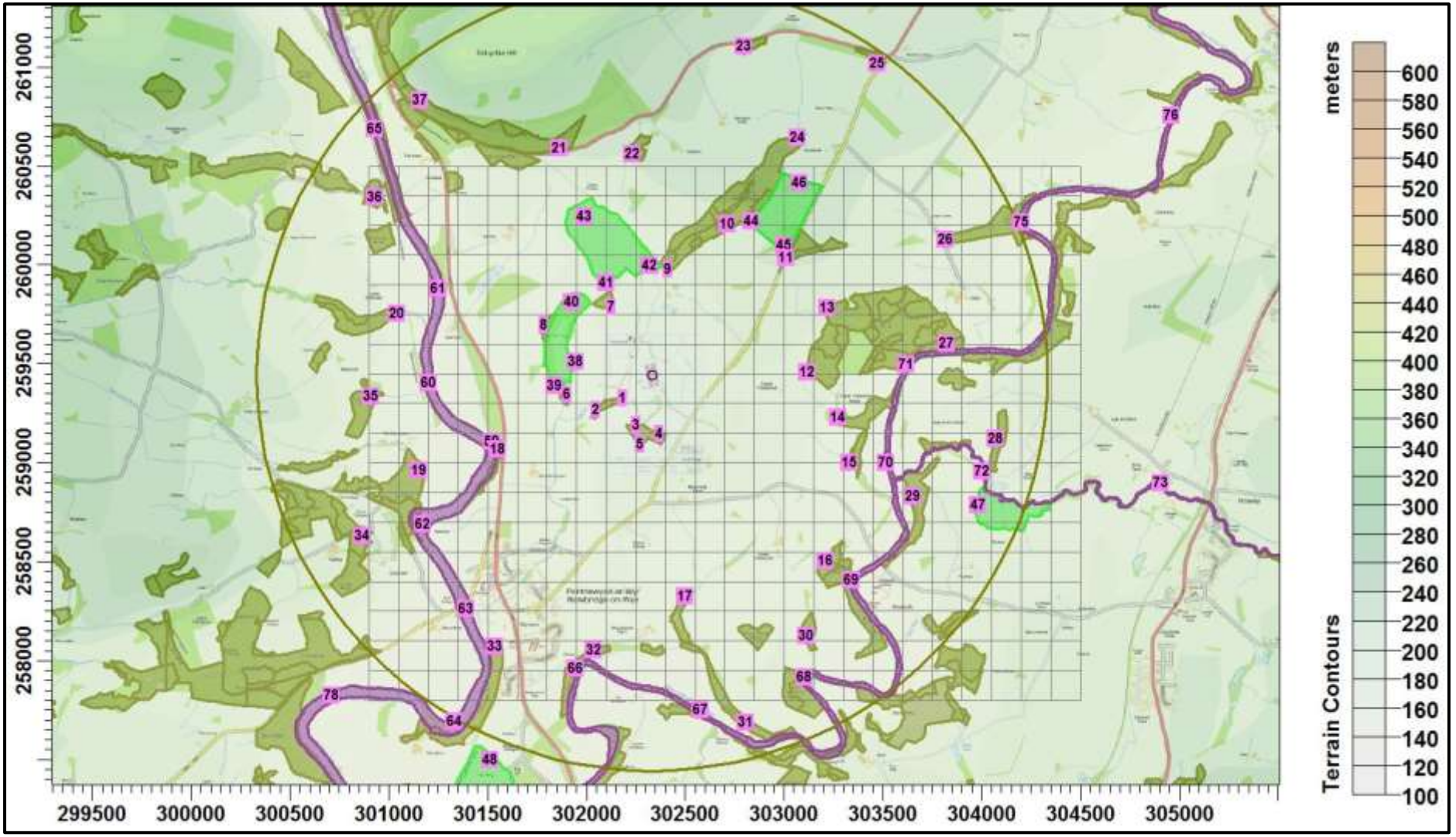


Figure 4b. The discrete receptors and regular Cartesian grid - a closer view



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 areas with rye grass to 0.05 m/s; 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 velocity is also set to 0.002 m/s where grid points are over the poultry housing or ranging areas and 0.015 m/s over heavily grazed grassland.

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, is used to define a deposition velocity field. The deposition velocities used are provided in Table 4.

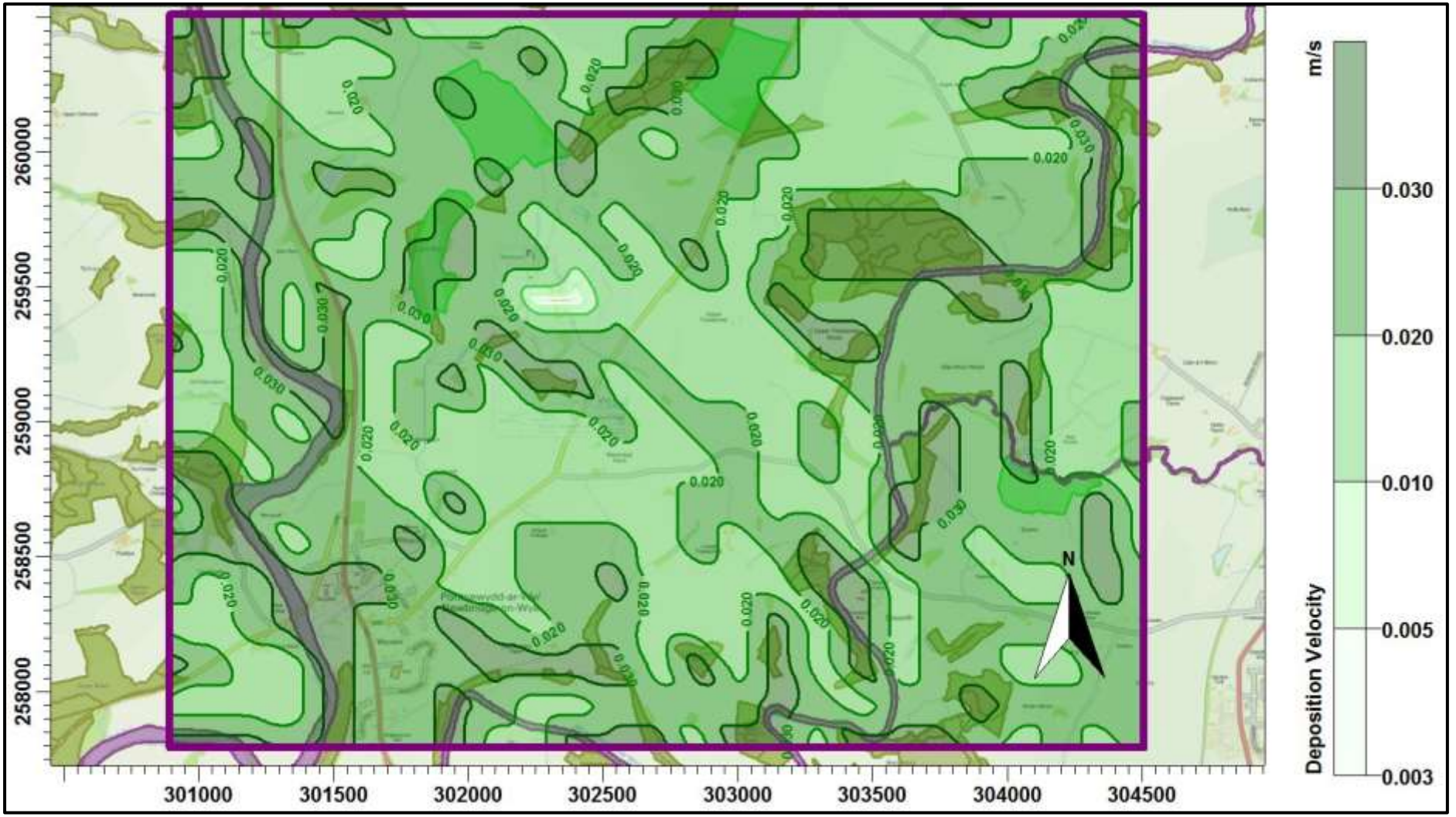
Table 4. Deposition velocities

NH3 concentration (PC + background) ($\mu g/m^3$)	< 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	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 fields 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-four 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 – Sennybridge data
- In basic mode without calms, or terrain – Shobdon 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 (20% of Critical Level or Load for a SAC/SPA, 50% of Critical Level or Load for a 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 (4% and 20% for a SAC/SPA, 20% and 50% for a SSSI and 50%[1] 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.

1. The pre-February 2016 value is used.

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

Receptor number	X(m)	Y(m)	Name	Maximum annual mean ammonia concentration (µg/m^3)					
				GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	Sennybridge No Calms No terrain	Shobdon No Calms No terrain	Trawscoed No Calms No terrain
1	302183	259325	Un-named	**0.538**	**0.533**	**0.736**	**0.649**	**0.676**	0.207
2	302049	259265	Un-named	0.250	0.248	0.323	0.267	0.335	0.092
3	302251	259190	Un-named	0.225	0.223	0.225	0.416	0.276	0.073
4	302367	259146	Un-named	0.149	0.148	0.173	0.177	0.204	0.078
5	302272	259090	Un-named	0.141	0.139	0.130	0.234	0.176	0.048
6	301902	259346	Un-named	0.199	0.197	0.188	0.121	0.270	0.111
7	302127	259785	Un-named	0.149	0.147	0.121	0.125	0.130	0.370
8	301787	259695	Un-named	0.090	0.088	0.083	0.051	0.075	0.126
9	302415	259977	Dyfnant Wood	0.174	0.171	0.181	0.190	0.119	0.233
10	302719	260202	Dyfnant Wood	0.094	0.092	0.114	0.116	0.062	0.071
11	303012	260033	Un-named	0.103	0.101	0.163	0.136	0.080	0.057
12	303121	259454	Lletty Wood	0.138	0.136	0.116	0.066	0.154	0.099
13	303223	259781	Lletty Wood	0.107	0.105	0.117	0.087	0.102	0.069
14	303275	259229	Upper Trawscoed wood	0.091	0.089	0.074	0.039	0.108	0.088
15	303335	258996	Upper Trawscoed wood	0.062	0.061	0.054	0.031	0.086	0.079
16	303215	258500	Berth-lwyd Wood	0.041	0.041	0.087	0.031	0.054	0.041
17	302501	258323	Long Wood	0.030	0.029	0.056	0.031	0.031	0.014
18	301555	259066	Merryhall Plantation	0.069	0.068	0.080	0.058	0.104	0.023
19	301154	258957	Dol wood	0.043	0.043	0.033	0.030	0.070	0.015
20	301045	259753	Un-named	0.032	0.032	0.029	0.017	0.032	0.041
21	301867	260590	Dol-y-fan Wood	0.031	0.031	0.037	0.042	0.026	0.094
22	302236	260559	Un-named	0.052	0.051	0.049	0.077	0.038	0.115
23	302797	261105	Un-named	0.030	0.030	0.025	0.047	0.027	0.039
24	303073	260642	Dyfnant Wood	0.044	0.043	0.062	0.060	0.032	0.033
25	303473	261016	Un-named	0.027	0.027	0.046	0.040	0.022	0.022
26	303822	260127	Lletty Cottage Covert	0.044	0.043	0.059	0.045	0.047	0.032
27	303827	259602	Lletty Wood	0.054	0.053	0.045	0.032	0.072	0.036
28	304071	259118	Un-named	0.040	0.039	0.022	0.023	0.058	0.040
29	303655	258827	Pen-y-rhiw Wood	0.042	0.041	0.032	0.024	0.065	0.055
30	303115	258125	Un-named	0.026	0.026	0.103	0.023	0.031	0.022
31	302808	257683	Long Wood	0.020	0.020	0.040	0.019	0.018	0.010
32	302043	258053	Dol-Ttylchau Wood	0.027	0.027	0.027	0.050	0.029	0.009
33	301539	258068	The Scaur	0.027	0.027	0.048	0.044	0.028	0.007
34	300868	258630	Garden Wood	0.026	0.026	0.040	0.025	0.044	0.010
35	300915	259332	Cefn-y-maes Wood	0.037	0.037	0.026	0.019	0.053	0.026
36	300931	260340	Un-named	0.023	0.023	0.024	0.010	0.020	0.038
37	301160	260829	Dol-y-fan Wood	0.016	0.016	0.019	0.011	0.015	0.043
38	301950	259511	Aberithon & Bedw	0.197	0.195	0.169	0.112	0.195	**0.222**
39	301844	259386	Aberithon & Bedw	0.165	0.163	0.153	0.088	**0.213**	0.113
40	301930	259811	Aberithon & Bedw	0.097	0.095	0.069	0.055	0.082	0.169
41	302106	259907	Rhos Dwfnant	0.103	0.102	0.089	0.100	0.087	**0.272**
42	302323	259993	Rhos Dwfnant	0.144	0.142	0.150	0.178	0.108	**0.277**
43	301991	260242	Rhos Dwfnant	0.050	0.049	0.054	0.058	0.041	0.141
44	302837	260217	Dwfnant Pastures	0.085	0.083	0.120	0.111	0.056	0.056
45	303003	260095	Dwfnant Pastures	0.094	0.093	0.152	0.126	0.071	0.053
46	303080	260412	Dwfnant Pastures	0.055	0.054	0.093	0.078	0.041	0.037
47	303988	258785	Rhos Penrhiw	0.034	0.034	0.021	0.020	0.055	0.043
48	301516	257494	Aberithon & Bedw	0.018	0.018	0.025	0.037	0.020	0.005
49	305736	259564	Pentrosfa Mire	0.017	0.016	0.008	0.015	0.032	0.014
50	306328	260292	Lake Wood	0.012	0.012	0.007	0.014	0.023	0.010
51	306540	261681	Llanfawr Quarries	0.009	0.009	0.013	0.012	0.013	0.008
52	305448	262350	Crebtree Green Meadow	0.010	0.010	0.023	0.015	0.011	0.008
53	304601	263146	Gweunydd coch-y-dwst	0.008	0.008	0.012	0.014	0.009	0.009
54	305338	263230	Moorlands Pastures	0.007	0.007	0.017	0.012	0.008	0.008
55	304000	255711	Neuadd & Tylelo Mires	0.009	0.009	0.013	0.011	0.009	0.006
56	303465	255916	Neuadd & Tylelo Mires	0.010	0.010	0.012	0.011	0.008	0.006
57	301654	255642	Cors-yLlyn	0.009	0.008	0.006	0.019	0.009	0.004
58	301504	255044	Cors-yLlyn	0.007	0.007	0.005	0.017	0.008	0.003

Table 5. (continued)

Receptor number	X(m)	Y(m)	Name	Maximum annual mean ammonia concentration ($\mu g/m^3$)					
				GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	Sennybridge No Calms No terrain	Shobdon No Calms No terrain	Trawscoed No Calms No terrain
59	301528	259108	River Wye SAC	**0.072**	**0.072**	**0.074**	**0.053**	**0.109**	0.026
60	301203	259401	River Wye SAC	**0.048**	**0.047**	**0.040**	0.024	**0.064**	0.038
61	301253	259880	River Wye SAC	0.036	0.035	0.036	0.018	0.032	**0.052**
62	301178	258688	River Wye SAC	0.032	0.031	**0.041**	0.034	**0.050**	0.011
63	301396	258260	River Wye SAC	0.028	0.028	**0.054**	0.039	0.034	0.007
64	301337	257690	River Wye SAC	0.021	0.020	0.035	0.035	0.022	0.006
65	300934	260685	River Wye SAC	0.018	0.017	0.020	0.009	0.016	0.036
66	301950	257958	River Wye SAC	0.026	0.026	0.029	**0.050**	0.028	0.008
67	302579	257748	River Wye SAC	0.020	0.019	0.032	0.023	0.019	0.009
68	303108	257916	River Wye SAC	0.023	0.023	**0.080**	0.020	0.024	0.016
69	303343	258403	River Wye SAC	0.036	0.035	**0.077**	0.028	**0.049**	0.036
70	303519	258999	River Wye SAC	**0.055**	**0.054**	**0.045**	0.026	**0.076**	**0.066**
71	303620	259494	River Wye SAC	**0.067**	**0.065**	**0.055**	0.037	**0.087**	**0.047**
72	304006	258957	River Wye SAC	0.038	0.038	0.021	0.022	**0.057**	**0.044**
73	304912	258898	River Wye SAC	0.023	0.023	0.011	0.017	0.039	0.025
74	305550	258571	River Wye SAC	0.017	0.016	0.009	0.014	0.030	0.020
75	304207	260215	River Wye SAC	0.032	0.032	**0.042**	0.033	0.038	0.025
76	304962	260752	River Wye SAC	0.018	0.018	0.027	0.022	0.022	0.015
77	300590	261499	River Wye SAC	0.010	0.010	0.013	0.008	0.010	0.029
78	300716	257824	River Wye SAC	0.016	0.016	0.025	0.021	0.025	0.005
79	300909	257102	River Wye SAC	0.015	0.014	0.025	0.024	0.016	0.004
80	301648	256884	River Wye SAC	0.014	0.014	0.016	0.030	0.015	0.005
81	300849	255574	River Wye SAC	0.008	0.008	0.011	0.019	0.010	0.003
82	299387	256941	River Wye SAC	0.009	0.009	0.021	0.010	0.016	0.004
83	297624	257706	River Wye SAC	0.009	0.008	0.004	0.005	0.017	0.003
84	300152	254905	River Wye SAC	0.007	0.007	0.011	0.015	0.008	0.003
85	303459	255001	River Wye SAC	0.008	0.007	0.007	0.010	0.006	0.004
86	304894	255766	River Wye SAC	0.008	0.008	0.016	0.011	0.012	0.008
87	306069	256791	River Wye SAC	0.010	0.010	0.014	0.011	0.018	0.013
88	306301	258294	River Wye SAC	0.013	0.012	0.007	0.011	0.024	0.016
89	305249	261819	River Wye SAC	0.012	0.012	0.025	0.017	0.014	0.009
90	305877	262953	River Wye SAC	0.008	0.008	0.019	0.012	0.009	0.007
91	299797	262229	River Wye SAC	0.007	0.007	0.007	0.005	0.007	0.020
92	298635	262885	River Wye SAC	0.005	0.005	0.003	0.003	0.005	0.014
93	296687	265740	River Wye SAC	0.003	0.003	0.002	0.002	0.003	0.009
94	295273	264013	Elan Valley Woodlands	0.003	0.003	0.001	0.002	0.004	0.008
95	295457	261840	Elenydd	0.004	0.004	0.001	0.002	0.005	0.007
96	295954	257416	River Wye SAC	0.006	0.006	0.002	0.003	0.013	0.003
97	297865	254956	River Wye SAC	0.005	0.005	0.011	0.007	0.009	0.002
98	294593	254458	River Wye SAC	0.003	0.003	0.003	0.003	0.007	0.002
99	300221	252495	River Wye SAC	0.004	0.004	0.006	0.011	0.005	0.002
100	303467	251631	River Wye SAC	0.004	0.004	0.003	0.007	0.003	0.002
101	299409	250349	River Wye SAC	0.003	0.003	0.005	0.008	0.004	0.002
102	306608	250846	River Wye SAC	0.003	0.003	0.004	0.005	0.004	0.003
103	307262	255846	River Wye SAC	0.007	0.007	0.008	0.009	0.013	0.009
104	308806	254092	River Wye SAC	0.005	0.005	0.004	0.007	0.009	0.005
105	307341	264274	River Wye SAC	0.005	0.005	0.012	0.008	0.006	0.005
106	308361	261395	River Wye SAC	0.006	0.006	0.004	0.009	0.012	0.006
107	310665	262180	River Wye SAC	0.004	0.004	0.032	0.006	0.008	0.004
108	308414	265923	River Wye SAC	0.003	0.003	0.009	0.005	0.005	0.004
109	304592	265426	River Wye SAC	0.005	0.005	0.004	0.010	0.006	0.008
110	302053	266211	River Wye SAC	0.006	0.006	0.004	0.013	0.005	0.016
111	297812	267285	River Wye SAC	0.003	0.003	0.002	0.004	0.002	0.010
112	293912	263620	Elan Valley Woodlands	0.003	0.002	0.001	0.002	0.003	0.006
113	293022	259432	Elenydd	0.004	0.004	0.001	0.001	0.007	0.003
114	293378	262359	Elenydd	0.003	0.003	0.001	0.001	0.004	0.005
115	296769	264952	Elenydd Mallaen	0.003	0.003	0.003	0.002	0.003	0.009
116	294282	264796	Elenydd Mallaen	0.002	0.002	0.001	0.002	0.003	0.006

5.2 Detailed deposition modelling

The detailed modelling was carried out over a restricted domain covering the poultry house and closer parts of the River Wye SAC; the area where the preliminary modelling indicated that annual mean ammonia concentrations could potentially exceed 4% of the Critical Level of 1.0 µg/m^3. At other AWs, SSSIs, SACs and the SPA the preliminary modelling indicated that ammonia levels (and nitrogen deposition rates) would be at levels that would be deemed insignificant, for permitting purposes.

Spatially varying deposition and terrain cannot be modelled in conjunction with the calms module of ADMS. In this case, the preliminary modelling suggests that the effect of calms is insignificant. Therefore, the deposition runs were made without calms and with terrain. The model was run four times, once for each year of the meteorological record.

The results of the predicted annual mean ground level ammonia concentrations at the discrete receptors within the restricted modelling domain are shown in Table 6. In the Table, predicted ammonia concentrations that are in excess of the Environment Agency's upper threshold (100% of Critical Level or Load for a non-statutory wildlife site) are coloured red. Concentrations that are between the Environment Agency's lower and upper thresholds (50% [1] and 100% for a non-statutory wildlife site) are coloured blue. The abbreviations PC, Cle and Clo, used in the tables means Process Contribution, Critical Level and Critical Load, respectively.

Where receptors at both ground level and 7.5 m are defined, the nitrogen deposition rate is calculated assuming that 50% of deposition occurs near ground level and 50% at canopy level.

A contour plot of the predicted ground level maximum annual mean ammonia concentration is shown in Figure 6a and a contour plot of the maximum nitrogen deposition rate is shown in Figure 6b.

1. The pre-February 2016 value for the lower threshold is used for non-statutory sites.

Table 6. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors – detailed deposition modelling

Receptor number	X(m)	Y(m)	Maximum annual mean ammonia concentration at ground level			Maximum annual deposition rate			
			PC ($\mu g/m^3$)	Critical Level ($\mu g/m^3$)	%age of Cle	Deposition Velocity (m/s)	PC (kg/ha)	Critical Level (kg/ha)	%age of Clo
59	301528	259108	0.063	1.0	**6.3**	0.03	0.49	10.0	**4.9**
60	301203	259401	0.038	1.0	3.8	0.03	0.29	10.0	2.9
61	301253	259880	0.026	1.0	2.6	0.03	0.20	10.0	2.0
62	301178	258688	0.033	1.0	3.3	0.03	0.26	10.0	2.6
63	301396	258260	0.035	1.0	3.5	0.03	0.27	10.0	2.7
66	301950	257958	0.014	1.0	1.4	0.03	0.11	10.0	1.1
68	303108	257916	0.022	1.0	2.2	0.03	0.17	10.0	1.7
69	303343	258403	0.058	1.0	**5.8**	0.03	0.45	10.0	**4.5**
70	303519	258999	0.044	1.0	**4.4**	0.03	0.34	10.0	3.4
71	303620	259494	0.060	1.0	**6.0**	0.03	0.47	10.0	**4.7**
75	304207	260215	0.031	1.0	3.1	0.03	0.24	10.0	2.4

Figure 6a. Maximum annual ammonia concentration

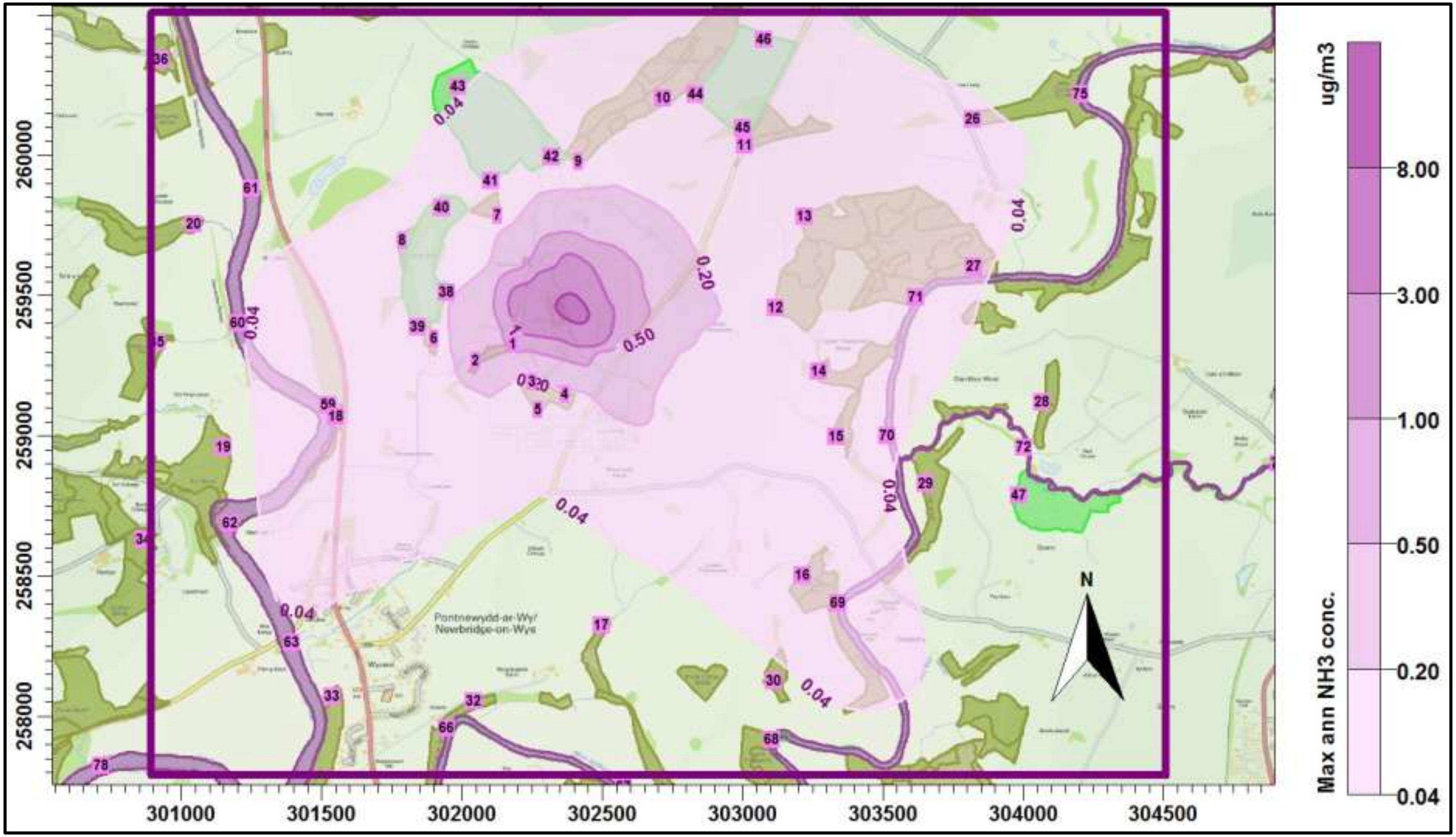


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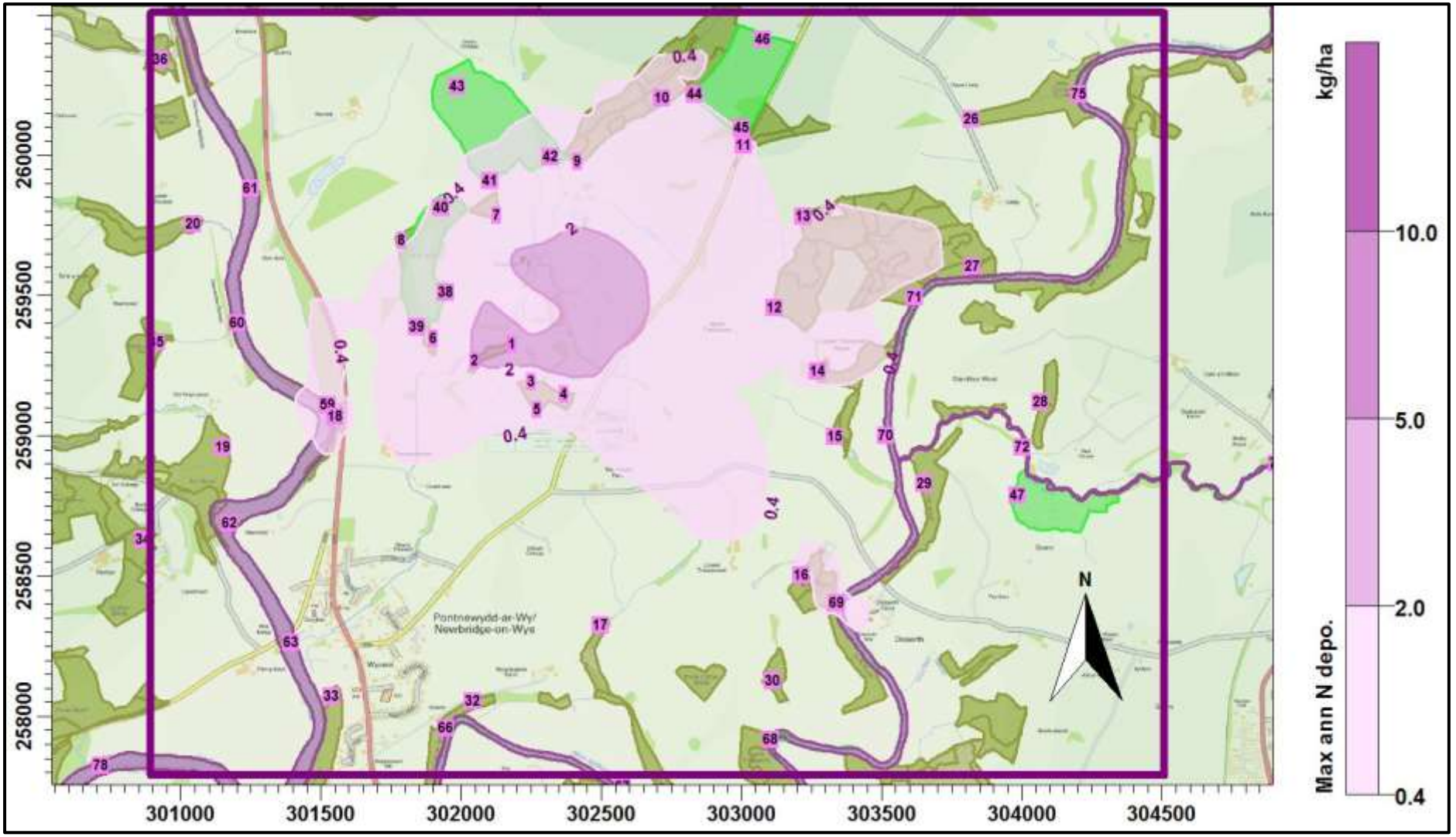
Figure 6b. Maximum annual nitrogen deposition rate



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Steve Raasch, on behalf of the applicant Raymond Powell, to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at Penpound, near Newbridge-on-Wye, Powys. LD1 6HR.

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.

At all sites designated as AWs, the process contributions to annual mean ammonia level and the annual nitrogen deposition rate are predicted to be at levels below the Environment Agency's lower threshold percentage of Critical Level or Load for an AW (100%).

At all sites designated as SSSIs, the process contributions to annual mean ammonia level and the annual nitrogen deposition rate are predicted to be at levels below the Environment Agency's lower threshold percentage of Critical Level or Load for a SSSI (20%).

There are small predicted exceedances of 4% of both the Critical Level of 1.0 µg-NH_3/m^3 and the Critical Load of 10 kg/ha/y over parts of the River Wye SAC to the west and east of the site of the proposed poultry houses. The predicted exceedances of 4% of the Critical level of 1.0 µg-NH_3/m^3, which provides the strictest test, extend along approximately 1.5 km of the River Ithon to the east and approximately 0.5 km of the River Wye to the west.

There are no predicted exceedances of 20% of any Critical Level or Critical Load at the River Wye SAC and AS Modelling & Data Ltd. have not identified any intensive animal rearing operations that are likely to act in-combination with the proposed poultry unit at Penpound (at levels above Environment Agency threshold values).

At other part of the River Wye SAC, other SACs and the SPA, the process contributions to annual mean ammonia level and the annual nitrogen deposition rate are predicted to be at levels below the Environment Agency's lower threshold percentage of Critical Level or Load for SACs (4%).

7. References

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