A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Free Range Egg Laying Chicken Houses at Cwm Farm, near Bwlch-y-ffridd in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Gail Lewis of Roger Parry & Partners LLP, on behalf of the applicant Mr Duncan Davies, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at Cwm Farm, near Bwlch-y-ffridd in Powys. SY16 3JD.

Ammonia emission rates from the existing and 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 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.

2. Background Details

The site of the existing and proposed free range chicken houses at Cwm Farm is in a rural area, approximately 690 m to the east of the village of Bwlch-y-ffridd in Powys. The surrounding land is used largely for arable farming and grazing, there is also another poultry rearing unit and wooded areas nearby. The site is at an altitude of around 190 m with the land rising towards hills to the north and falling towards valleys to the south and west.

There is currently one existing poultry house at Cwm Farm, which provide accommodation for up to 32,000 free range egg laying chickens. Under the proposal a new proposed building would be built to the south of the existing poultry house. The proposed poultry unit would provide accommodation for an additional 32,000 free range chickens. The existing and proposed poultry houses are/would be ventilated by high speed roof fans each with a small chimney.

There are several areas of Ancient Woodlands (AWs) within 2 km of the site of Cwm Farm. There are also four Sites of Special Scientific Interest (SSSIs) within 5 km; namely Gregynog SSSI, Gweunydd Penstrowed SSSI, Llyn Mawr SSSI and Penstrowed Quarry SSSI, which is a geological designation. Parts of the Montgomery Canal Special Area of Conservation (SAC) also lie within 10 km of the farm, but there are no other internationally designated wildlife sites within 10 km.

A broad scale view map of the surrounding area showing the positions of the existing and proposed poultry houses and the nearby wildlife sites are provided in Figure 1a. A closer view of the AWs is provided in Figure 1b. In these figures, the AWs are outlined in olive, the SSSIs are shaded green, the SAC is shaded purple and the site of the poultry houses is outlined in blue.

Figure 1a. The area surrounding the site, a broad view – concentric circles radii at 2 km (olive), 5 km (green) and 10 km (purple)

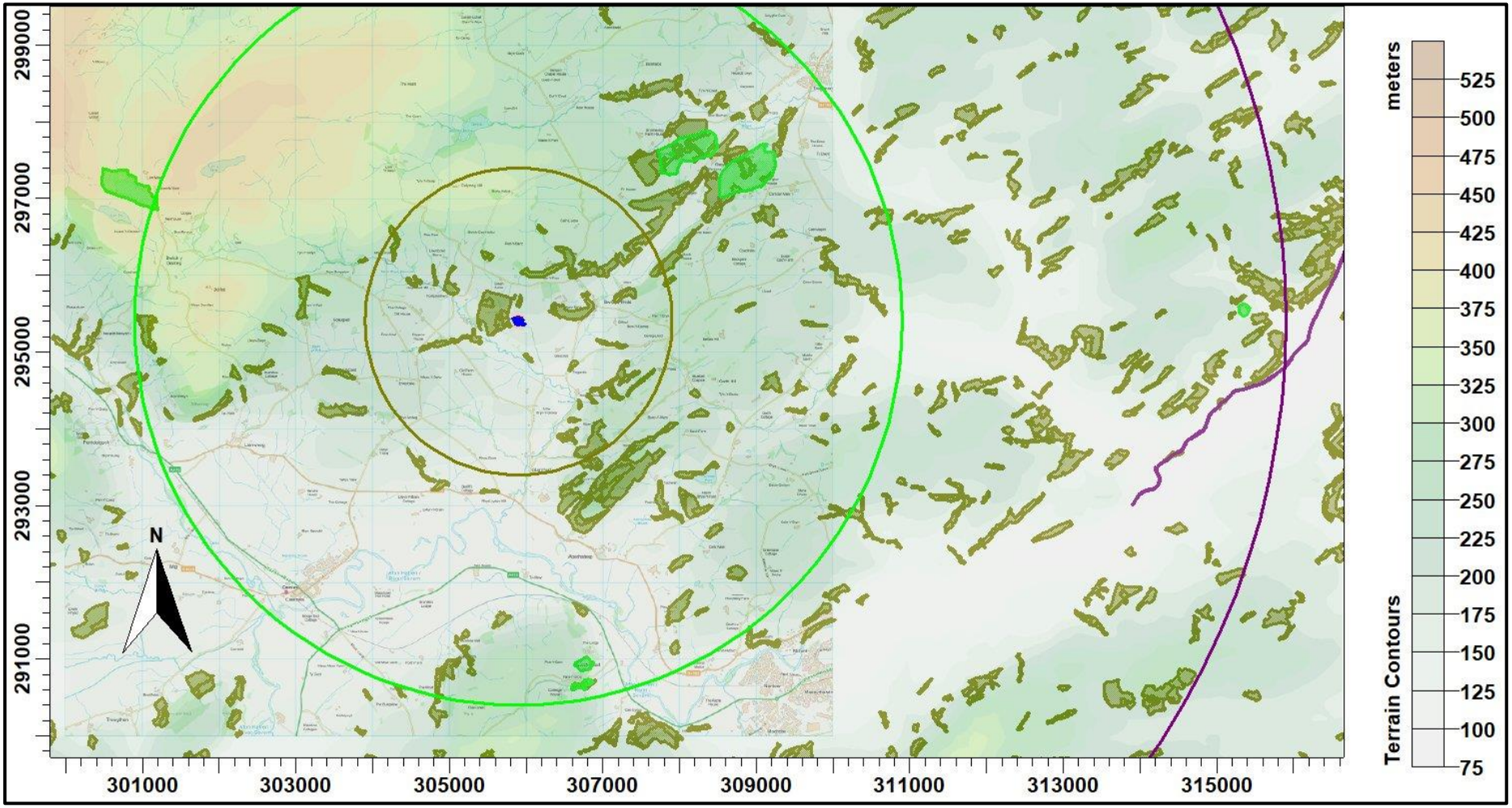
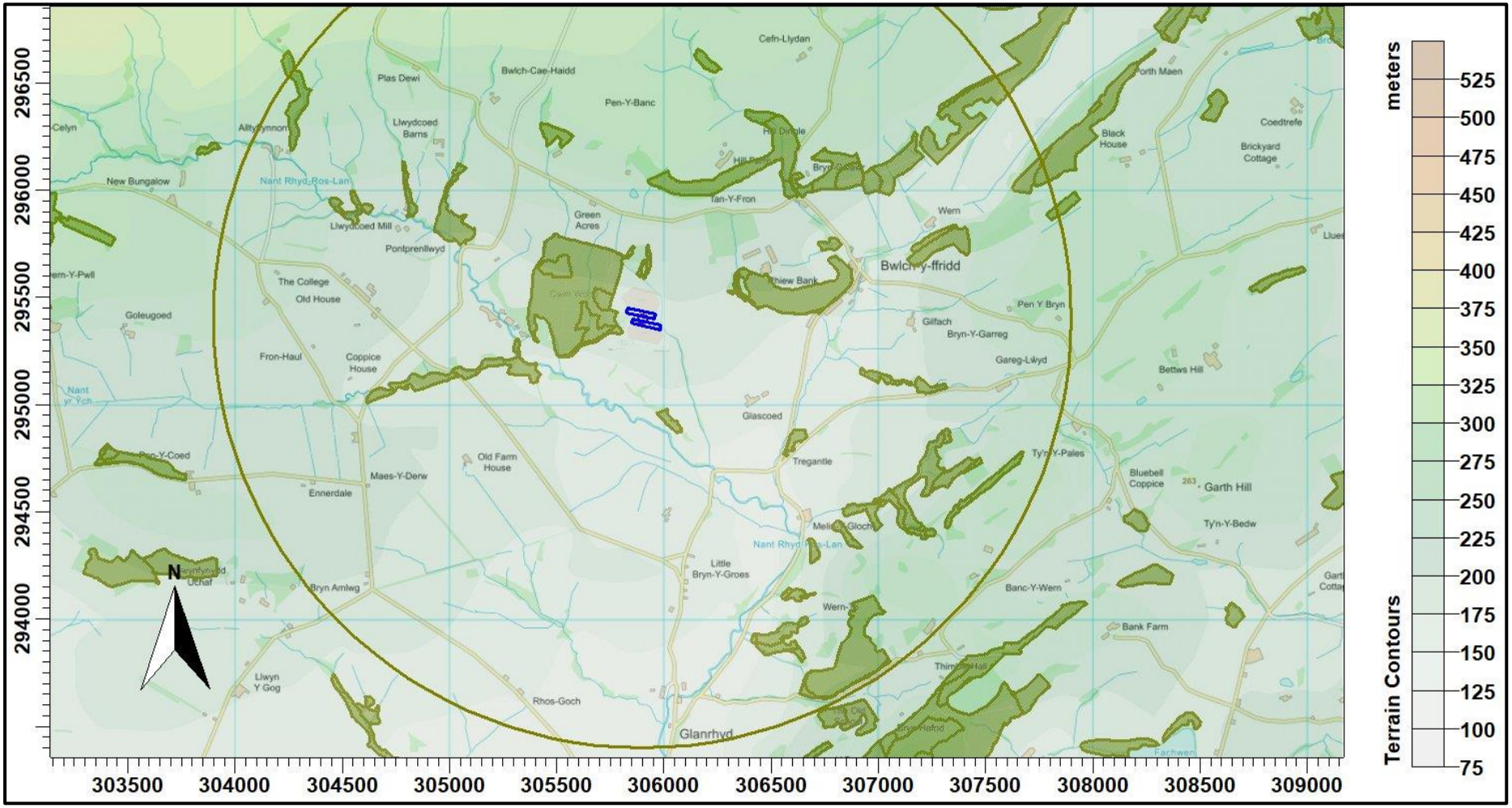


Figure 1b. The area surrounding the site, a closer view



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 (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). Acid deposition is expressed in terms of kilograms equivalent (of H^+ ions) per hectare per year (keq/ha/y).

3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around the site of the proposed poultry unit and the wildlife sites is 1.12 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 24.5 kg-N/ha/y and to short vegetation is 14.98 kg-N/ha/y. The background acid deposition rate to woodland is 1.88 keq/ha/y and to short vegetation is 1.18 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, July 2017).

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. However, it may be necessary to consider nitrogen deposition should a Critical Load of 5.0 kg-N/ha/y be appropriate. 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]	-	-
Gregynog SSSI & Llyn Mawr SSSI	1.0 [1]	-	-
Gweunydd Penstrowe SSSI	3.0 [2]	10.0 [2]	-
Penstrowed Quarry SSSI	-	-	-
Mongomeray Canal SAC (bankside vegetation)	3.0 [2]	10.0 [2]	-
Mongomeray Canal SAC (aquatic vegetation)	3.0 [2]	3.0 [2 & 3]	-

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to sensitive lichens and/or bryophytes.
2. Based upon the citation for the site and information from APIS.
3. The Critical Load for Floating water-plantain, *luronium natans (*N.B. a deposition velocity of 0.005 m/s is assumed*).*

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 provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For free-range egg laying chickens, in an aviary system, where manure is removed frequently using a belt system, the Environment Agency figure is 0.08 kg-NH_3/bird place/year.

As the birds in the new egg laying chicken house would have access to outdoor ranging areas, some of the birds' droppings, which is the source of the ammonia, would be deposited on these ranging areas. For modelling purposes, it is assumed that 20% of the droppings are deposited on the ranging areas; this assumption is based upon Environment Agency guidance. To estimate the ammonia emissions from the ranges, it has been assumed that laying hens produce 0.8 kg-N/y (Misselbrook) in their droppings and that 20% of ammoniacal nitrogen is emitted as ammonia (typically 40% to 50% is emitted as ammonia from stored manure, but this has been reduced to allow for mineralisation and leaching due to the contact with mineral soils). This equates to an emission factor of 0.194 kg-NH_3/bird/y, which is rounded up to 0.2 kg-NH_3/bird/y for use in the emission calculations.

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 ($kg\text{-}NH_3/place/y$)	Emission rate ($g\text{-}NH_3/s$)
Housing	64,000 (x 0.8)	Egg laying chickens, aviary system. Manure removal twice a week by belt.	0.08 (EA figure)	0.129794
Ranges	64,000 (x 0.2)	Ranging areas	0.20 (AS Modelling & Data figure)	0.081122

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). Observational meteorological data from Trawscoed and Lake Vyrnwy are also considered.

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 wind rose for the raw GFS data at the site of Cwm Farm is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the location at the existing and proposed poultry houses at Cwm Farm is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ more, or less, markedly and that the resolution of the wind field in terrain runs is approximately 650 m in the preliminary modelling, 200 m in the high resolution detailed deposition modelling and 600 m in the low resolution detailed modelling.

Data from the meteorological recording station at Lake Vyrnwy, the closest station to the site at Cwm Farm, and Trawscoed have also been considered. However, neither Lake Vyrnwy nor Trawscoed can be considered to have an aspect that in any way could be considered similar to that at Cwm Farm; therefore, it should be noted that the frequency of winds from a particular direction in the Trawscoed

or Lake Vyrnwy data may be either high or low in comparison to what might occur at Cwm Farm, 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, are less likely to have gross errors than the results obtained using the observational data and should be given more weight when interpreting the results of the modelling. The wind roses for Trawscoed and Lake Vyrnwy are shown in Figure 2c and 2d, respectively.

Figure 2a. The wind rose. Raw GFS derived data, for 52.548 N, 3.388 W, 2013-2016

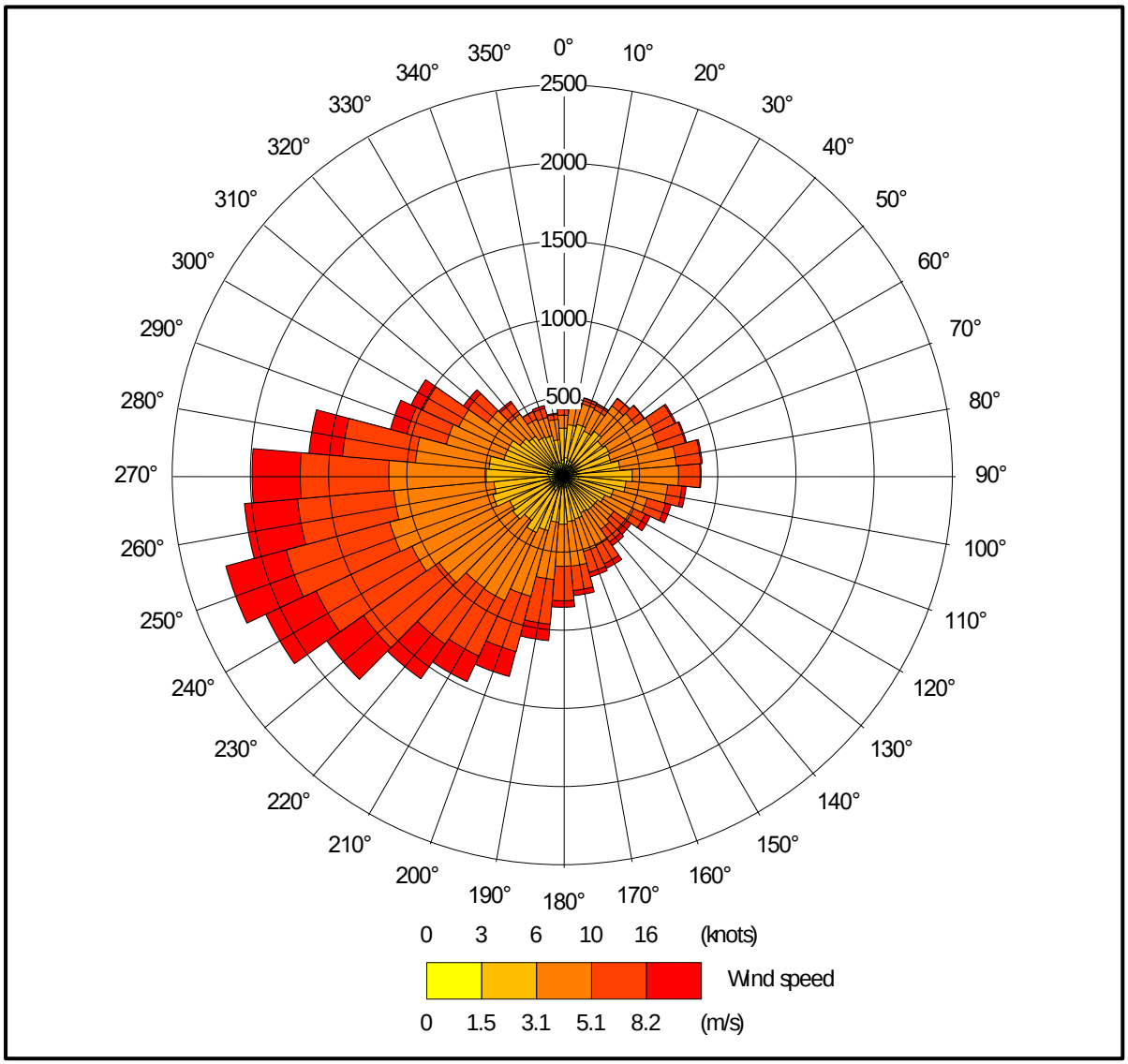


Figure 3b. The wind rose. FLOWSTAR modified GFS derived data for NGR 305900, 295400

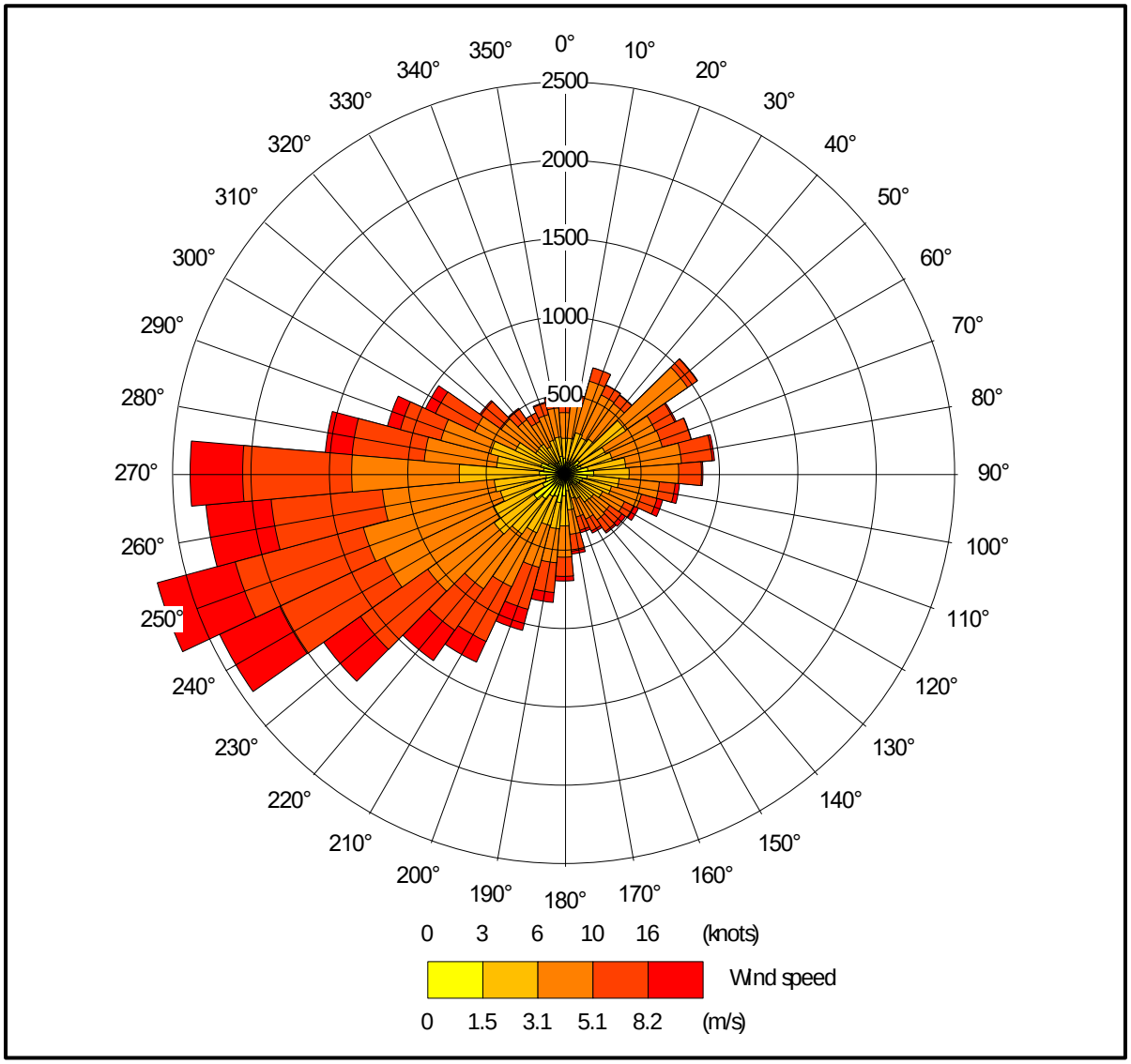


Figure 2c. The wind rose. Trawscoed, 2013 – 2016

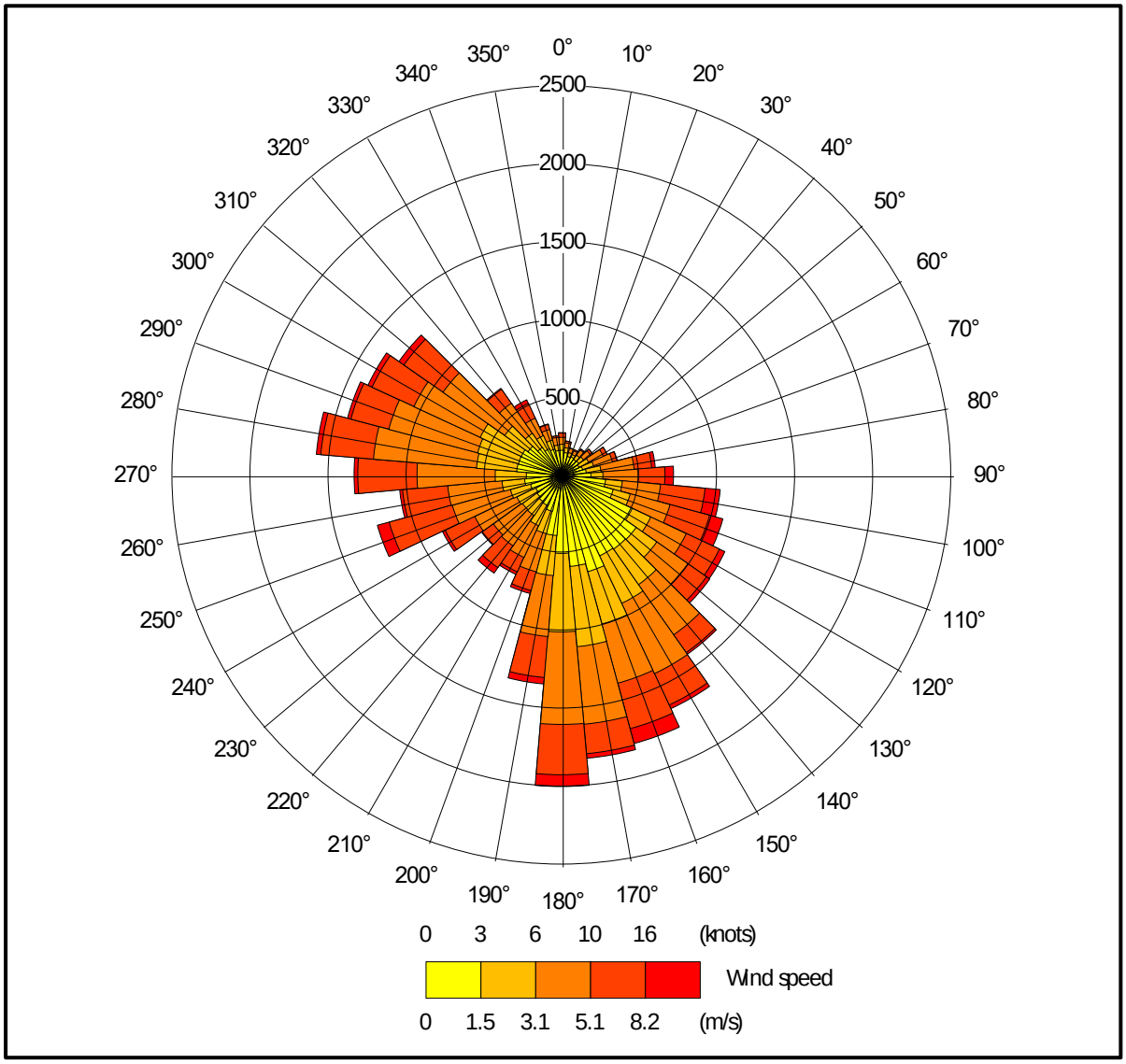
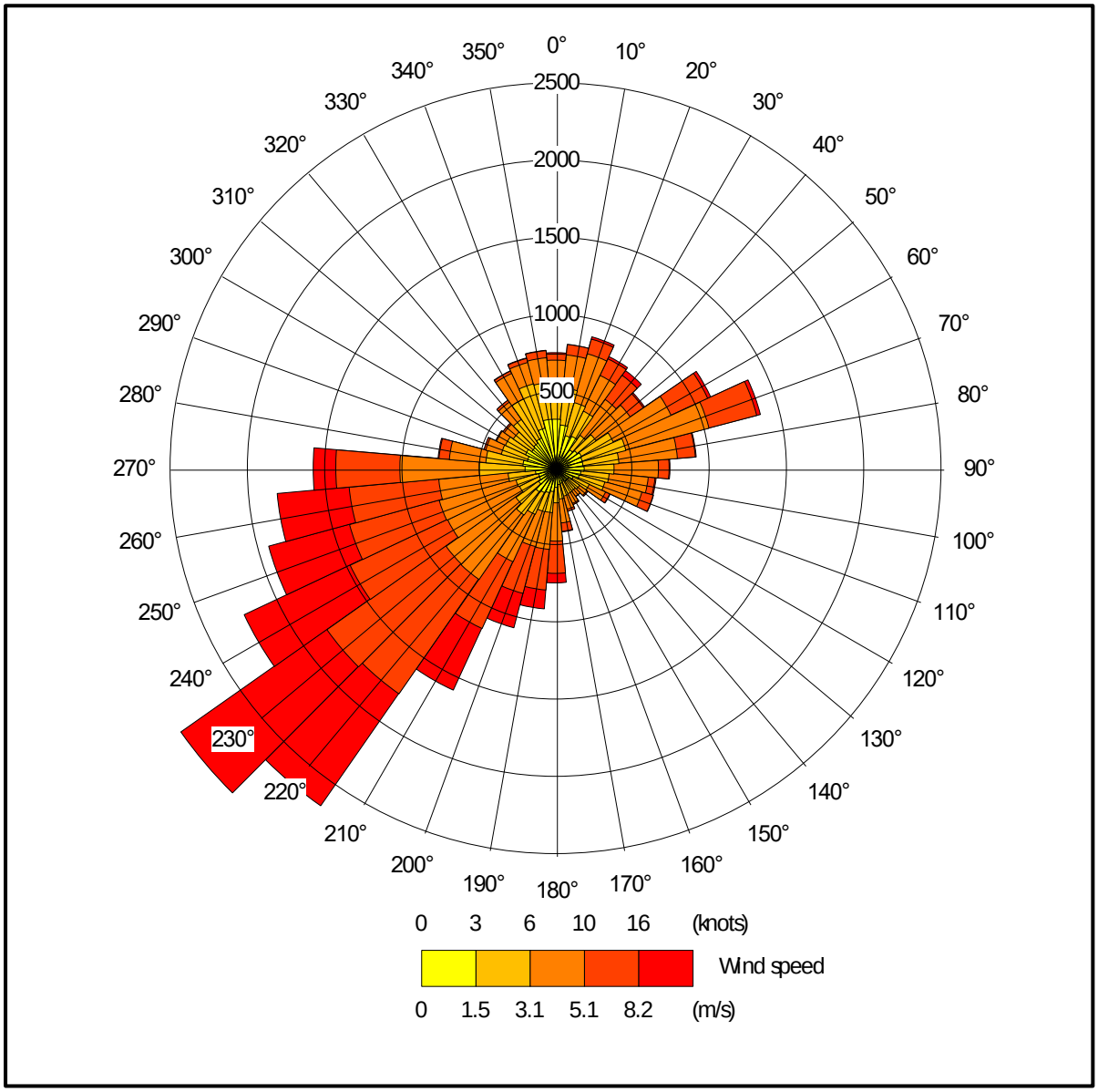


Figure 2d. The wind rose. Trawscoed, 2013 – 2016



4.2 Emission sources

Emissions from the high speed ridge/roof fans that are/would be used to ventilate the existing and proposed poultry houses are represented by three point sources per house within ADMS (EX1 a, b & c and PR1 a, b & c). Details of the point source parameters are shown in Table 3a. The positions of the point sources may be seen in Figure 3, where they are indicated by red star symbols.

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
EX1 a, b & c and PR1 a, b & c	6.0	0.8	11.0	22.0	0.021632

The poultry houses have/would have ranging areas, which are represented by two area sources within ADMS (EX1_ran and PR1_ran). Note that the area sources cover the parts of the ranges most likely to be used frequently and not the whole ranging area.

Details of the area source parameters are provided in Table 3b. The position of the area source is shown in Figure 3.

Table 3b. Area source parameters

Source ID	Area (m^2)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
EX_ran	14756.10	0.0	Ambient	0.040561
PR_ran	10402.41	0.0	Ambient	0.040561

4.3 Modelled buildings

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

4.4 Discrete receptors

Fifty discrete receptors have been defined: forty at the AWs (1 to 40), seven at the SSSIs (41 to 47 and three at the SAC (48 to 50). 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 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 22.0 km x 22.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the preliminary modelling, a 6.4 x 6.4 km domain has been resampled at 50 m horizontal resolution for use within ADMS for the high resolution detailed modelling and a 20 km x 20 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the low resolution detailed modelling. N.B. The resolution of FLOWSTAR is 32 x 32 grid points; therefore, the effective resolution of the wind field is approximately 650 m for the preliminary modelling domain, 200 m for the high resolution detailed modelling domain and approximately 600 m for the low resolution detailed modelling domain.

4.7 Roughness Length

A fixed surface roughness length of 0.375 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 0.350 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of the modelled buildings and sources

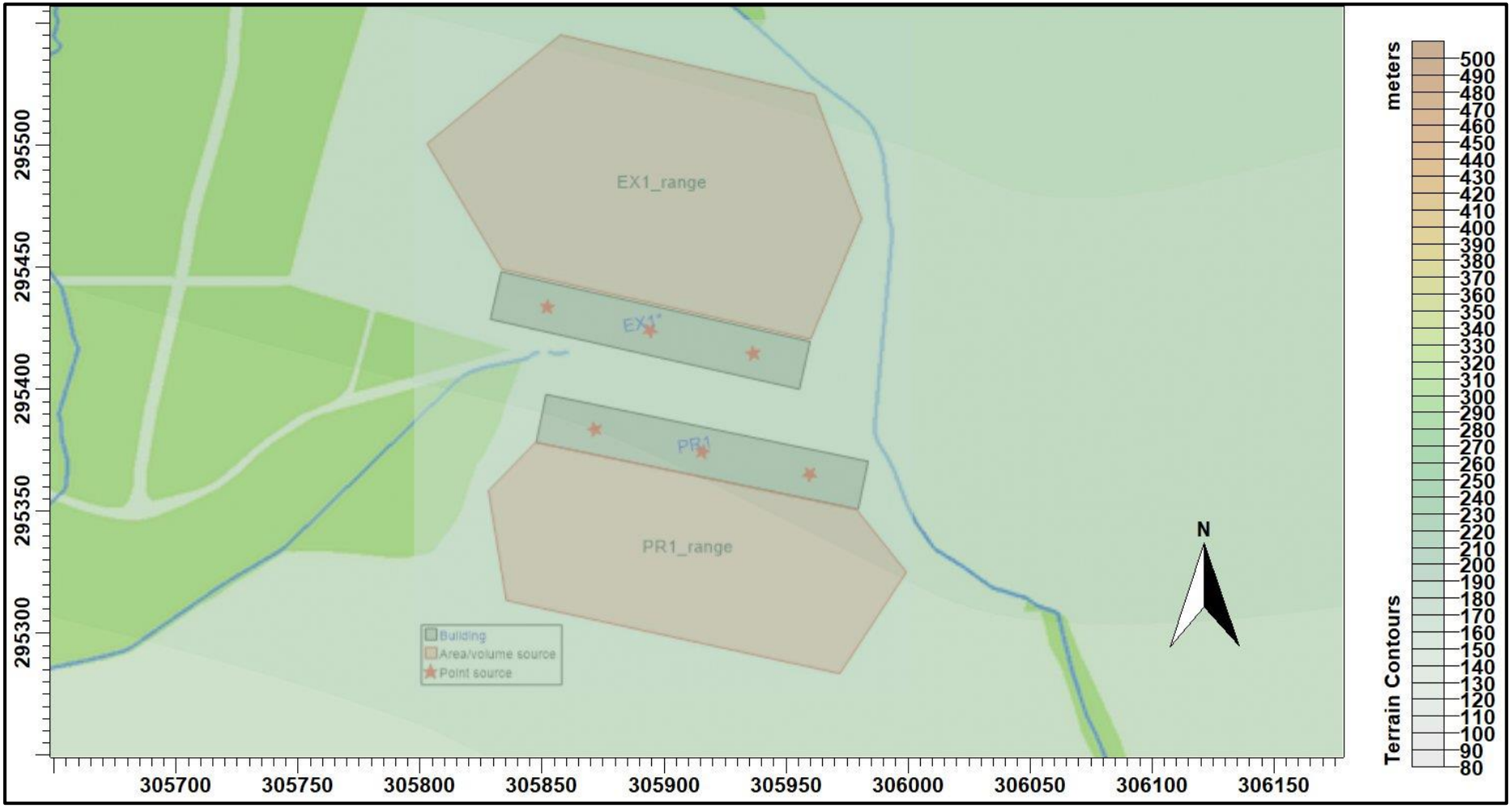


Figure 4a. The discrete receptors with concentric circles radii at 10 km (purple), 5 km (green) and 2 km (olive)

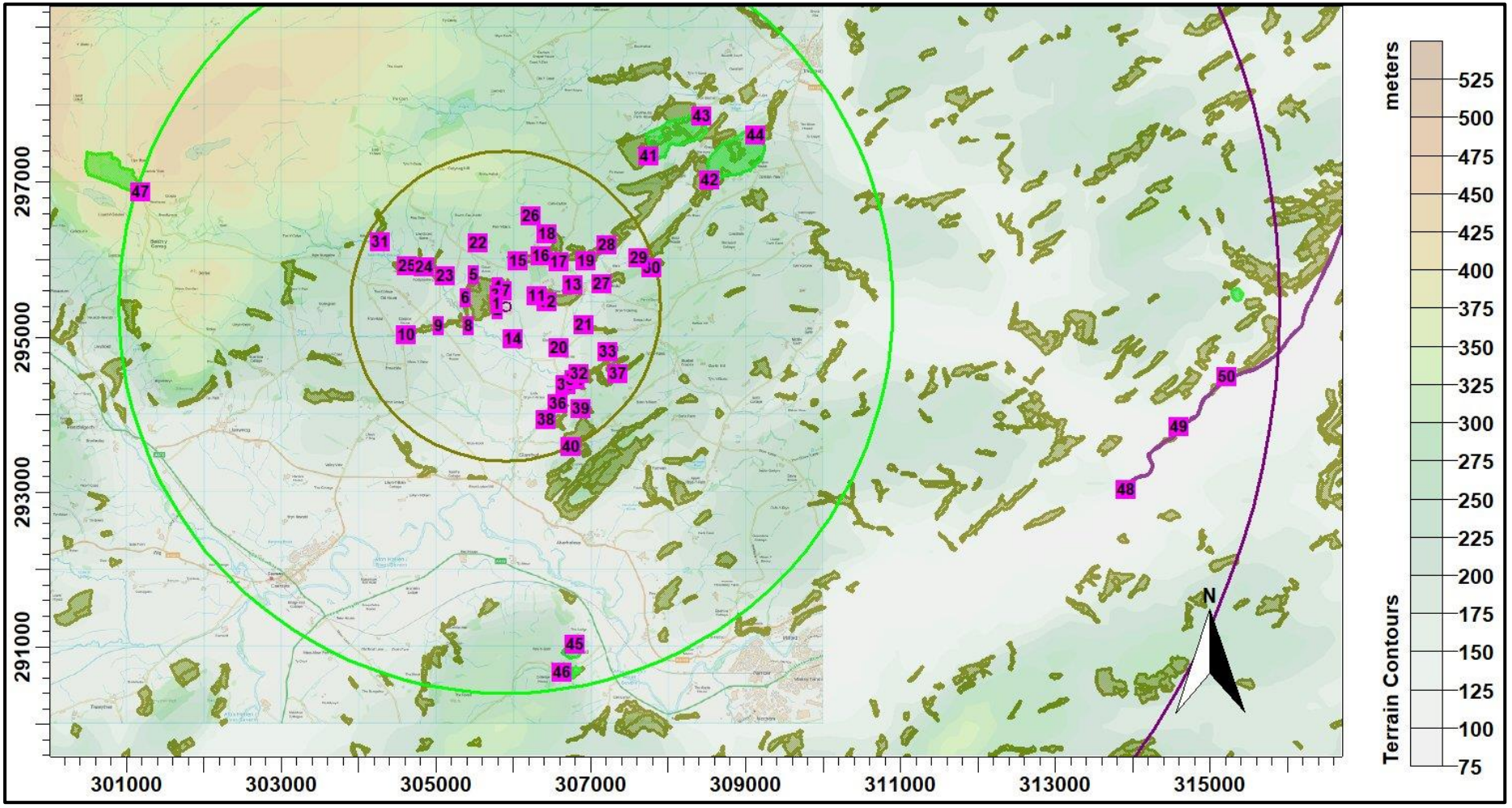
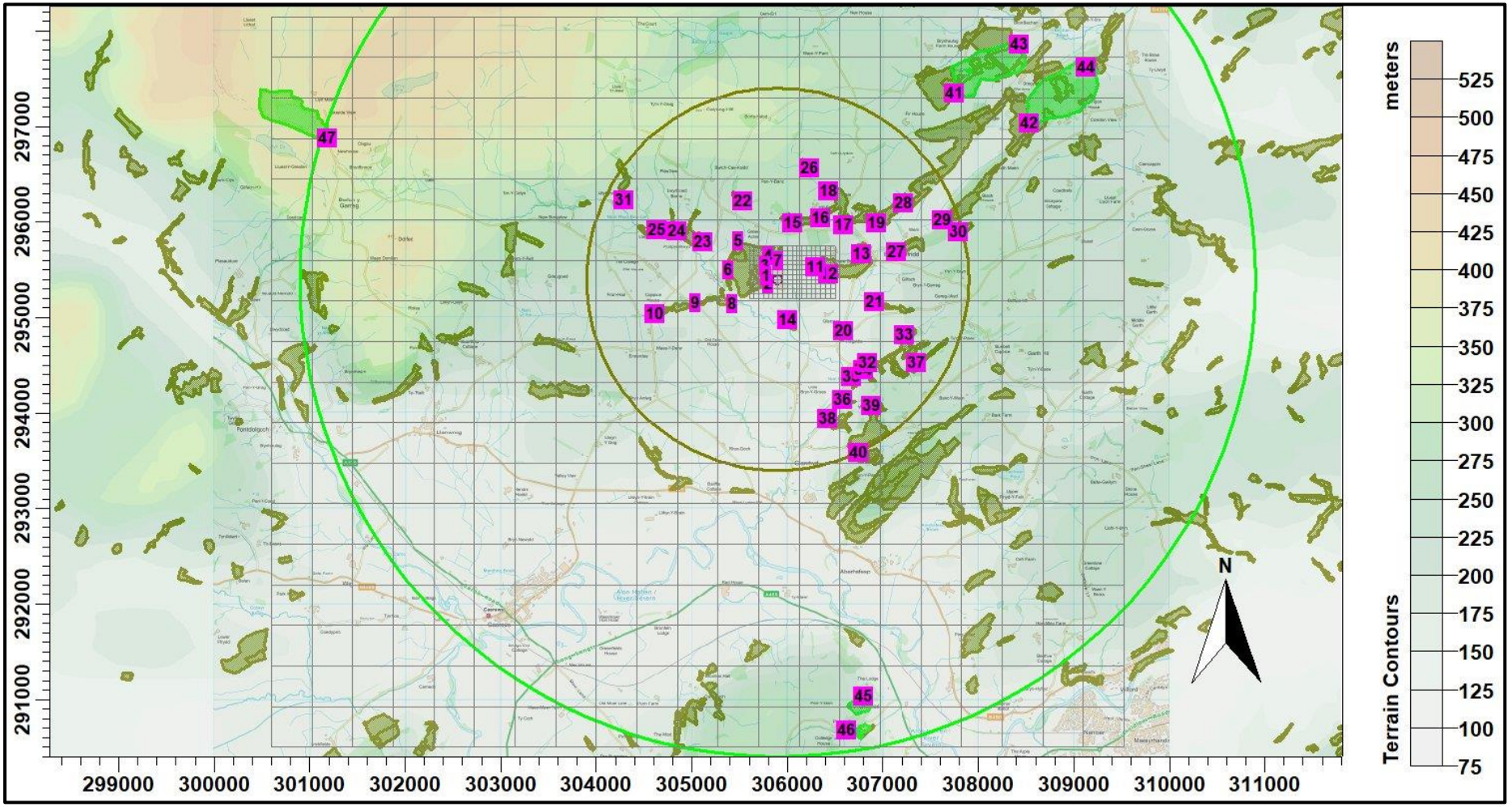


Figure 4b. The discrete receptors and Cartesian grids



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.

Contour plots of the high resolution and low resolution spatially varying deposition fields are provided in Figures 5a and 5b, respectively.

Figure 5a. The spatially varying deposition field – high resolution

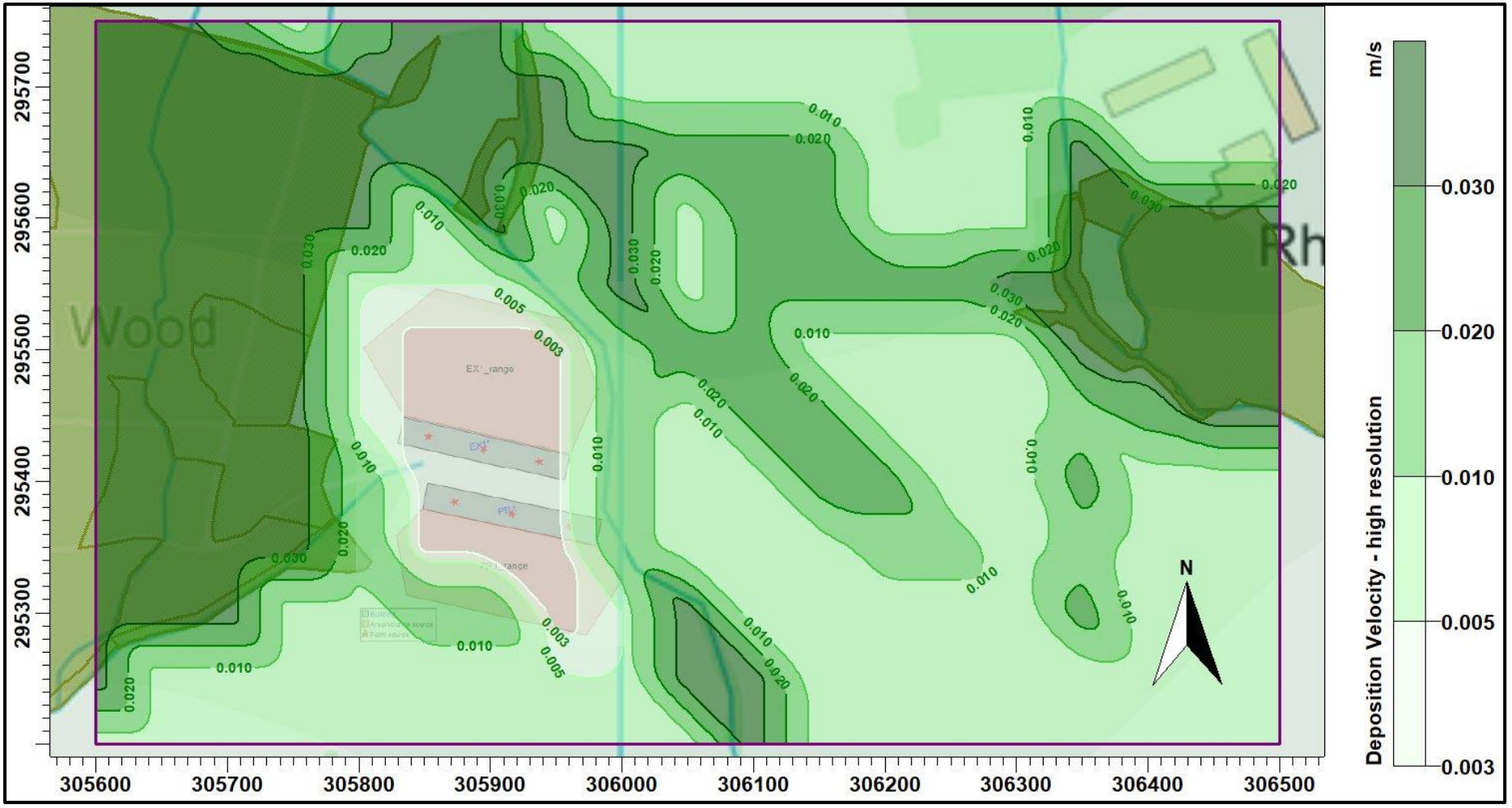
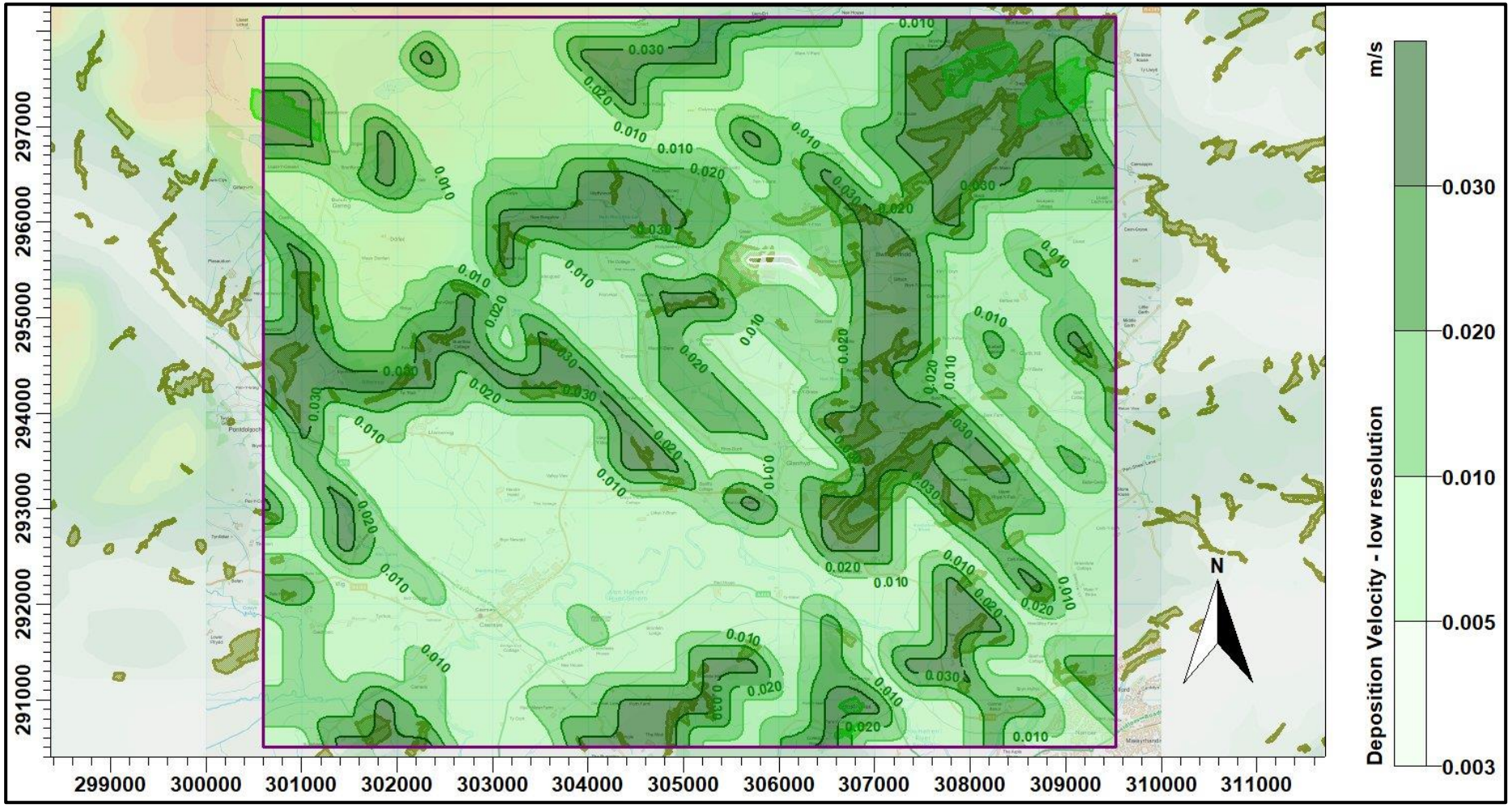


Figure 5b. The spatially varying deposition field – low resolution



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 and in the following three 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 – 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, including those that would lead to a nitrogen deposition rate, that are in excess of the Natural Resources Wales/Environment Agency's upper threshold (8% of Critical Level or Load for a SAC and SSSI and 100% of a Critical Level or Load for an AW) are coloured red. Concentrations in the range between the Natural Resources Wales/Environment Agency's upper threshold and lower threshold (1% to 8% for a SAC and SSSI and 50% to 100% for an AW) are coloured blue. For convenience, cells referring to the AWs are shaded olive, cells referring to the SSSIs are shaded green and cells referring to the SAC are shaded purple.

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

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)				
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vyrnwy No Calms No Terrain	Trawscoed No Calms No Terrain
1	305782	295432	Cwm Wood AW	5.827	5.851	7.545	6.393	7.943
2	305800	295349	Cwm Wood AW	8.318	8.314	10.882	9.890	8.509
3	305772	295537	Cwm Wood AW	4.030	4.043	4.931	2.773	8.802
4	305800	295645	Cwm Wood AW	1.878	1.852	2.344	1.037	6.109
5	305486	295798	Cwm Wood AW	0.370	0.374	0.419	0.251	1.082
6	305385	295498	Cwm Wood AW	0.592	0.592	0.678	0.494	0.703
7	305907	295588	Cwm Wood AW	5.214	5.194	5.692	4.285	11.260
8	305422	295144	Unnamed AW	0.497	0.493	0.560	0.711	0.289
9	305031	295148	Unnamed AW	0.218	0.221	0.263	0.286	0.159
10	304617	295031	Unnamed AW	0.117	0.119	0.137	0.154	0.086
11	306298	295532	The Gorallt AW	1.266	1.243	1.702	1.333	1.026
12	306431	295455	The Gorallt AW	0.857	0.844	1.041	0.917	0.757
13	306773	295667	The Gorallt AW	0.330	0.325	0.461	0.342	0.271
14	305998	294976	Unnamed AW	0.628	0.628	0.652	1.394	0.501
15	306055	295986	Unnamed AW	0.474	0.473	0.385	0.416	0.780
16	306350	296040	Unnamed AW	0.362	0.358	0.346	0.388	0.286
17	306583	295967	Unnamed AW	0.340	0.334	0.426	0.346	0.230
18	306429	296323	Unnamed AW	0.200	0.199	0.172	0.209	0.181
19	306937	295986	Astley's Wood AW	0.214	0.209	0.301	0.205	0.154
20	306588	294861	Unnamed AW	0.256	0.251	0.215	0.293	0.342
21	306915	295158	Unnamed AW	0.259	0.257	0.246	0.235	0.300
22	305537	296217	Unnamed AW	0.201	0.199	0.254	0.104	0.658
23	305113	295789	Unnamed AW	0.215	0.214	0.251	0.171	0.413
24	304841	295901	Unnamed AW	0.136	0.135	0.156	0.111	0.257
25	304633	295913	Unnamed AW	0.113	0.113	0.123	0.092	0.188
26	306233	296558	Unnamed AW	0.144	0.144	0.105	0.129	0.234
27	307138	295681	The Forest AW	0.188	0.185	0.254	0.211	0.162
28	307210	296193	Astley's Wood AW	0.141	0.138	0.193	0.136	0.101
29	307626	296013	Blackhouse Wood AW	0.103	0.101	0.131	0.105	0.086
30	307786	295889	Unnamed AW	0.093	0.092	0.108	0.103	0.081
31	304284	296229	Unnamed AW	0.065	0.065	0.059	0.054	0.135
32	306842	294529	Unnamed AW	0.135	0.132	0.120	0.171	0.165
33	307226	294813	Unnamed AW	0.127	0.126	0.107	0.132	0.185
34	306794	294452	Unnamed AW	0.127	0.124	0.117	0.180	0.147
35	306674	294376	Unnamed AW	0.119	0.117	0.115	0.205	0.129
36	306574	294132	Unnamed AW	0.091	0.090	0.090	0.185	0.082
37	307354	294525	Unnamed AW	0.090	0.089	0.074	0.101	0.135
38	306422	293936	Unnamed AW	0.078	0.077	0.072	0.177	0.062
39	306878	294076	Sgwylfa Wood AW	0.080	0.078	0.077	0.143	0.086
40	306747	293581	Unnamed AW	0.053	0.053	0.045	0.112	0.045
41	307749	297340	Gregynog SSSI	0.051	0.051	0.055	0.057	0.041
42	308530	297030	Gregynog SSSI	0.046	0.045	0.061	0.045	0.034
43	308430	297856	Gregynog SSSI	0.034	0.034	0.042	0.038	0.028
44	309128	297612	Gregynog SSSI	0.032	0.031	0.045	0.032	0.023
45	306795	291029	Penstrowed Quarry SSSI	0.016	0.016	0.020	0.043	0.013
46	306622	290672	Gweunydd Penstrowed SSSI	0.014	0.014	0.039	0.040	0.012
47	301184	296875	Llyn Mawr SSSI	0.018	0.018	0.007	0.015	0.025
48	313908	293031	Montgomery Canal SAC	0.011	0.011	0.013	0.011	0.014
49	314595	293846	Montgomery Canal SAC	0.011	0.011	0.015	0.012	0.012
50	315212	294490	Montgomery Canal SAC	0.011	0.011	0.015	0.012	0.010

5.2 Detailed deposition modelling

The detailed modelling was carried out in both high and low resolution over restricted domains 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. A high resolution domain covers the existing and proposed poultry houses at Cwm Farm and the closest AWs, whilst a low resolution domain covers the Gregynog SSSI, Penstorwed Quarry SSSI, Gwuenydd Penstrowed SSSI and Llyn Mawr SSSI. 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 high and low resolution detailed modelling domains are shown in Table 6a and Table 6b respectively. In the Tables, 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 SAC and 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 SAC and SSSI and 50% to 100% for an AW) are coloured blue.

The contour plots of the predicted ground level maximum annual mean ammonia at high and low resolution are shown in Figures 6a and 6b. Contour plots of the maximum nitrogen deposition rates at high and low resolution are shown in Figures 6c and 6d.

Table 6a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors within the high resolution domain

Receptor number	X(m)	Y(m)	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
			Deposition Velocity	Critical Level (µg/m³)	Critical Load (kg/ha)	Process Contribution (µg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	305782	295432	0.030	1.0	10.0	4.460	**446.0**	34.75	**347.5**
2	305800	295349	0.030	1.0	10.0	6.405	**640.5**	49.90	**499.0**
3	305772	295537	0.030	1.0	10.0	2.829	**282.9**	22.04	**220.4**
4	305800	295645	0.030	1.0	10.0	0.869	**86.9**	6.77	**67.7**
7	305486	295798	0.030	1.0	10.0	3.106	**310.6**	24.20	**242.0**
11	305385	295498	0.030	1.0	10.0	0.911	**91.1**	7.10	**71.0**
12	305907	295588	0.030	1.0	10.0	0.571	**57.1**	4.44	44.4

Table 6b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors within the low resolution domain

Receptor number	X(m)	Y(m)	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
			Deposition Velocity	Critical Level (µg/m³)	Critical Load (kg/ha)	PC (µg/m³)	%age of Critical Level	PC Existing (kg/ha)	%age of Critical Load
41	307749	297340	0.030	1.0	5.0	0.027	**2.7**	0.21	**4.2**
42	308530	297030	0.030	1.0	5.0	0.028	**2.8**	0.22	**4.4**
43	308430	297856	0.030	1.0	5.0	0.019	**1.9**	0.15	**3.0**
44	309128	297612	0.030	1.0	5.0	0.020	**2.0**	0.16	**3.1**
45	306795	291029	0.030	1.0	10.0	0.006	0.6	0.04	0.4
46	306622	290672	0.030	3.0	10.0	0.004	0.1	0.03	0.3
47	301184	296875	0.030	1.0	5.0	0.002	0.2	0.01	0.2

Figure 6a. Maximum annual ammonia concentration – high resolution

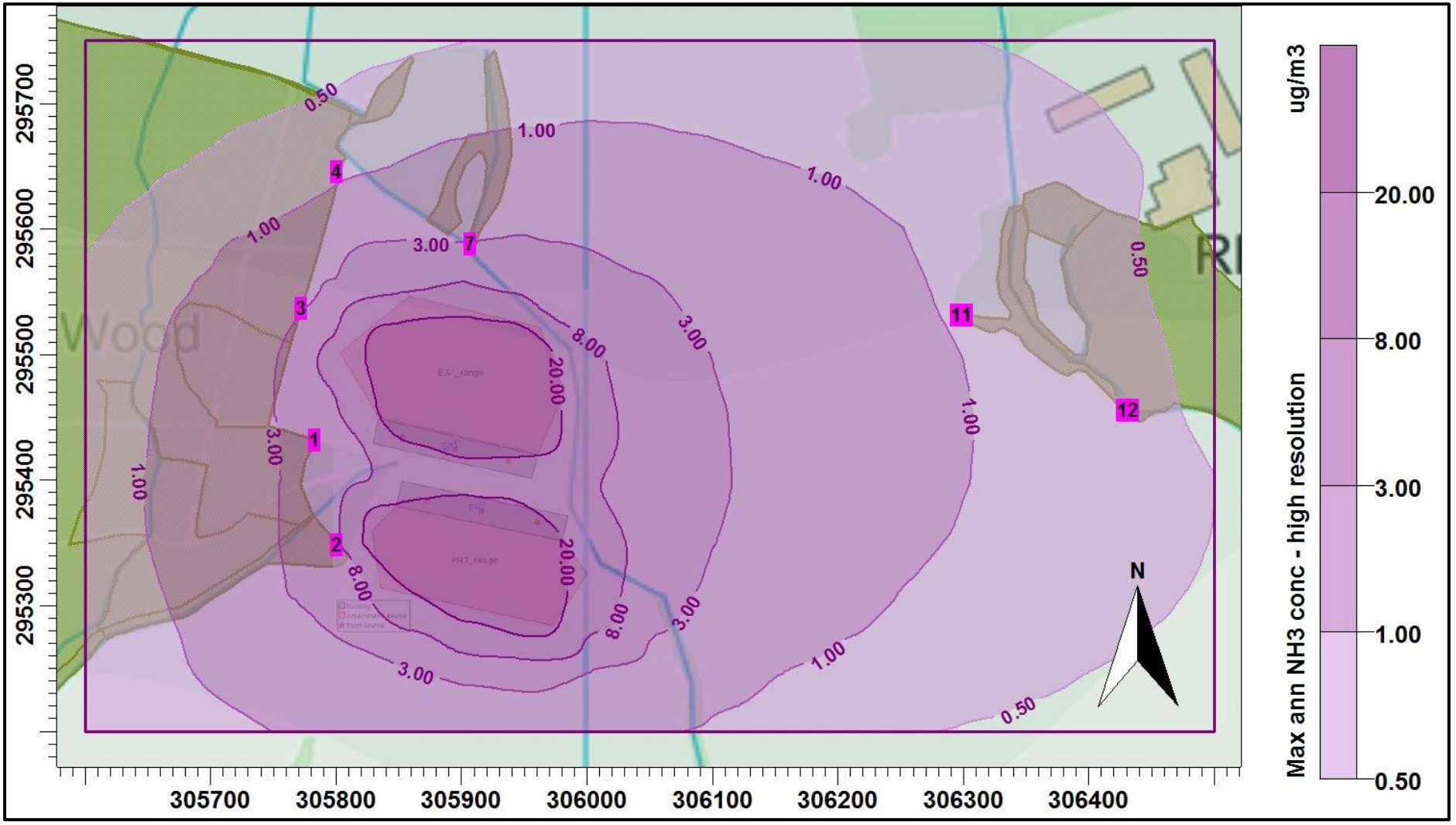


Figure 6b. Maximum annual ammonia concentration – low resolution

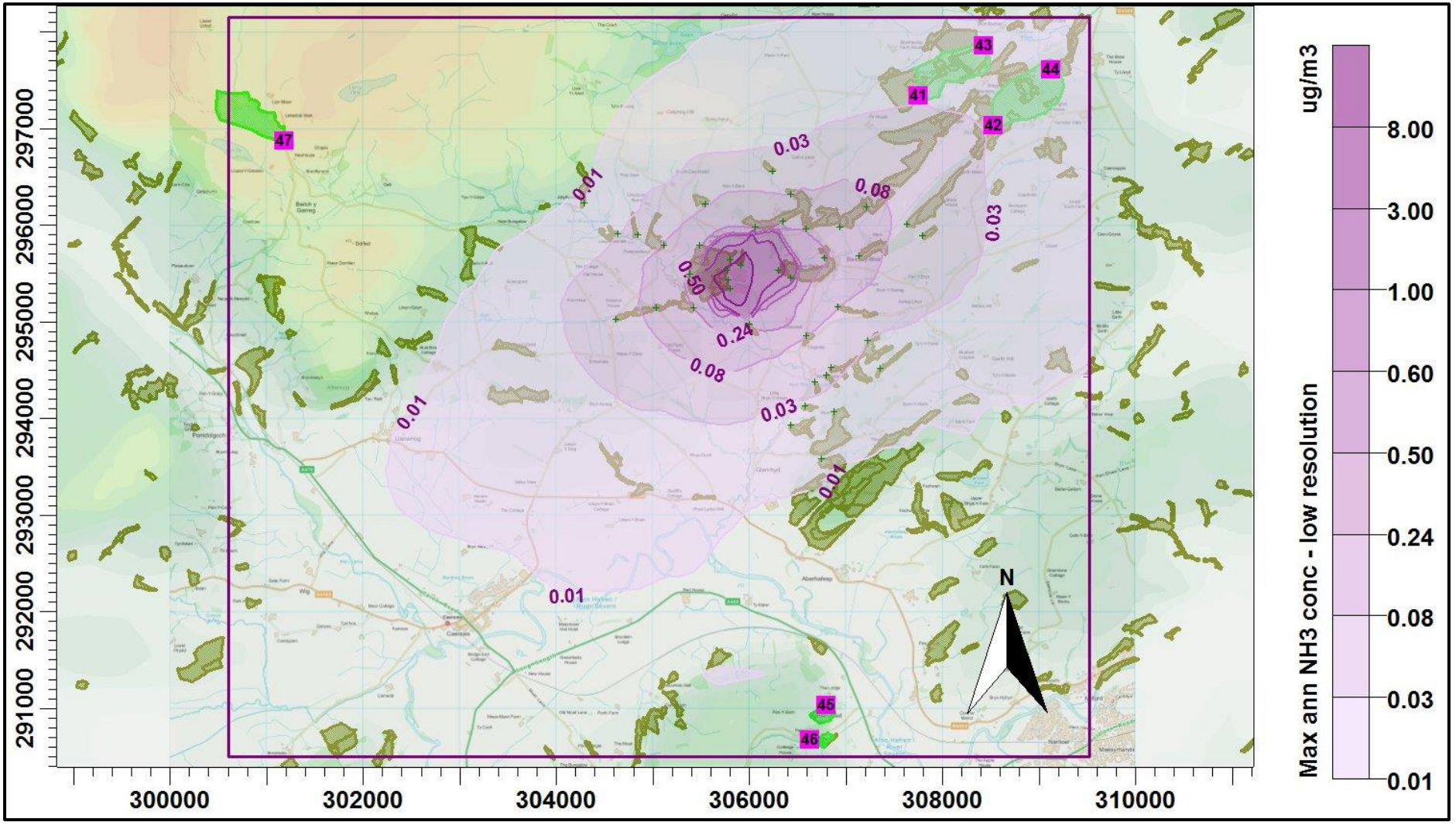


Figure 6c. Maximum annual nitrogen deposition rates – high resolution

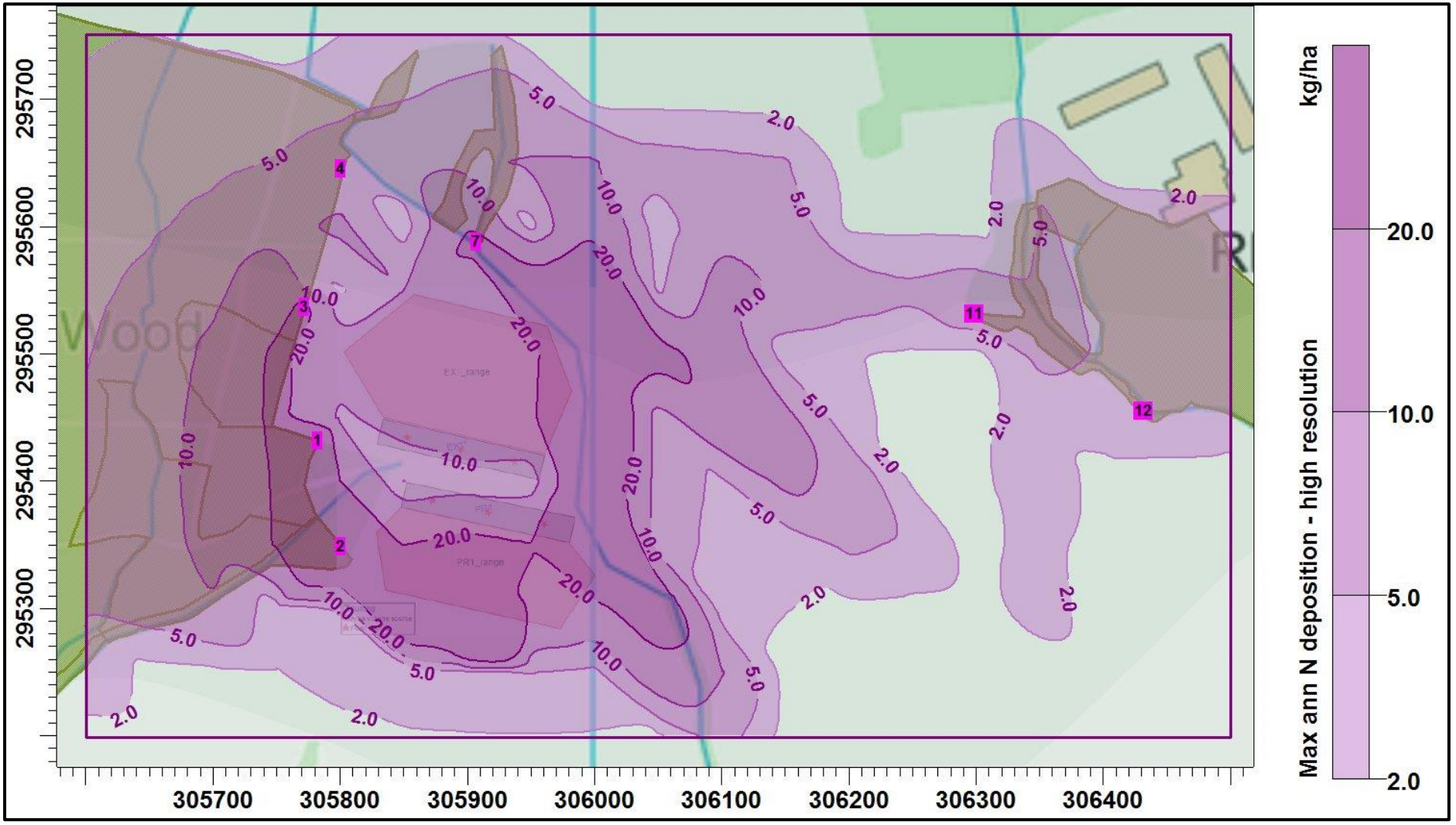
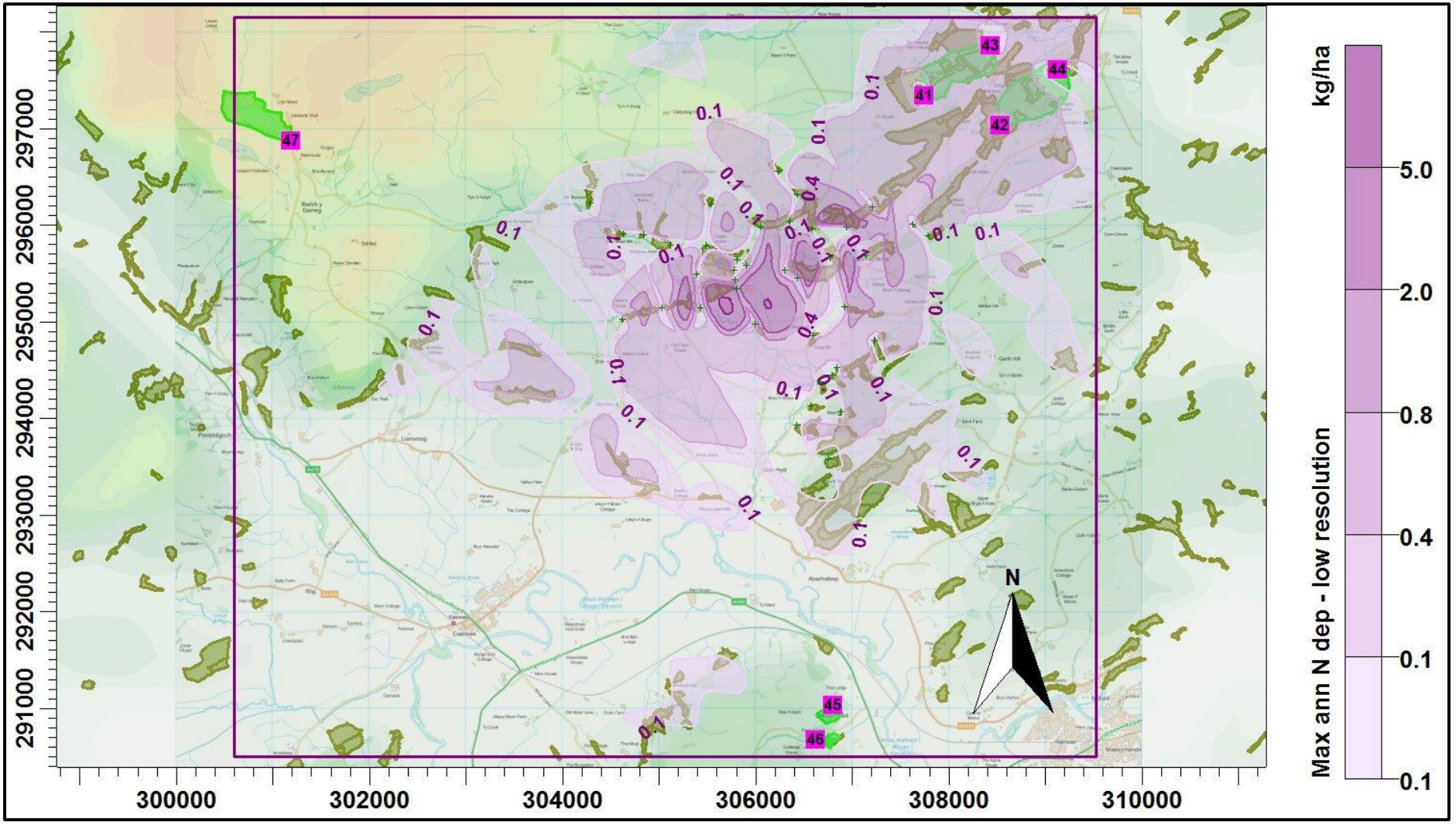


Figure 6d. Maximum annual nitrogen deposition rates – low resolution



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Gail Lewis of Roger Parry & Partners LLP, on behalf of the applicant Mr Duncan Davies, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at Cwm Farm, near Bwlch-y-ffridd in Powys. SY16 3JD.

Ammonia emission rates from the existing and 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 and acid 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 AWs would potentially exceed the Natural Resources Wales upper threshold (100% for non-statutory sites) of the Critical Level of 1.0 µg/m³ and the Critical Load of 10.0 kg/ha. At the nearby non-geological SSSIs; Gregynog SSSI, Gweunydd Penstrowed SSSI and Llyn Mawr SSSI, the predicted process contribution to ammonia concentrations would potentially exceed the Natural Resources Wales lower threshold (1% for SSSIs) of the strictest Critical Level of 1.0 µg/m³.

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 (1% for a SAC and 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 upper threshold (100% for non-statutory sites) of the Critical Level of 1.0 µg/m³ and the Critical Load of 10.0 kg/ha over approximately 2.5 ha of the nearby AWs to the north and west of the existing and proposed poultry buildings. At Gregynog SSSI the modelling predicts that the process contribution to ammonia concentrations and nitrogen deposition rates would exceed the Natural Resources Wales lower threshold (1% for SSSIs) of the Critical Level of 1.0 µg/m³ and the Critical Load of 10.0 kg/ha.

At all other sites considered, the high and low resolution 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 and SSSI and 100% for non-statutory sites).

Mitigation

Where exceedances of the upper threshold for non-statutory sites are predicted, some form of mitigation is usually required. AS Modelling & Data Ltd. would recommend that, if available, to compensate for possible detrimental effects on the nearby AWs, the woodland is actively managed for wildlife, and/or, that land of at least a similar area to the exceedance of 100% of the Critical Level (approximately 2.5 ha) is set aside for nature conservation and be planted/seeded with native species. Woodland planting schemes, or restoration to traditional unimproved grassland, could replace what is currently improved grassland with low ecological value. If planted between the poultry unit and the AWs, the newly planted woodland would act as a sink for ammonia from the poultry houses and ranges (and from other sources of ammonia), thus reducing ammonia concentrations (and nitrogen and acid deposition rates) at the nearby AWs. Such schemes may be particularly effective at increasing bio-diversity if they border, or connect with, existing remnants of woodland or unimproved grasslands.

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 and the sensitivity of the wildlife sites involved. Since the exceedance is in the lower half of the range between the lower and upper thresholds, consideration of the IAQM guidance (Section 3.5) might be applicable; however, since Critical Levels and Critical Loads are already exceeded at Gregynog SSSI and it is likely that there are other intensive farming installations that would be considered to act in-combination, it should be noted that the Natural Resources Wales lower threshold criterion of 1% of Critical Level or Critical Load may be enforced strictly and that some form of mitigation might be required.

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