A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Free Range Egg Laying Chicken House at Bron Heulog, near Llanfair Talhaiarn in Conwy

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Rosina Bloor of Richard Parry & Partners LLP, on behalf of the applicant R. J. & N. M. Lloyd & Sons, to use computer modelling to assess the impact of ammonia emissions from the proposed free range egg laying chicken house at Bron Heulog, Llanfair Talhaiarn, Abergele, Conwy. LL22 8PE.

Ammonia emission rates from the proposed poultry house 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 proposed free range chicken house at Bron Heulog is in a rural area, approximately 850 m to the north-north-east of the village of Llanfair Talhaiarn in Abergele. The surrounding land is used for a mixture of arable and livestock farming, but there are also several wooded areas and areas of semi-natural grassland/heathland nearby. The site is at an altitude of around 125 m within the River Elwy valley with land rising to hills and mountains in the north and south.

The proposed poultry house would provide accommodation for up to 32,000 free range egg laying chickens. The poultry house would have pop holes which would provide the birds with daytime access to an outside ranging area and would be ventilated by ridge/roof mounted fans, each with a short chimney. Every four days, the birds' droppings would be removed by a belt collection system and stored temporarily on the farm, prior to being removed from site or spreading to land.

There are several areas of unnamed Ancient Woodlands (AWs) within 2 km of the site of Bron Heulog. There are also three Sites of Special Scientific Interest (SSSIs) within 5 km; namely Coedydd Derw Elwy SSSI, Llanddulas Limestone and Gwrych Castle Wood SSSI and Coed Y Gopa SSSI. There are no internationally designated sites within 5 km of the farm.

A broad scale view map of the surrounding area showing the positions of the proposed poultry house and the nearby wildlife sites is provided in Figure 1a and 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 and the site of the proposed poultry house is outlined in blue.

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

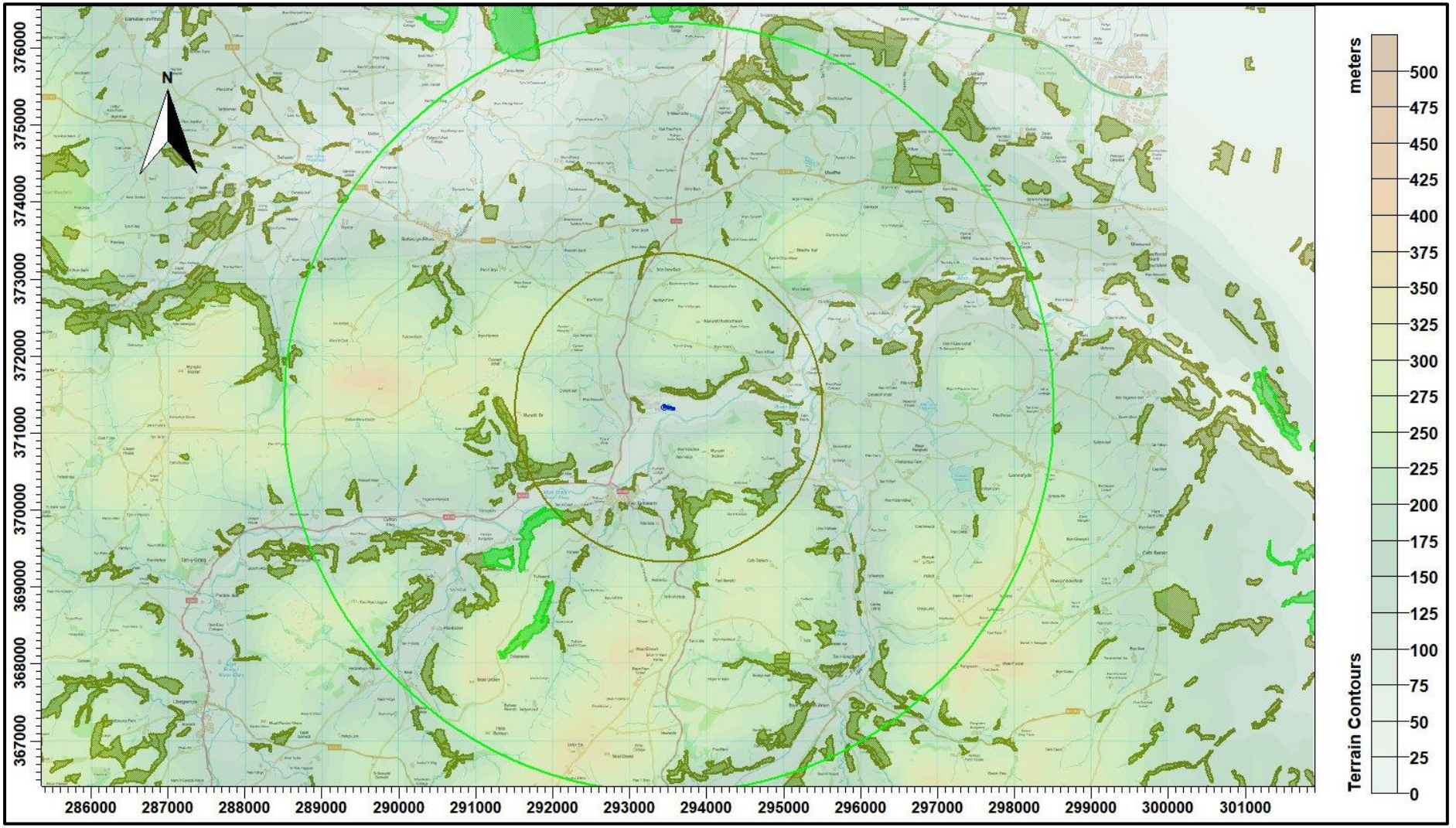
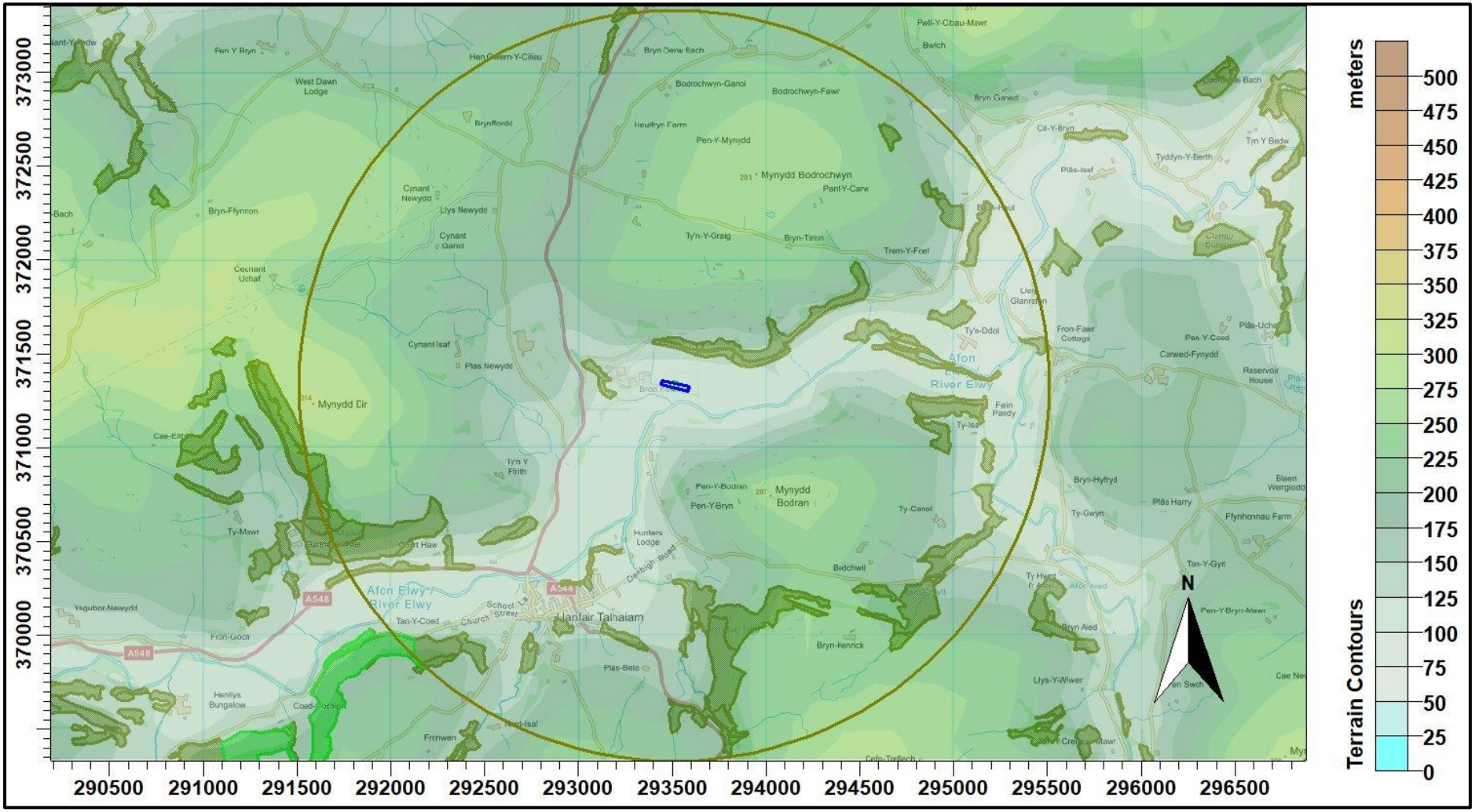


Figure 1b. The area surrounding the site, a closer view



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 1.33 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 26.46 kg-N/ha/y and to short vegetation is 17.22 kg-N/ha/y. The background acid deposition rate to woodland is 2.08 keq/ha/y and to short vegetation is 1.39 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, January 2018).

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]	-	-
SSSIs	1.0 [1]	-	-

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.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Natural Resources Wales criteria

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%).

3.4.2 Environment Agency criteria

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." And, "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.

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 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, ranging areas and manure spreading 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.

3.6.1 Proposed chicken housing ammonia 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.

3.6.2 Proposed ranging area ammonia emissions

As the birds 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 12%[1] of the droppings are deposited on the ranging areas; this assumption is based upon figures from "Ammonia emission factors for UK agriculture" (Misselbrook *et al*). 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 35% of ammoniacal nitrogen is emitted as ammonia (Misselbrook and Defra). This equates to an emission factor of 0.34 kg-NH_3/bird/y.

Details of the poultry numbers and types, the emission factors used and the calculated ammonia emission rates are provided in Table 2.

1. A figure of 20% is sometimes assumed. However, it should be noted that this figure is probably based primarily upon the widely accepted figure of 80% of dropping occurring at night when birds are housed and a single report; however, because, even under optimal conditions, not all of the birds go outside (50% is considered a high percentage), this does not imply that 20% of droppings occur outside the house.

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)
Housing	32,000 (x 0.88)	Egg laying chickens, aviary system	0.08 (EA/BREF figure)	0.071387
Ranges	32,000 (x 0.12)	Ranging areas	0.34 (AS Modelling & Data figure)	0.041372

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).

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 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 proposed poultry house at Bron Heulog is shown in Figure 2b. In this case, the flow predicted in the local area is strongly affected by the alignment of nearby valleys and hills; however, it should be noted elsewhere in the modelling domain, the modified wind roses may differ markedly, reflecting the local flow in that part of the domain. The resolution of the wind field in terrain runs is approximately 300 m for the preliminary modelling and is approximately 100 m for the detailed modelling. Please also note that FLOWSTAR is used to obtain a local flow field, not to explicitly model dispersion in complex terrain as defined in the ADMS User Guide; therefore, the ADMS default value for minimum turbulence length has been amended.

Figure 2a. The wind rose. Raw GFS derived data, for 53.228 N, 3.596 W, 2013-2016

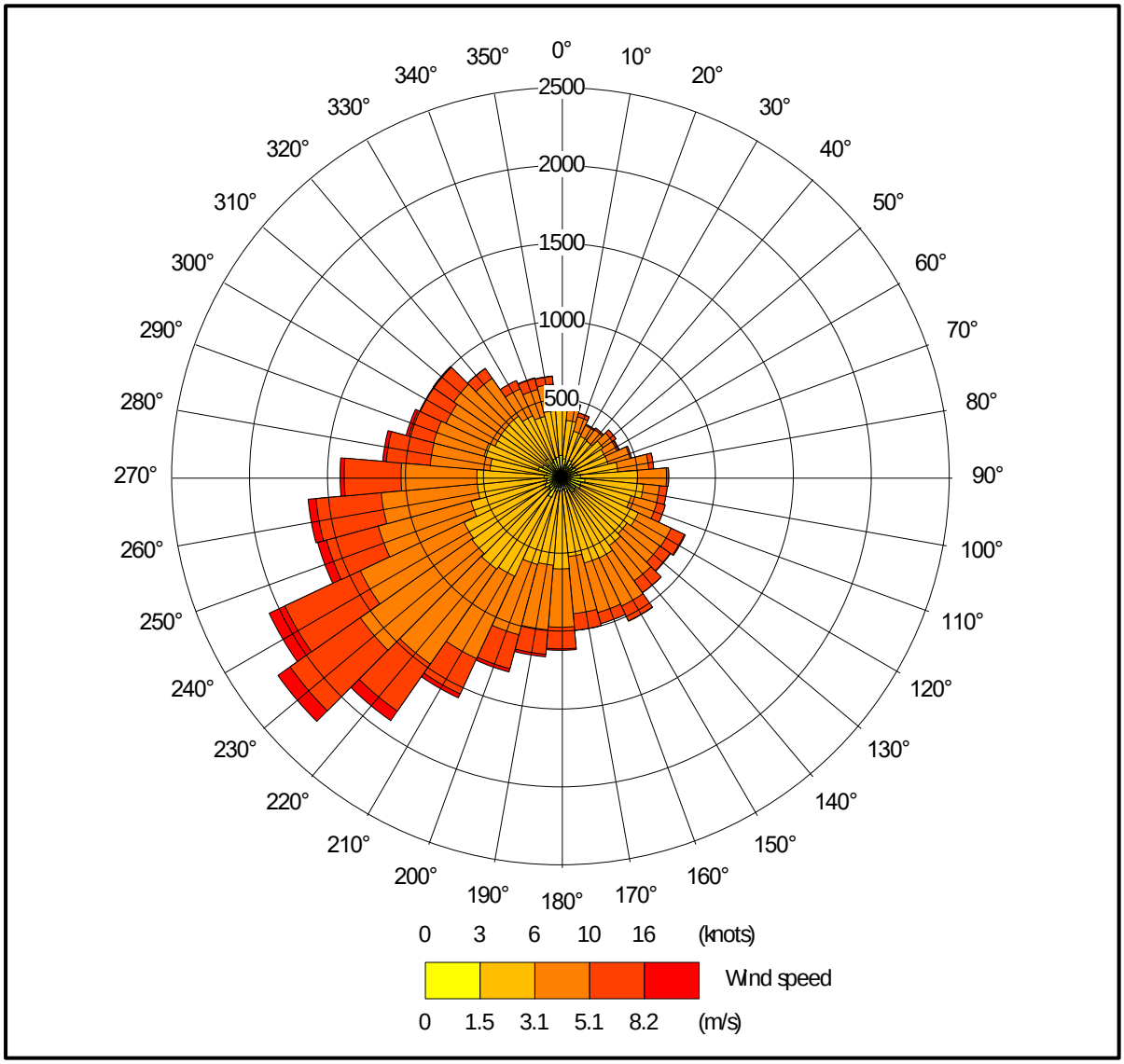
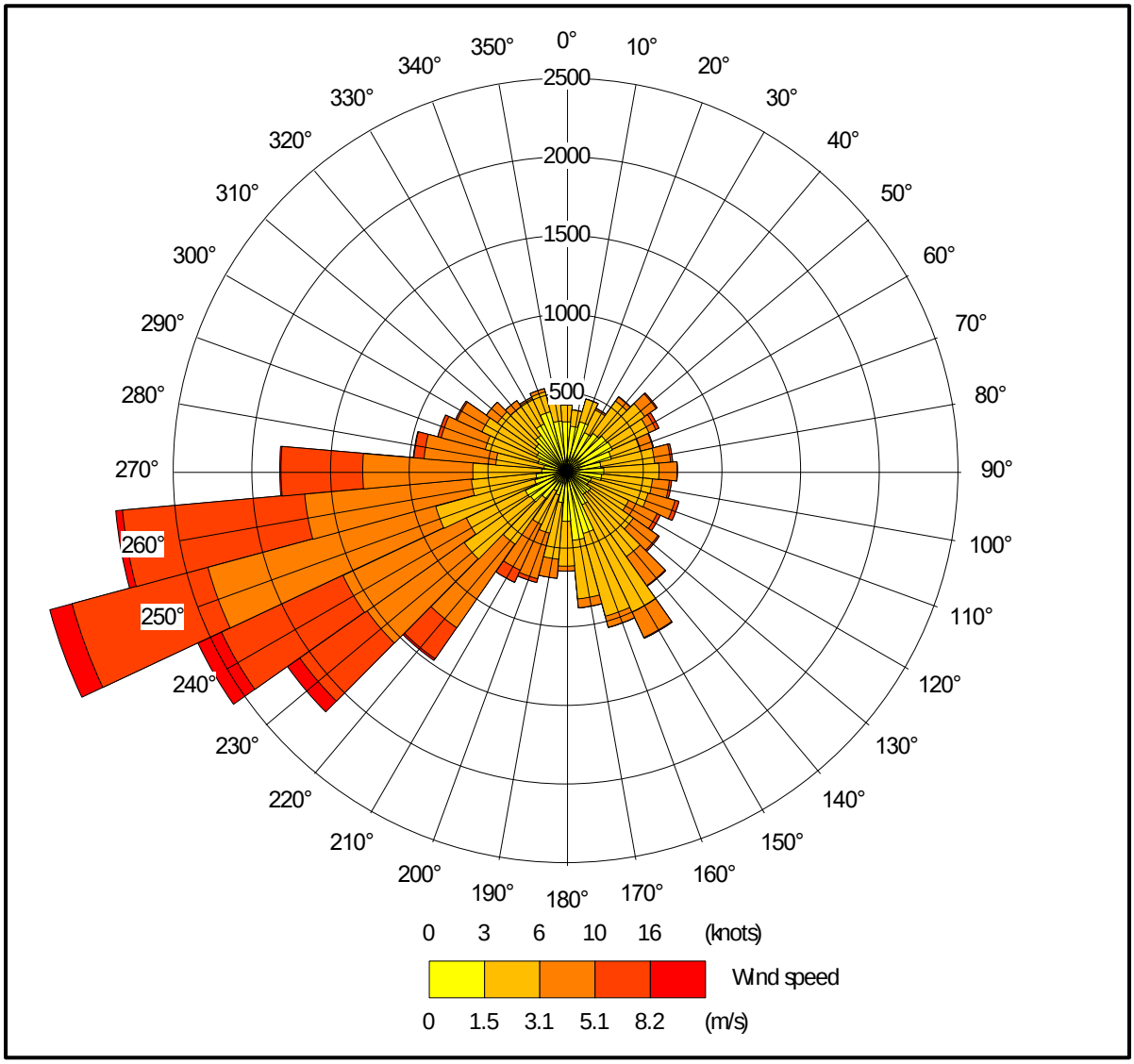


Figure 3b. The wind rose. FLOWSTAR modified GFS derived data for NGR 293500, 371300



4.2 Emission sources

Emissions from the high speed ridge/roof fans that would be used to ventilate the proposed poultry house are represented by three point sources within ADMS (PR 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)
PR a, b & c	6.5	0.8	11.0	19.0	0.023796

The poultry house would have a ranging area, which is represented by an area source within ADMS (PR_range). Note that the area source covers the parts of the range 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)
PR_range	10402.63	0.0	Ambient	0.041372

4.3 Modelled buildings

The structure of the poultry house may affect the plumes from the point sources. Therefore, the building is modelled within ADMS. The position of the modelled building may be seen in Figure 3, where it is marked by a grey rectangle.

4.4 Discrete receptors

Forty-four discrete receptors have been defined: thirty-six at the AWs (1 to 36) and eight at the SSSIs (37 to 44). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 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 fields used in the detailed modelling, two regular Cartesian grids have been defined within ADMS one at high resolution and one at a lower resolution. The grid receptors are defined at ground level within ADMS. The position of the Cartesian grids may be seen in Figure 4, 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 for the preliminary modelling and a 6.4 km x 6.4 km domain has been resampled at 100 m horizontal resolution for the detailed modelling runs. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 300 m in the preliminary modelling and is 100 m in the detailed modelling runs.

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 stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of the modelled buildings and sources

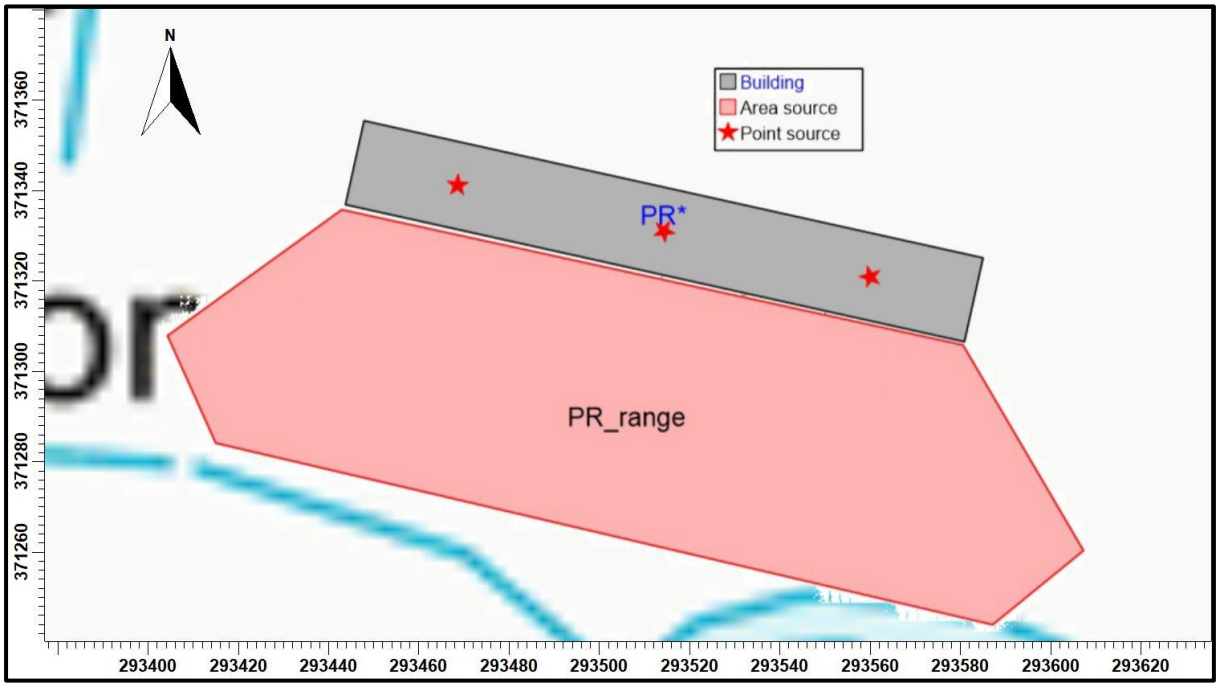
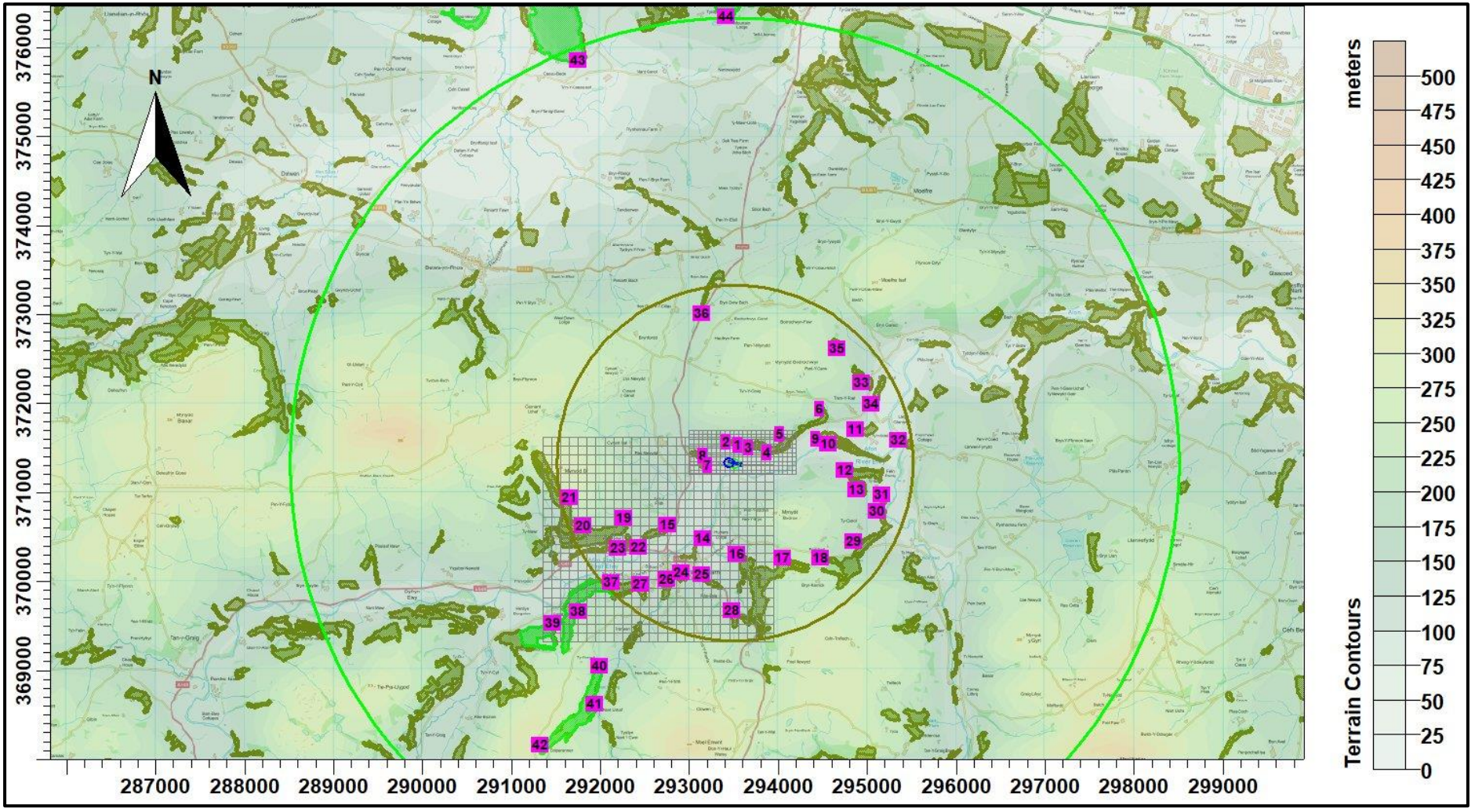


Figure 4. The discrete receptors and regular Cartesian grids



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 a deposition velocity field. 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 low and high resolution spatially varying deposition fields are provided in Figures 5a and 5b respectively. Note that the high resolution deposition field includes proposed tree planting between the proposed poultry house and the AW to the north.

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

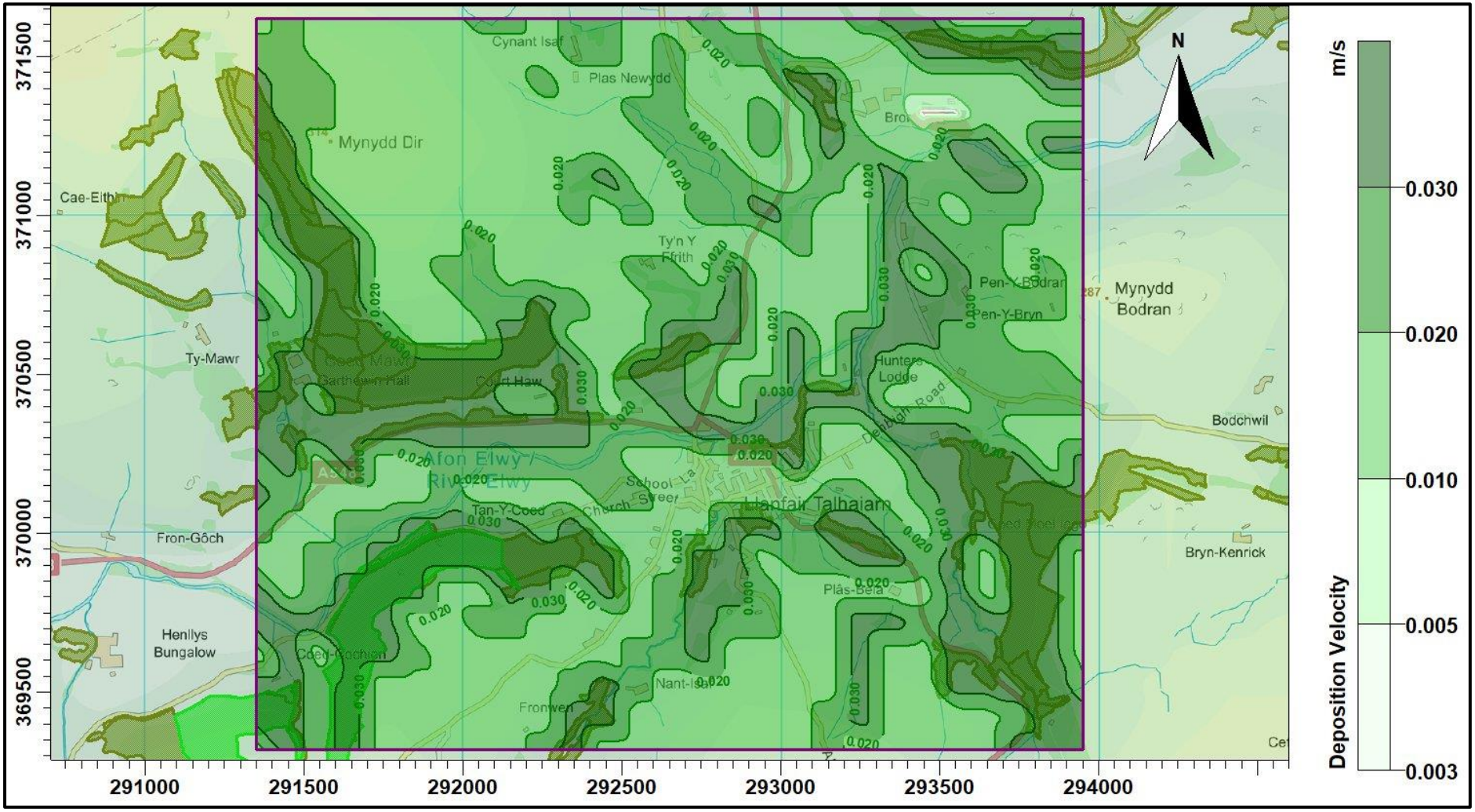
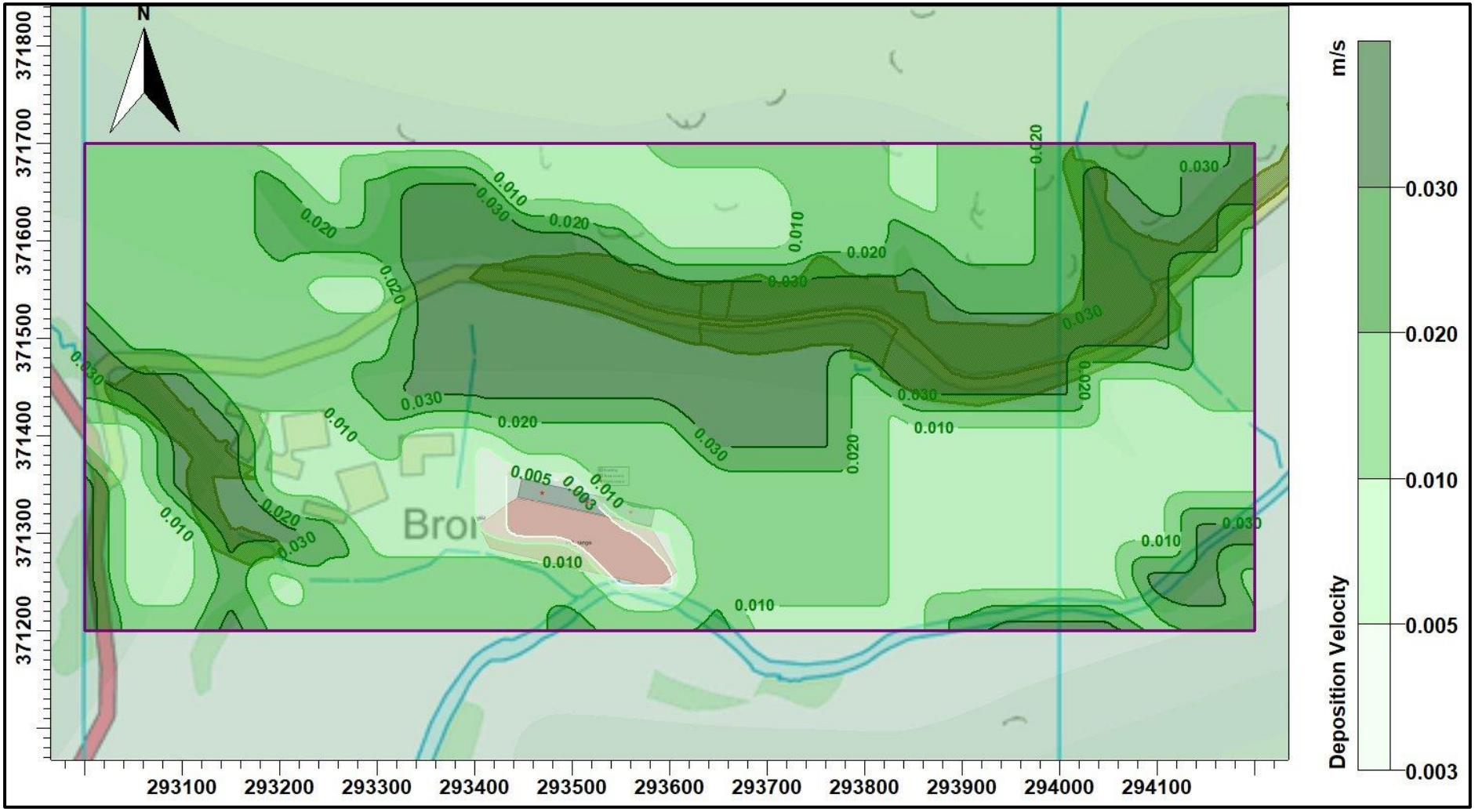


Figure 5b. The spatially varying deposition field – high resolution



5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of sixteen times; once for each year of the meteorological record and in the following four modes:

- In basic mode without calms or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- Without calms, with terrain and fixed deposition at 0.003 m/s – GFS data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled.

Details of the predicted 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 upper threshold (8% of Critical Level or Load for a SSSI and 100% of a Critical Level or Load for an AW) are coloured red. Concentrations in the range between the Natural Resources Wales upper threshold and lower threshold (1% to 8% for a SSSI and 50%[1] to 100% for an AW) are coloured blue. For convenience, cells referring to the SSSIs are shaded green and cells referring to the AWs are shaded olive.

1. The Pre-February 2016 figure is retained.

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/m^3)			
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Dep 0.003 m/s
1	293547	371521	Unnamed AW	**2.044**	**2.034**	**1.952**	**1.299**
2	293414	371554	Unnamed AW	**1.269**	**1.265**	**1.405**	**0.924**
3	293667	371486	Unnamed AW	**2.267**	**2.241**	**2.360**	**1.611**
4	293868	371436	Unnamed AW	**0.890**	**0.874**	**1.217**	**0.903**
5	294011	371645	Unnamed AW	0.461	0.457	**0.503**	0.343
6	294467	371925	Unnamed AW	0.156	0.155	0.193	0.130
7	293200	371289	Unnamed AW	**0.944**	**0.966**	**1.249**	**0.715**
8	293145	371398	Unnamed AW	**0.855**	**0.864**	**1.017**	**0.536**
9	294419	371587	Unnamed AW	0.189	0.186	0.295	0.213
10	294565	371533	Unnamed AW	0.149	0.147	0.222	0.163
11	294867	371697	Unnamed AW	0.099	0.097	0.178	0.126
12	294750	371242	Unnamed AW	0.098	0.098	0.106	0.072
13	294874	371024	Unnamed AW	0.077	0.076	0.079	0.046
14	293152	370473	Unnamed AW	0.095	0.098	0.149	0.078
15	292757	370626	Coed Ty-crwn AW	0.095	0.094	0.168	0.074
16	293535	370300	Coed Moel Lago AW	0.130	0.127	0.167	0.060
17	294047	370257	Coed Moel Lago AW	0.089	0.089	0.112	0.043
18	294471	370250	Unnamed AW	0.073	0.073	0.074	0.030
19	292261	370699	Coed Mawr AW	0.064	0.064	0.116	0.043
20	291803	370615	Coed Mawr AW	0.042	0.042	0.057	0.021
21	291645	370926	Coed Mawr AW	0.039	0.040	0.046	0.017
22	292430	370379	Unnamed AW	0.056	0.055	0.101	0.042
23	292193	370368	Unnamed AW	0.048	0.047	0.088	0.035
24	292909	370087	Unnamed AW	0.050	0.052	0.080	0.034
25	293133	370072	Unnamed AW	0.063	0.062	0.100	0.040
26	292743	370014	Unnamed AW	0.045	0.046	0.071	0.027
27	292453	369957	Unnamed AW	0.039	0.039	0.061	0.022
28	293481	369657	Unnamed AW	0.059	0.058	0.078	0.023
29	294846	370435	Unnamed AW	0.060	0.060	0.063	0.028
30	295106	370783	Unnamed AW	0.058	0.057	0.075	0.040
31	295160	370964	Unnamed AW	0.057	0.056	0.073	0.041
32	295354	371578	Unnamed AW	0.059	0.058	0.087	0.048
33	294930	372226	Unnamed AW	0.082	0.081	0.120	0.082
34	295045	371981	Coed Bron Haul AW	0.075	0.074	0.164	0.115
35	294655	372604	Unnamed AW	0.088	0.087	0.082	0.049
36	293133	373000	Unnamed AW	0.059	0.059	0.070	0.046
37	292120	369983	Coedydd Derw Elwy SSSI	**0.034**	**0.034**	**0.056**	**0.022**
38	291745	369654	Coedydd Derw Elwy SSSI	**0.024**	**0.024**	**0.037**	**0.013**
39	291465	369521	Coedydd Derw Elwy SSSI	**0.021**	**0.021**	**0.030**	**0.011**
40	291987	369043	Coedydd Derw Elwy SSSI	**0.019**	**0.019**	**0.019**	0.005
41	291932	368613	Coedydd Derw Elwy SSSI	**0.015**	**0.015**	**0.013**	0.004
42	291321	368150	Coedydd Derw Elwy SSSI	**0.012**	**0.012**	0.008	0.002
43	291753	375851	Llanddulas Limestone and Gwrych Castle Wood SSSI	**0.012**	**0.012**	**0.016**	0.008
44	293414	376337	Coed Y Gopa SSSI	**0.011**	**0.011**	**0.012**	0.006

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 could potentially exceed the relevant lower threshold percentage of the Critical Level of 1.0 µg-NH_3/m^3. The domain covers the proposed poultry house and range at Bron Heulog, two of the closer unnamed AWs and the closer parts of the Coedydd Derw Elwy SSSI. At all other receptors considered, the preliminary modelling indicated that ammonia levels (and nitrogen and acid deposition rates) would be below the Environment Agency's 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 low and high resolution detailed modelling domains are shown in Tables 6a and 6b respectively. In these 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 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 thresholds (1% to 8% for a SSSI and 50%[1] to 100% for an AW) are coloured blue.

Contour plots of the predicted ground level maximum annual mean ammonia at low and high resolutions are shown in Figures 6a and 6b, respectively. Contour plots of the maximum nitrogen deposition rate at low and high resolutions are shown in Figures 6c and 6b, respectively.

1. The pre-February 2016 figure is retained.

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

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
14	293152	370473	Unnamed AW	0.030	1.0	10.0	0.031	3.1	0.24	2.4
15	292757	370626	Coed Ty-crwn AW	0.030	1.0	10.0	0.030	3.0	0.23	2.3
16	293535	370300	Coed Moel Lago AW	0.030	1.0	10.0	0.016	1.6	0.13	1.3
19	292261	370699	Coed Mawr AW	0.030	1.0	10.0	0.015	1.5	0.12	1.2
20	291803	370615	Coed Mawr AW	0.030	1.0	10.0	0.009	0.9	0.07	0.7
21	291645	370926	Coed Mawr AW	0.030	1.0	10.0	0.006	0.6	0.04	0.4
22	292430	370379	Unnamed AW	0.030	1.0	10.0	0.020	2.0	0.16	1.6
23	292193	370368	Unnamed AW	0.030	1.0	10.0	0.017	1.7	0.13	1.3
24	292909	370087	Unnamed AW	0.030	1.0	10.0	0.015	1.5	0.12	1.2
25	293133	370072	Unnamed AW	0.030	1.0	10.0	0.013	1.3	0.10	1.0
26	292743	370014	Unnamed AW	0.030	1.0	10.0	0.012	1.2	0.10	1.0
27	292453	369957	Unnamed AW	0.030	1.0	10.0	0.009	0.9	0.07	0.7
28	293481	369657	Unnamed AW	0.030	1.0	10.0	0.005	0.5	0.04	0.4
37	292120	369983	Coedydd Derw Elwy SSSI	0.030	1.0	10.0	0.010	1.0	0.08	0.8
38	291745	369654	Coedydd Derw Elwy SSSI	0.030	1.0	10.0	0.005	0.5	0.04	0.4
39	291465	369521	Coedydd Derw Elwy SSSI	0.030	1.0	10.0	0.005	0.5	0.04	0.4

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

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m³)	Critical Load (kg/ha)	Process Contribution (µg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	293547	371521	Unnamed AW	0.030	1.0	10.0	0.462	46.2	3.60	36.0
2	293414	371554	Unnamed AW	0.030	1.0	10.0	0.317	31.7	2.47	24.7
3	293667	371486	Unnamed AW	0.030	1.0	10.0	0.569	**56.9**	4.43	44.3
4	293868	371436	Unnamed AW	0.030	1.0	10.0	0.541	**54.1**	4.22	42.2
5	294011	371645	Unnamed AW	0.030	1.0	10.0	0.104	10.4	0.81	8.1
7	293200	371289	Unnamed AW	0.030	1.0	10.0	0.519	**51.9**	4.04	40.4
8	293145	371398	Unnamed AW	0.030	1.0	10.0	0.365	36.5	2.84	28.4

Figure 6a. Maximum annual ammonia concentration – low resolution

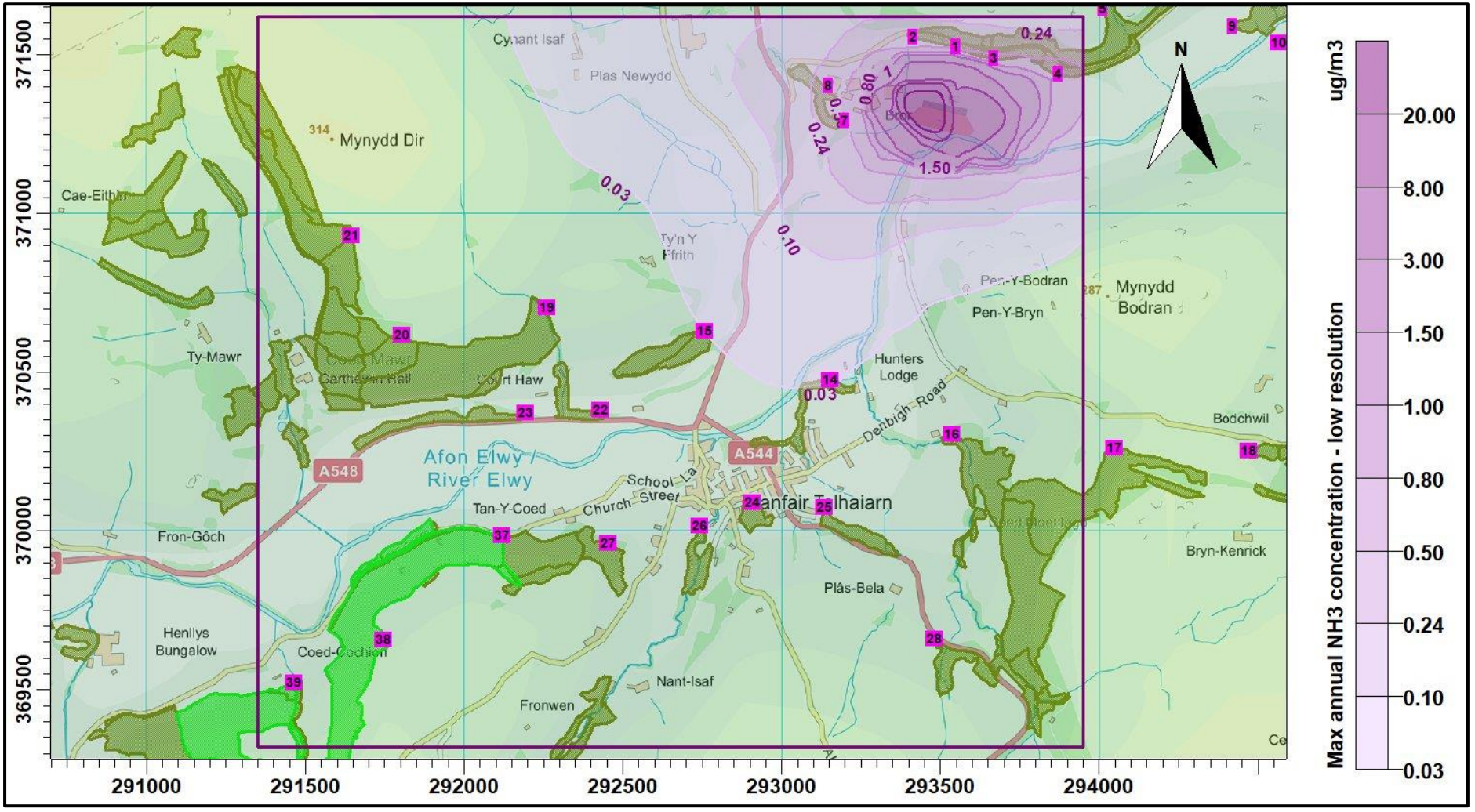


Figure 6b. Maximum annual ammonia concentration – high resolution

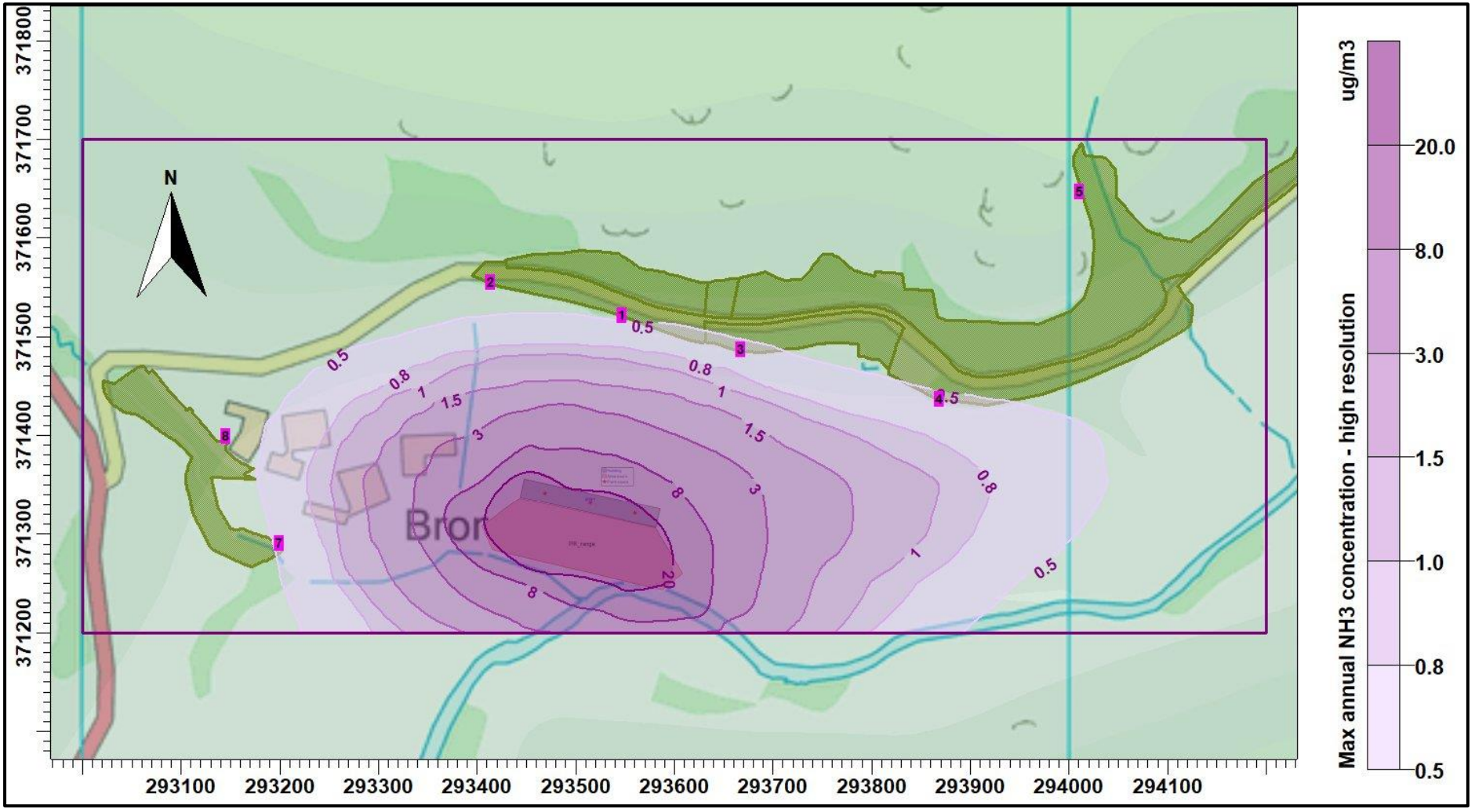


Figure 6c. Maximum annual nitrogen deposition rates – low resolution

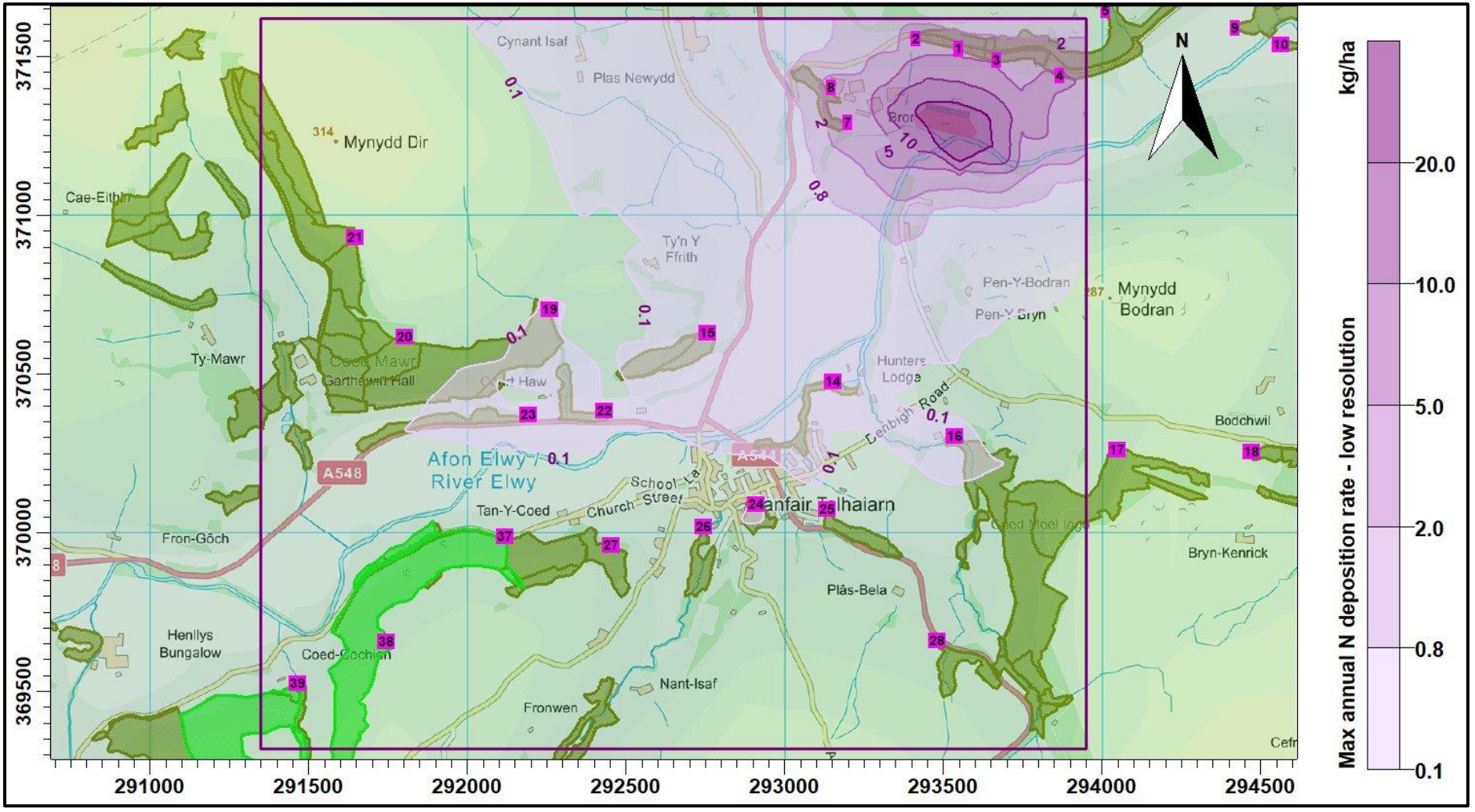
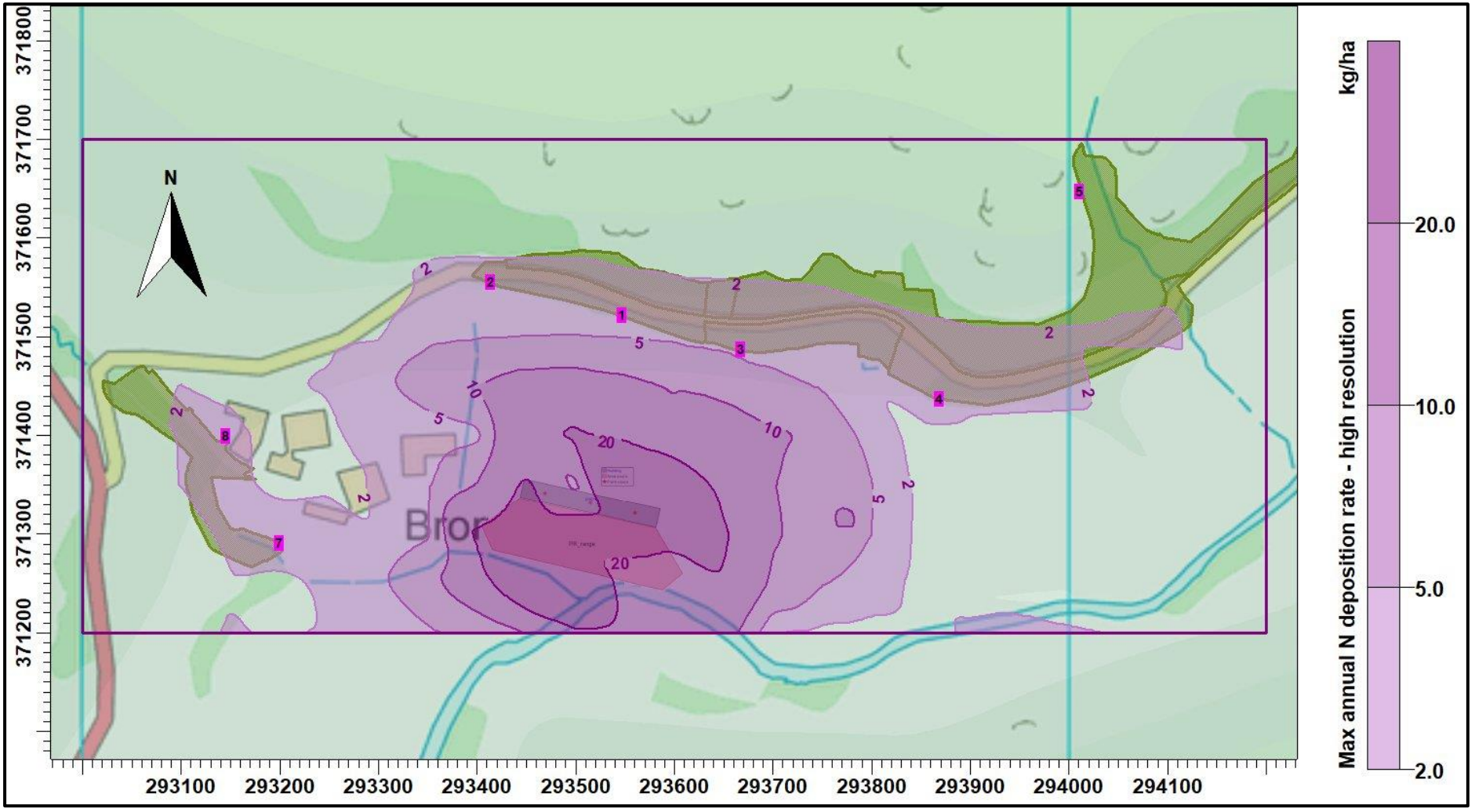


Figure 6d. Maximum annual nitrogen deposition rates – high resolution



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Rosina Bloor of Richard Parry & Partners LLP, on behalf of the applicant R. J. & N. M. Lloyd & Sons, to use computer modelling to assess the impact of ammonia emissions from the proposed free range egg laying chicken house at Bron Heulog, Llanfair Talhaiarn, Abergele, Conwy. LL22 8PE.

Ammonia emission rates from the proposed poultry house 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 at closer parts of the Coedydd Derw Elwy SSSI and at two of the closer unnamed AWs would potentially exceed Natural Resources Wales lower threshold (1% for a SSSI and 50% to 100% for an AW) of the Critical Level of 1.0 µg-NH_3/m^3.

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 Natural Resources Wales lower threshold percentage of Critical Level for the site (1% for a SSSI and 100% for non-statutory sites).

Detailed deposition modelling

The detailed modelling predicts that, when deposition and consequent plume depletion are considered:

- At the Coedydd Derw Elwy SSSI, the process contribution to ammonia concentration is predicted to be below the Natural Resources Wales lower threshold percentage (1%) of the Critical Level of 1.0 µg-NH_3/m^3.
- At the two unnamed AWs, the process contribution to ammonia concentrations is predicted to be below the Natural Resources Wales lower threshold percentage (100%) of the Critical Level of 1.0 µg-NH_3/m^3.

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