A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Proposed Broiler Chicken Rearing Houses at Upper Maenllwyd, near Kerry in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Rosina Bloor, of Roger Parry & Partners LLP, on behalf of the applicant, to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at land near to Upper Maenllwyd, Kerry, Newtown, Powys. SY16 4NB.

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 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 poultry houses at land south-east of Upper Maenllwyd is in a rural area approximately 2.5 km to the north-east of the village of Kerry near Newtown in Powys. The site is situated in the valley of the River Mule, a tributary of the River Severn, at an elevation of around 150 m, with the land rising towards higher ground to the north-east and south-west. The surrounding land is predominantly pasture, although there are some arable fields and wooded areas nearby.

Under the proposal, two new poultry houses would be constructed at Upper Maenllwyd. The proposed poultry houses would provide accommodation for up to 112,000 broiler chickens and would be ventilated by high speed ridge or roof fans. The chickens would be reared from day old chicks to up to around 38 days old and there would be approximately 7.5 crops per year.

There are several areas of unnamed Ancient Woodlands (AWs) within 2 km of Upper Maenllwyd. There are two Sites of Special Scientific Interest (SSSIs) within 5 km of the farm, namely: Hollybush Pastures SSSI and Montgomery Canal SSSI. The Montgomery Canal is also designated as a Special Area of Conservation (SAC). There are no other internationally designated sites within 5 km of Upper Maenllwyd.

A map of the surrounding area showing the positions of the proposed poultry unit at Upper Maenllwyd, the AWs, SSSIs and SAC is provided in Figures 1a and 1b. In the figures, the AWs are shaded in olive, the SSSIs are shaded in green, the SAC is shaded in purple and the site of the proposed poultry houses are indicated by a blue rectangle.

Figure 1a. The area surrounding Upper Maenllwyd – concentric circles radii 5 km (purple) and 2 km (olive)

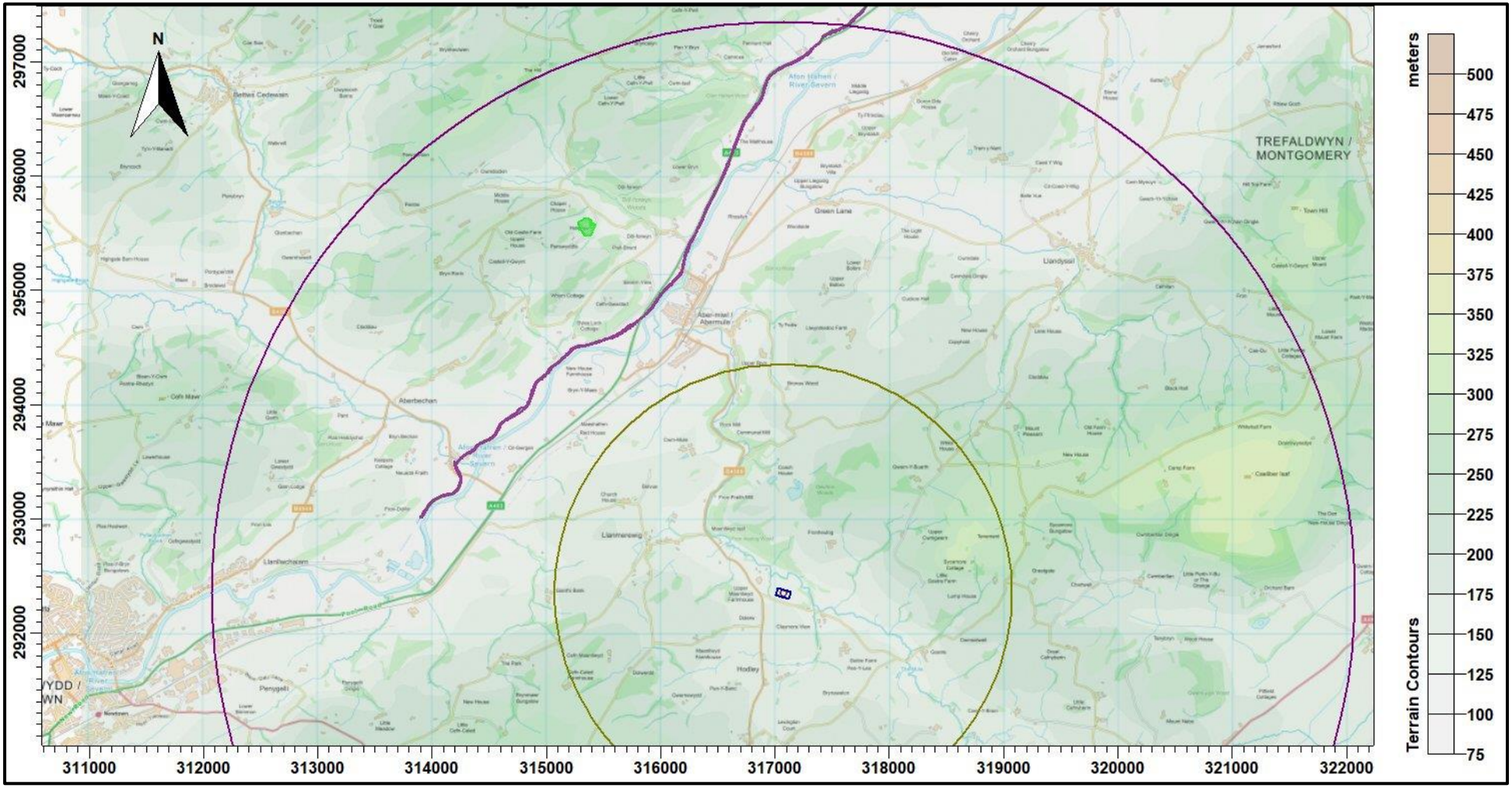
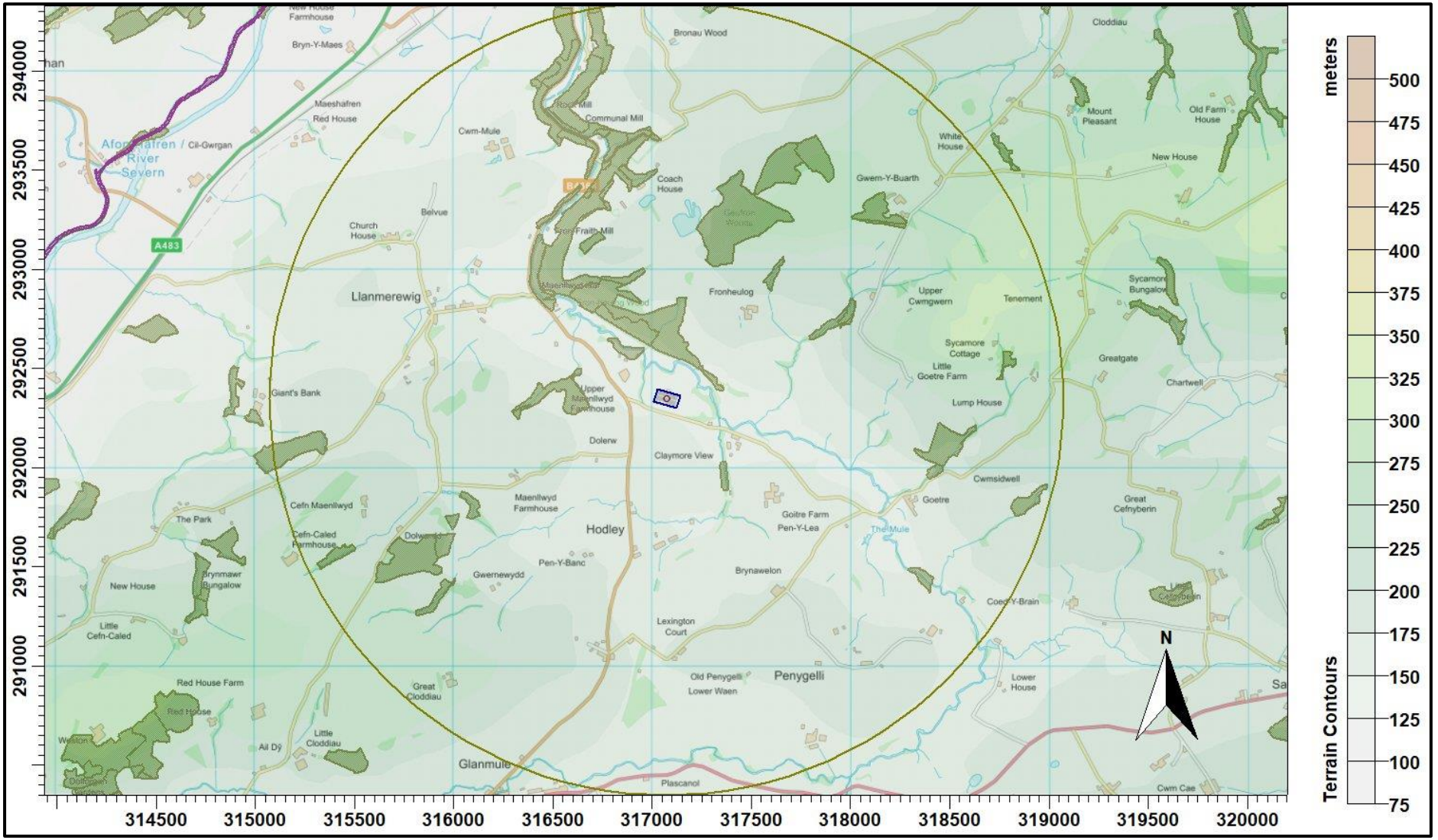


Figure 1b. The area surrounding Upper Maenllwyd – a closer view showing the AWs



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). 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 Upper Maenllwyd is 1.78 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 30.24 kg-N/ha/y and to short vegetation is 18.90 kg-N/ha/y. The background acid deposition rate to woodland is 2.27 keq/ha/y and to short vegetation is 1.45 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, December 2018).

3.3 Critical Levels and 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. Normally, the Critical Load for nitrogen deposition provides a stricter test than the Critical Load for acid deposition.

Table 1. Critical Levels and Critical Loads at the wildlife sites

Site	Critical Level (µg-NH_3/m^3)	Critical Load - Nitrogen Deposition (kg-N/ha/y)	Critical Load - Acid Deposition (keq/ha/y)
AWs	1.0 [1]	-	-
Hollybush Pastures SSSI	3.0 [1 & 2]	10.0 [2]	-
Montgomery Canal SAC/SSSI	3.0 [1 & 2]	10.0 [2]	-

1. A precautionary figure, used where details of the site are unavailable, or citations indicate that sensitive lichens and bryophytes may be present.
2. Based upon the citation for the sites and data from APIS (December, 2018).

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 1% 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.

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

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

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

Within the range between the lower and upper thresholds, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. N.B. In the case of LWSs and AWs, the Environment Agency do not usually consider other farms that may act in combination and therefore a PC of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

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

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

3.6 Quantification of ammonia emissions

Ammonia emission rates from poultry houses depend on many factors and are likely to be highly variable. However, the benchmarks for assessing impacts of ammonia and nitrogen deposition are framed in terms of an annual mean ammonia concentration and annual nitrogen deposition rates.

To obtain relatively robust figures for these statistics it is not necessary to model short term temporal variations and a steady continuous emission rate can be assumed. In fact, modelling short term temporal variations might introduce rather more uncertainty than modelling continuous emissions.

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

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

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	0.120668

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 Lake Vyrnwy and Shawbury have also been considered.

The GFS is a spectral model: the physics/dynamics model has an equivalent resolution of approximately 13 km; terrain is understood to be resolved at a resolution of approximately 2 km (with sub-13 km effects parameterised) and data are archived at a resolution of 0.25 degrees. 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 records may be over represented, this is because the instrumentation used may not record wind speed below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

- Traditional records may include very local deviations from the broad-scale wind flow that would not necessarily be representative of the site being modelled; these deviations are difficult to identify and remove from a meteorological record. Conversely, local effects at the site being modelled are relatively easy to impose on the broad-scale flow and provided horizontal resolution is not too great, the meteorological records from NWP data may be expected to represent well the broad-scale flow.

- Information on the state of the atmosphere above ground level which would otherwise be estimated by the meteorological pre-processor may be included explicitly.

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, wind speeds and directions will be further modified. The terrain and roughness length modified wind rose for Upper Maenllwyd is shown in Figure 2b. Note that in this case the local flow is strongly influenced by the valley formed by the River Mule; however, elsewhere in the modelling domain the modified wind roses may differ significantly ((particularly in the River Severn Valley for example) and that the resolution of the wind field in terrain runs is approximately 150 m in the preliminary modelling and low resolution detailed modelling and 100 m in the high resolution 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.

Data from the meteorological recording stations at Lake Vyrnwy and Shawbury have also been considered. However, neither Lake Vyrnwy nor Shawbury, has an aspect that in any way could be considered similar to Upper Maenllwyd; therefore, it should be noted that the frequency of winds from a particular direction in the Lake Vyrnwy and Shawbury data may be either high or low in comparison to what might occur at Upper Maenllwyd, which means mean concentrations downwind may be either over or under predicted. Additionally, periods of light winds and calms cannot be properly modelled. Therefore, 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 roses for Lake Vyrnwy and Shawbury are shown in Figures 2c and 2d.

Figure 2a. The wind rose. Raw GFS derived data, for 52.523 N, 3.223 W, 2014 – 2017

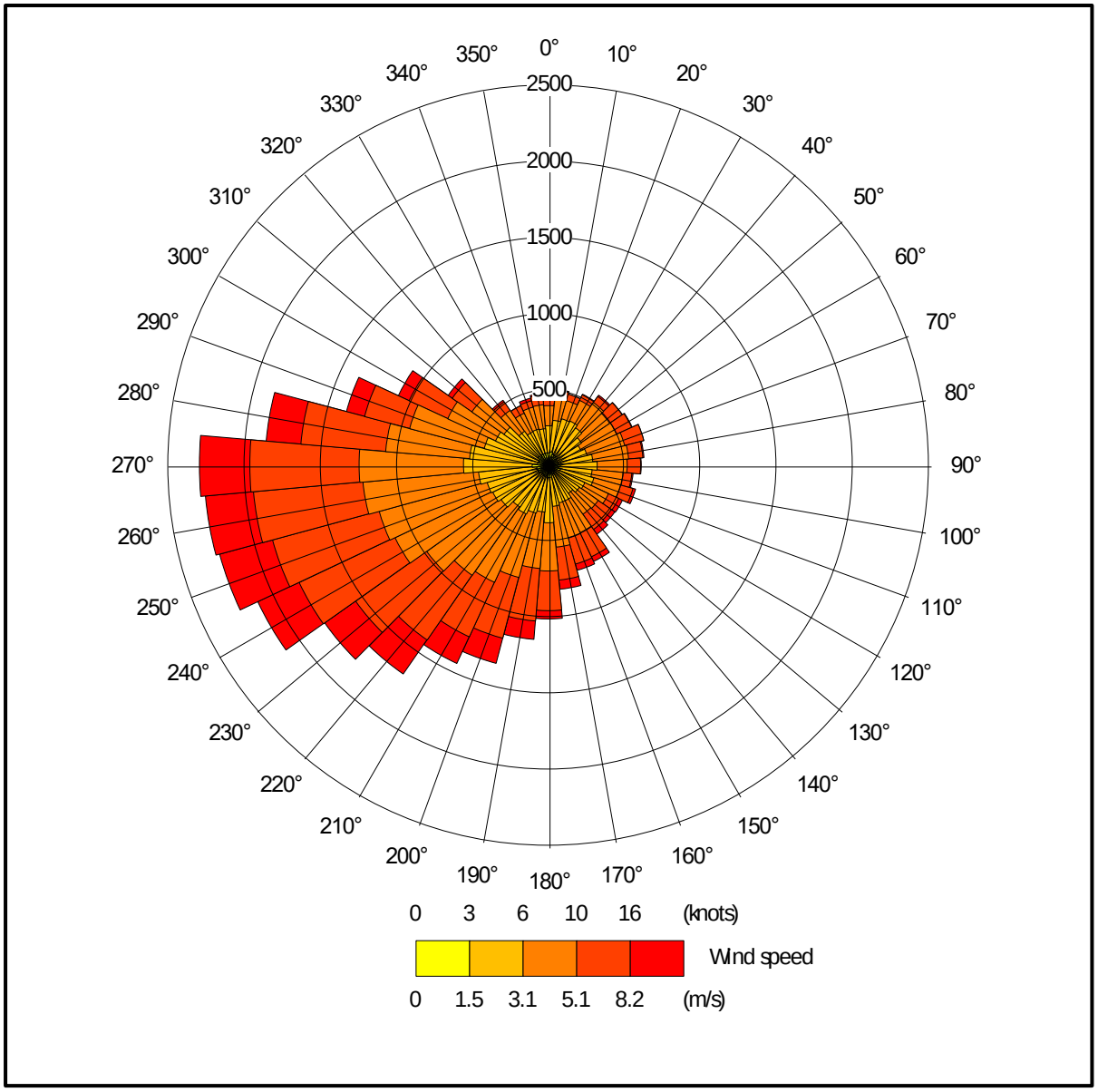


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 317050, 292400 2014-2017

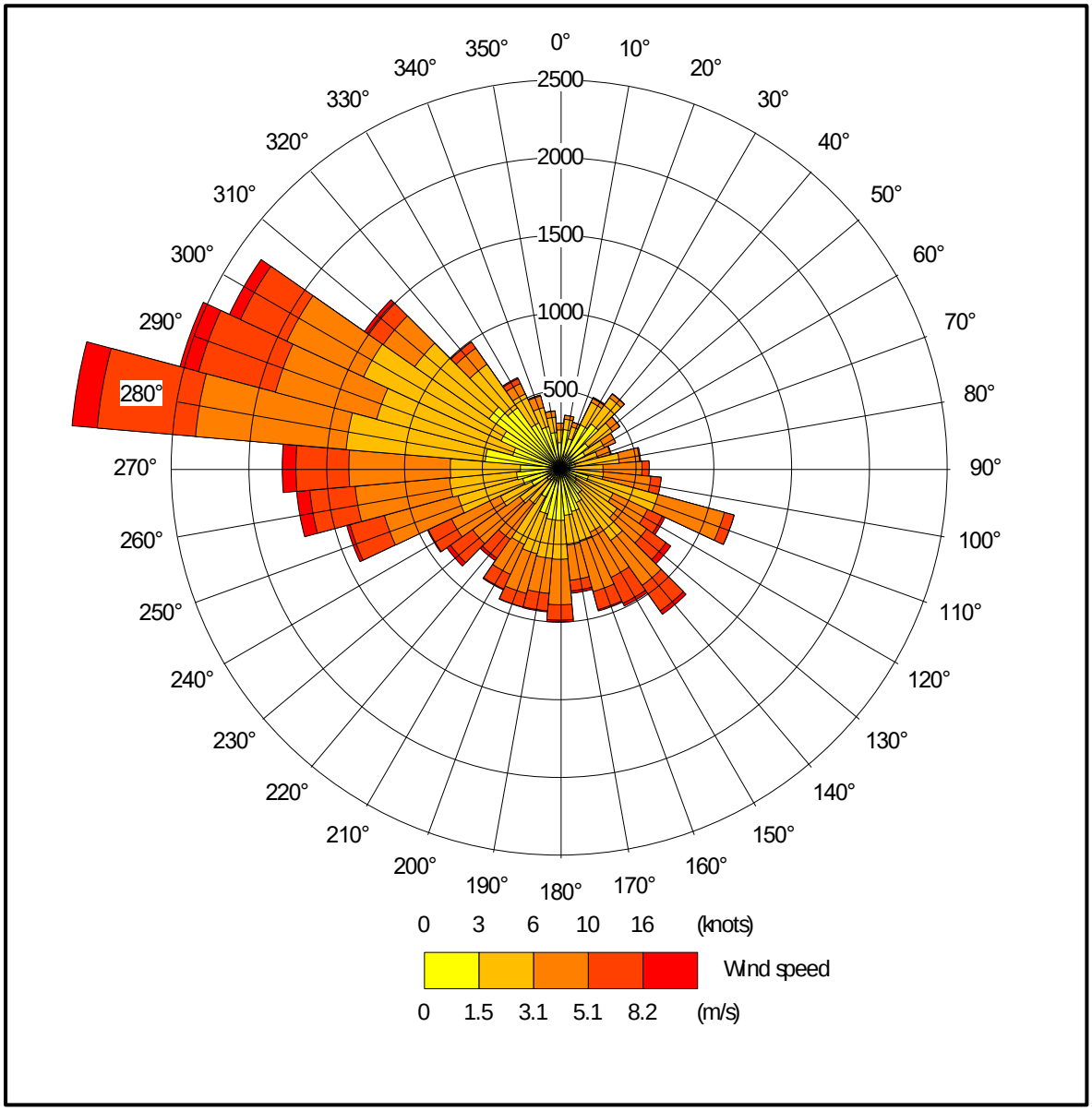


Figure 2c. The wind rose. Lake Vyrnwy, 2014 – 2017

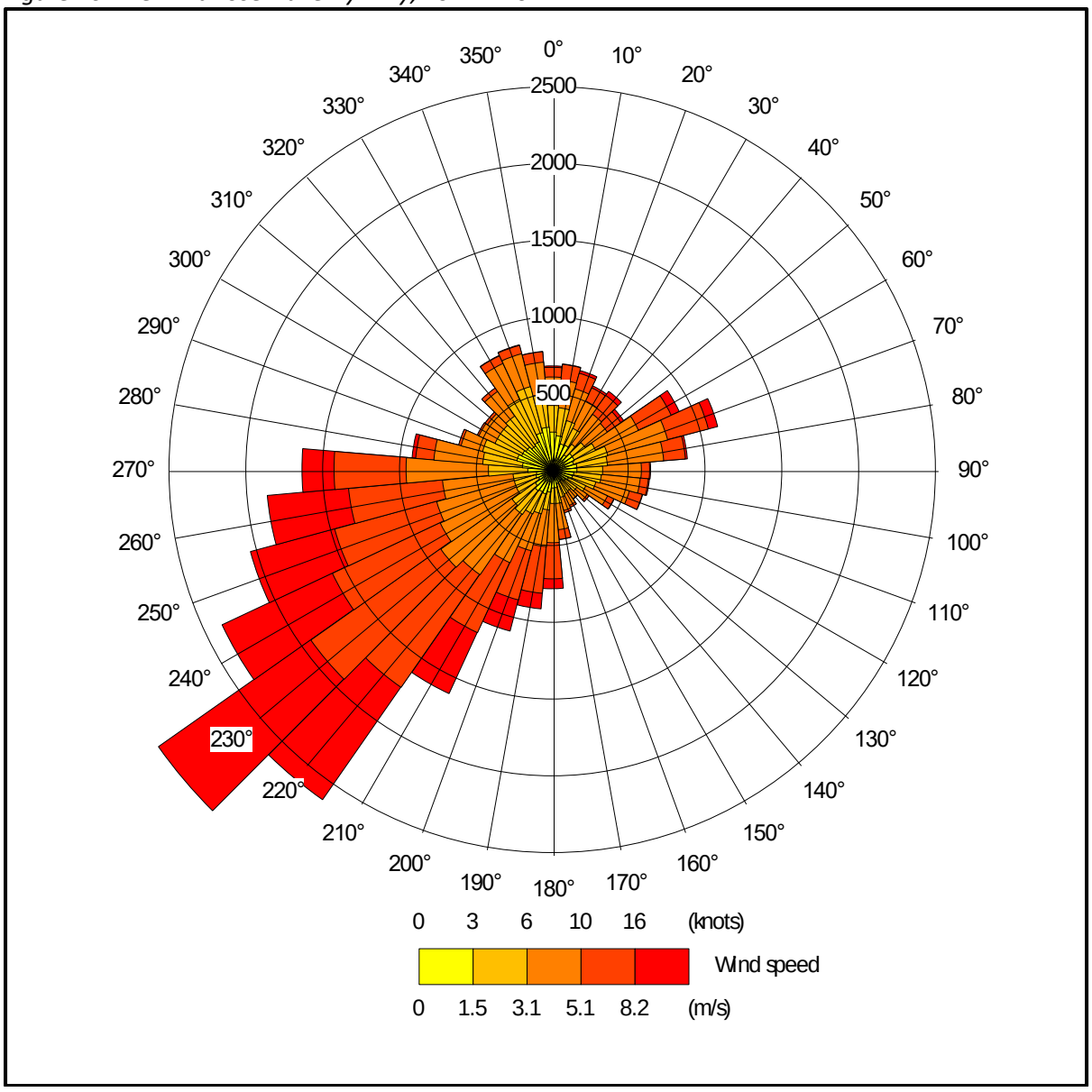
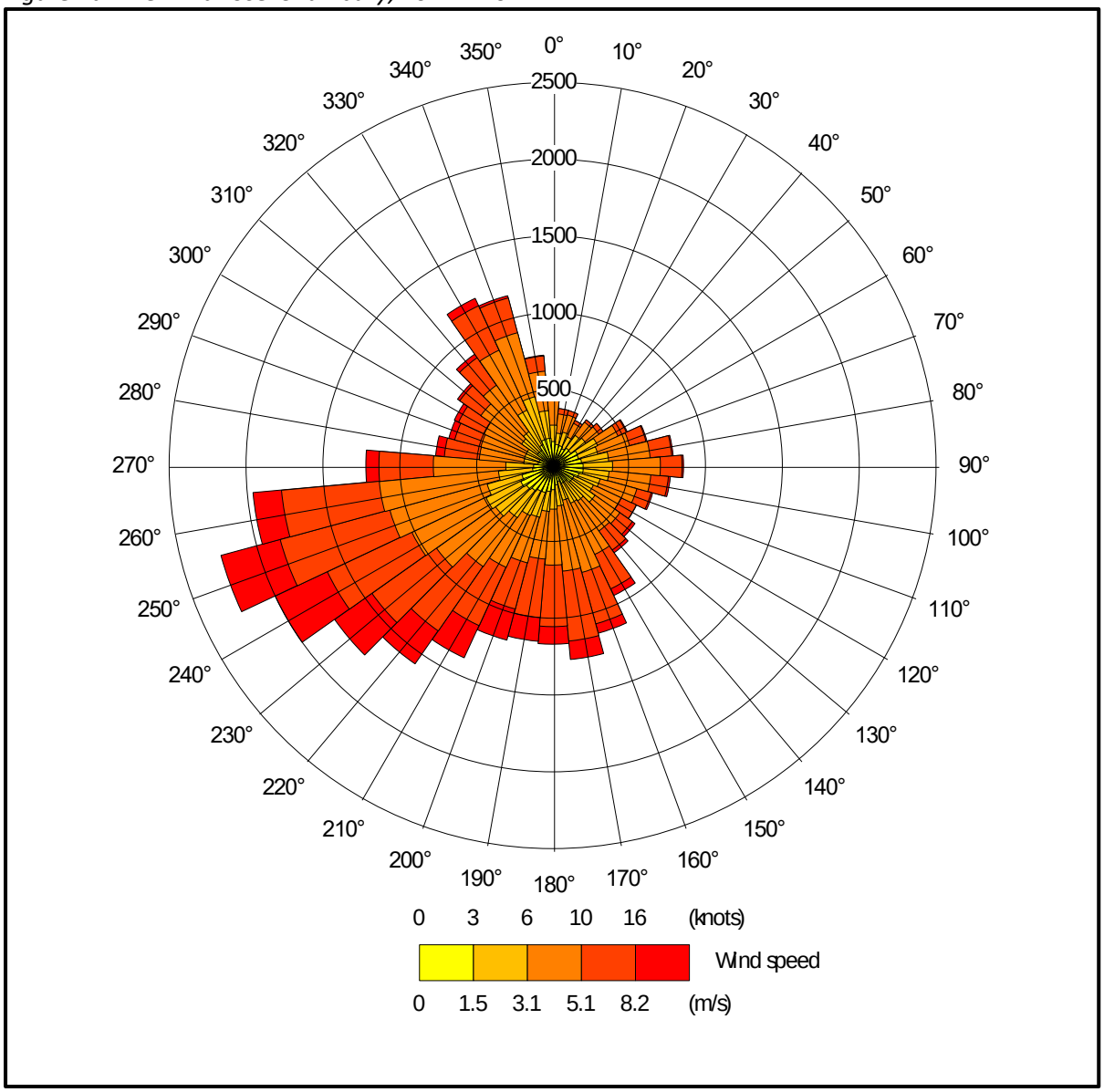


Figure 2d. The wind rose. Shawbury, 2014 – 2017



4.2 Emission sources

Emissions from the high speed ridge/roof fans that would be used to ventilate the proposed poultry houses are represented by three point sources per house within ADMS (PR1 a, b & c and PR2 a, b & c). Details of the point source parameters are shown in Table 3 and the positions of the sources may be seen in Figure 3.

Table 3. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
PR1 a, b & c to PR2 a, b & c	5.5	0.8	11.0	22.0	0.020111

4.3 Modelled buildings

The structure of the proposed poultry houses may affect the odour 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

Thirty-three discrete receptors have been defined: twenty-nine at the AWs (1 to 29), one at the SSSI (30) and three at the SSSI/SAC (31 to 33). 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 fields used in the detailed modelling, regular Cartesian grids have been defined at high and low resolution at ground level within ADMS. The positions of the Cartesian grids may be seen in Figures 4a and 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 10.0 km x 10.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the preliminary modelling and low resolution detailed modelling runs and a 6.4 km x 6.4 km domain has been resampled at 50 m horizontal resolution for use within ADMS for the high resolution 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 150 m for the preliminary modelling and low resolution detailed modelling runs and is 100 m for the high resolution 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 the stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of modelled sources and buildings

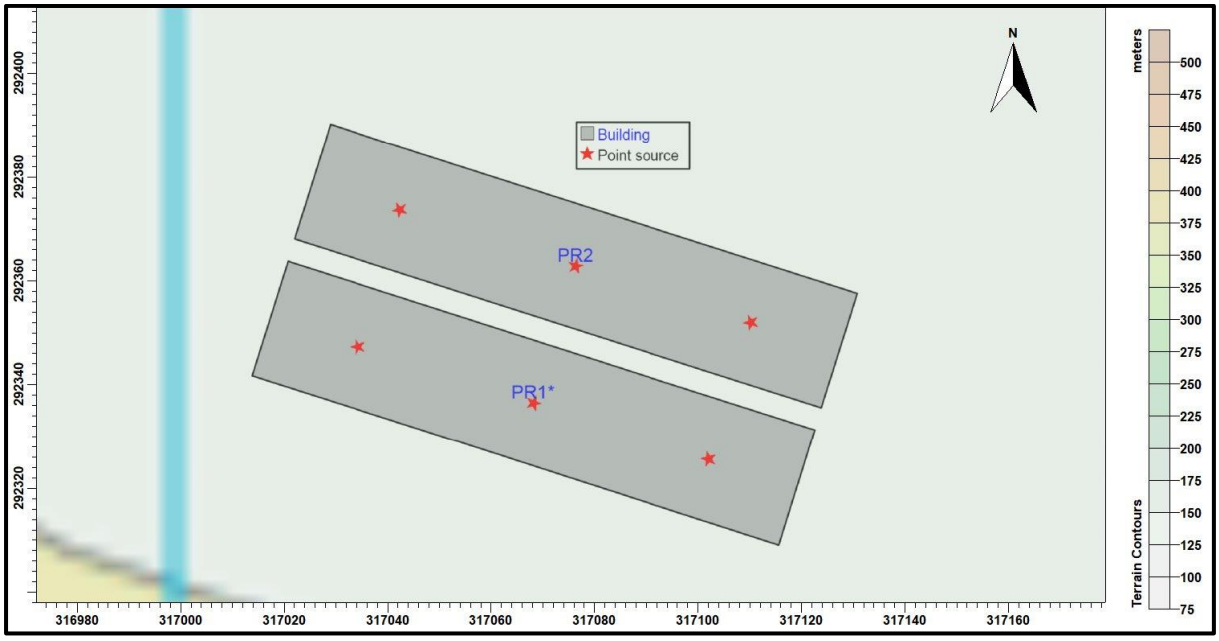


Figure 4a. The discrete receptors and regular Cartesian grids – a broad-scale view

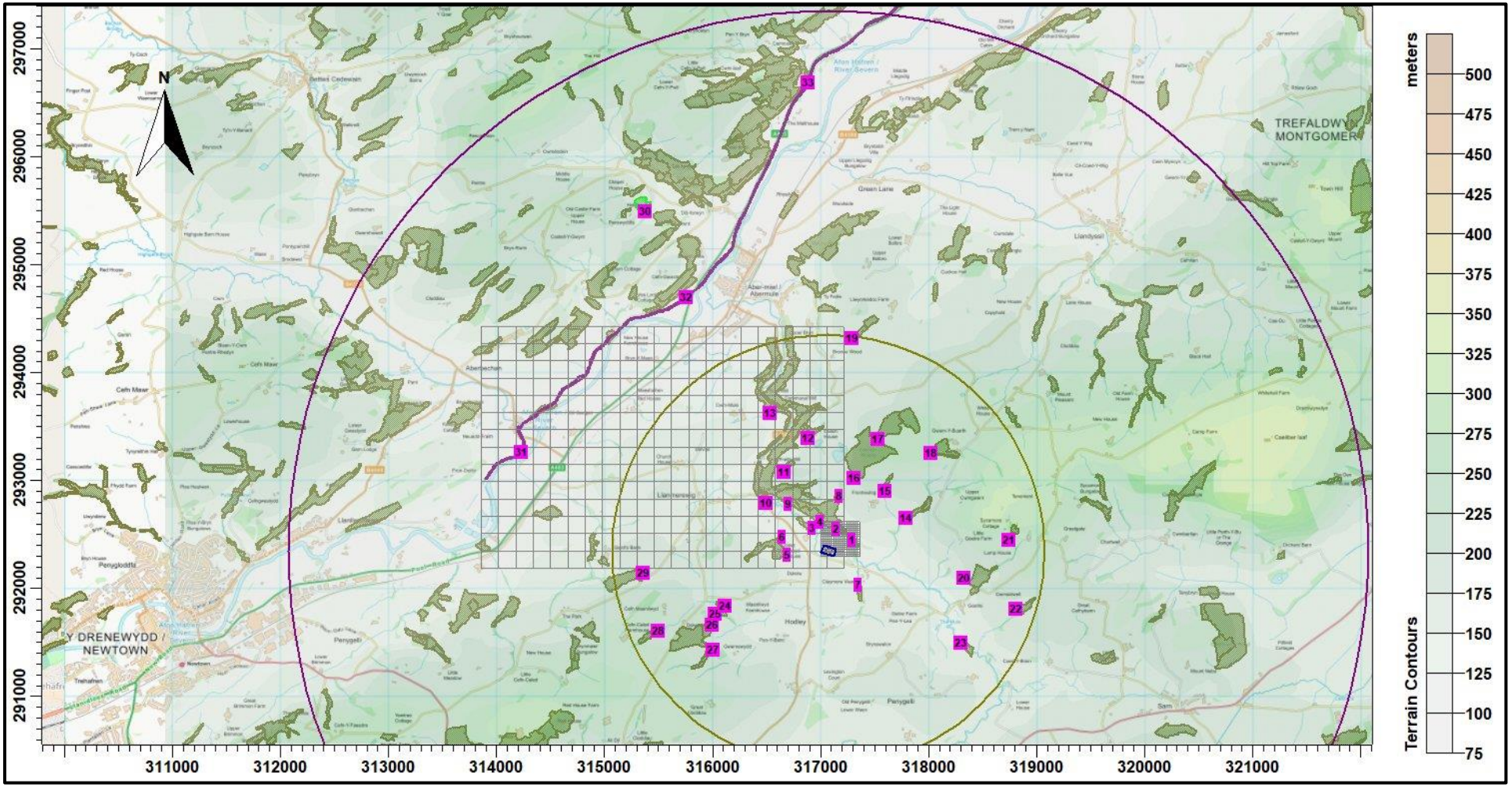
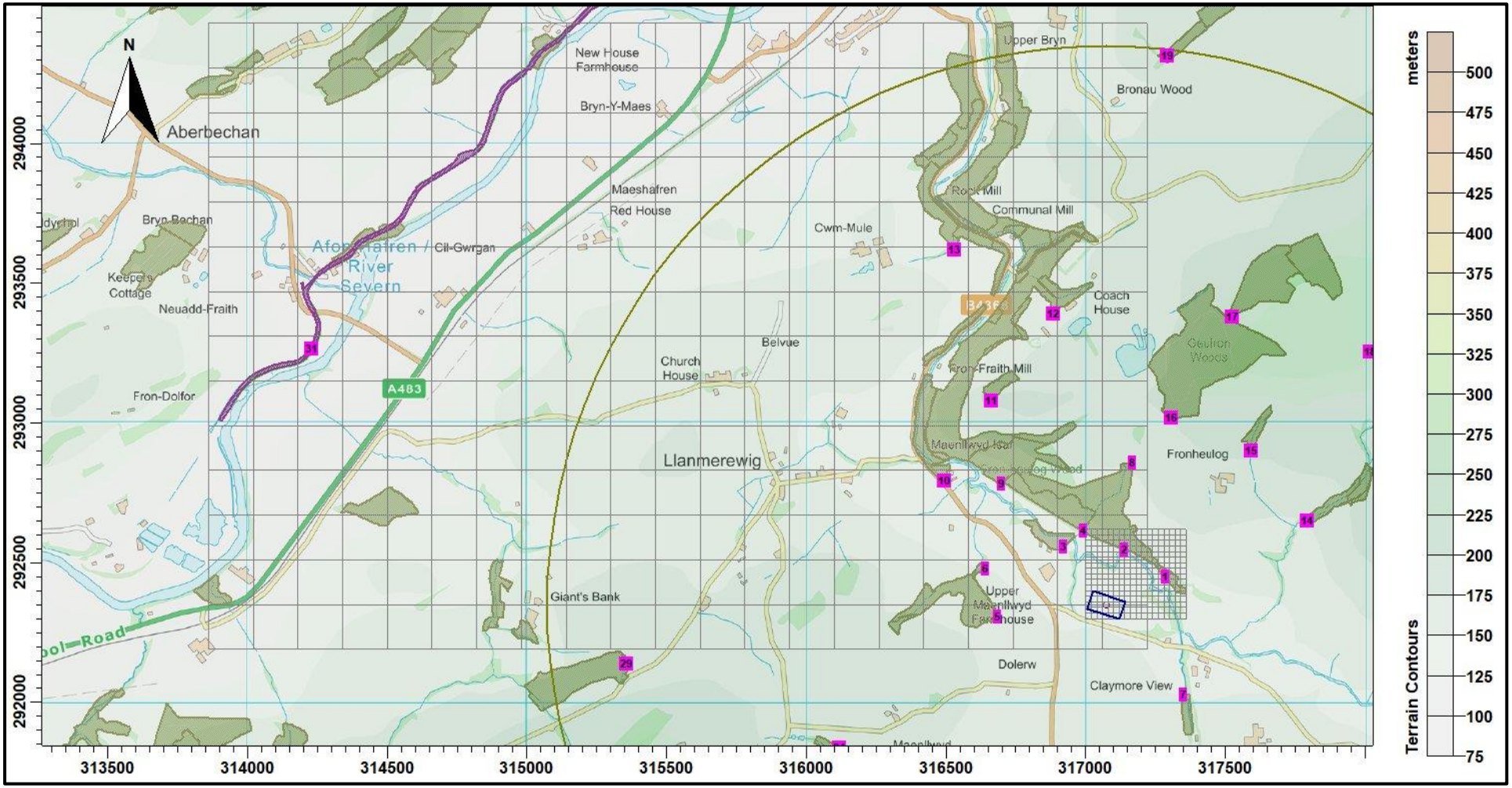


Figure 4b. The discrete receptors and regular Cartesian grids – a closer view



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 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. N.B deposition to water surfaces is calculated assuming a deposition velocity of 0.005 m/s.

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

NH_3 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 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 resolution and high resolution spatially varying deposition fields are provided in Figures 5a and 5b, respectively.

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

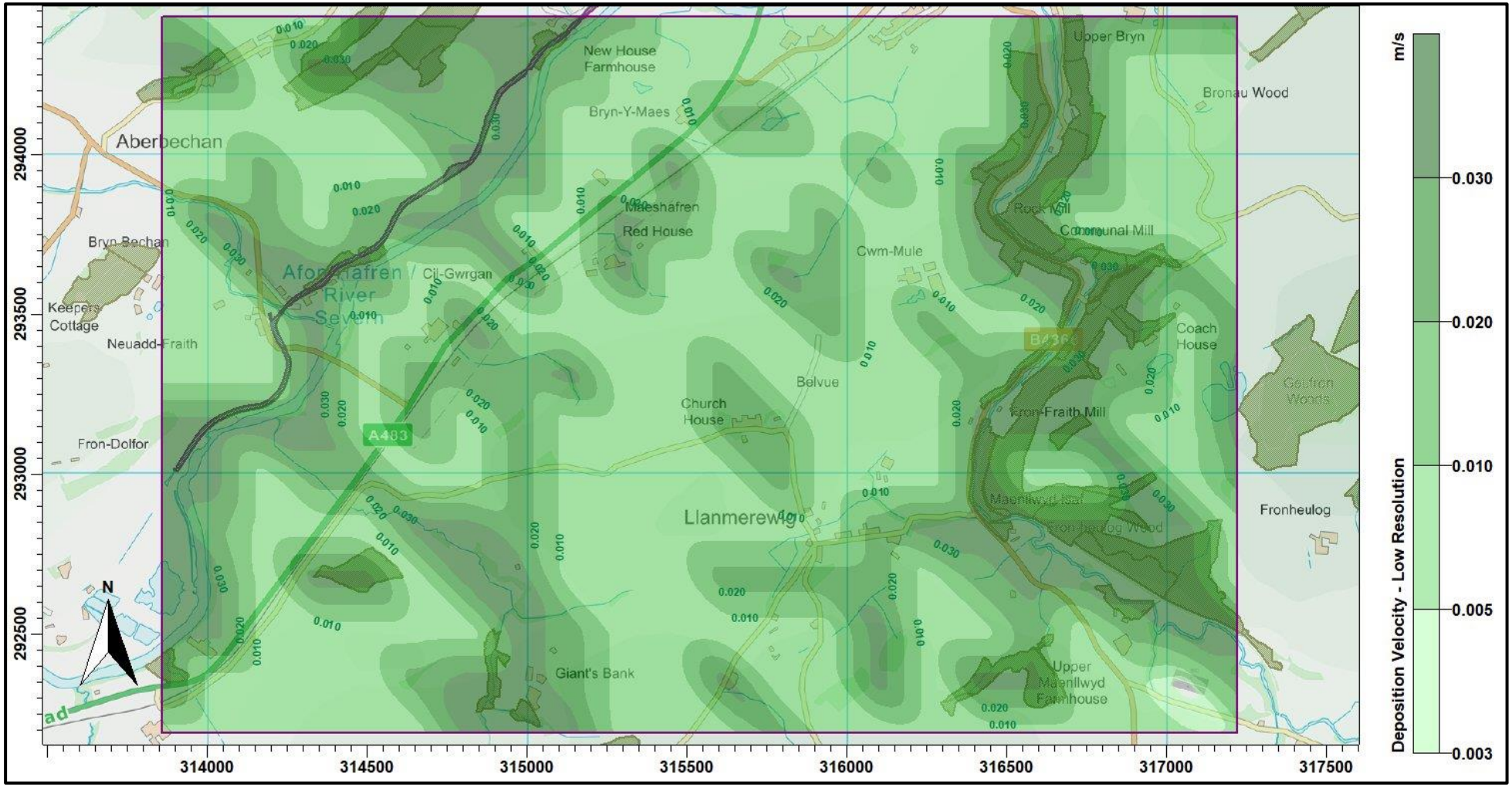
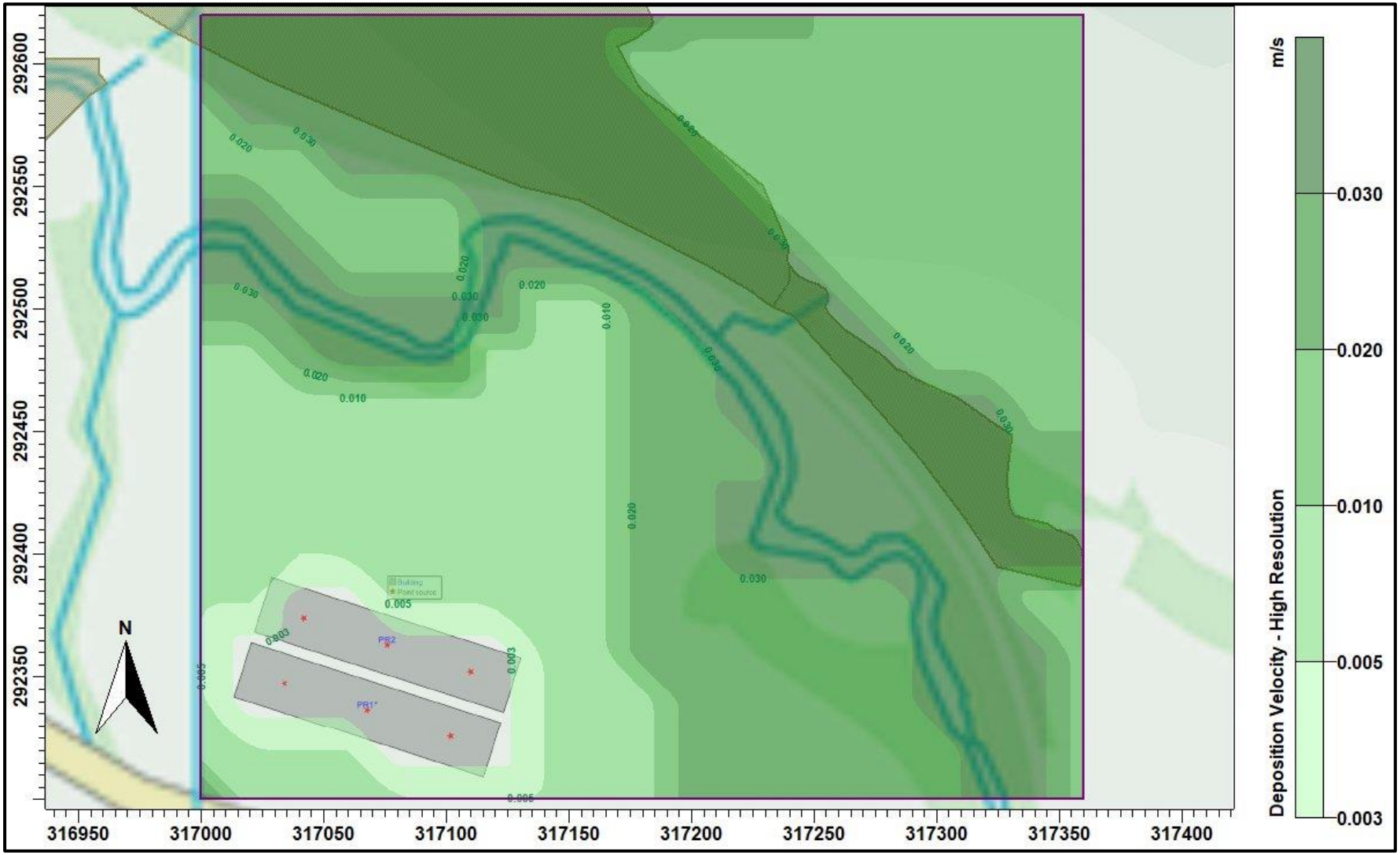


Figure 5b. The spatially varying deposition field – high resolution



5. Details of the Model Runs and Results

5.1 Preliminary modelling and model sensitivity tests

ADMS was run a total of twenty-eight times, once for each year in 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.
- Without calms and with terrain – GFS data with a fixed deposition at 0.003 m/s.
- In basic mode without calms, or terrain – Lake Vyrnwy data.
- In basic mode without calms, or terrain – Shawbury 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/SAC 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/SAC and 50%[1] to 100% for an AW) are coloured blue. For convenience, cells referring to the AWs are shaded olive, cells referring to the SSSI are shaded green and cells referring to the SAC are shaded purple.

Where a Critical Level of 3.0 µg-NH_3/m^3 is assumed, the Critical Load for nitrogen deposition then provides the stricter test and the following equivalences may be useful in interpreting Table 5.

- Assuming a deposition velocity of 0.03 m/s, 1% of the Critical Load of 10.0 kg-N/ha/y is equivalent to an annual mean ammonia concentration of 0.0129 µg-NH_3/m^3.

1. The pre-2016 figure has been retained

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

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	GFS No Calms Terrain Fixed Dep 0.003 m/s	Lake Vyrnwy No Calms No Terrain	Shawbury No Calms No Terrain
1	317286	292450	AW	**1.202**	**1.186**	**0.619**	**0.596**	**1.116**	**1.106**
2	317139	292547	AW	**0.953**	**0.939**	**0.588**	**0.567**	**0.728**	**0.771**
3	316919	292557	AW	0.346	0.341	**0.550**	**0.533**	0.141	0.452
4	316990	292614	AW	0.377	0.372	0.423	0.406	0.187	0.486
5	316684	292306	AW	0.217	0.215	0.136	0.127	0.236	0.233
6	316641	292477	AW	0.149	0.148	0.257	0.223	0.127	0.156
7	317348	292027	AW	0.154	0.153	0.228	0.211	0.173	0.213
8	317168	292858	AW	0.217	0.214	0.143	0.131	0.133	0.168
9	316698	292780	AW	0.101	0.100	0.127	0.120	0.042	0.115
10	316493	292791	AW	0.072	0.071	0.094	0.086	0.039	0.066
11	316664	293079	AW	0.057	0.056	0.060	0.056	0.026	0.076
12	316886	293390	AW	0.051	0.050	0.063	0.057	0.028	0.058
13	316531	293620	AW	0.031	0.031	0.037	0.032	0.015	0.038
14	317794	292650	AW	0.190	0.188	0.114	0.105	0.149	0.180
15	317593	292900	AW	0.138	0.137	0.067	0.059	0.159	0.136
16	317305	293018	AW	0.142	0.141	0.090	0.078	0.096	0.108
17	317526	293378	AW	0.071	0.070	0.052	0.042	0.052	0.056
18	318019	293255	AW	0.062	0.061	0.041	0.034	0.070	0.066
19	317294	294314	AW	0.025	0.025	0.026	0.021	0.018	0.024
20	318325	292092	AW	0.094	0.093	0.077	0.067	0.062	0.040
21	318742	292444	AW	0.070	0.069	0.026	0.023	0.045	0.047
22	318807	291805	AW	0.052	0.052	0.053	0.045	0.042	0.021
23	318299	291494	AW	0.038	0.038	0.116	0.090	0.042	0.027
24	316117	291836	AW	0.042	0.042	0.033	0.028	0.065	0.043
25	316021	291765	AW	0.037	0.037	0.029	0.024	0.056	0.037
26	315996	291663	AW	0.035	0.035	0.027	0.022	0.050	0.033
27	316002	291432	AW	0.032	0.032	0.023	0.019	0.038	0.026
28	315499	291601	AW	0.023	0.023	0.014	0.011	0.036	0.026
29	315357	292139	AW	0.032	0.031	0.018	0.014	0.029	0.033
30	315379	295487	Hollybush Pastures SSSI	0.010	0.010	0.004	0.003	0.004	0.010
31	314228	293263	Montgomery Canal SAC/SSSI	**0.015**	**0.014**	**0.039**	**0.022**	0.012	**0.013**
32	315752	294696	Montgomery Canal SAC/SSSI	**0.013**	**0.013**	0.010	0.007	0.006	**0.014**
33	316885	296687	Montgomery Canal SAC/SSSI	0.008	0.008	0.011	0.008	0.007	0.009

5.2 Detailed modelling

The detailed modelling, which includes ammonia deposition and the consequent plume depletion, was carried out over a restricted domain covering the proposed poultry houses at Upper Maenllwyd, the closer parts of the AW to the north-east and north and the closer parts of Montgomery Canal SAC/SSSI, the areas where preliminary modelling (GFS terrain and fixed deposition run) indicated that annual mean ammonia concentrations or nitrogen deposition rates would potentially exceed 1% or 50% of the relevant Critical Level or Critical Load, which are the Natural Resources Wales lower threshold percentages for a SSSI/SAC and AW.

At the other wildlife sites considered, the preliminary modelling indicated that ammonia levels (and nitrogen deposition rates) would be below Natural Resources Wales relevant lower threshold percentage of Critical Level/Load for the designation of the site.

Terrain effects may be significant at some receptors; therefore, the detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition; therefore, calms have not been included in the detailed modelling; however, the results of the preliminary modelling indicate that the effects of calms are insignificant in this case.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors within the detailed modelling domain are shown in Tables 6a and 6b. In the Table, predicted ammonia concentrations or nitrogen deposition rates that are in excess of the Natural Resources Wales upper threshold (8% of Critical Level or Load for a SSSI/SAC 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/SAC and 50%[1] 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.

1. The 2016 figure has been retained.

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

Receptor number	X(m)	Y(m)	Name	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	317286	292450	AW	0.030	1.0	10.0	0.53	**52.7**	4.11	41.1
2	317139	292547	AW	0.030	1.0	10.0	0.40	40.2	3.13	31.3

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

Receptor number	X(m)	Y(m)	Name	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
3	316919	292557	AW	0.030	1.0	10.0	0.47	46.6	3.63	36.3
4	316990	292614	AW	0.030	1.0	10.0	0.33	33.1	2.58	25.8
5	316684	292306	AW	0.030	1.0	10.0	0.12	12.3	0.96	9.6
6	316641	292477	AW	0.030	1.0	10.0	0.19	18.5	1.44	14.4
8	317168	292858	AW	0.030	1.0	10.0	0.12	11.9	0.93	9.3
9	316698	292780	AW	0.030	1.0	10.0	0.10	9.8	0.76	7.6
10	316493	292791	AW	0.030	1.0	10.0	0.07	7.0	0.54	5.4
11	316664	293079	AW	0.030	1.0	10.0	0.04	4.5	0.35	3.5
12	316886	293390	AW	0.030	1.0	10.0	0.04	4.2	0.33	3.3
13	316531	293620	AW	0.030	1.0	10.0	0.02	2.4	0.19	1.9
31	314228	293263	Montgomery Canal SAC/SSSI	0.030	3.0	10.0	0.02	0.6	0.14	**1.4**

Figure 6a. Maximum annual ammonia concentration - high resolution

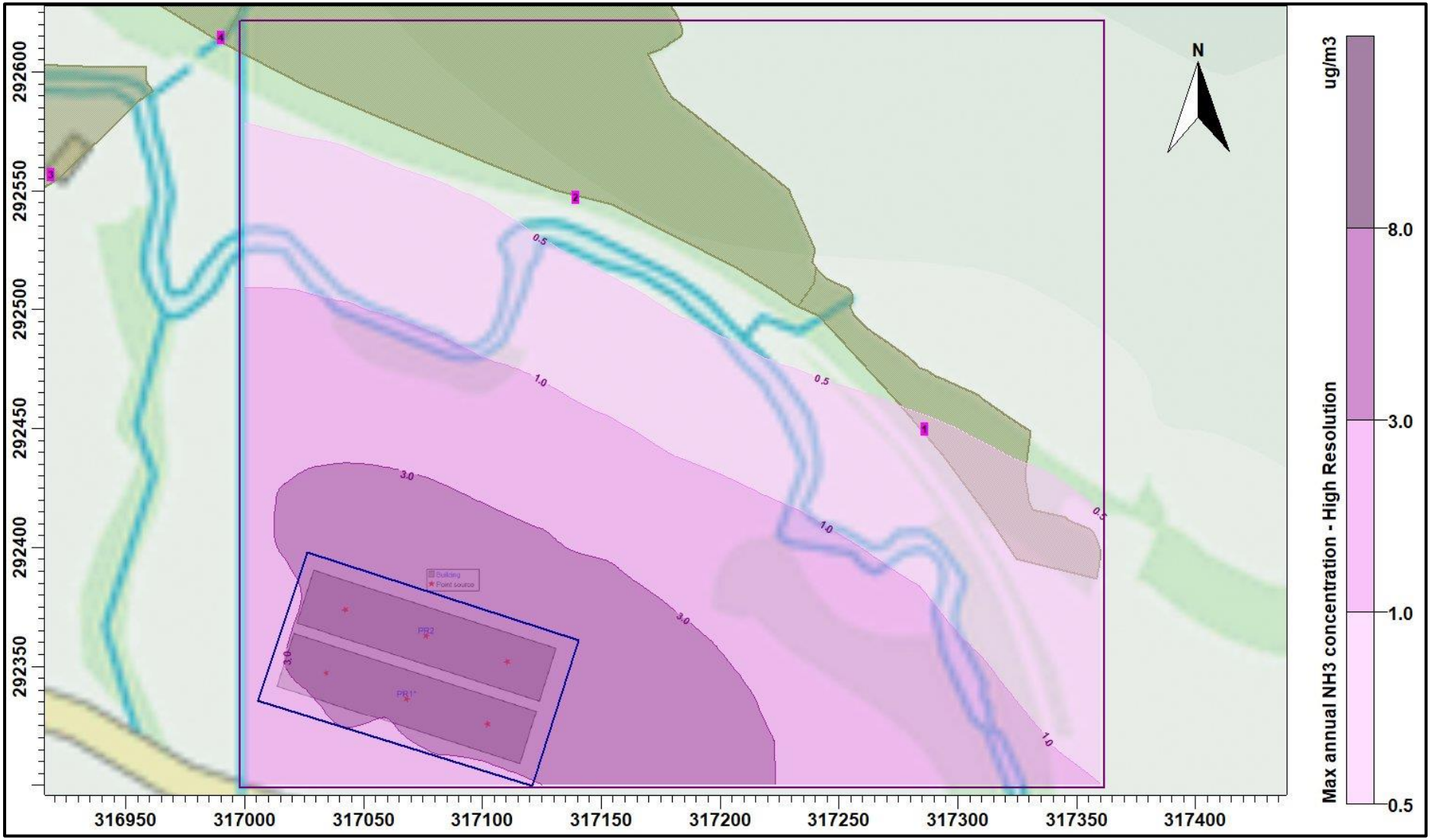


Figure 6b. Maximum annual ammonia concentration - low resolution

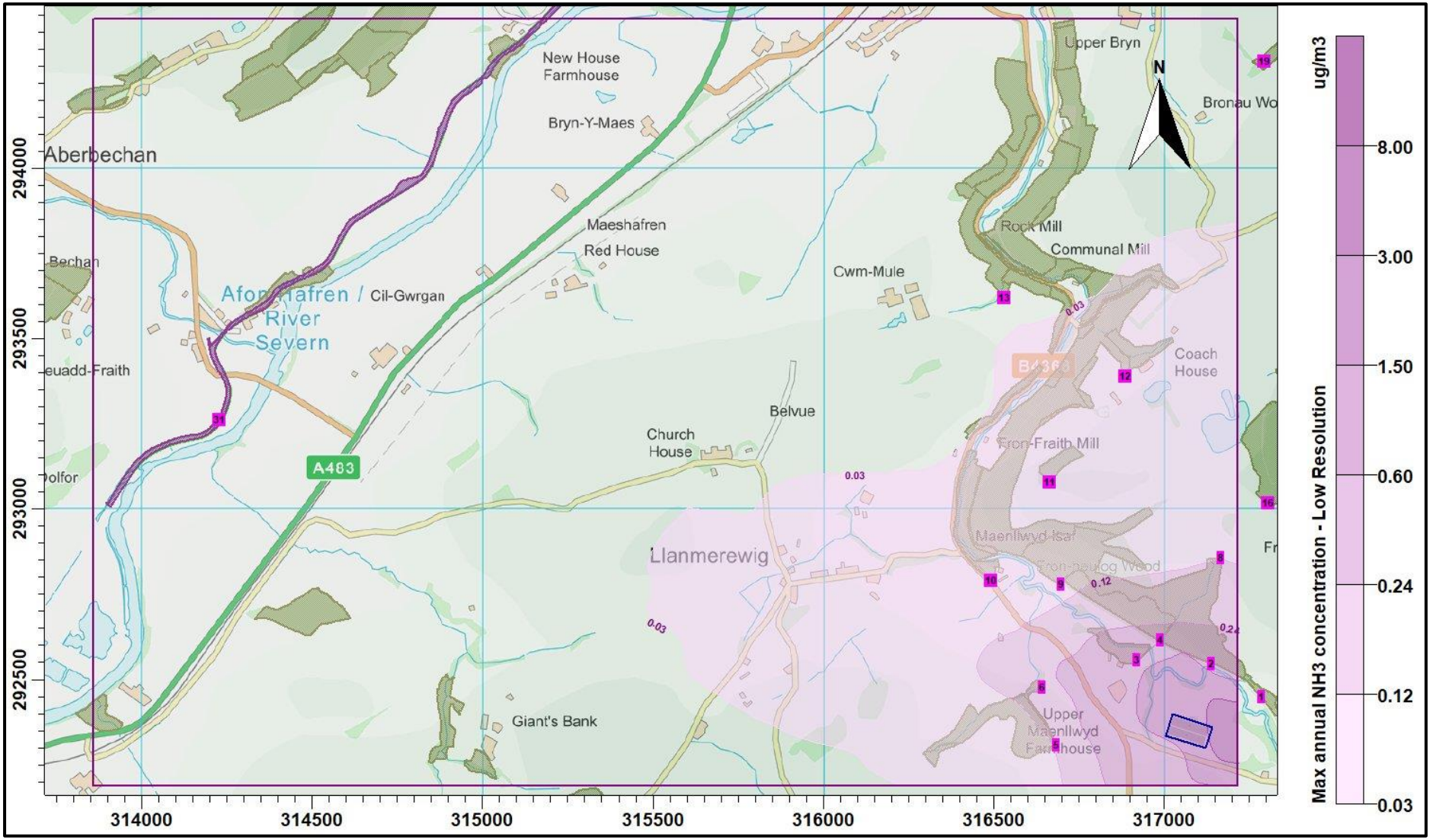


Figure 6c. Maximum annual nitrogen deposition rates – high resolution

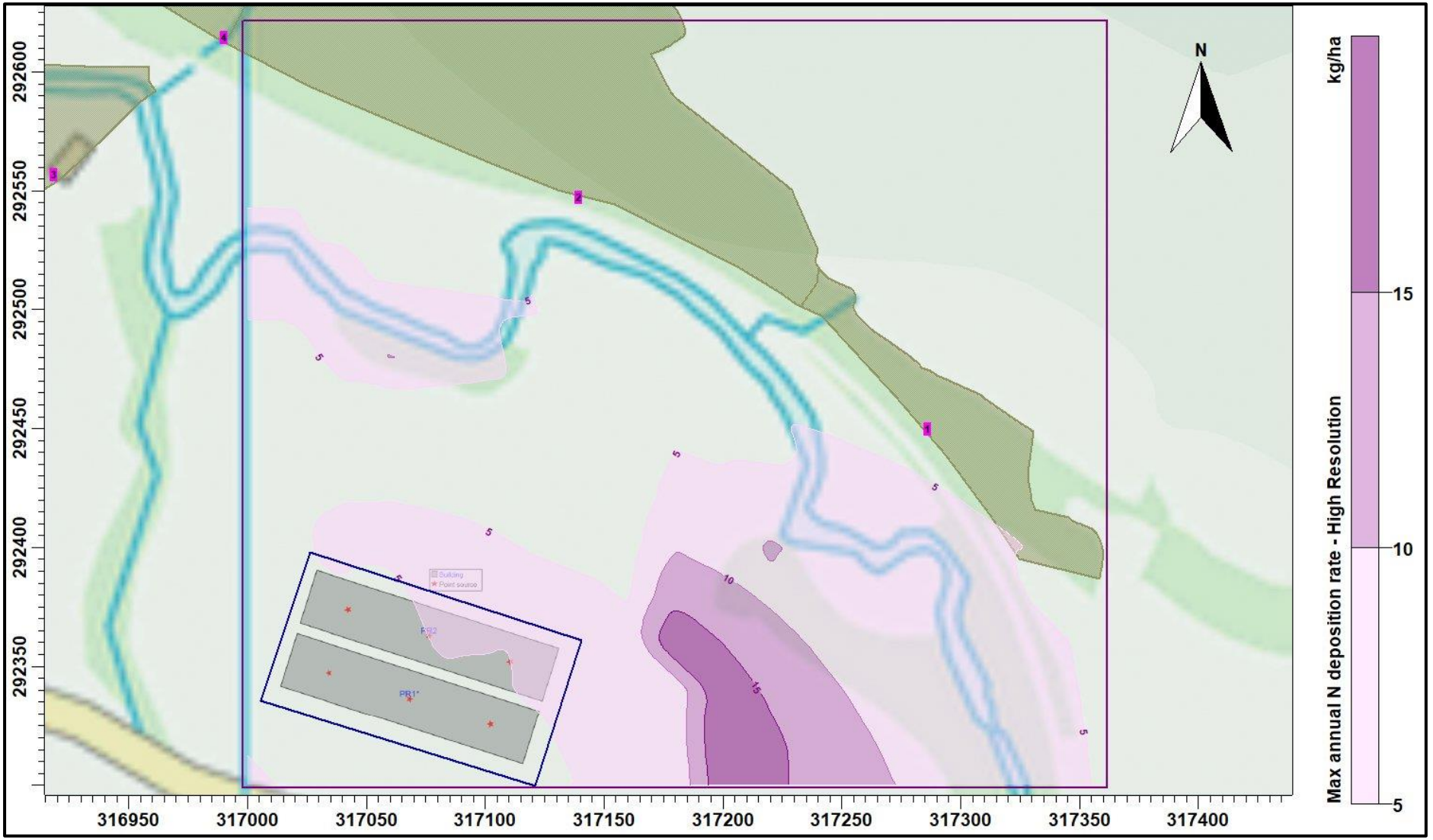
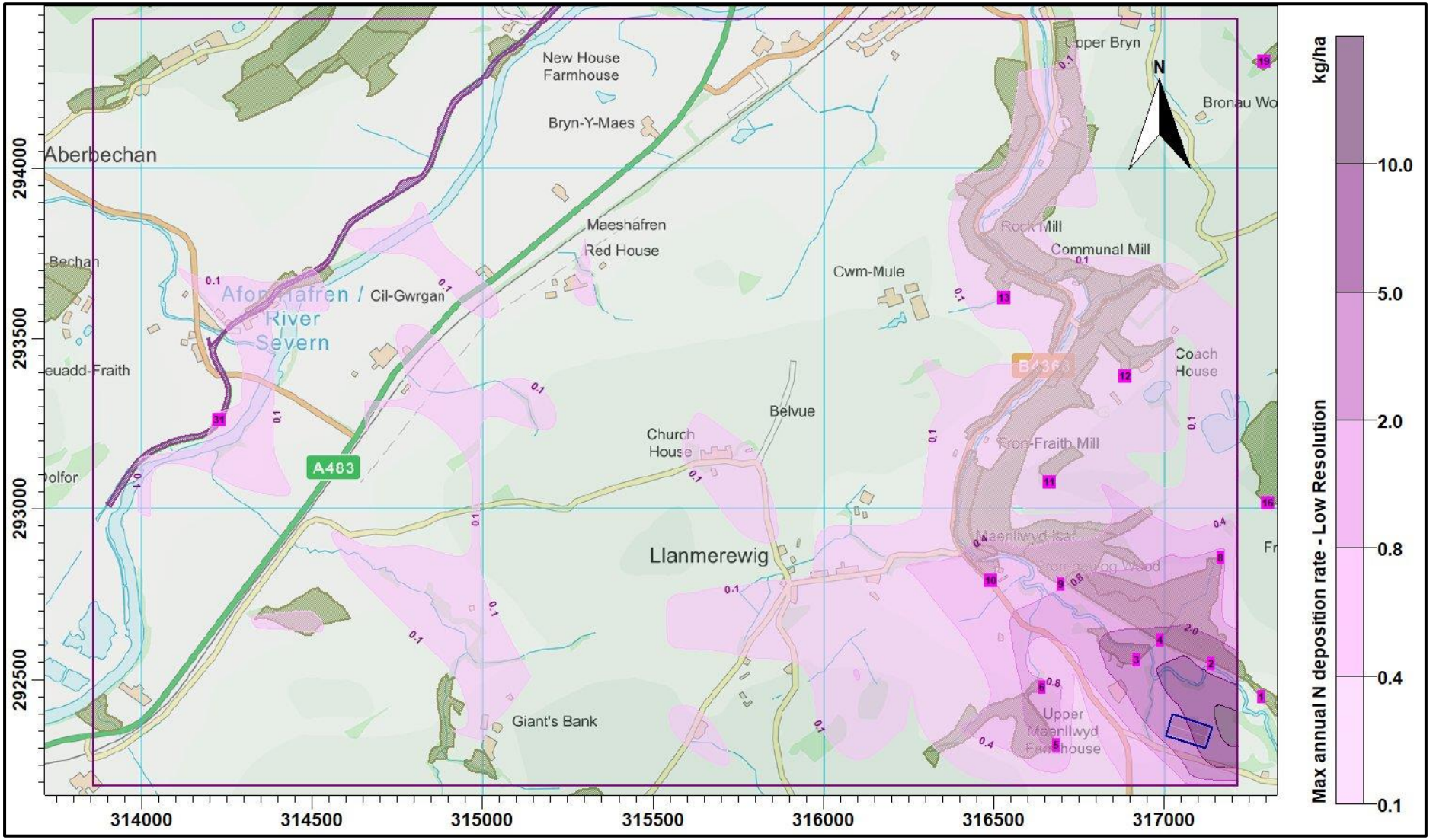


Figure 6d. Maximum annual nitrogen deposition rates – low resolution



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Rosina Bloor, of Roger Parry & Partners LLP, on behalf of the applicant, to use computer modelling to assess the impact of ammonia emissions from the proposed broiler chicken rearing houses at land near to Upper Maenllwyd, Kerry, Newtown, Powys. SY16 4NB.

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 and acid deposition rates in the surrounding area.

Preliminary modelling

The preliminary modelling predicts that:

- The process contribution of the proposed poultry houses to the annual ammonia concentration and the nitrogen deposition rate (GFS fixed deposition run) would potentially exceed the Natural Resources Wales lower threshold percentage of the Critical Level (50% for an AW) at the closer parts of the AW to the north-east/north of the poultry houses.

- The process contribution of the proposed poultry houses to the annual ammonia concentration and the nitrogen deposition rate (GFS fixed deposition run) would potentially exceed the Natural Resources Wales lower threshold percentage of the Critical Level and/or Load (1% for a SSSI/SAC) at the closer parts of Montgomery Canal SAC/SSSI.

- At the other wildlife sites considered, the preliminary modelling indicated that ammonia levels (and nitrogen deposition rates) would be below the Natural Resources Wales lower threshold percentage of Critical Level/Load for the designation of the site.

Detailed deposition modelling

The detailed modelling predicts that when deposition and consequent plume depletion are fully considered, the process contribution to ammonia concentrations and nitrogen deposition rates:

- Would be below the Natural Resources Wales lower threshold of 50% of the strictest Critical Level of 1.0 µg-NH_3/m^3 at the closest unnamed AW to the north.

- Would be below the Natural Resources Wales lower threshold of 1% of the Critical Level of 3.0 µg-NH_3/m^3 but would exceed by a small margin the Natural Resources Wales lower threshold of 1% of the lower bound Critical Load of 10.0 kg-N/ha/y (assuming a deposition velocity of 0.03 m/s) over closer parts of the Montgomery Canal SAC/SSSI.

In such cases, where the predicted process contributions to ammonia concentrations and nitrogen deposition rates are between the Natural Resources Wales/Environment Agency's lower and upper

thresholds, depending on background levels, the sensitivity of the wildlife sites and the presence or not of other new ammonia sources, including those currently in planning, an in-combination assessment may be necessary as part of the competent authority's appropriate assessment.

7. References

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