A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Free Range Egg Laying Chicken Houses at Upper Bryn Farm, near Abermule in Powys

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The modelling undertaken is totally dependent on the adequacy and accuracy of the information supplied by the client and/or the assumptions made. Should project details prove to be incorrect or inadequate, the accuracy of the results and/or reports are likely to be affected and we reserve the right to amend our modelling and/or reports.

1. Introduction

AS Modelling & Data Ltd. has been instructed by Ms. Rosina Riddle, of Roger Parry & Partners LLP, on behalf of their client, to use computer modelling to assess the impact of ammonia emissions from the free range egg-laying chicken houses at Upper Bryn Farm, Abermule, Montgomery, Powys. SY15 6JW.

Ammonia emission rates from the poultry houses have been assessed and quantified based upon the Natural Resources Wales standard ammonia emission factors (for screening and modelling). 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 site 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 farmstead at Upper Bryn is in a rural area around 1.0 km to the south-east of the village of Abermule in Powys. The site is at an elevation of around 175 m, with the land falling towards the River Severn Valley to the north-west and rising towards hills and mountains to the south-east. The surrounding land use is predominantly pasture, although there are also some arable fields and wooded areas.

The existing poultry house at Upper Bryn Farm is approximately 500 m to the south-south-east of the main farm buildings. This poultry house provides accommodation for up to 32,000 egg-laying chickens and is ventilated by high-speed ridge fans. Within the sheds the chickens are housed in vertical tiers and manure is removed twice weekly by a belt system and taken off the site. The chickens have daytime access to an outdoor ranging area via a series of pop holes along the side of the house.

It is proposed that a second poultry house be constructed on a green-field site approximately 50 m to the west of the existing poultry house. The new poultry house would provide accommodation for up to 32,000 egg-laying chickens and would be ventilated by high-speed fans. A belt system would remove manure from the house twice weekly and the manure would be taken off site. The chickens would have daytime access to outdoor ranging areas via a series of pop holes along the sides of the house.

There are a number of areas designated as Ancient Woodlands (AWs) within 2 km of the poultry houses at Upper Bryn Farm. There are two Sites of Special Scientific Interest (SSSI), namely Hollybush Pastures SSSI, and parts of Montgomery Canal SSSI, which is also designated as a Special Area of Conservation (SAC), within 5 km of the farm. There are two other SSSIs and some woodlands designated by Natural Resources Wales as ammonia sensitive AWs within 10 km of the site that have also been considered. Some further details of the statutory sites are provided below:

- **Hollybush Pastures SSSI** - Approximately 2.2 km to the north-west - A fine example of an unimproved dry pasture supporting species-rich grassland communities.
- **Montgomery Canal SSSI/SAC** - Approximately 1.4 km to the north-west, at its closest point - Of special interest because it supports aquatic, emergent and marginal plant communities of exceptional richness, including a large population of the internationally rare and threatened floating water plantain *Luronium natans* and several other rare and scarce water plants. An important aquatic invertebrate assemblage is also present.
- **Caeau Glyn SSSI** - Approximately 8.8 km to the north - A fine example of unimproved, slightly base-rich, dry grassland supporting several locally uncommon plant species.
- **Gregynog SSSI** - Approximately 8.5 km to the west-north-west - Of special interest for its wood-pasture/parkland habitat and associated epiphytic lichens and specialist invertebrates associated with ancient trees.

Maps of the surrounding area showing the positions of the poultry houses and the nearby wildlife sites are provided in Figures 1a and 1b. In these figures, the AWs are outlined in olive, the SSSIs are shaded in green, the SAC is shaded in purple, the ammonia sensitive AWs are shaded in blue and the positions of the existing and proposed poultry houses are outlined in blue.

Figure 1a. The area surrounding Upper Bryn Farm - concentric circles radii of 2 km (olive), 5 km (green) and 10km (purple)

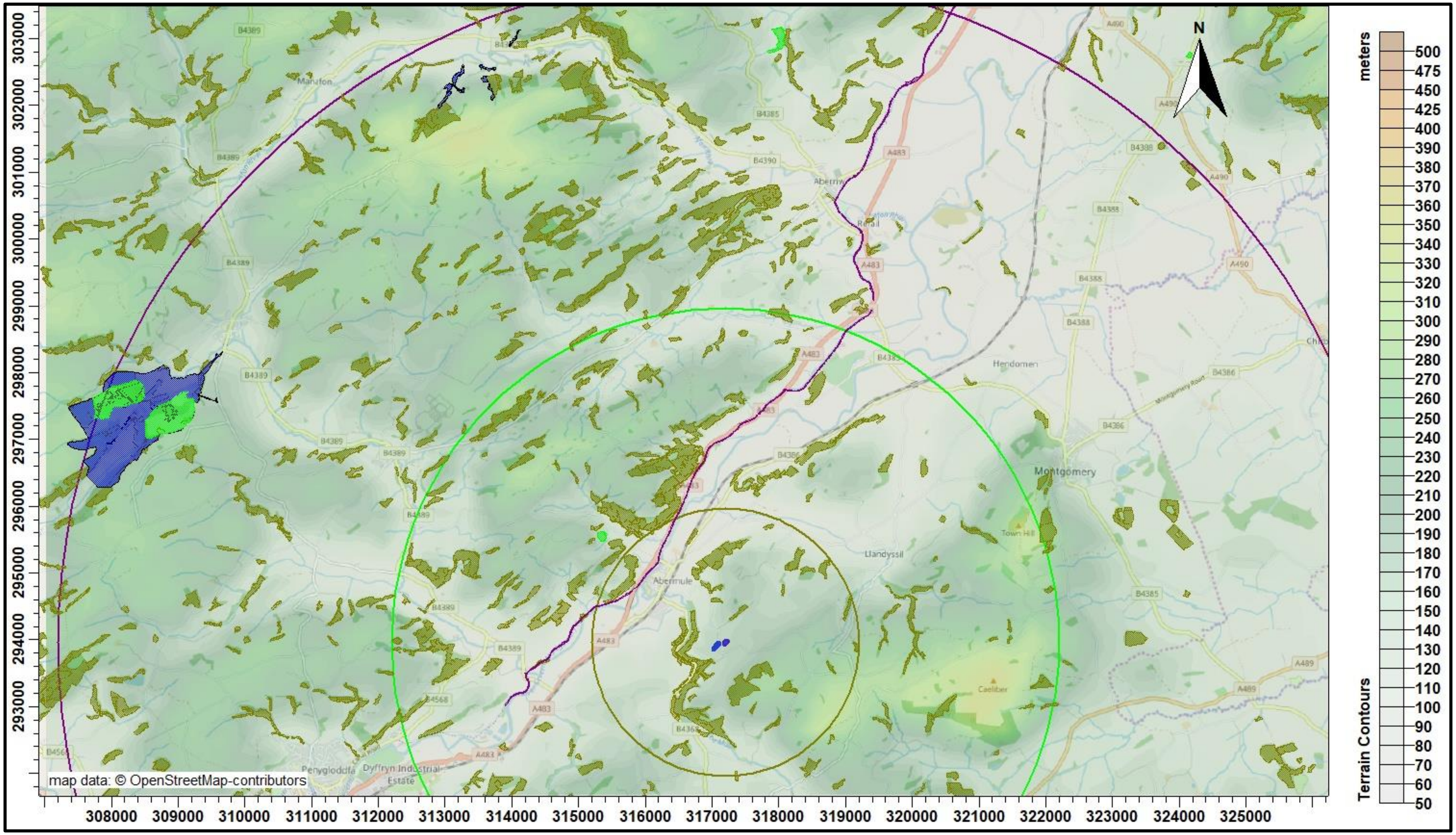
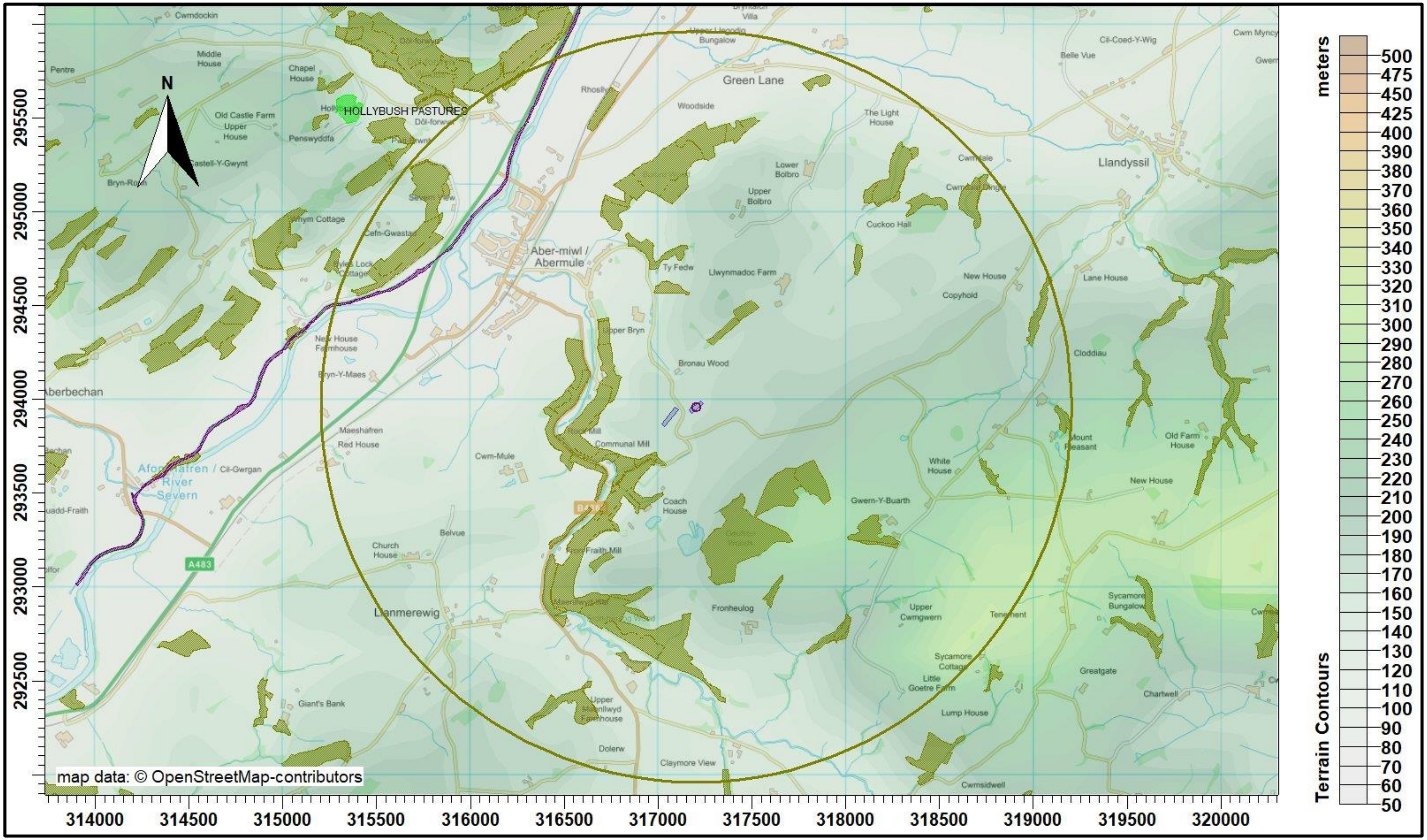


Figure 1b. The area surrounding Upper Bryn Farm – a closer view



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 source of the background figures is the Air Pollution Information System (APIS, February 2025). It should be noted that the 1 km APIS database background levels are extrapolated from 5 km modelled data. Ammonia levels may vary markedly over relatively short distances and the APIS website itself notes that, the background values should be used only to assist the user in obtaining a broad indication of the likely pollutant impact at a specific location and cannot be considered representative of any particular location within the 5 km grid square; extrapolation to a 1 km grid does not alter this.

The APIS figures for background ammonia concentration in the area around Upper Bryn Farm is 1.86 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 30.34 kg-N/ha/y and to short vegetation is 17.34 kg-N/ha/y. The background acid deposition rate to woodland is 2.27 keq/ha/y and to short vegetation is 1.3 keq/ha/y.

The APIS background figures are subject to revision and appear to change fairly frequently, the latest figures can be obtained at https://www.apis.ac.uk/search-location.

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, or lower, 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)
Unnamed AWs	1.0 [1]	-	-
Hollybush Pastures SSSI and Caeau Glyn SSSI	3.0 [2 & 4]	20.0 [3]	-
Gregynog SSSI	1.0 [1 & 4]	10.0 [3]	
Montgomery Canal SSSI/SAC	3.0 [2]	n/a [3]	n/a [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 APIS and the citation for the site.
3. The appropriate Critical Load from APIS chosen based on the present habitats and whether lichens and/or bryophytes are integral.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Natural Resources Wales Guidance

In September 2022 Natural Resources Wales published "How to interpret the results from your screening or modelling exercise for Ammonia Emissions (GN 020)":

> *"We are using critical level as a standard to ensure the sensitive site is protected and to enable sustainable development. The following statements should help you decide on the next course of action.*
>
> *If the process contribution and background levels do not exceed the critical level and there are no other sources to consider then normally the application can proceed.*
>
> *There will be occasions where the critical level is close to being reached. It is important to note that the critical level is not a target but a level that we want to avoid. Where the background is close to the critical level we may advise against the development even if the critical level is not exceeded.*

If the process contribution plus the background level reaches or exceeds the critical level then abatement must be used to reduce the process contribution to below 1% of the critical level, in order for the application to proceed. Assuming there are no other sources of ammonia to consider.

If your process contribution is below 1% of the critical level and there are no other sources of ammonia to consider, the application can proceed regardless of the background level."

This guidance appears only to apply to statutory sites and some Ancient Woodlands seemed ammonia sensitive by Natural Resources Wales. For non-statutory sites it is assumed that the Environment Agency "Intensive farming risk assessment for your environmental permit (November 2024)" is still applicable as there is no other official guidance that AS Modelling & Data Ltd. are aware of. In this document the lower and upper thresholds for National Nature Reserves, Local Nature Reserves, Local Wildlife Sites and Ancient Woodland within 2 km of a site are 100% and 100% of the Critical Level and Critical Load, respectively.

3.4.3 Joint Nature Conservancy Committee - Guidance on Decision-making Thresholds for Air Pollution

In December 2021, the Joint Nature Conservancy Committee (JNCC) published a report titled, "Guidance on Decision-making Thresholds for Air Pollution" This report provides decision-making criteria to inform the assessment of air quality impacts on designated conservation sites. The criteria are intended to be applied to individual sources to identify those for which a decision can be taken without the need for further assessment effort.

The Decision-making thresholds (DMT) for on-site emission sources provided in the JNCC report are reproduced below:

- For lichens and bryophytes - 0.08%, 0.20%, 0.34% and 0.75% of the Critical Level for high, medium, low and very low development density areas, respectively.
- For higher plants - 0.08%, 0.20%, 0.34% and 0.75% of the Critical Level for high, medium, low and very low development density areas, respectively.
- For nitrogen deposition to woodland (Critical Load 10 kg-N/ha/y) - 0.13%, 0.34%, 0.57% and 1.30% of the Critical Level for high, medium, low and very low development density areas, respectively.
- For nitrogen deposition to grassland (Critical Load 10 kg-N/ha/y) 0.09%, 0.24%, 0.40% and 0.88% of the Critical Level for high, medium, low and very low development density areas, respectively.

Note that 'development density' is defined as, the assumed number of additional new sources below the DMT within 5 km of the proposed development over 13 years: very low density being 1 development; low 5 developments; medium 10 developments and high 30 developments.

Subject to some exceptions, where the process contribution from an on-site source is below the DMT, no further assessment is required. Where the process contribution exceeds the DMT there are two possible outcomes:

- Where site-relevant thresholds have been derived these can be applied to see if it is possible to avoid further assessment effort on the basis of site specific circumstances.

- If site-relevant thresholds have not yet been derived, further assessment in combination with other plans and projects is required.

3.5 Quantification of ammonia emissions

Ammonia emission rates from poultry houses and ranging areas 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 emission factors used for the poultry housing and ranging areas at Upper Bryn Farm have been obtained from:
https://naturalresources.wales/guidance-and-advice/business-sectors/farming/ammonia-assessments/emission-factors-for-poultry-for-modelling-and-reporting/?lang=en

The indoor portion emission factor for free range egg laying chickens in an aviary system with manure belts is 0.066 kg-NH_3/bird place/y; this figure is used as a basis to calculate emissions from the poultry houses.

The outdoor portion emission factor for free range egg laying chickens in an aviary system with manure belts is 0.024 kg-NH_3/bird place/y; this figure is used as a basis to calculate emissions from the ranging areas.

Please note that Natural Resources Wales no longer provide information on the ratio of housing/ranging emissions.

4. The Atmospheric Dispersion Modelling System (ADMS) and Model Parameters

The Atmospheric Dispersion Modelling System (ADMS) ADMS 6 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 that include: 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)[1]. Meteorological data from nearby observational stations were considered, however the data, in particular the wind speeds and directions are unlikely to be representative of the area surrounding the site (on inspection by a qualified meteorologist).

The GFS is a discrete model. The physics/dynamics model has a resolution or had a resolution of approximately 7 km over the central UK; terrain is understood to be resolved at a resolution of approximately 2 km, with sub-7 km terrain effects parameterised. Site specific data may be extrapolated from nearby archive grid points or a most representative grid point chosen. 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[2]). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional records may be overrepresented 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 and wind directions are modified during the modelling by the treatment of roughness lengths (see Section 4.7) and because terrain data is included in the modelling. The terrain and roughness length modified wind rose for the site is shown in Figure 2b; as expected there is marked modification in this case, elsewhere in the modelling domain the modified wind roses may differ more or less markedly, reflecting the local flow in that part of the domain. Please note that FLOWSTAR[2] 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[3].

1. The GFS data used is derived from the high resolution operational GFS datasets, the data is not obtained from the lower resolution (0.5 degree) long-term archive.
2. Note that FLOWSTAR requirements are for meteorological data representative of the upwind flow over the modelling domain and that single site meteorological data (observational or from high resolution modelled data) that is representative of the application site is not generally suitable (personal correspondence: CERC 2019 and UK Met O 2015). If data are deemed representative of a particular application site, either wholly or partially, then these data cannot also be representative of the upstream flow over the modelling domain. Furthermore, it would be extremely poor practice to use such data as the boundary conditions for a flow-solver, such as FLOWSTAR.
3. When modelling complex terrain with ADMS, by default, the minimum turbulence length has 0.1 m added to the flat terrain value (calculated from the Monin-Obukhov length). Whilst this might be appropriate over hill/mountain tops in terrain with slopes > 1:10 (and quite possibly only in certain wind directions) in lesser terrain it introduces model behaviour that is not desirable where FLOWSTAR is simply being used to modify the upwind flow. Specifically, the parameter sigma z of the Gaussian plume model is overly constrained, which for elevated point sources emissions, may on occasion cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013), conversely for low level emission sources, this will cause gross under prediction. Note that this becomes particularly important overnight and if calm and light wind conditions are not being ignored, as they often are when using traditional observational meteorological datasets. To reduce this behaviour, where terrain is modelled, AS Modelling & Data Ltd. have set a minimum turbulence length of 0.025 m in ADMS. This approximates the normal behaviour of ADMS with flat terrain.

Figure 2a. The wind rose. Raw GFS derived data, for 52.537 N, 3.222 W, 2021 - 2024

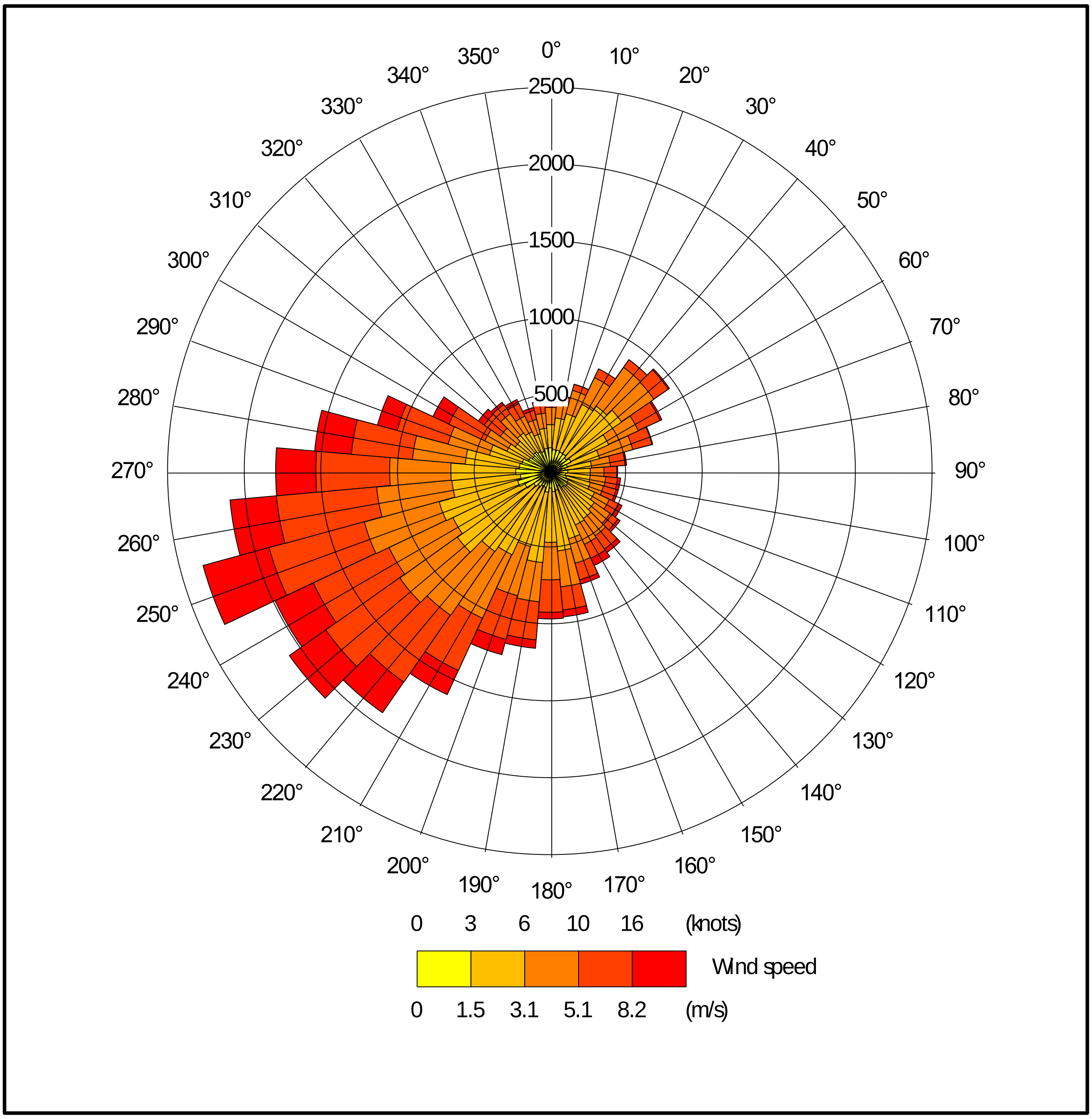
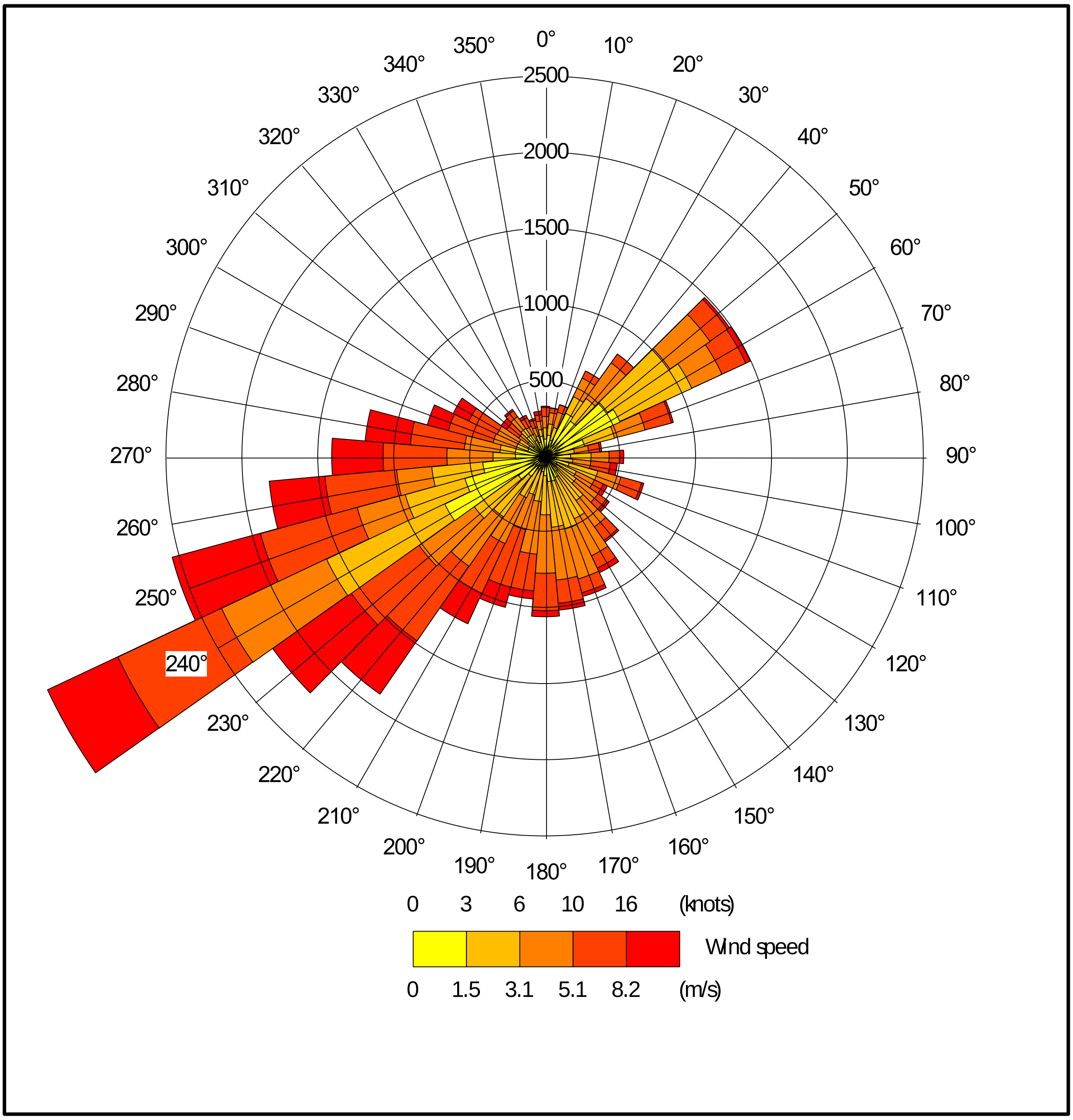


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 317150,293950, 2021 - 2024



4.2 Emission sources

Emissions from the high-speed ridge or roof fans that are, or would be, used to ventilate the existing and proposed poultry houses are represented by three point sources within ADMS (EX1 and PR1; 1, 2 and 3). Details of the point source parameters are provided in Table 2a. The positions of the point sources are shown in Figure 3 (marked by green circles).

Table 2a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Baseline emission rate per source (g-NH_3/s)
EX1 & PR1; 1, 2 & 3	6.0	0.8	11.0	21.0	0.022308

The poultry houses have, or would have ranging areas, which are represented by area sources within ADMS (EX1_ran, P1_ranN and P1_ranS). Note that the area sources cover the parts of the ranges most likely to be used frequently and not the whole of the ranging areas. Details of the area source parameters are provided in Table 2b. The positions of the area sources are shown in Figure 3 (marked by red shaded polygons.

Table 2b. Area source parameters

Source ID	Area (m^2)	Base height (m)	Emission temperature (°C)	Baseline emission rate (g-NH_3/s)
EX1_ran	5,303	0.0	Ambient	0.024336
PR1_ranN	3,193	0.0	Ambient	0.012168
PR1_ranS	2,739	0.0	Ambient	0.012168

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 (marked by grey rectangles).

4.4 Discrete receptors

Sixty-one discrete receptors have been defined at the wildlife sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figures 4a and 4b (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, Cartesian grid have been defined at ground level within ADMS. The position of the regular Cartesian grids may be seen in Figures 4a and 4b (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. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 340 m.

4.7 Roughness Length

In this case, a spatially varying roughness length file has been defined, this is based upon the UK Centre for Ecology and Hydrology 25 m land use database, with permission. The GFS meteorological data is assumed to have a roughness length of 0.187 m (arithmetic average of the spatially varying roughness over the modelling domain). The sample of the central area of the spatially varying roughness length field is shown in Figure 5.

Figure 3. The positions of the modelled buildings and sources

Figure 4a. The discrete receptors and regular Cartesian grids

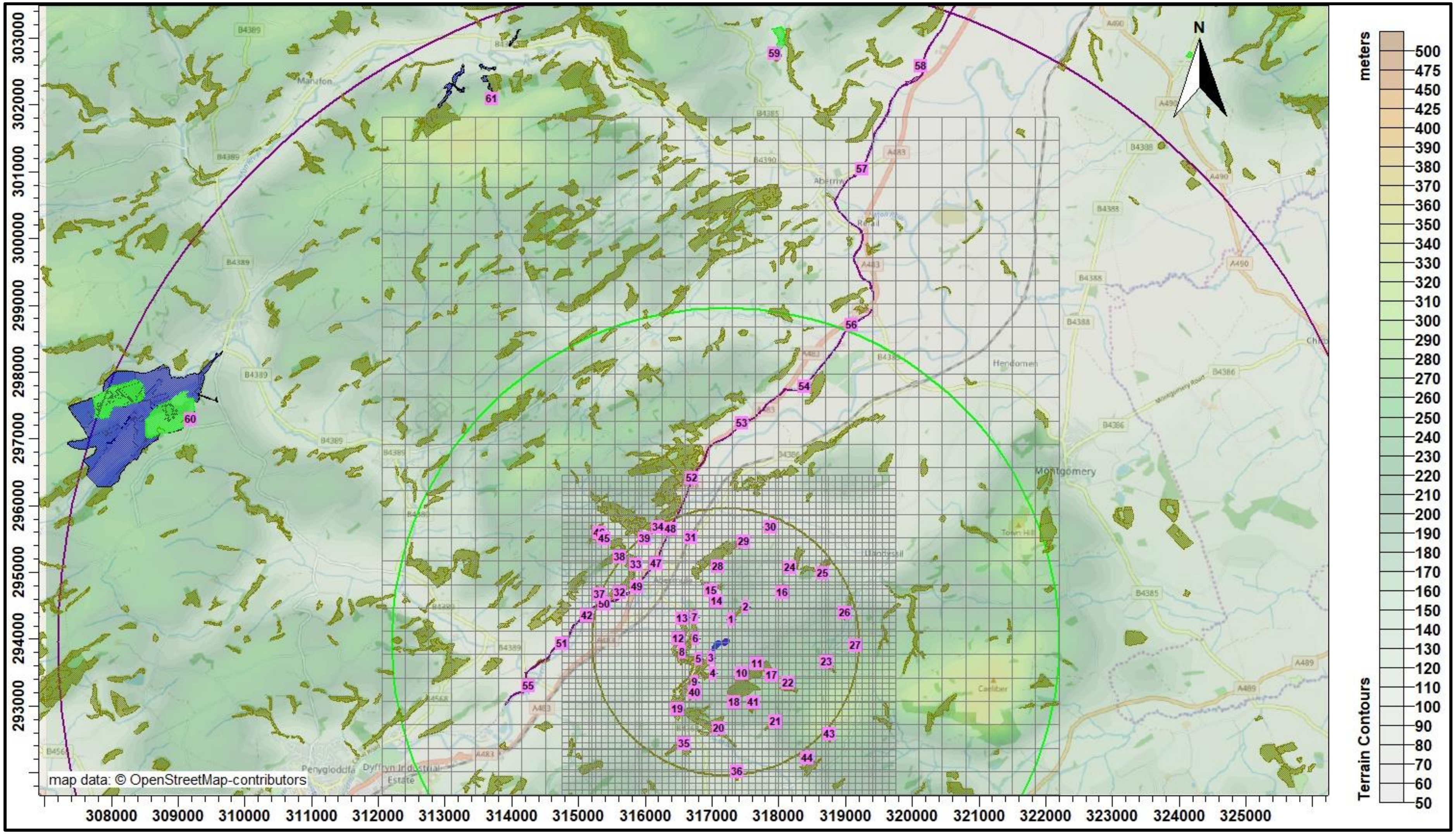


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Figure 4b. The discrete receptors – a closer view

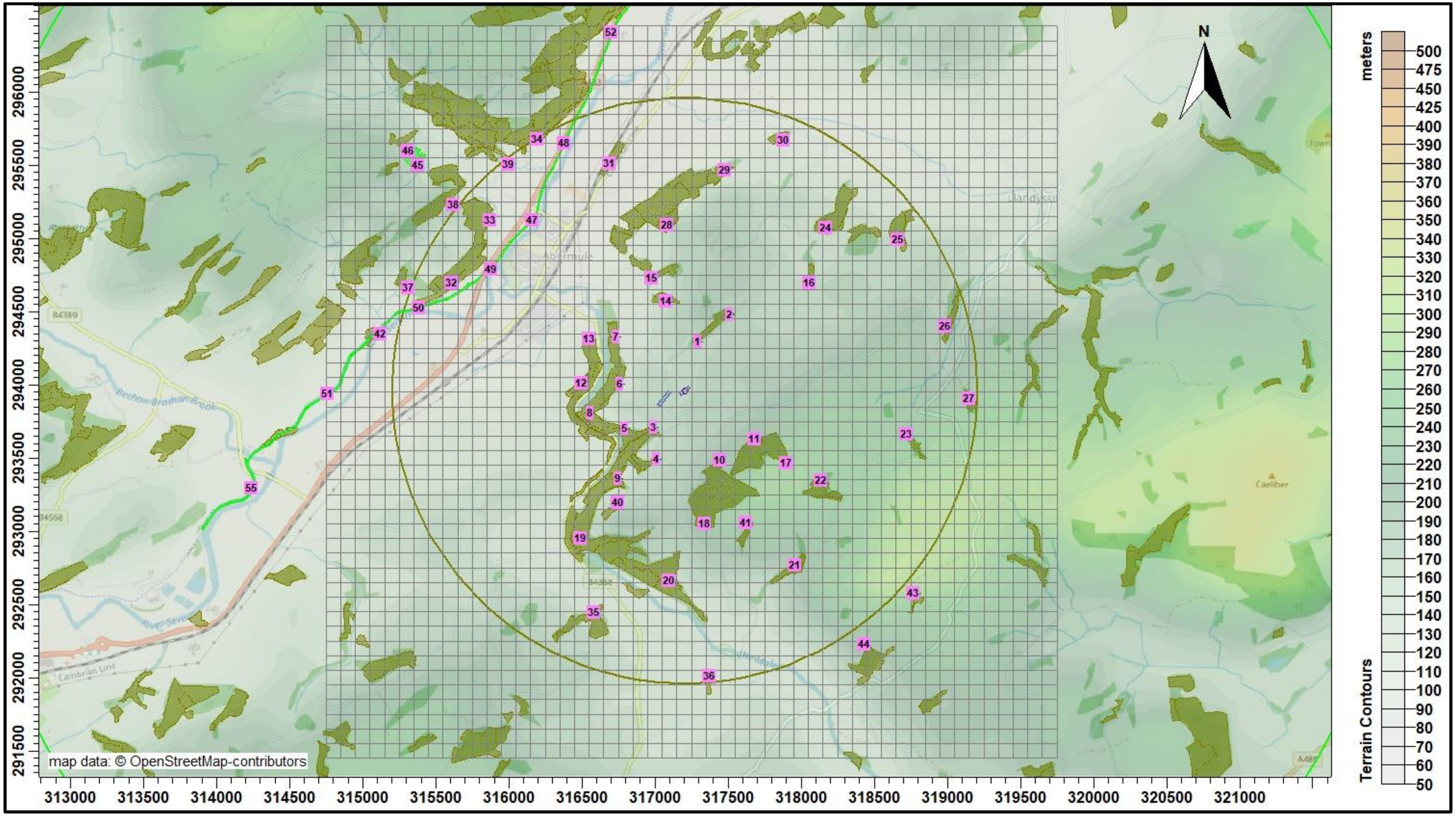
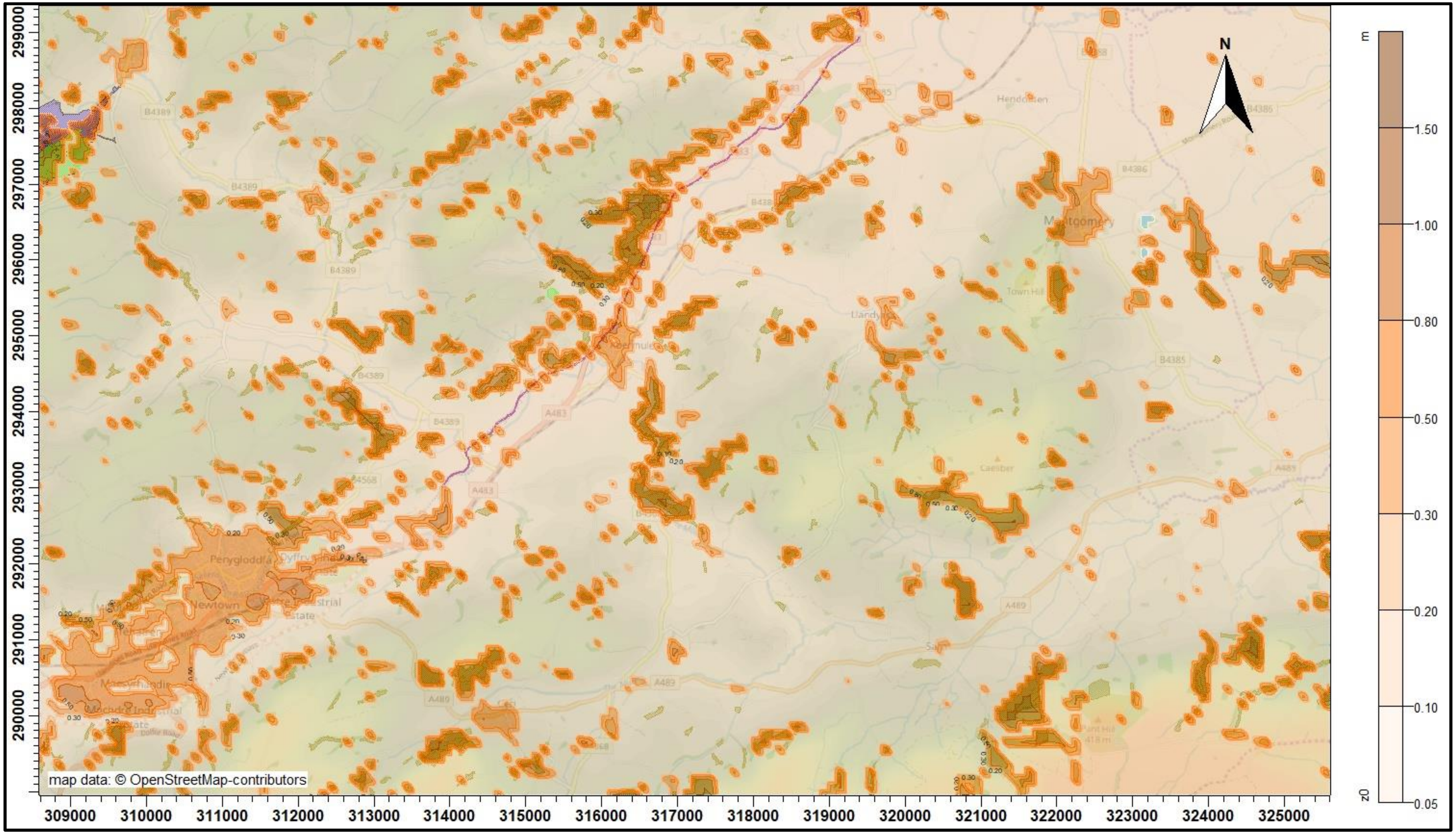


Figure 5. The spatially varying surface roughness field (central area)



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based primarily upon Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: A Review of Recent Studies (2004-2013). 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 housing and 0.01 m/s to 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 3.

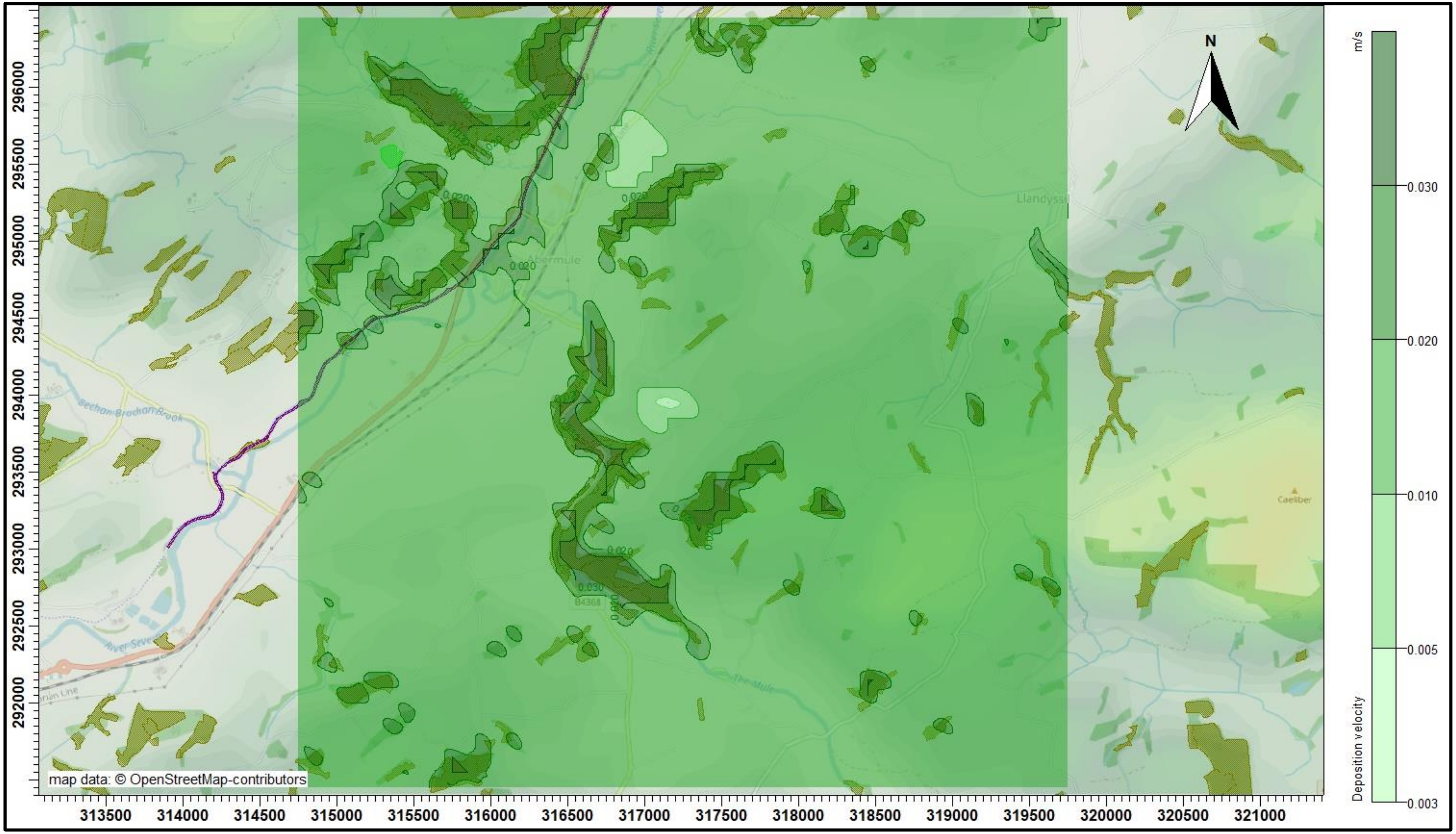
Table 3. Deposition velocities

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 (0.010 to 0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity - arable farmland/rye grass (m/s)	0.005	0.005	0.005	0.005	0.003

- The model is then rerun with the spatially varying deposition module.

A contour plot of the spatially varying deposition fields is provided in Figure 6.

Figure 6. The spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling and model sensitivity tests

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

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – 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 4. The primary purpose of the preliminary modelling is to assess the effect of calms on the results.

Table 4. Predicted maximum annual mean ammonia concentrations at the discrete receptors - preliminary modelling

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m^3)	
				GFS No Calms No Terrain	GFS Calms No Terrain
1	317290	294295	Unnamed AW	0.410	0.398
2	317512	294481	Unnamed AW	0.179	0.174
3	316987	293711	Unnamed AW	0.384	0.377
4	317010	293493	Unnamed AW	0.149	0.145
5	316794	293700	Unnamed AW	0.161	0.157
6	316760	294003	Unnamed AW	0.098	0.097
7	316735	294329	Unnamed AW	0.074	0.073
8	316557	293806	Unnamed AW	0.063	0.062
9	316746	293357	Unnamed AW	0.094	0.093
10	317444	293482	Unnamed AW	0.095	0.091
11	317683	293628	Unnamed AW	0.112	0.109
12	316494	294009	Unnamed AW	0.043	0.043
13	316551	294314	Unnamed AW	0.048	0.047
14	317078	294568	Unnamed AW	0.118	0.116
15	316979	294725	Unnamed AW	0.074	0.072
16	318058	294693	Unnamed AW	0.077	0.076
17	317900	293464	Unnamed AW	0.053	0.052
18	317336	293051	Unnamed AW	0.034	0.033
19	316489	292951	Unnamed AW	0.040	0.040
20	317096	292660	Unnamed AW	0.019	0.019
21	317954	292766	Unnamed AW	0.015	0.015
22	318133	293347	Unnamed AW	0.034	0.034
23	318720	293664	Unnamed AW	0.032	0.032
24	318166	295070	Unnamed AW	0.045	0.045
25	318661	294991	Unnamed AW	0.036	0.035
26	318985	294397	Unnamed AW	0.035	0.034
27	319150	293908	Unnamed AW	0.026	0.026
28	317083	295090	Unnamed AW	0.043	0.043
29	317479	295466	Unnamed AW	0.031	0.030
30	317875	295671	Unnamed AW	0.025	0.024
31	316687	295513	Unnamed AW	0.022	0.021
32	315610	294694	Unnamed AW	0.011	0.011
33	315868	295123	Unnamed AW	0.013	0.013
34	316191	295678	Unnamed AW	0.013	0.013
35	316581	292442	Unnamed AW	0.018	0.018
36	317373	292013	Unnamed AW	0.009	0.009
37	315308	294663	Unnamed AW	0.009	0.009
38	315622	295231	Unnamed AW	0.010	0.010
39	315994	295505	Unnamed AW	0.012	0.012
40	316747	293195	Unnamed AW	0.064	0.063
41	317618	293058	Unnamed AW	0.029	0.028
42	315122	294350	Unnamed AW	0.007	0.007
43	318763	292578	Unnamed AW	0.010	0.010
44	318430	292226	Unnamed AW	0.008	0.008

Table 4. Continued.

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - ($\mu g/m^3$)	
				GFS No Calms No Terrain	GFS Calms No Terrain
45	315379	295499	Hollybush Pastures SSSI	0.008	0.008
46	315313	295598	Hollybush Pastures SSSI	0.007	0.007
47	316161	295126	Montgomery Canal SSSI/SAC	0.017	0.017
48	316380	295651	Montgomery Canal SSSI/SAC	0.016	0.016
49	315879	294788	Montgomery Canal SSSI/SAC	0.014	0.014
50	315383	294525	Montgomery Canal SSSI/SAC	0.009	0.009
51	314758	293938	Montgomery Canal SSSI/SAC	0.005	0.006
52	316696	296410	Montgomery Canal SSSI/SAC	0.012	0.012
53	317450	297241	Montgomery Canal SSSI/SAC	0.008	0.008
54	318382	297777	Montgomery Canal SSSI/SAC	0.007	0.007
55	314241	293294	Montgomery Canal SSSI/SAC	0.005	0.005
56	319091	298699	Montgomery Canal SSSI/SAC	0.005	0.005
57	319253	301033	Montgomery Canal SSSI/SAC	0.003	0.003
58	320127	302582	Montgomery Canal SSSI/SAC	0.002	0.002
59	317941	302765	Caeau Glyn SSSI	0.002	0.002
60	309195	297291	Gregynog SSSI/NH_3 Sensitive AW	0.001	0.001
61	313704	302090	NH_3 Sensitive AW	0.002	0.002

5.2 Detailed modelling

In this case, detailed modelling has been carried out over a high resolution (100 m) domain that extends 5.0 km by 5.0 km around the site. The primary purpose is to determine the magnitude of deposition of ammonia and consequent plume depletion close to the sources where it is of the greatest importance. Outside of this 5.0 km by 5.0 km domain, a fixed deposition velocity of 0.005 m/s is assumed (with appropriate deposition velocities applied post-modelling at the discrete receptors).

The detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition and in this case, the preliminary modelling indicates that the effects of calms are insignificant.

The predicted process contribution to maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 5. In this case, there are no predicted ammonia concentrations and nitrogen deposition rates at non-statutory sites that are in excess of 100% of the precautionary Critical Level or Critical Load. Additionally, there are no process contributions which exceed 1% of the relevant Critical Level or Critical Load at statutory sites.

Contour plots of the predicted process contributions to maximum annual mean ammonia concentration and maximum annual nitrogen deposition rate are shown in Figures 7a and 7b.

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

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level ($\mu g/m^3$)	Critical Load (kg/ha)	Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	317290	294295	Unnamed AW	0.03	1.0	10.0	0.524	52.4	4.08	40.8
2	317512	294481	Unnamed AW	0.03	1.0	10.0	0.254	25.4	1.98	19.8
3	316987	293711	Unnamed AW	0.03	1.0	10.0	0.939	93.9	7.32	73.2
4	317010	293493	Unnamed AW	0.03	1.0	10.0	0.192	19.2	1.50	15.0
5	316794	293700	Unnamed AW	0.03	1.0	10.0	0.487	48.7	3.79	37.9
6	316760	294003	Unnamed AW	0.03	1.0	10.0	0.207	20.7	1.61	16.1
7	316735	294329	Unnamed AW	0.03	1.0	10.0	0.125	12.5	0.98	9.8
8	316557	293806	Unnamed AW	0.03	1.0	10.0	0.112	11.2	0.87	8.7
9	316746	293357	Unnamed AW	0.03	1.0	10.0	0.145	14.5	1.13	11.3
10	317444	293482	Unnamed AW	0.03	1.0	10.0	0.079	7.9	0.61	6.1
11	317683	293628	Unnamed AW	0.03	1.0	10.0	0.112	11.2	0.87	8.7
12	316494	294009	Unnamed AW	0.03	1.0	10.0	0.071	7.1	0.55	5.5
13	316551	294314	Unnamed AW	0.03	1.0	10.0	0.071	7.1	0.55	5.5
14	317078	294568	Unnamed AW	0.03	1.0	10.0	0.194	19.4	1.51	15.1
15	316979	294725	Unnamed AW	0.03	1.0	10.0	0.123	12.3	0.96	9.6
16	318058	294693	Unnamed AW	0.03	1.0	10.0	0.170	17.0	1.32	13.2
17	317900	293464	Unnamed AW	0.03	1.0	10.0	0.051	5.1	0.40	4.0
18	317336	293051	Unnamed AW	0.03	1.0	10.0	0.031	3.1	0.24	2.4
19	316489	292951	Unnamed AW	0.03	1.0	10.0	0.057	5.7	0.45	4.5
20	317096	292660	Unnamed AW	0.03	1.0	10.0	0.025	2.5	0.19	1.9
21	317954	292766	Unnamed AW	0.03	1.0	10.0	0.014	1.4	0.11	1.1
22	318133	293347	Unnamed AW	0.03	1.0	10.0	0.033	3.3	0.26	2.6
23	318720	293664	Unnamed AW	0.03	1.0	10.0	0.028	2.8	0.21	2.1
24	318166	295070	Unnamed AW	0.03	1.0	10.0	0.074	7.4	0.58	5.8
25	318661	294991	Unnamed AW	0.03	1.0	10.0	0.097	9.7	0.76	7.6
26	318985	294397	Unnamed AW	0.03	1.0	10.0	0.057	5.7	0.45	4.5
27	319150	293908	Unnamed AW	0.03	1.0	10.0	0.023	2.3	0.18	1.8
28	317083	295090	Unnamed AW	0.03	1.0	10.0	0.073	7.3	0.57	5.7
29	317479	295466	Unnamed AW	0.03	1.0	10.0	0.051	5.1	0.40	4.0
30	317875	295671	Unnamed AW	0.03	1.0	10.0	0.040	4.0	0.31	3.1
31	316687	295513	Unnamed AW	0.03	1.0	10.0	0.036	3.6	0.28	2.8
32	315610	294694	Unnamed AW	0.03	1.0	10.0	0.012	1.2	0.09	0.9
33	315868	295123	Unnamed AW	0.03	1.0	10.0	0.012	1.2	0.09	0.9

Table 5. Continued.

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
34	316191	295678	Unnamed AW	0.03	1.0	10.0	0.019	1.9	0.14	1.4
35	316581	292442	Unnamed AW	0.03	1.0	10.0	0.020	2.0	0.16	1.6
36	317373	292013	Unnamed AW	0.03	1.0	10.0	0.012	1.2	0.10	1.0
37	315308	294663	Unnamed AW	0.03	1.0	10.0	0.010	1.0	0.08	0.8
38	315622	295231	Unnamed AW	0.03	1.0	10.0	0.009	0.9	0.07	0.7
39	315994	295505	Unnamed AW	0.03	1.0	10.0	0.014	1.4	0.11	1.1
40	316747	293195	Unnamed AW	0.03	1.0	10.0	0.080	8.0	0.63	6.3
41	317618	293058	Unnamed AW	0.03	1.0	10.0	0.023	2.3	0.18	1.8
42	315122	294350	Unnamed AW	0.03	1.0	10.0	0.011	1.1	0.09	0.9
43	318763	292578	Unnamed AW	0.03	1.0	10.0	0.010	1.0	0.08	0.8
44	318430	292226	Unnamed AW	0.03	1.0	10.0	0.008	0.8	0.06	0.6
45	315379	295499	Hollybush Pastures SSSI	0.03	3.0	20.0	0.0068	0.23	0.05	0.3
46	315313	295598	Hollybush Pastures SSSI	0.03	3.0	20.0	0.0062	0.21	0.05	0.2
47	316161	295126	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0193	0.64	0.15	-
48	316380	295651	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0244	0.81	0.19	-
49	315879	294788	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0123	0.41	0.10	-
50	315383	294525	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0116	0.39	0.09	-
51	314758	293938	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0116	0.39	0.09	-
52	316696	296410	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0177	0.59	0.14	-
53	317450	297241	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0213	0.71	0.17	-
54	318382	297777	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0158	0.53	0.12	-
55	314241	293294	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0097	0.32	0.08	-
56	319091	298699	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0103	0.34	0.08	-
57	319253	301033	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0049	0.16	0.04	-
58	320127	302582	Montgomery Canal SSSI/SAC	0.03	3.0	n/a	0.0034	0.11	0.03	-
59	317941	302765	Caeau Glyn SSSI	0.02	3.0	20.0	0.0020	0.07	0.01	0.1
60	309195	297291	Gregynog SSSI/NH3 Sensitive AW	0.03	1.0	10.0	0.0009	0.09	0.01	0.1
61	313704	302090	NH3 Sensitive AW	0.03	1.0	10.0	0.0014	0.14	0.01	0.1

Figure 7a. Maximum annual mean ammonia concentration

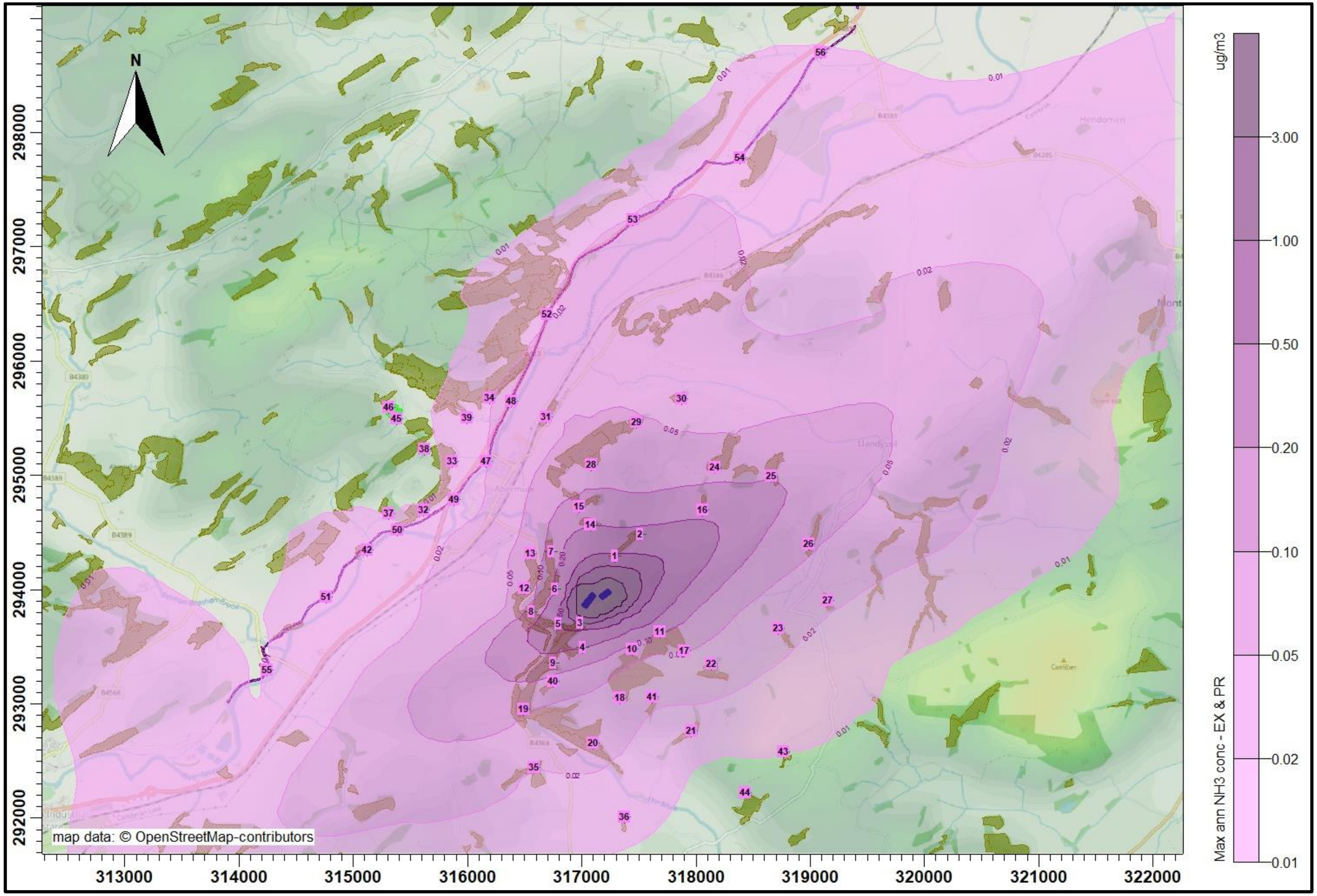


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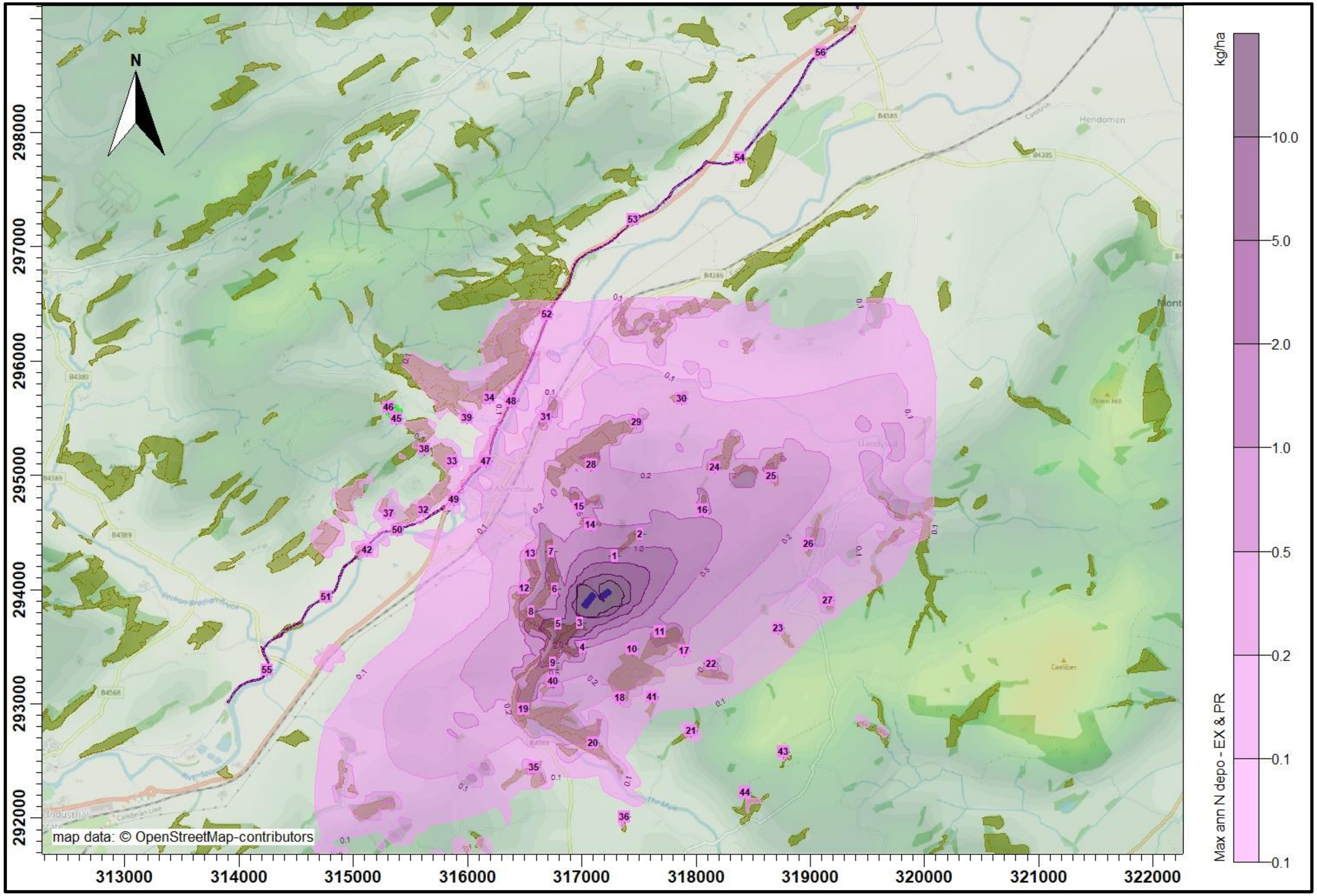
Figure 7b. Maximum annual nitrogen deposition rate



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Ms. Rosina Riddle, of Roger Parry & Partners LLP, on behalf of their client, to use computer modelling to assess the impact of ammonia emissions from the free range egg-laying chicken houses at Upper Bryn Farm, Abermule, Montgomery, Powys. SY15 6JW.

Ammonia emission rates from the poultry houses have been assessed and quantified based upon the Natural Resources Wales standard ammonia emission factors (for screening and modelling). 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.

The modelling predicts that:

- The process contributions to annual mean ammonia concentrations and nitrogen deposition rates would be below 100% of the precautionary Critical Level and Critical Loads applied to all nearby non-statutory sites considered.

- At all statutory sites considered, the process contributions would be below 1% of the relevant Critical Level and Critical Load.

7. References

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