A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Free Range Egg Laying Chicken Houses at Blackhall, Llandyssil, near Montgomery in Powys

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20th June 2017

1. Introduction

AS Modelling & Data Ltd., has been instructed by Matt Evans of Ian Price Property Services Ltd., on behalf of the applicant, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at Blackhall, Llandyssil, near to Montgomery in Powys. SY15 6HR.

Ammonia emission rates from the existing and proposed poultry houses have been assessed and quantified based upon the English Environment Agency's standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen deposition rates in the surrounding area.

This report is arranged in the following manner:

- Section 2 provides relevant details of the farm and potentially sensitive receptors in the area.

- Section 3 provides some general information on ammonia; details of the method used to estimate ammonia emissions, relevant guidelines and legislation on exposure limits and where relevant, details of likely background levels of ammonia.

- Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling procedure.

- Section 5 contains the results of the modelling.

- Section 6 provides a discussion of the results and conclusions.

2. Background Details

Blackhall, Llandyssil, is in a rural area around 1.0 km to the south-south-east of the village of Llandyssil, near to Montgomery in Powys. The land surrounding the site is predominantly used for livestock pasture and there are some isolated wooded areas nearby. Blackhall is at an elevation of around 250 m with the land falling towards the River Severn Valley to the north-west and rising towards hills to the south-east.

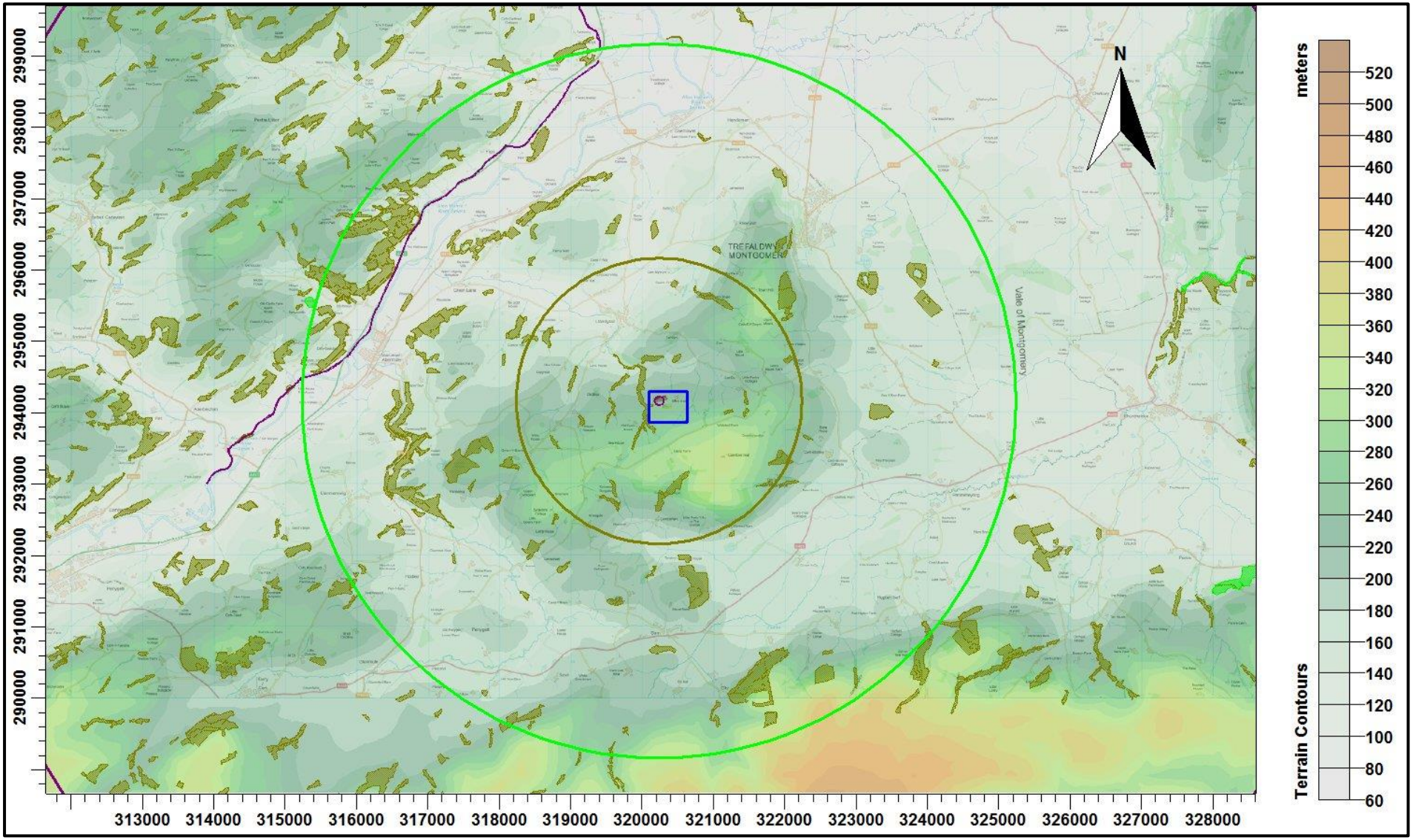
Currently there is a single poultry house at Blackhall providing accommodation for up to 32,000 layer chickens. The existing house is ventilated by high speed ridge mounted fans, each with a short chimney and gable end fans provide additional ventilation during hot weather. The chickens have access to an external ranging area via a series of pop-holes and manure is removed from the poultry house by a belt system twice a week, with the spent litter being stored in a manure store before being spread to land.

Under the proposal, a new poultry house would be constructed adjacent to the existing house. This new poultry house would provide accommodation for a further 32,000 layer chickens. The proposed house would be ventilated via high speed ridge mounted fans, each with a short chimney and gable end fans would provide additional ventilation during hot weather. The chickens would have access to an external ranging area via a series of pop-holes and manure would be removed from the poultry house by a belt system twice a week. The proposals also include moving the manure store to a new location, where the spent litter from the existing and proposed houses would be held before being spread to land.

There are numerous Ancient Woodlands (AWs) within 2 km of Blackhall and there are also two Sites of Special Scientific Interest (SSSIs) within 5 km of the site, namely Montgomery Canal SSSI, which is also designated as a Special Area of Conservation (SAC) and Hollybush Pastures SSSI.

A map of the surrounding area showing the position of the existing and proposed poultry houses and the nearby wildlife sites is provided in Figure 1. In this figure, the AWs are shaded olive, the SSSIs are shaded green, the SAC is shaded purple and the site of the poultry unit, including the existing and proposed manure stores, is outlined in blue.

Figure 1. The area surrounding the site of the poultry houses at Blackhall, with concentric circles radii 5 km (green) and 2 km (olive)



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 the site of the proposed poultry unit and the wildlife sites is 1.74 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 31.78 kg-N/ha/y and to short vegetation is 19.88 kg-N/ha/y. The background acid deposition rate to woodland is 2.37 keq/ha/y and to short vegetation is 1.51 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, June 2017).

3.3 Critical Levels & Critical Loads

Critical Levels and Critical Loads are a benchmark for assessing the risk of air pollution impacts to ecosystems. It is important to distinguish between a Critical Level and a Critical Load. The Critical Level is the gaseous concentration of a pollutant in the air, whereas the Critical Load relates to the quantity of pollutant deposited from air to the ground.

Critical Levels are defined as, "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors, such as human beings, plants, ecosystems or materials, may occur according to present knowledge". (UNECE)

Critical Loads are defined as, "a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge". (UNECE)

For ammonia concentration in air, the Critical Level for higher plants is 3.0 $\mu g\text{-}NH_3/m^3$ 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. 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 Deposition (kg-N/ha/y)	Critical Load - Acid Deposition (keq/ha/y)
AWs	1.0 [1]	-	-
Hollybush Pastures SSSI	3.0 [2]	10.0 [3]	-
Montgomery Canal (floating/aquatic vegetation)	3.0 [2]	3.0 [3 & 4]	-
Montgomery Canal (bankside/marginal vegetation)	3.0 [1]	10.0 [3]	-

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 of the site.
3. The lower bound of the range of Critical Loads for the site/species, obtained from APIS.
4. The lower bound of the Critical Load for the native habitat Floating Water-plantain (*Luronium natans*). Note that this is probably not appropriate in a man-made nutrient fed system such as the Montgomery Canal.

3.4 Guidance on the significance of ammonia emissions

In March 2017, Natural Resources Wales (Regulation and Permitting Department, EPP) published Operational Guidance Note 41 (OGN 41), "Assessment of ammonia and nitrogen impacts from livestock units when applying for an Environmental Permit or Planning Permission". This guidance was intended to update the way Natural Resources Wales (NRW) assessed emissions, in particular by changing the thresholds of insignificance and the upper threshold process contributions for designated sites. These designated sites include European sites, such as Special Areas of Conservation (SACs), Special Protection Areas (SPAs) and Ramsar sites as well as Sites of Special Scientific Interest (SSSIs).

Table 1 in OGN 41 describes the revised screening distance and thresholds for livestock developments; the threshold of insignificant percentage of the designated site Critical Level or Load is given as 1%; the upper threshold percentage of the designated site Critical Level or Load is given as 8%.

Table 2 in OGN 41 describes the possible outcomes of assessment and for detailed modelling of the application alone, where process contributions, considered in isolation, are up to 1% of the

designated site Critical Level or Load, then it should be determined that there is no significant environmental effect/no likely significant effect/damage to scientific interest.

Where process contributions, considered in isolation, are between 1% and 8% of the designated site Critical Level or Load, an in-combination assessment is required. Should the in-combination process contributions be between 1% and 8% of the designated site Critical Level or Load then it should be determined that the application would cause no significant environmental effect/likely significant effect/damage to scientific interest.

When considering process contributions in isolation or in-combination, if they exceed 8% of the designated site Critical Level or Load it is necessary to consider background concentrations and whether the designated site Critical Level or Load is breached and whether additional controls may be necessary. The application will then be determined based on whether there will be significant environmental effect/adverse effect/damage to scientific interest.

Please note that as far as AS Modelling & Data Ltd. is aware, currently, there is no publicly available ledger or database of sites with extant planning permission, or other proposed sites in planning, that would provide sufficient information to make an in-combination modelling assessment. Therefore, if Natural Resources Wales, or the Local Authority concerned do not consider the details of the modelling of ammonia emissions from this site provided by this study as sufficient information to fulfil the requirements of their appropriate assessment, then in most cases it would not be possible for AS Modelling & Data Ltd. to provide this information.

For Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and Ancient Woodlands (AWs), the current assessment procedure 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 Process Contribution of up to 100% of Critical Level or Critical Load is usually deemed acceptable for permitting purposes and therefore the upper and lower thresholds are the same (100%).

3.5 Quantification of ammonia emissions

Ammonia emission rates from poultry houses depend on many factors and are likely to be highly variable. However, the benchmarks for assessing impacts of ammonia and nitrogen deposition are framed in terms of an annual mean ammonia concentration and annual nitrogen deposition rates. To obtain relatively robust figures for these statistics, it is not necessary to model short term temporal variations and a steady continuous emission rate can be assumed. In fact, modelling short term temporal variations might introduce rather more uncertainty than modelling continuous emissions.

The English 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 free range chickens in an aviary system, where the manure is removed frequently by a belt system, the figure is 0.08 kg-NH_3/bird place/y and for manure storage the figure is 2.38 kg-NH_3/tonne/y; these figures have been used to calculate the emissions from the proposed poultry houses.

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

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

Table 2. Details of animal numbers and ammonia emission rates

Source	Animal numbers/tonnes	Type or weight	Emission factor (kg-NH_3/place/y or kg-NH_3/tonne/y)	Emission rate (g-NH_3/s)
Existing Housing	32,000 (x 0.8)	Egg laying chickens manure belts	0.08 (EA figure)	0.064897
Proposed Housing	32,000 (x 0.8)	Egg laying chickens manure belts	0.08 (EA figure)	0.064897
Existing Range	32,000 (x 0.2)	Ranging area	0.2 (AS Modelling & Data figure)	0.040561
Proposed Range	32,000 (x 0.2)	Ranging area	0.2 (AS Modelling & Data figure)	0.040561
Existing Manure Store	10	Manure store - belts	2.38 (EA figure)	0.000754
Proposed Manure Store	20	Manure store - belts	2.38 (EA figure)	0.001508

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 topographical 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 closest meteorological recording station that records all the parameters required for atmospheric dispersion modelling is at Lake Vrynwy, approximately 30 km to the north-west of Blackhall. Data from the meteorological recording stations at Shobdon and Shawbury have also been considered; Shobdon is around 37 km to the south-east of the site and Shawbury is around 44 km to the north-east of Blackhall. However, neither Lake Vyrnwy, Shobdon nor Shawbury has an aspect that in any way could be considered similar to Blackhall; therefore, it should be noted that the frequency of winds from a particular direction in the Lake Vyrnwy, Shobdon or Shawbury data may be either high or low in comparison to what might occur at Blackhall, which means mean concentrations downwind may be either over or under predicted. Additionally, periods of light winds and calms cannot be properly modelled. Therefore, it is the opinion of AS Modelling & Data Ltd. that the results obtained using the GFS data, particularly when modified by using FLOWSTAR, should be given more weight when interpreting the results of the modelling.

The wind rose for the raw GFS data at the site of the poultry house at Blackhall, Llandyssil is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and because terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified further. The terrain and roughness length modified wind rose for the location of the poultry house at Blackhall, Llandyssil is shown in Figure 2b. Note that elsewhere in the modelling domain the modified wind roses may differ more or less markedly and that the resolution of the wind field in terrain runs is approximately 300 m for the preliminary modelling and approximately 150 m for the detailed modelling.

The wind roses for Lake Vyrnwy, Shobdon and Shawbury are shown in Figures 2c, 2d and 2e respectively.

Figure 2a. The wind rose. Raw GFS derived data, for 52.539 N, 3.177 W, 2013 – 2016

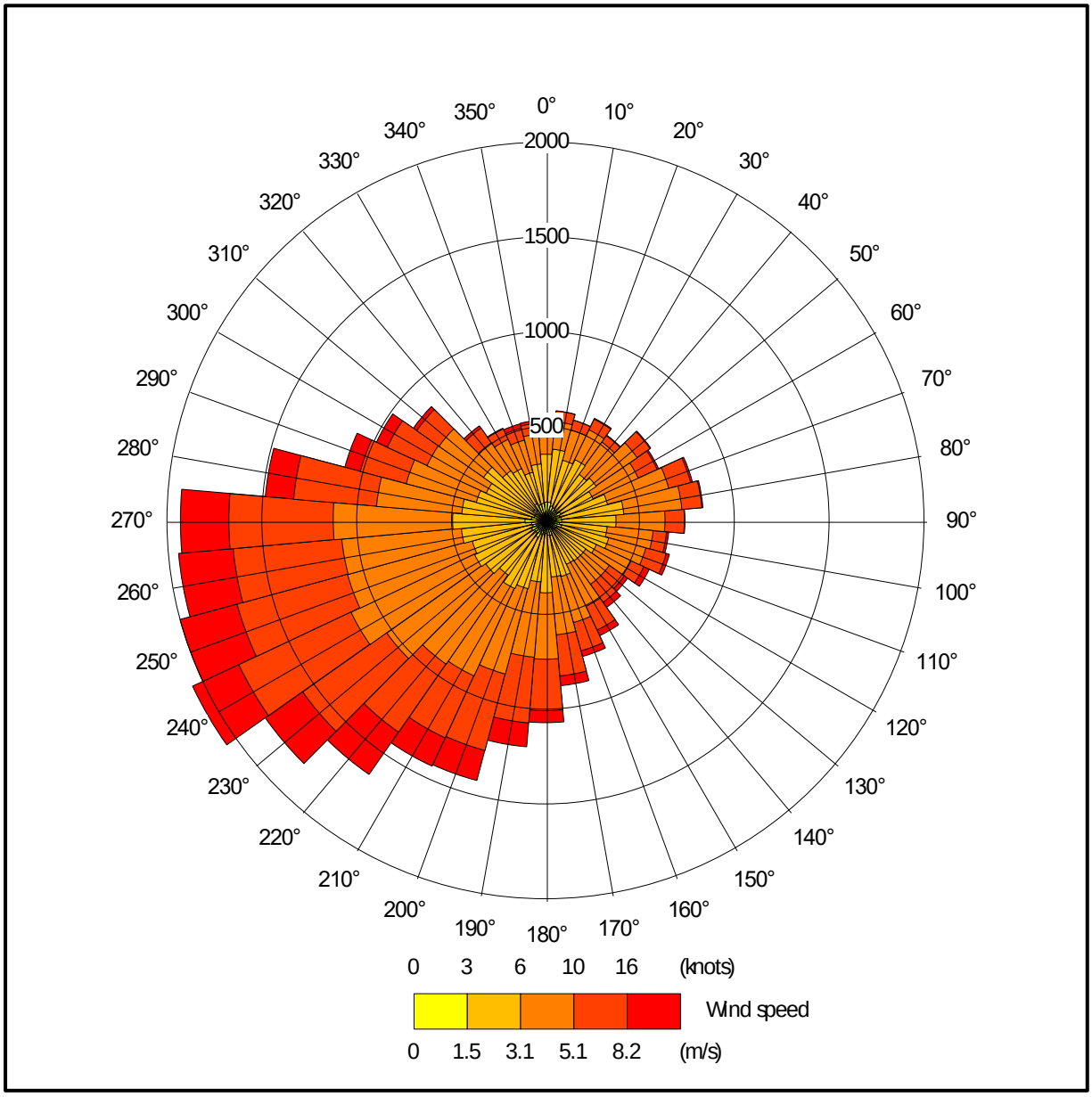


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for 52.539 N, 3.177 W, 2013 – 2016

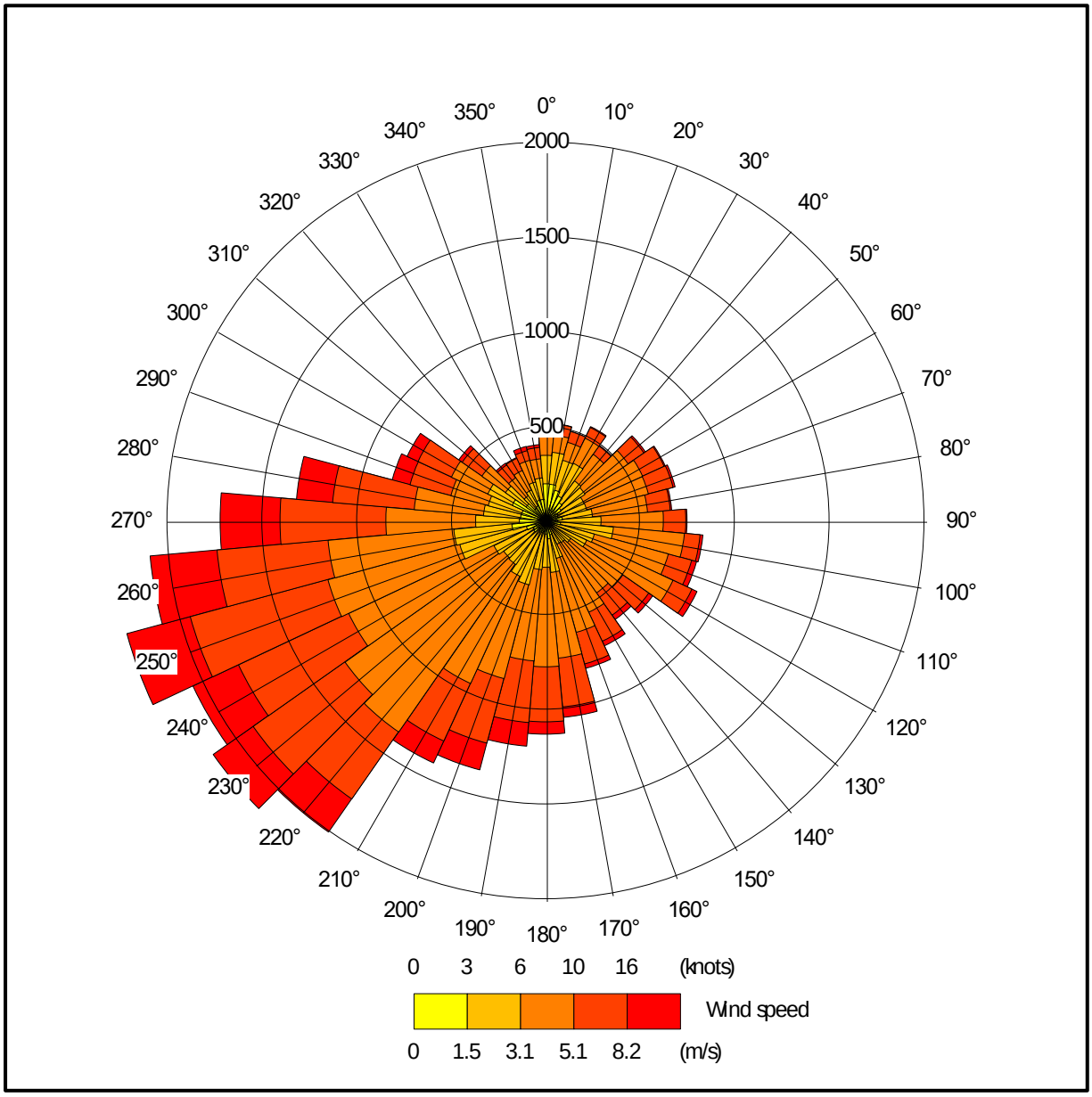


Figure 2c. The wind rose. Recorded meteorological data at Lake Vyrnwy, 2013-2016

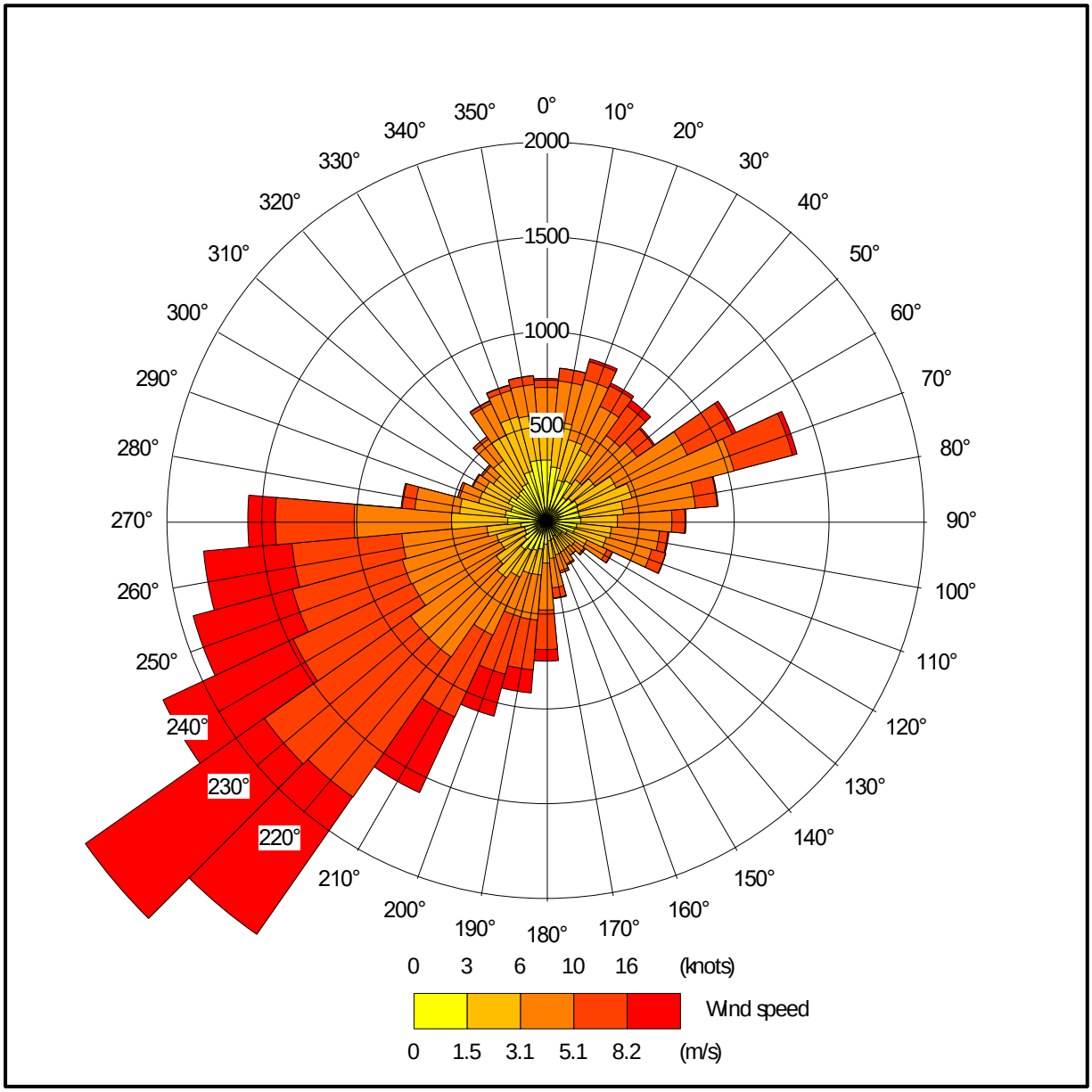


Figure 2d. The wind rose. Recorded meteorological data at Shobdon, 2013-2016

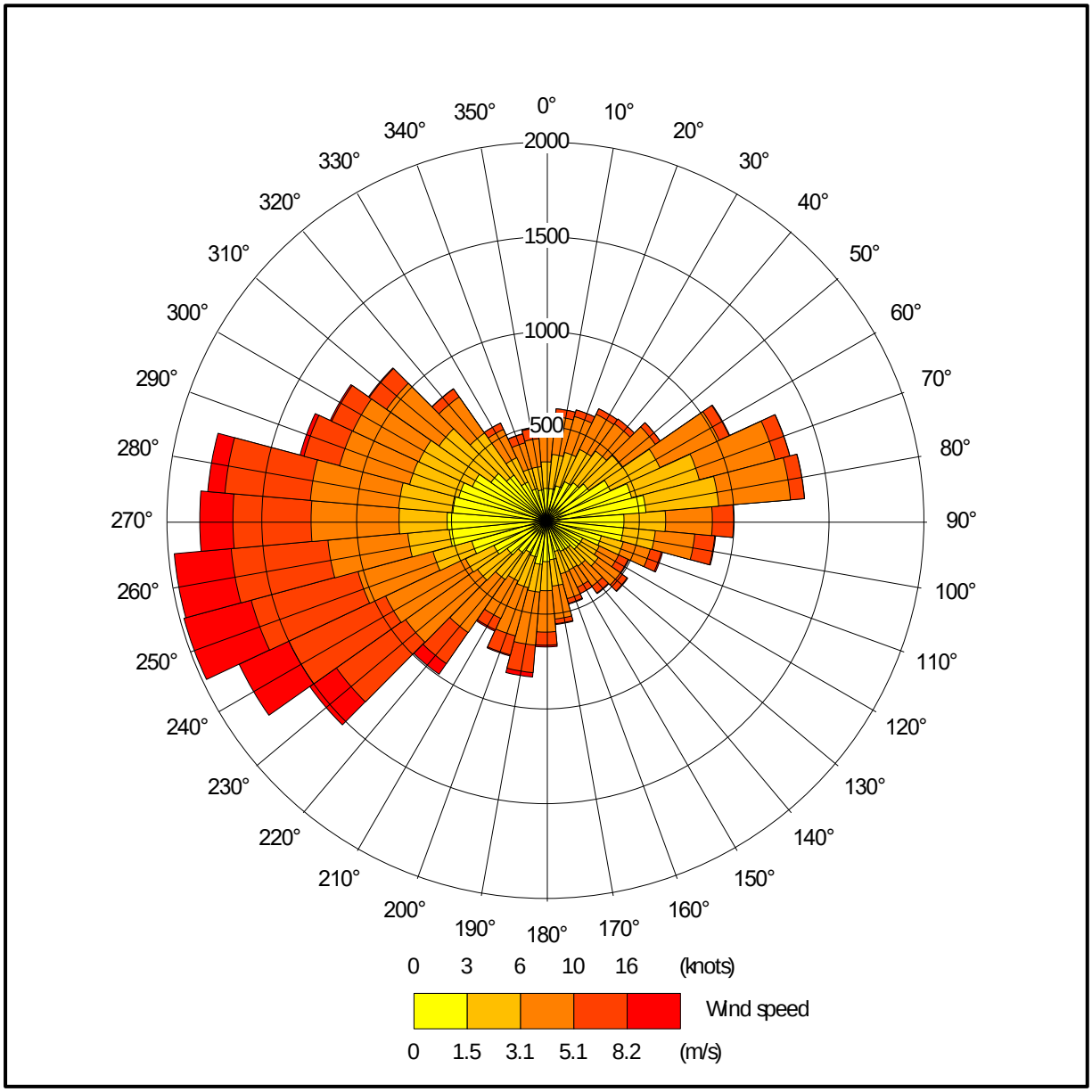
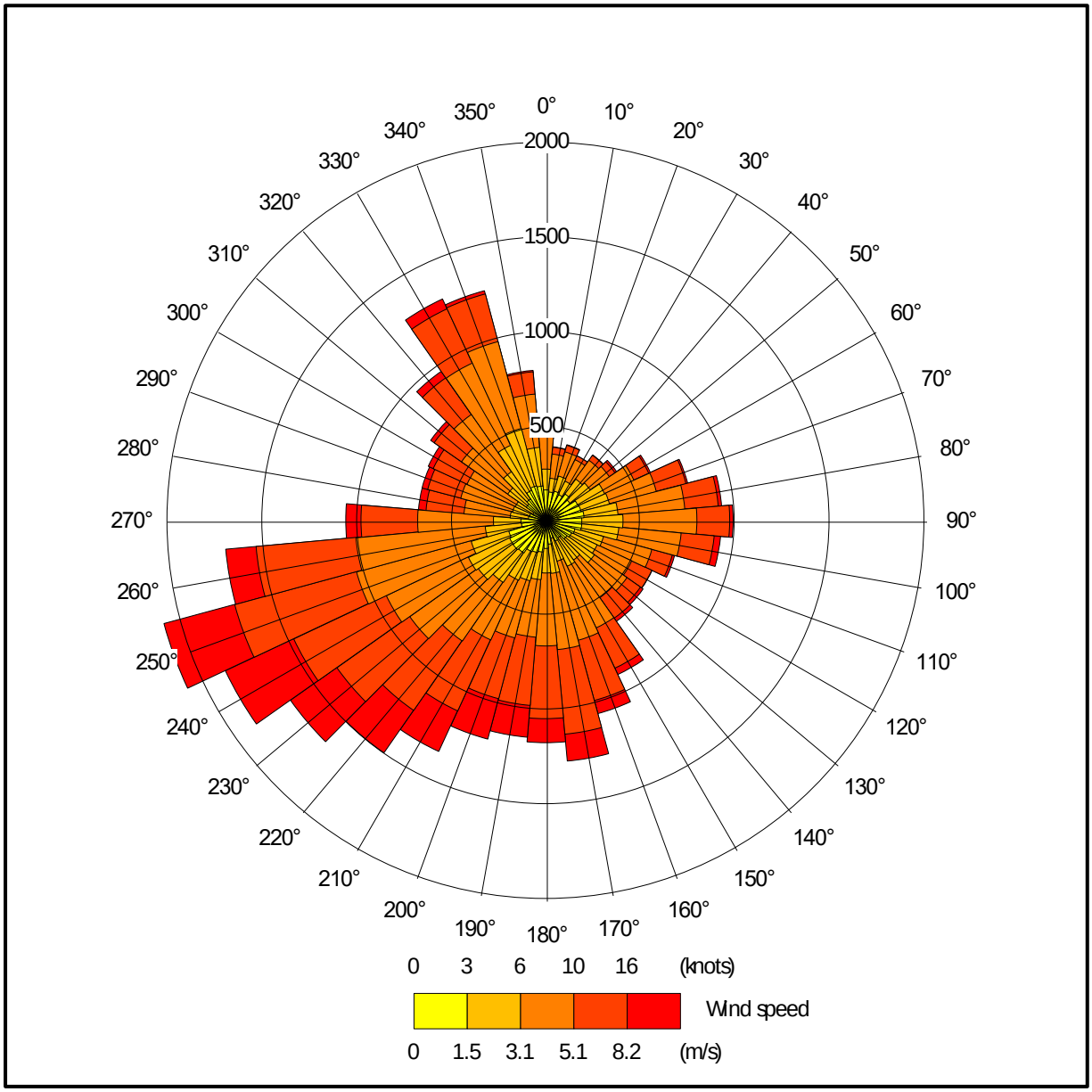


Figure 2e. The wind rose. Recorded meteorological data at Shawbury, 2013-2016



4.2 Emission sources

Emissions from the chimneys of the uncapped 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 per house within ADMS (EX and PR; a, b and c). Details of the point source parameters are shown in Table 3a and their positions may be seen in Figure 3, where they are marked by red stars.

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source ($g/NH_3/s$)
EX and PR; a, b & c	6.5	0.8	11.0	22.0	0.021632 [1]

1. Reduced by 50% when the ambient temperature equals or exceeds 21 Celsius.

The existing and proposed poultry houses are, or would be, fitted with gable end fans which would be used to provide supplementary ventilation in hot weather conditions. The emissions from these gable end fans are represented by a single volume source per house within ADMS (EX_gab and PR_gab). These volume sources are assumed to emit 50% of the total emissions for the existing and proposed poultry houses only when the ambient temperature equals or exceeds 21 Celsius; when these volume sources are emitting, emissions from the associated point sources are reduced by 50%. Details of the volume source parameters are shown in Table 3b and their positions may be seen in Figure 3, where they are marked by red rectangles.

Table 3b. Volume source parameters

Source ID	Length Y (m)	Width X (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate ($g\text{-}NH_3/s$)
EX_gab and PR_gab	30.0	5.0	3.0	0.0	Ambient	0.032449 [2]

2. 50% of the total emission is emitted when the ambient temperature equals or exceeds 21 Celsius.

The chickens in the existing and proposed houses have, or would have, access to ranging areas. These ranging areas are represented by area sources within ADMS (EX_ran and PR_ran). Note that the area sources cover the parts of the ranges most likely to be used frequently and not the whole ranging area. Spent litter from the existing and proposed poultry houses is stored in a manure store, which, under the proposals, will be moved to a location south of the existing manure store. The existing and proposed manure stores are also represented by area sources within ADMS (EX_man and PR_man).

Details of the area source parameters are provided in Table 3c. The position of the area sources is shown in Figure 3, where they are represented by red polygons.

Table 3c. Area source parameters

Source ID	Area (m^2)	Base height (m)	Emission temperature (°C)	Emission rate ($g\text{-}NH_3/s$)
EX_ran	2,573	0.0	Ambient	0.040561
PR_ran	2,542	0.0	Ambient	0.040561
EX_man	526	0.0	Ambient	0.000754
PR_man	571	0.0	Ambient	0.001508

4.3 Modelled buildings

The structure of the proposed poultry houses may affect the plumes from the point sources. Therefore, these 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

Sixty discrete receptors have been defined: forty-six at the AWs (1 to 46), one at the SSSIs (47) and thirteen at the SSSI/SAC (48 to 60). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4a, a broad scale view and Figure 4b, a closer view focussing on the non-statutory sites, where they are marked by enumerated pink rectangles.

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition field used in the detailed modelling, two regular Cartesian grids have been defined within ADMS; one with a horizontal resolution of 50 m for a modelling domain that includes the nearby AWs and one with a coarser horizontal resolution of 200 m that includes the more distant Montgomery Canal SAC. The individual grid receptors are defined at ground level within ADMS. The position of the Cartesian grids may be seen in Figure 4a and Figure 4b, where they are marked by grey lines.

4.6 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 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 10.0 km x 10.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the detailed modelling for the nearby AW. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 300 m for the preliminary modelling and approximately 150 m for the detailed modelling.

4.7 Roughness Length

A fixed surface roughness length of 0.275 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 0.25 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and stability and therefore increases predicted ground level concentrations.

Figure 3. The positions of the modelled buildings and sources

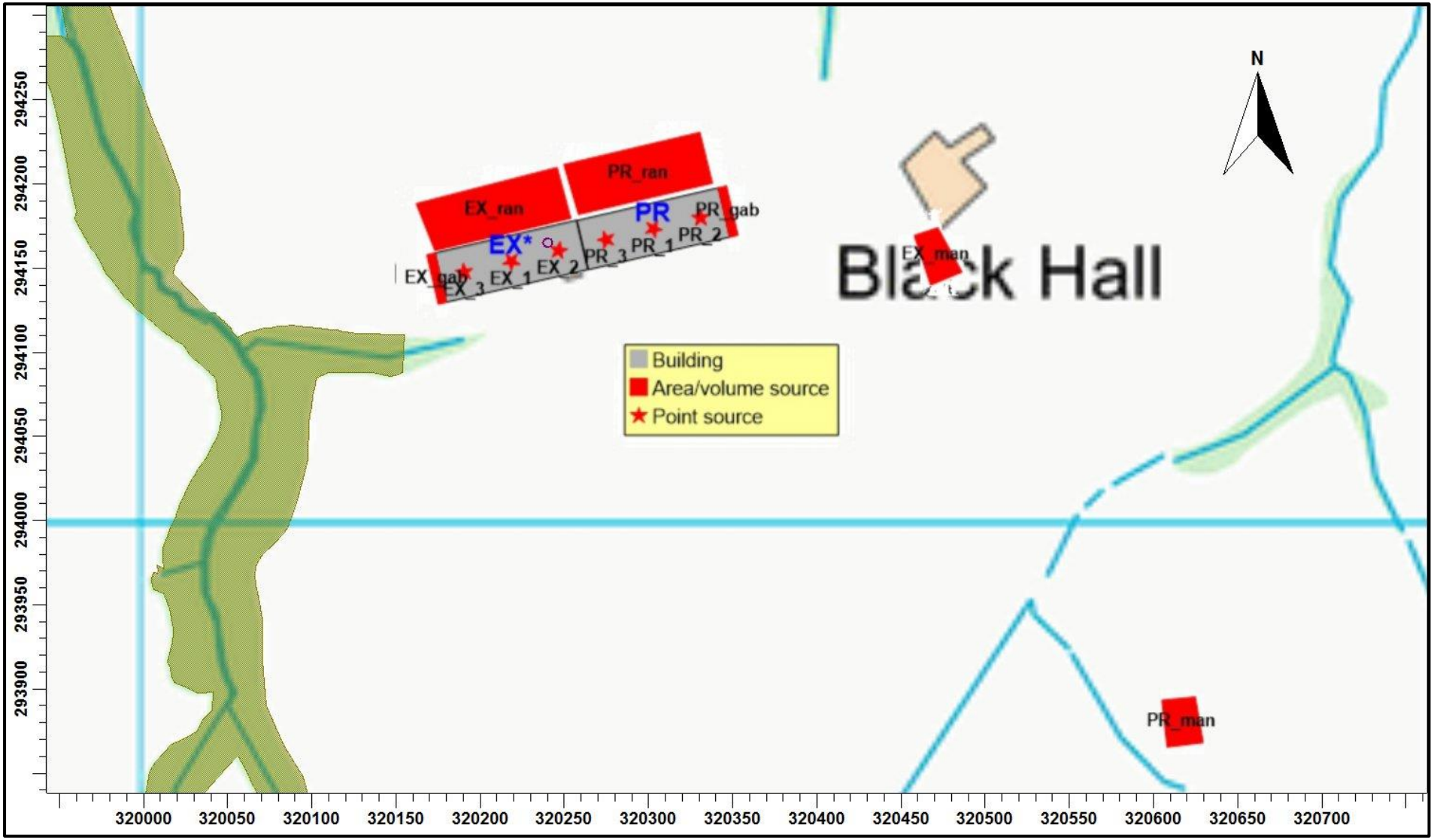


Figure 4a. The discrete receptors, a broad scale view, with concentric circles radii 10 km (purple), 5 km (green) and 2 km (olive)

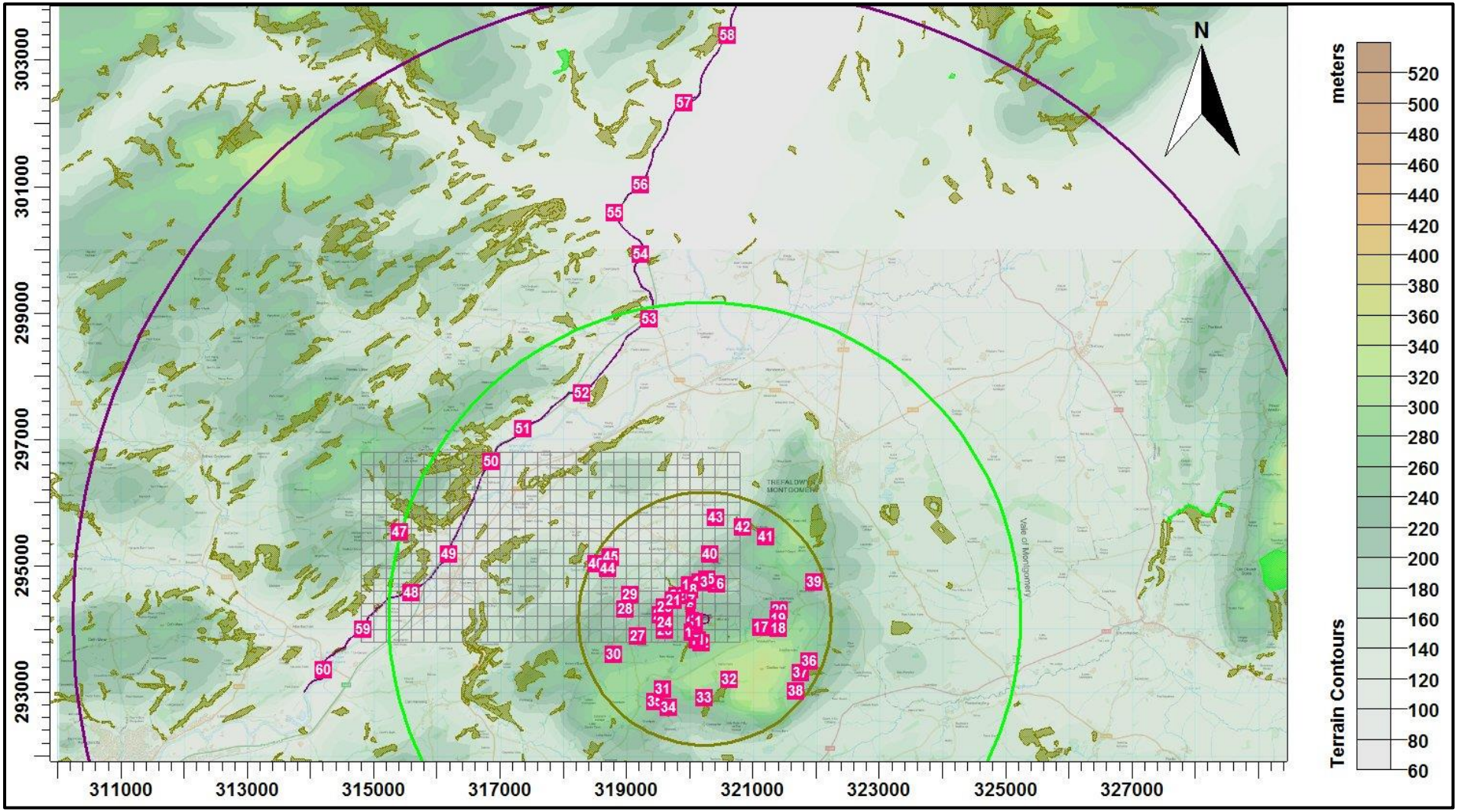
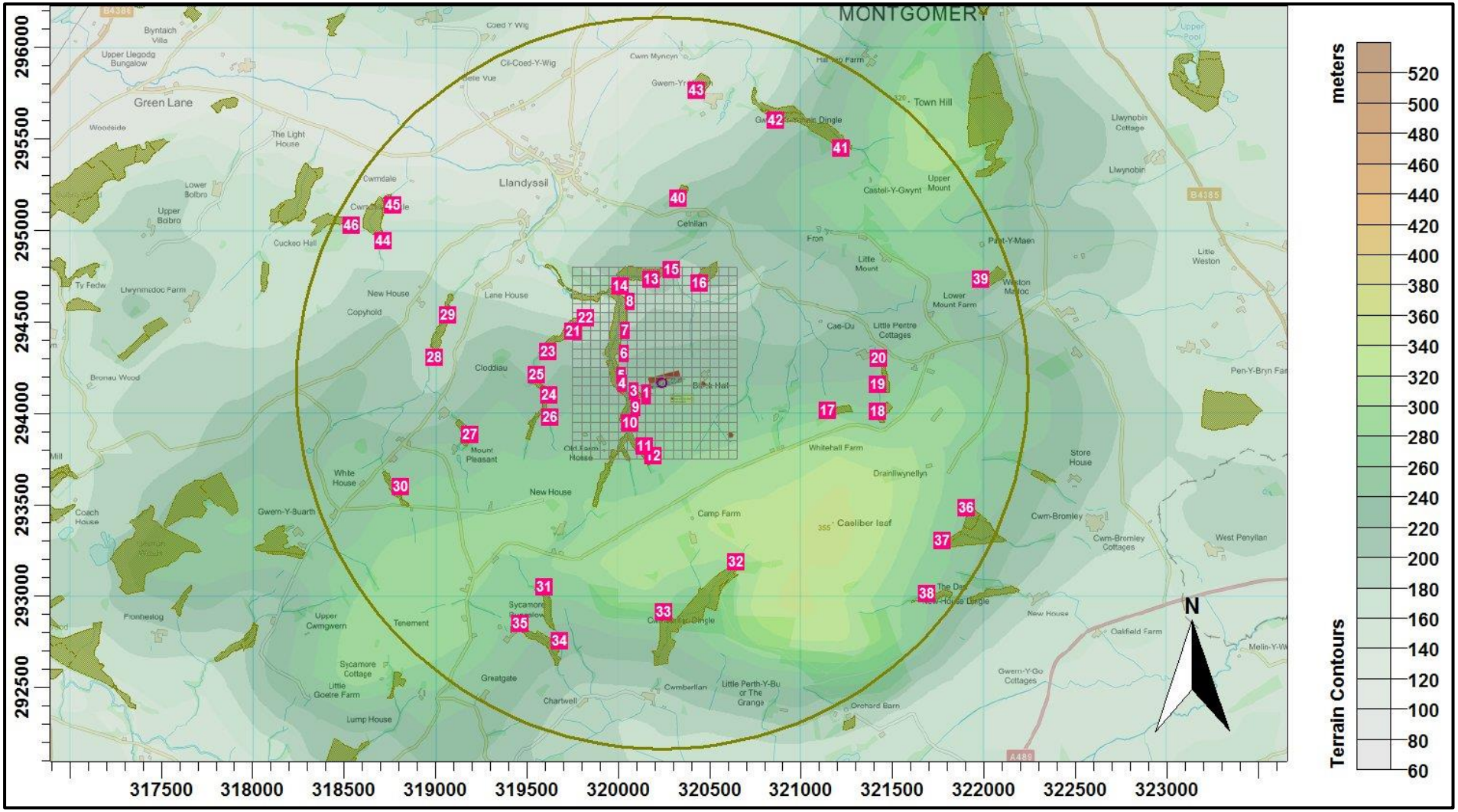


Figure 4b. The discrete receptors and Cartesian grid, a closer view focussing on the non-statutory sites, with concentric circle radii 2 km (olive)



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based on a document titled "Guidance on modelling the concentration and deposition of ammonia emitted from intensive farming" from the Environment Agency's Air Quality Modelling and Assessment Unit, 22 November 2010. N.B. AS Modelling & Data Ltd. has restricted deposition over arable farmland and heavily grazed and fertilised pasture; this is to compensate for possible saturation effects due to fertilizer application and to allow for periods when fields are clear of crops (Sutton), the deposition is also restricted over areas with little or no vegetation and the deposition velocity is set to 0.002 m/s where grid points are over the poultry housing and 0.015 m/s over heavily grazed grassland. Where deposition over water surfaces is calculated, a deposition velocity of 0.005 m/s is used.

In summary, the method is as follows:

- A preliminary run of the model without deposition is used to provide an ammonia concentration field.
- The preliminary ammonia concentration field, along with land usage, has been used to define two deposition velocity fields. The deposition velocities used are provided in Table 4.

Table 4. Deposition velocities

NH3 concentration (PC + background) (µg/m^3)	< 10	10 - 20	20 - 30	30 – 80	> 80
Deposition velocity – woodland (m/s)	0.03	0.015	0.01	0.005	0.003
Deposition velocity – short vegetation (m/s)	0.02 (0.015 over heavily grazed grassland)	0.015	0.01	0.005	0.003
Deposition velocity – arable farmland/rye grass (m/s)	0.005	0.005	0.005	0.005	0.003

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

Contour plots of the spatially varying deposition fields used in this study are provided in Figure 5a, for the detailed modelling domain that includes Montgomery Canal SAC and Figure 5b, for the detailed modelling domain that includes the nearby non-statutory sites.

Figure 5a. The spatially varying deposition field for the modelling domain that includes Montgomery Canal SAC

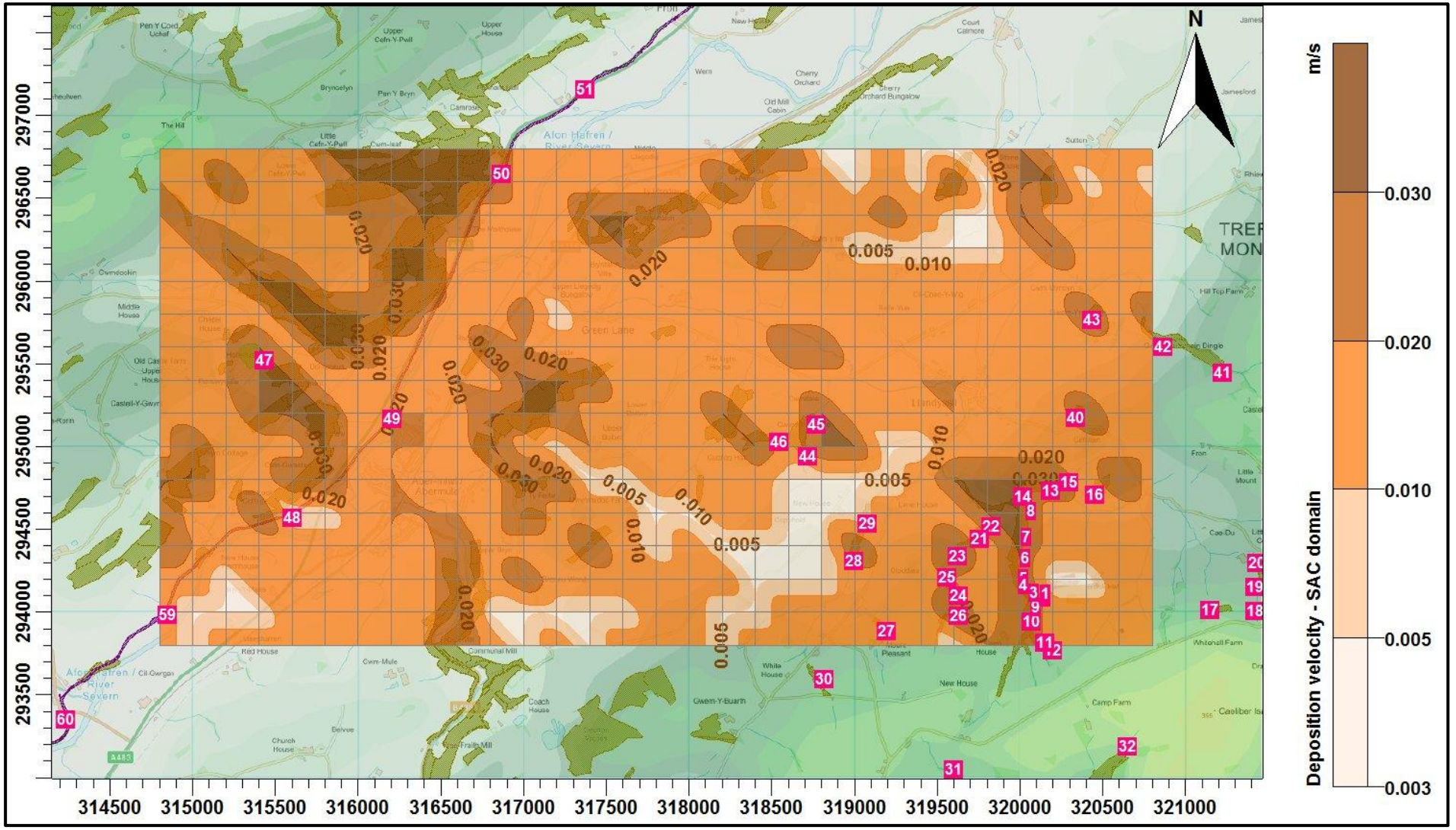
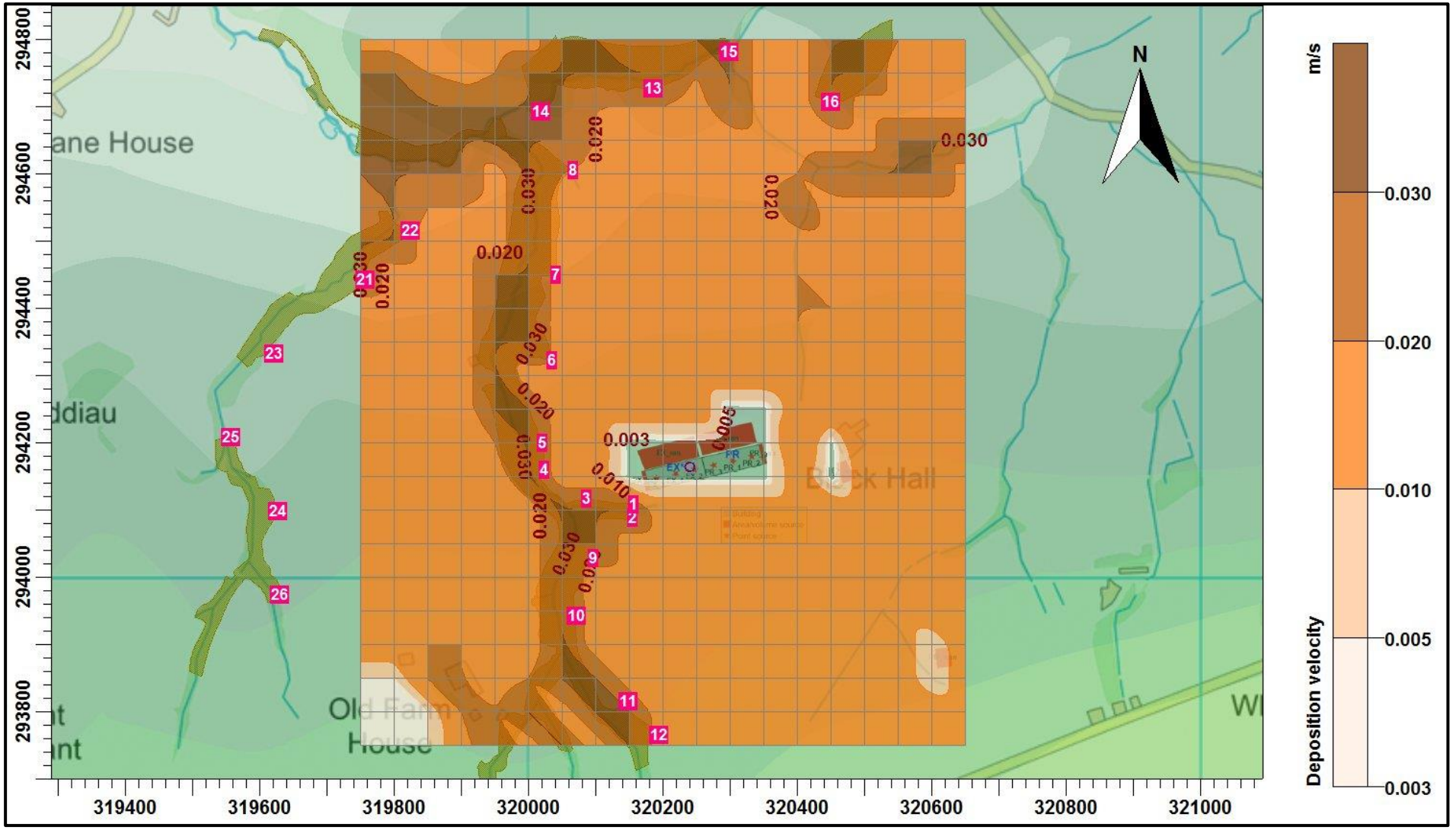


Figure 5b. The spatially varying deposition field for the modelling domain that includes the nearby non-statutory sites



5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of twenty-four times for the existing and proposed poultry houses; once for each year of the meteorological record and in the following three modes:

- In basic mode without calms or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- In basic mode without calms or terrain – Lake Vyrnwy data.
- In basic mode without calms or terrain – Shobdon 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 4. In the Table, predicted ammonia concentrations (or concentrations equivalent to deposition rates) that are in excess of Natural Resources Wales' or the Environment Agency's upper threshold (8% of Critical Level or Load for a SAC or SSSI, and 100% of Critical Level or Load for an AW) are coloured red. Concentrations (or concentrations equivalent to deposition rates) in the range between Natural Resources Wales' or the Environment Agency's lower and upper thresholds (1% and 8% for a SAC or SSSI and 50%[1] and 100% for an AW) are coloured blue. For convenience, cells referring to the AWs are shaded olive, cells referring to the SSSIs are shaded green and cells referring to the SAC are shaded pink.

1. The pre-February 2016 value is used.

Table 4. Predicted maximum annual mean ammonia concentration at the discrete receptors

Receptor number	X(m)	Y(m)	Maximum annual mean ammonia concentration (µg/m^3)					
			GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vrynwy No Calms No Terrain	Shobdon No Calms No Terrain	Shawbury No Calms No Terrain
1	320156	294108	**7.981**	**7.912**	**10.458**	**15.268**	**8.696**	**12.831**
2	320155	294088	**6.050**	**5.997**	**7.954**	**11.692**	**6.408**	**9.024**
3	320086	294117	**3.924**	**3.909**	**4.743**	**6.600**	**5.221**	**10.201**
4	320023	294159	**2.958**	**2.927**	**3.549**	**3.436**	**3.740**	**7.429**
5	320021	294200	**3.025**	**2.980**	**3.697**	**2.977**	**3.685**	**6.206**
6	320034	294322	**1.950**	**1.893**	**2.376**	**1.410**	**2.150**	**2.383**
7	320041	294450	**0.977**	**0.971**	**1.089**	**0.684**	**1.168**	**1.085**
8	320066	294605	**0.627**	**0.637**	**0.642**	0.380	**0.719**	**0.617**
9	320097	294028	**2.462**	**2.470**	**3.012**	**4.332**	**2.666**	**3.967**
10	320072	293943	**1.385**	**1.371**	**1.734**	**2.521**	**1.442**	**2.017**
11	320148	293815	**1.017**	**1.012**	**1.206**	**2.061**	**0.872**	**1.078**
12	320195	293765	**0.809**	**0.811**	**0.932**	**1.819**	**0.798**	**0.839**
13	320185	294727	**0.532**	**0.531**	**0.515**	0.350	**0.552**	**0.591**
14	320019	294693	0.448	0.455	0.448	0.269	**0.514**	0.432
15	320298	294780	0.461	0.456	0.429	0.370	**0.516**	**0.590**
16	320450	294707	**0.605**	**0.599**	**0.553**	**0.593**	**0.672**	**0.678**
17	321149	294011	0.357	0.351	0.332	0.387	0.223	**0.745**
18	321422	294005	0.237	0.233	0.222	0.268	0.149	0.490
19	321422	294152	0.251	0.247	0.264	0.311	0.182	**0.512**
20	321431	294296	0.237	0.234	0.265	0.300	0.218	0.491
21	319757	294442	**0.530**	**0.512**	**0.601**	0.426	**0.563**	**0.698**
22	319825	294515	0.486	0.472	**0.559**	0.341	**0.539**	**0.559**
23	319622	294332	0.462	0.454	0.484	0.424	**0.528**	**0.783**
24	319627	294098	0.491	0.487	0.474	**0.558**	**0.617**	**1.243**
25	319557	294208	0.423	0.419	0.411	0.400	**0.528**	**0.865**
26	319630	293974	0.401	0.399	0.380	**0.610**	**0.525**	**1.156**
27	319196	293881	0.179	0.178	0.155	0.248	0.224	**0.512**
28	318999	294304	0.157	0.155	0.153	0.145	0.192	0.294
29	319075	294535	0.158	0.154	0.167	0.141	0.172	0.249
30	318816	293594	0.091	0.091	0.073	0.153	0.124	0.272
31	319599	293045	0.128	0.127	0.125	0.232	0.118	0.164
32	320650	293185	0.170	0.172	0.153	0.345	0.262	0.208
33	320253	292909	0.129	0.130	0.123	0.309	0.146	0.126
34	319687	292751	0.109	0.108	0.117	0.203	0.086	0.120
35	319470	292844	0.098	0.098	0.098	0.176	0.091	0.127
36	321910	293478	0.093	0.092	0.075	0.112	0.051	0.244
37	321777	293298	0.086	0.086	0.070	0.114	0.052	0.242
38	321696	293008	0.075	0.076	0.057	0.109	0.057	0.197
39	321989	294727	0.105	0.104	0.100	0.121	0.144	0.206
40	320335	295172	0.193	0.190	0.161	0.158	0.218	0.253
41	321225	295445	0.110	0.110	0.080	0.139	0.142	0.119

Receptor number	X(m)	Y(m)	Maximum annual mean ammonia concentration (µg/m^3)					
			GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vrynwy No Calms No Terrain	Shobdon No Calms No Terrain	Shawbury No Calms No Terrain
42	320864	295597	0.109	0.109	0.086	0.111	0.125	0.123
43	320433	295761	0.088	0.087	0.083	0.076	0.102	0.119
44	318720	294941	0.085	0.082	0.090	0.071	0.088	0.111
45	318771	295133	0.072	0.070	0.077	0.056	0.077	0.084
46	318545	295023	0.072	0.070	0.076	0.061	0.074	0.094
47	315434	295519	0.018	0.018	0.033	0.017	0.020	0.030
48	315605	294568	0.021	0.021	**0.035**	0.020	**0.026**	**0.040**
49	316204	295167	**0.024**	**0.024**	**0.046**	0.023	**0.027**	**0.040**
50	316870	296641	0.018	0.017	**0.024**	0.013	0.020	0.022
51	317374	297155	0.016	0.016	0.016	0.013	0.020	0.019
52	318306	297725	0.018	0.019	0.018	0.011	0.020	0.017
53	319380	298895	0.017	0.017	0.020	0.010	0.016	0.018
54	319247	299922	0.012	0.013	0.016	0.008	0.012	0.014
55	318829	300569	0.011	0.011	0.013	0.006	0.010	0.011
56	319247	301016	0.010	0.010	0.013	0.006	0.009	0.011
57	319923	302309	0.008	0.008	0.012	0.005	0.008	0.010
58	320618	303385	0.006	0.006	0.011	0.005	0.007	0.009
59	314851	293982	0.017	0.017	**0.027**	0.017	0.022	**0.039**
60	314231	293351	0.014	0.014	0.021	0.016	0.018	**0.038**

5.2 Detailed deposition modelling

The detailed modelling was carried out over two restricted domains for the existing and proposed poultry houses; the first that covered the proposed poultry houses and the closest AWs, the second covered the existing and proposed poultry houses and parts of Montgomery Canal SAC; these are the areas where the preliminary modelling indicated that annual mean ammonia concentrations and nitrogen deposition rates could potentially exceed Natural Resources Wales' or the Environment Agency's lower threshold percentage of the Critical Level or Critical Load for the site. At the other AWs and Hollybush Pastures SSSI, the preliminary modelling indicated that ammonia levels (and nitrogen deposition rates) would be below the Environment Agency's lower threshold percentage of Critical Level/Load for the designation of the site.

Terrain effects may be significant; therefore, the detailed deposition run was made with terrain. Calms cannot be used with terrain or spatially varying deposition; however, the results of the preliminary runs demonstrate that the effect of calms upon the modelling is not significant in this case.

The results of the predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates are shown in Table 6a, for the discrete receptors located at the nearby AWs and in Table 6b, for the discrete receptors located at Montgomery Canal SAC that were considered within the detailed modelling. In these Tables, predicted ammonia concentrations that are in excess of Natural Resources Wales' or the Environment Agency's upper threshold for the site (8% for a SAC or SSSI and 100% of Critical Level or Load for a non-statutory wildlife site) are coloured red. Concentrations in the range between Natural Resources Wales' or the Environment Agency's upper threshold and lower threshold for the site (1% for a SAC or SSSI and 50%[1] to 100% of Critical Level or Load for a non-statutory wildlife site) are coloured blue. The abbreviations PC, CLe and CLo, used in the Table mean Process Contribution, Critical Level and Critical Load, respectively.

For the detailed modelling of the nearby AWs, a contour plot of the predicted ground level maximum annual mean ammonia is shown in Figure 6a and a contour plot of the maximum nitrogen deposition rates is shown in Figure 6b. For the detailed modelling of Montgomery Canal SAC, a contour plot of the predicted ground level maximum annual mean ammonia is shown in Figure 7a and a contour plot of the maximum nitrogen deposition rates is shown in Figure 7b.

1. The pre-February 2016 value is used.

Table 6a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors – detailed modelling for the nearby AWs

Receptor number	X (m)	Y (m)	Ammonia Concentration		Nitrogen Deposition	
			Maximum annual PC (µg/m^3)	%age of Cle_1	Maximum annual PC (kg/ha) [1]	%age of Clo_{10}
1	320156	294108	4.153	**415.3**	32.356	**323.6**
2	320155	294088	2.972	**297.2**	23.152	**231.5**
3	320086	294117	1.834	**183.4**	14.285	**142.8**
4	320023	294159	1.358	**135.8**	10.578	**105.8**
5	320021	294200	1.307	**130.7**	10.184	**101.8**
6	320034	294322	0.825	**82.5**	6.430	**64.3**
7	320041	294450	0.438	43.8	3.409	34.1
8	320066	294605	0.221	22.1	1.721	17.2
9	320097	294028	1.140	**114.0**	8.885	**88.8**
10	320072	293943	0.595	**59.5**	4.632	46.3
11	320148	293815	0.392	39.2	3.054	30.5
12	320195	293765	0.305	30.5	2.380	23.8
13	320185	294727	0.169	16.9	1.315	13.2
14	320019	294693	0.133	13.3	1.037	10.4
15	320298	294780	0.160	16.0	1.247	12.5
16	320450	294707	0.222	22.2	1.732	17.3
21	319757	294442	0.191	19.1	1.487	14.9
22	319825	294515	0.213	21.3	1.658	16.6

1. Deposition velocity of 0.03 m/s.

Table 6b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors – detailed modelling for Montgomery Canal SAC – bankside vegetation

Receptor number	X (m)	Y (m)	Ammonia Concentration		Nitrogen Deposition	
			Maximum annual PC ($\mu g/m^3$)	%age of Cle_3	Maximum annual PC (kg/ha) [2]	%age of Clo_{10}
48	315605	294568	0.009	0.3	0.049	0.5
49	316204	295167	0.013	0.4	0.068	0.7
50	316870	296641	0.006	0.2	0.032	0.3
59	314851	293982	0.006	0.2	0.031	0.3

2. Deposition velocity of 0.02 m/s.

Table 6c. Predicted maximum annual mean ammonia concentrations and nitrogen deposition at the discrete receptors – detailed modelling for Montgomery Canal SAC – aquatic vegetation

Receptor number	X (m)	Y (m)	Ammonia Concentration		Nitrogen Deposition	
			Maximum annual PC ($\mu g/m^3$)	%age of Cle_3	Maximum annual PC (kg/ha) [3]	%age of Clo_{10}
48	315605	294568	0.009	0.3	0.012	0.4
49	316204	295167	0.013	0.4	0.017	0.6
50	316870	296641	0.006	0.2	0.008	0.3
59	314851	293982	0.006	0.2	0.008	0.3

3. Deposition velocity of 0.005 m/s.

Figure 6a. Maximum annual ammonia concentration – nearby AW

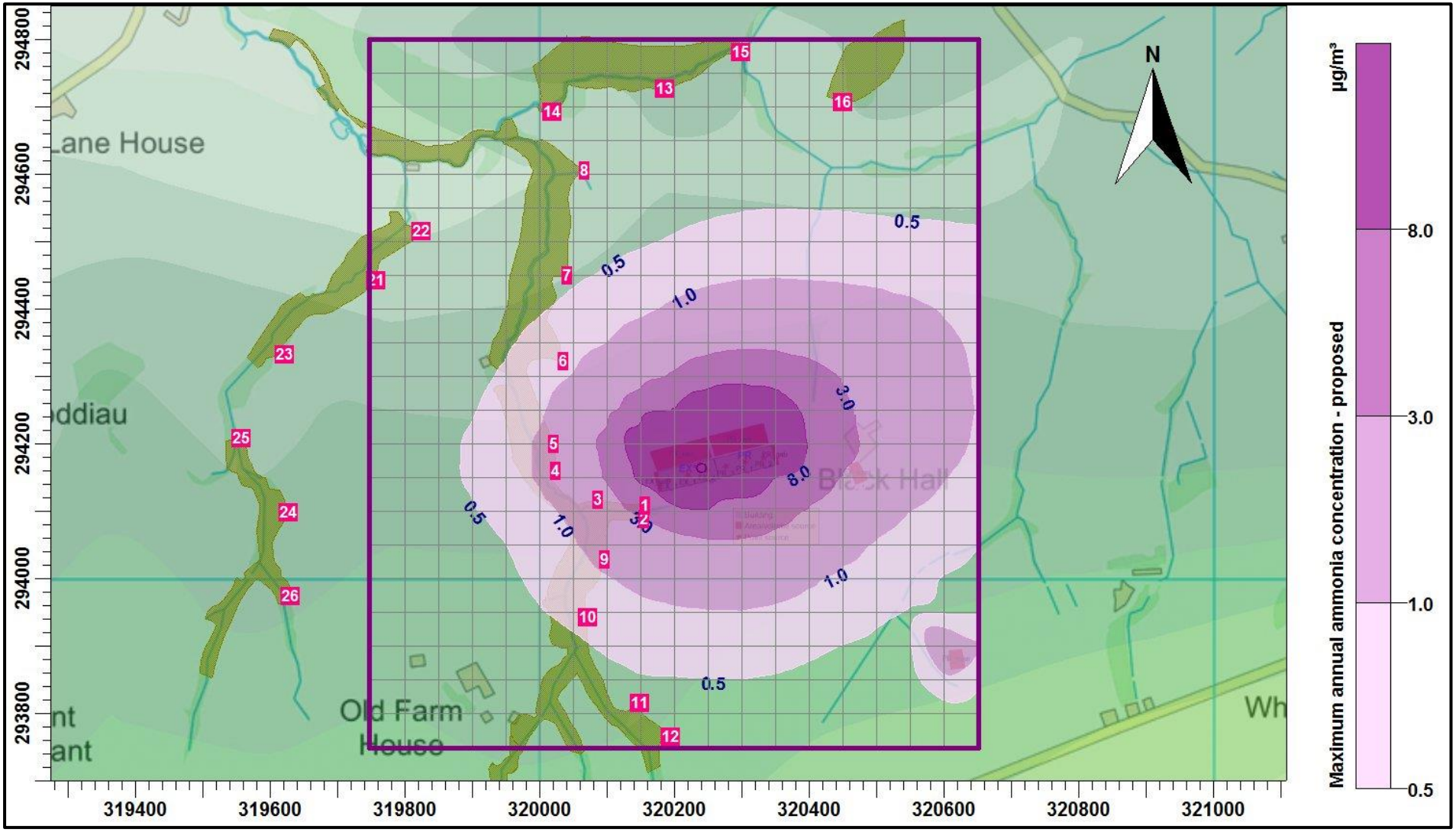


Figure 6b. Maximum annual nitrogen deposition rates – nearby AW

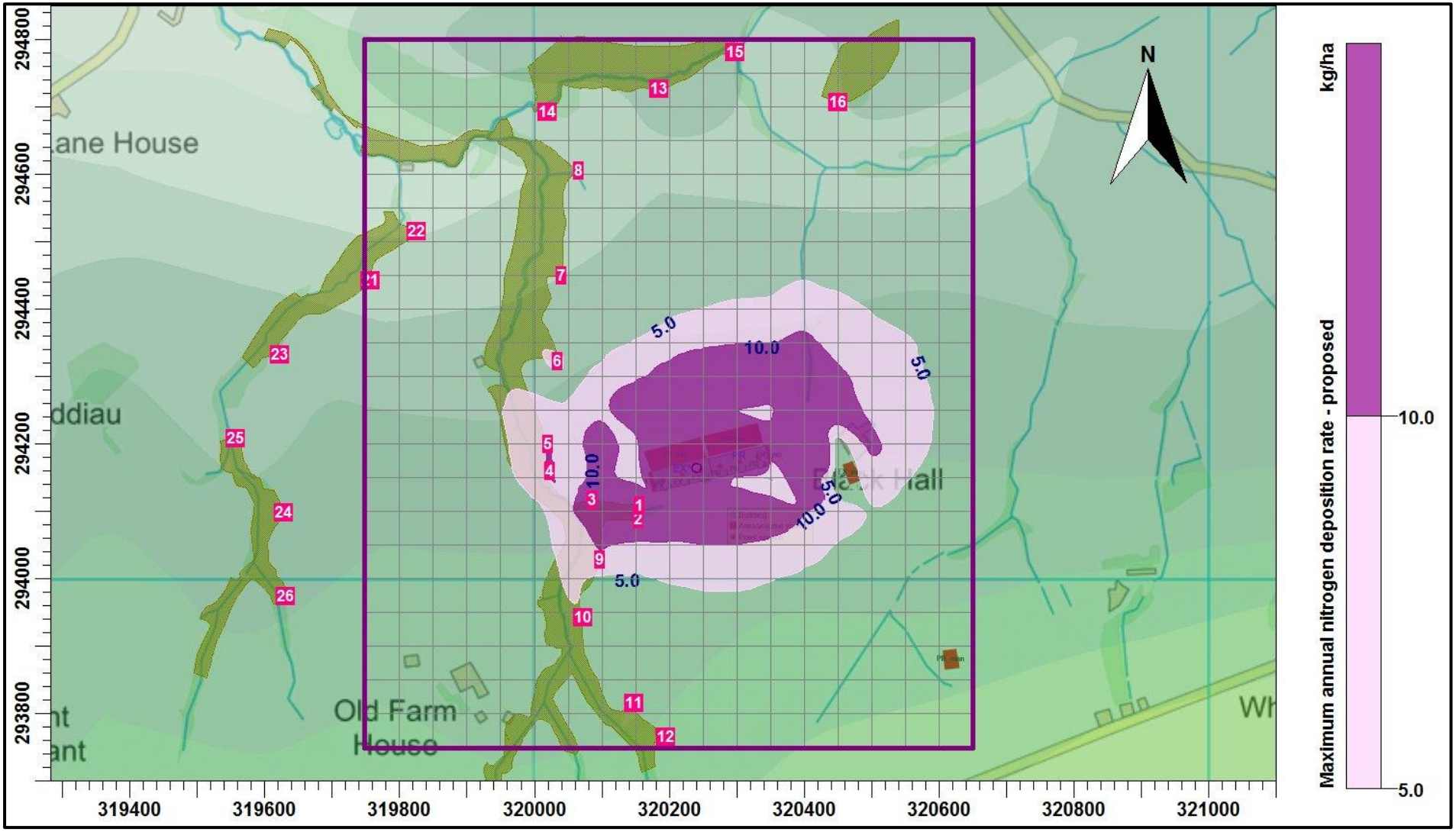


Figure 7a. Maximum annual ammonia concentration – Montgomery Canal SAC

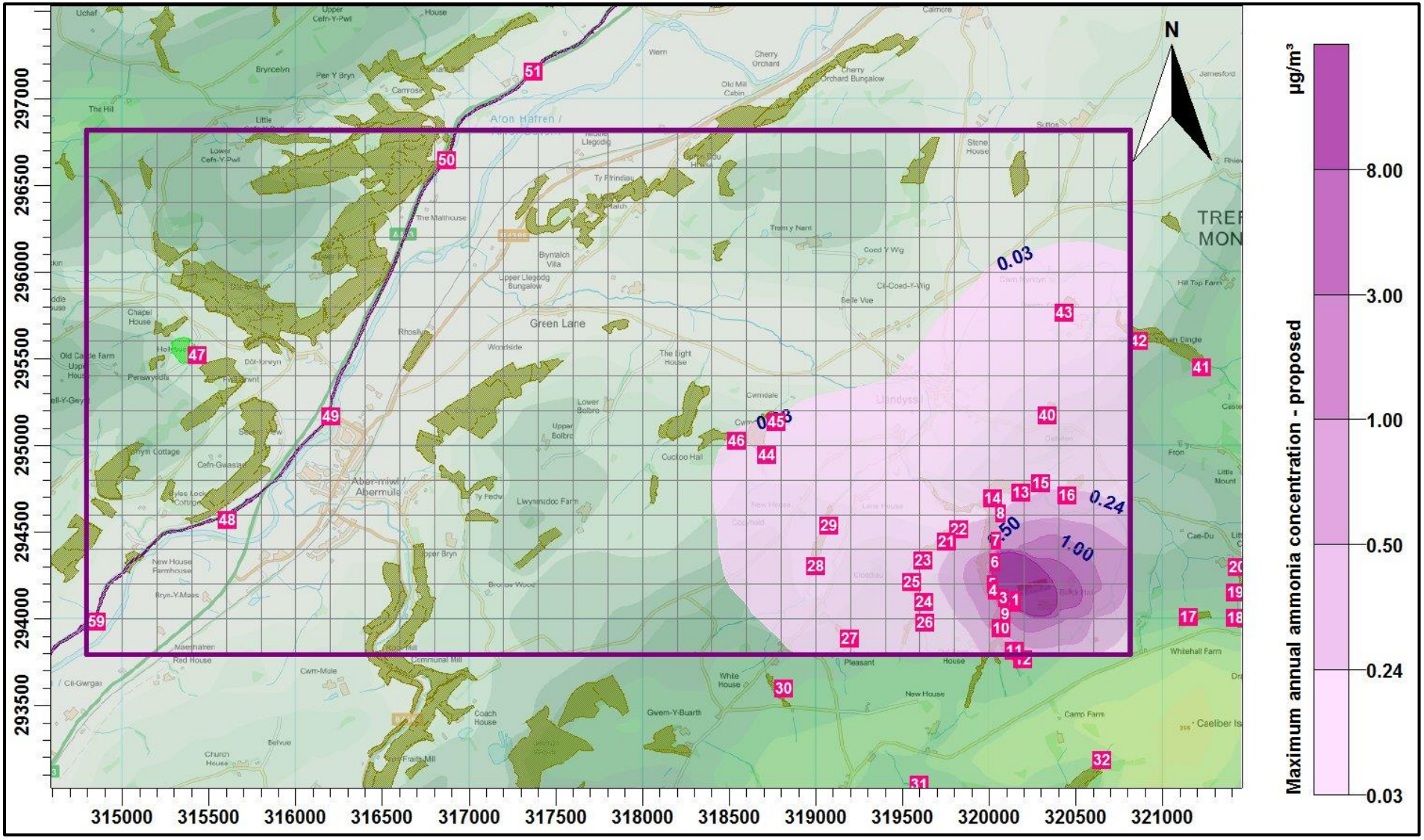
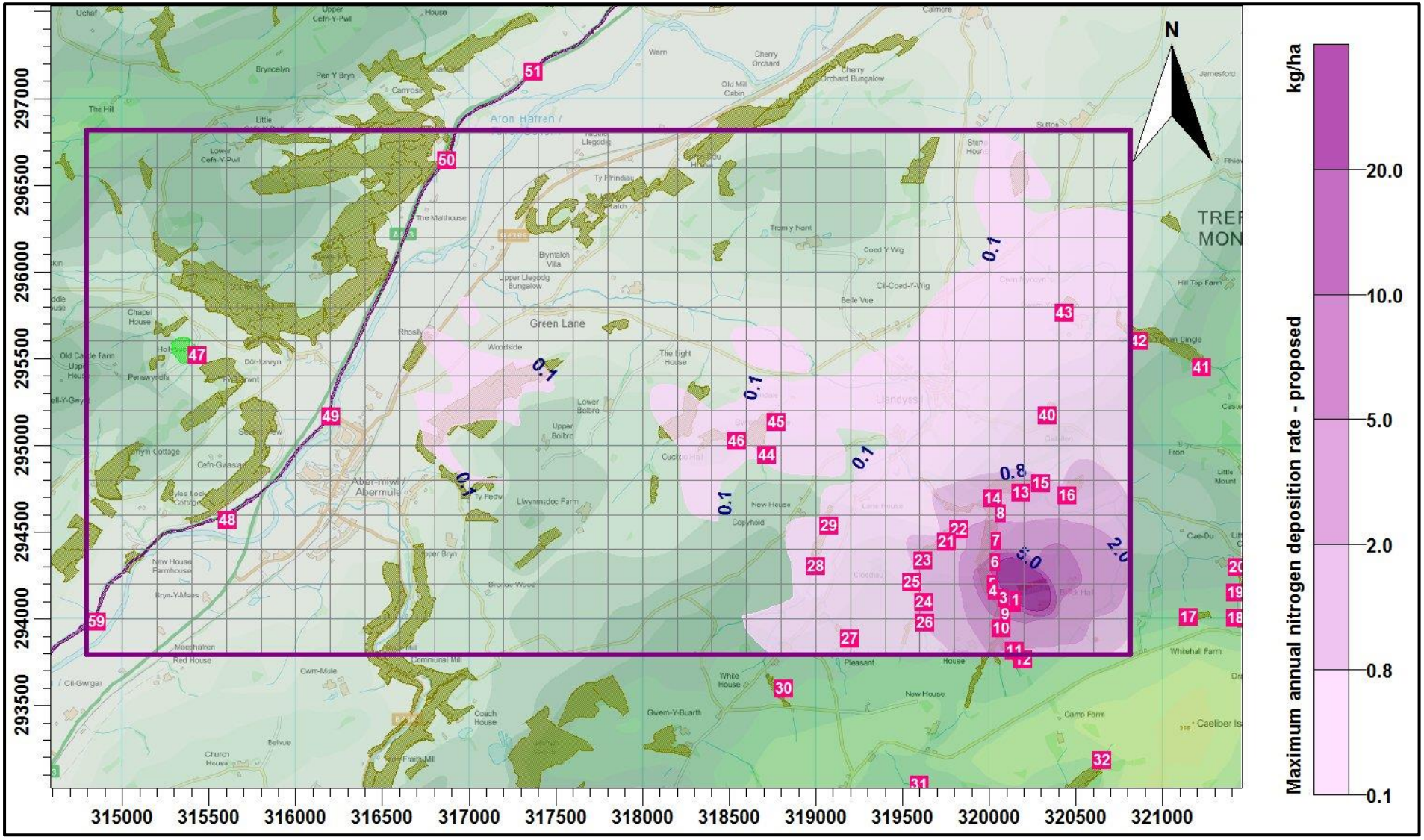


Figure 7b. Maximum annual nitrogen deposition rates – Montgomery Canal SAC



6. Summary and Conclusions

AS Modelling & Data Ltd., has been instructed by Matt Evans of Ian Price Property Services Ltd., on behalf of the applicant, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at Blackhall, Llandyssil, near to Montgomery in Powys. SY15 6HR.

Ammonia emission rates from the existing and proposed poultry houses have been assessed and quantified based upon the English Environment Agency's standard ammonia emission factors. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen deposition rates in the surrounding area.

The detailed modelling predicts that the process contribution from the existing and proposed poultry houses at Blackhall to both the annual ammonia concentration and the annual nitrogen deposition rate would exceed the English Environment Agency's upper threshold percentage of the precautionary Critical Level or the Critical Load (100% for a non-statutory site) at the closest AW. The detailed modelling predicts that the exceedance of the upper threshold of the precautionary Critical Level for ammonia concentration would impact approximately 0.92 ha of the AW and the exceedance of the upper threshold of the Critical Load for nitrogen deposition rates would impact upon approximately 0.34 ha of the AW. At all wildlife sites, other AWs, Hollybush Patures SSSI and the Montgomery Canal SAC, the predicted process contributions are below the relevant lower threshold percentage of the Critical Level or Critical Load for the site.

It should be noted that the Critical Level assumed for ammonia concentrations at the AWs is precautionary and should it be deemed, by a suitably qualified ecologist, that a less strict Critical Level would be more appropriate, then the area of the AW impacted by exceedances of the upper threshold of the Critical Level would be reduced. However, the impact of exceedances of the Critical Load for nitrogen deposition rates at the AWs would remain.

Where exceedances of the upper threshold are predicted, some form of mitigation is usually required. AS Modelling & Data Ltd. would recommend that, if available, to compensate for possible detrimental effects on the nearby AWs, the sites are actively managed for wildlife, and/or, that land of at least a similar area to the exceedance of 100% of the Critical Level is set aside for nature conservation and be planted with native species. Alternatively, or additionally, unfertilised and only lightly grazed buffer zones and corridors could be set up around and between the AWs; such buffer zones and corridors can greatly enhance bio-diversity over time. Also, research by Beasley et al, 2013 (Defra project AC0201) have found that tree planting locally can be used as a measure to help protect downwind sensitive ecosystems from ammonia emissions from agricultural installations.

7. References

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