A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Free Range Egg Laying Chicken Houses at Bache Farm, New Radnor in Powys

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Gerallt Davies of Roger Parry & Partners LLP, on behalf of Owen and Christine Hardwick, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at Bache Farm, New Radnor, Powys. LD8 2TG.

Ammonia emission rates from the existing and proposed poultry houses have been assessed and quantified based upon the Environment Agency's standard ammonia emission factors and the Best Available Techniques (BAT) Reference Document for the Intensive Rearing of Poultry or Pigs. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

This report is arranged in the following manner:

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

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

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

- Section 5 contains the results of the modelling.

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

2. Background Details

The site of the existing and proposed free range chicken houses at Bache Farm is in a rural area, approximately 1.8 km to the north-east of the town of New Radnor and lies to the east of Radnor Forest in Powys. The surrounding land is used predominantly for livestock and arable farming, but there are several wooded areas and some areas of semi-natural grassland nearby. The site is at an altitude of around 275 m with land rising to mountains and hill tops to the north-west and falling gently towards several small brooks to the south-east.

There are currently two existing mobile poultry units at Bache Farm, which provide accommodation for 8,000 free range egg laying chickens. The mobile units are naturally ventilated and manure collects within the mobile poultry units throughout the lifetime of the flocks and is removed at the end of each flock cycle, which is approximately once per year.

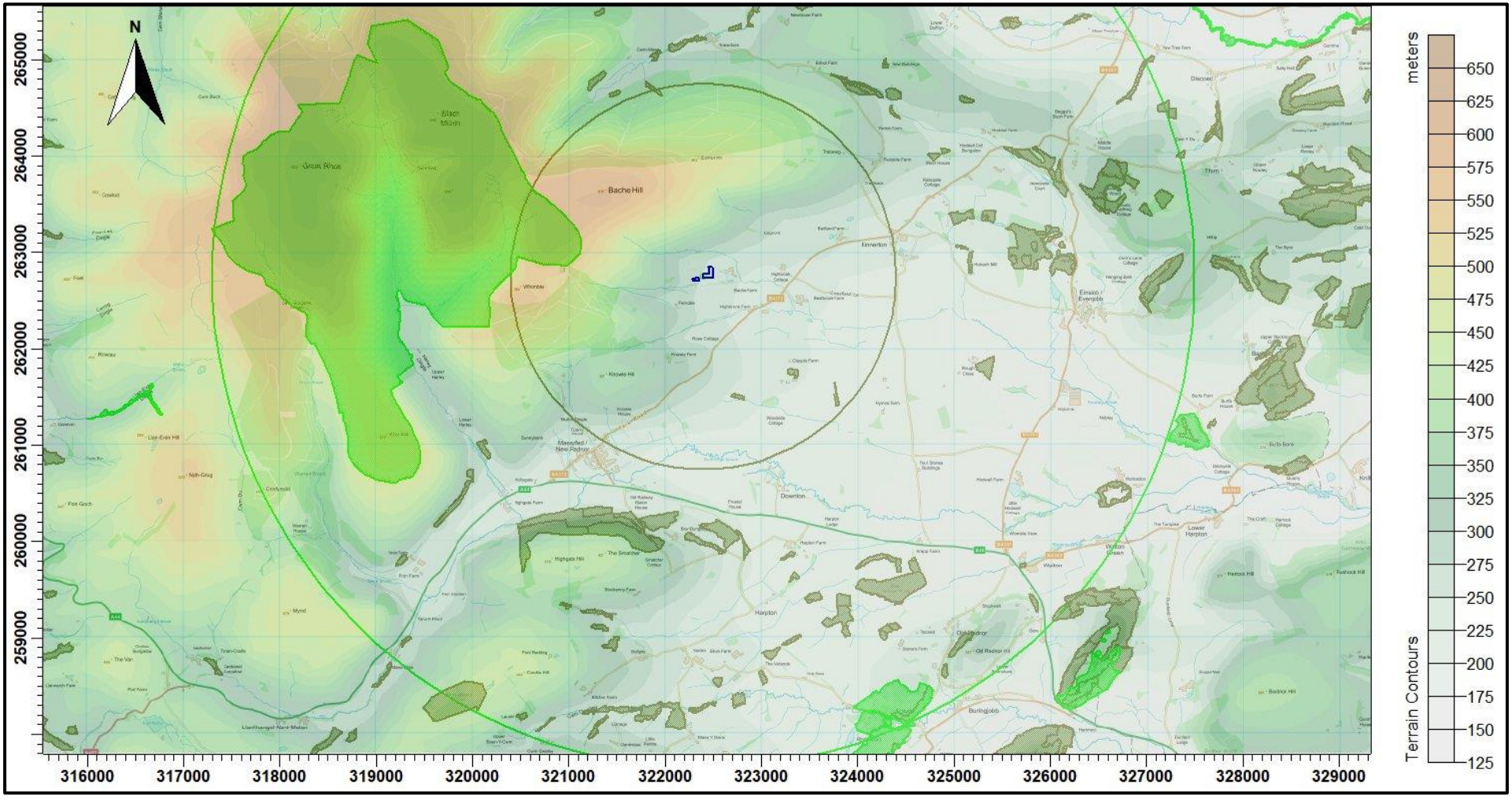
There is also another existing poultry house at Bache Farm, which provides accommodation for a further 16,000 free range egg laying chickens. The poultry house has pop holes which provide the birds with daytime access to an outside ranging area and it is ventilated by uncapped high speed ridge/roof mounted fans, each with a short chimney. Every four days, the birds' droppings are removed by a belt collection system and stored temporarily on the farm, prior to being removed from site or spreading to land.

Under the proposal, the two existing mobile poultry units would be removed and a new poultry house would be constructed adjacent to the existing poultry house. The poultry houses would then provide accommodation for up to 40,000 free range egg laying chickens. The poultry houses have/would have pop holes to provide the birds with daytime access to outside ranging areas and are/would be ventilated by ridge/roof mounted fans, each with a short chimney. Every four days, the birds' droppings are/would be removed by a belt collection system and stored temporarily on the farm, prior to being removed from site or spreading to land.

There are four areas of unnamed Ancient Woodlands (AWs) within 2 km of Bache Farm. There are also four Sites of Special Scientific Interest (SSSIs) within 5 km, namely: Radnor Forest SSSI; Dolyhir Quarry SSSI; Dolyhir Meadows SSSI and Burfa Boglands SSSI. There are no internationally designated wildlife sites within 5 km of the farm.

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

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



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 1.20 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 30.24 kg-N/ha/y and to short vegetation is 18.62 kg-N/ha/y. The background acid deposition rate to woodland is 2.27 keq/ha/y and to short vegetation is 1.42 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, February 2019).

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 be appropriate. Normally, the Critical Load for nitrogen deposition provides a stricter test than the Critical Load for acid deposition.

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

Site	Critical Level (µg-NH_3/m^3)	Critical Load Nitrogen (kg-N/ha/y)	Critical Load Acid (keq/ha/y)
AWs	1.0 [1]	-	-
Radnor Forest SSSI, Dolyhir Quarry SSSI, Dolyhir Meadows SSSI and Burfa Boglands SSSI	1.0 [1 & 2]	5.0 [2 & 3]	-

1. A precautionary figure used where no details of the ecology of the site are available, or the citation for the site contains reference to sensitive lichens and/or bryophytes.
2. Based in the citation for the site and information obtained from the APIS website (February 2019).
3. The lower bound of the range of Critical Loads for habitats present at the site.

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 usually applied is based on the Environment Agency's horizontal guidance, H1 Environmental Risks Assessment, H1 Annex B - Intensive Farming. The following are taken from this document.

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

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

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

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

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

3.6 Quantification of ammonia emissions

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

3.6.1 Existing mobile unit chicken housing ammonia emissions

The Environment Agency provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For egg laying chickens, in a deep litter system, where manure accumulates within the houses and is removed at the end of each flock cycle, the Environment Agency figure is 0.29 kg-NH_3/bird place/year.

3.6.2 Existing 16,000 bird house and the proposed chicken housing ammonia emissions

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

3.6.2 Existing and proposed ranging area ammonia emissions

As the birds would have access to outdoor ranging areas, some of the birds' droppings, which is the source of the ammonia, would be deposited on these ranging areas. For modelling purposes, it is assumed that 12%[1] of the droppings are deposited on the ranging areas; this assumption is based upon figures from "Ammonia emission factors for UK agriculture" (Misselbrook *et al*). To estimate the ammonia emissions from the ranges, it has been assumed that laying hens produce 0.8 kg-N/y (Misselbrook) in their droppings and that 35% of ammoniacal nitrogen is emitted as ammonia (Misselbrook and Defra). This equates to an emission factor of 0.34 kg-NH_3/bird/y.

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

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

Table 2. Details of poultry numbers and ammonia emission rates

Source	Animal numbers	Type or weight	Emission factor ($kg\text{-}NH_3/place/y$)	Emission rate ($g\text{-}NH_3/s$)
Existing Housing (mobile)	8,000 (x 0.88)	Egg laying chickens, deep litter system	0.29	0.064694
Existing Housing (16 k unit)	16000 (x0.88)	Egg laying chickens, aviary system	0.08	0.035693
Existing Ranges	24,000 (x 0.12)	Ranging areas	0.34 (AS Modelling & Data figure)	0.031029
Proposed Housing	40,000 (x 0.88)	Egg laying chickens, aviary system	0.08 (EA/BREF figure)	0.089234
Proposed Ranges	40,000 (x 0.12)	Ranging areas	0.34 (AS Modelling & Data figure)	0.051715

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: 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 terrain effects parameterised) and data are archived at a resolution of 0.25 degrees (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). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional observational records may be over represented, this is because the instrumentation used may not record wind speeds below approximately 0.5 m/s and start up wind speeds may be greater than 1.0 m/s. In NWP data, the wind speed is continuous down to 0.0 m/s, allowing the calms module of ADMS to function correctly.

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

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

The wind rose for the raw GFS data is shown in Figure 2a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the location at the proposed poultry houses at Bache Farm is shown in Figure 2b. It should be noted that the local wind flow is strongly affected by the nearby hills/mountains to the west and the valley to the east and that elsewhere in the modelling domain, the modified wind roses may differ markedly, reflecting the local flow in that part of the domain. The resolution of the wind field in terrain runs is approximately 300 m for the preliminary modelling runs and approximately 150 m for the detailed modelling runs. Please also note that FLOWSTAR is used to obtain a local flow field, not to explicitly model dispersion in complex terrain as defined in the ADMS User Guide; therefore, the ADMS default value for minimum turbulence length has been amended.

Figure 2a. The wind rose. Raw GFS derived data, for 52.257 N, 3.137 W, 2014-2017

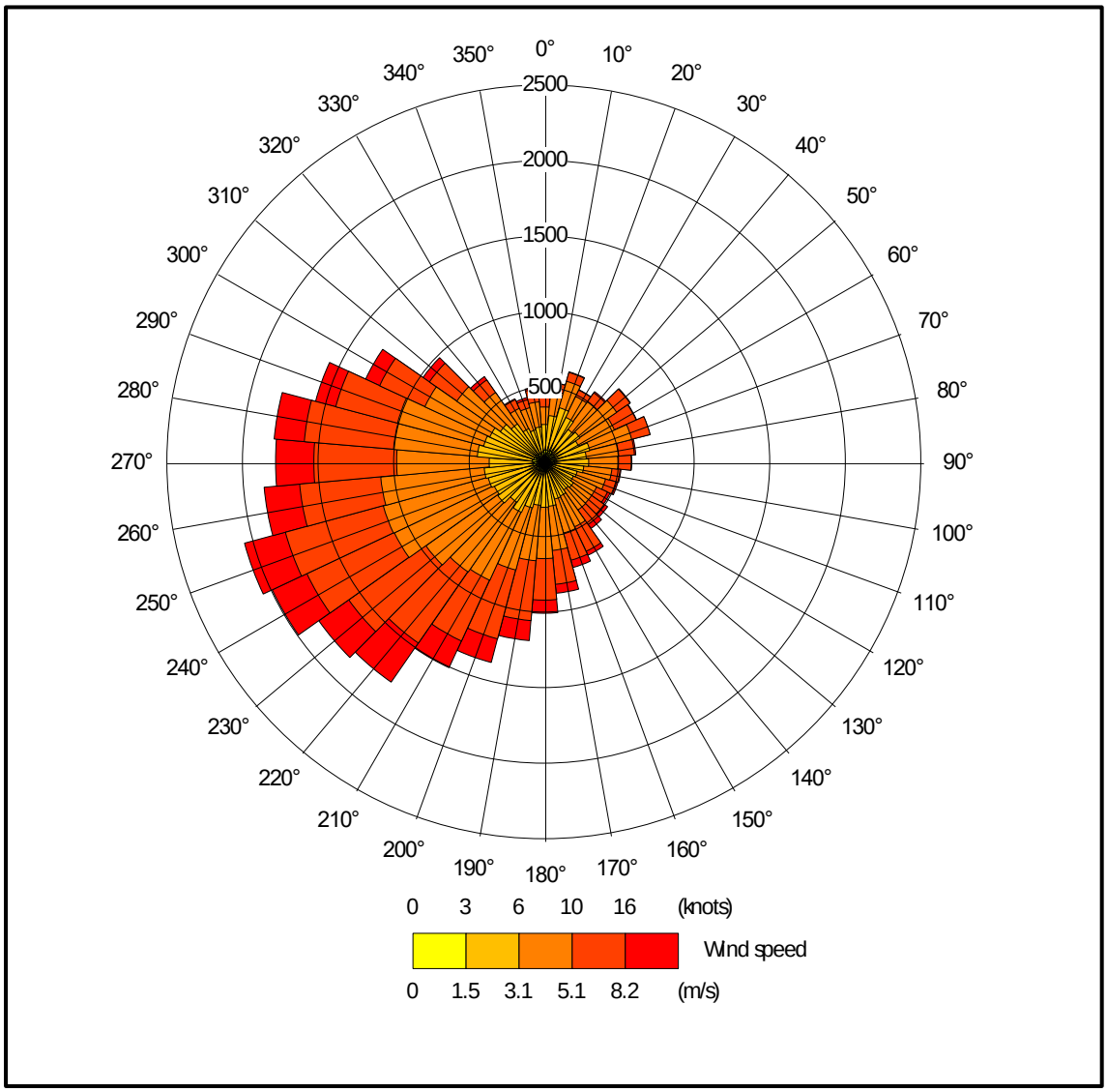
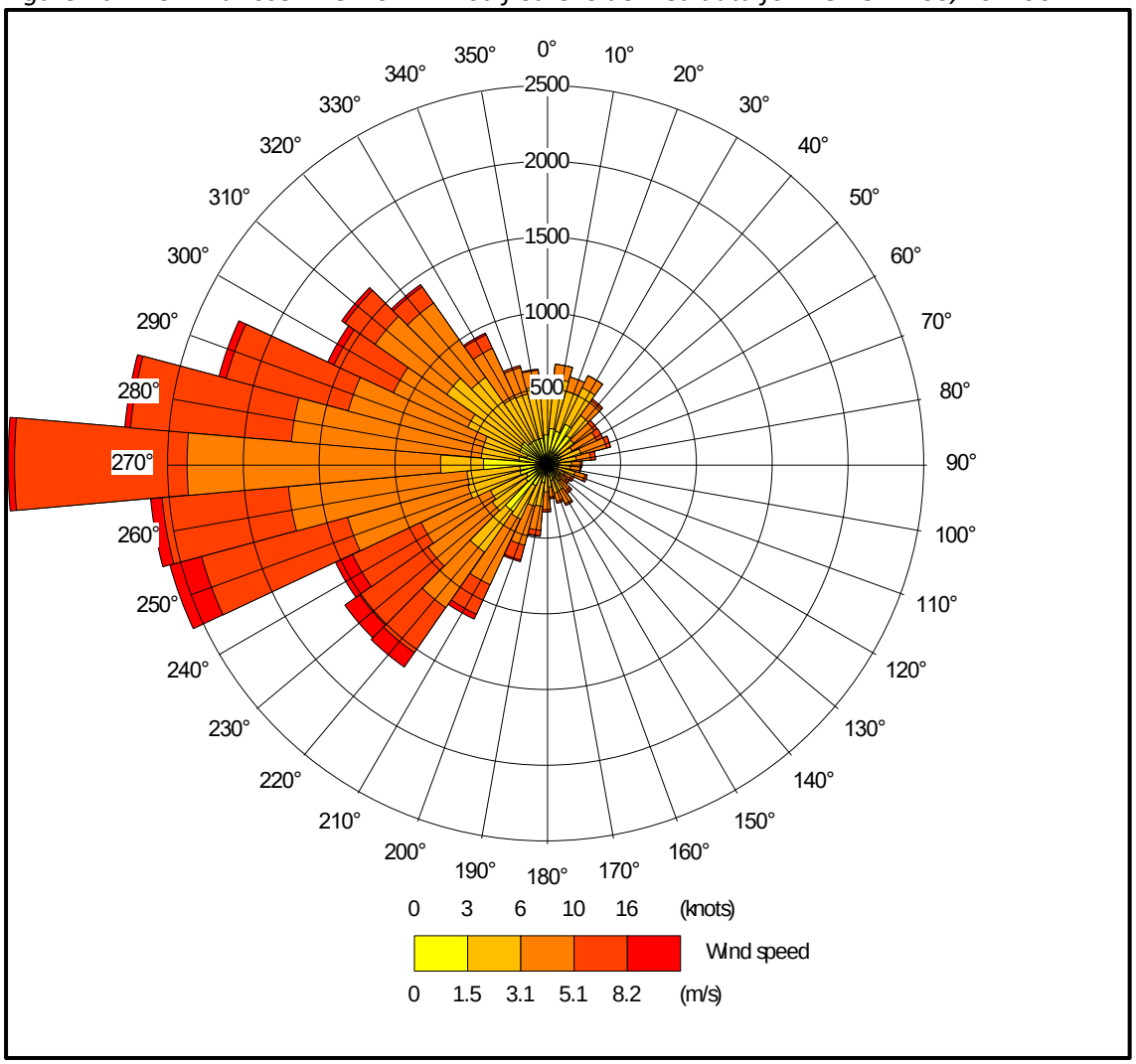


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 322400, 262750



4.2 Emission sources

The existing mobile poultry units are naturally ventilated, emissions are represented by a single volume source per unit within ADMS (EX1_4K and EX2_4K). Details of the volume source parameters are shown in Table 3a.

Emissions from the high speed ridge/roof fans that would be used to ventilate the existing and proposed poultry houses in the proposed scenario are represented by three point sources per house within ADMS (EX16K a, b & c and PR24K a, b & c). Details of the point source parameters are shown in Tables 3.

The existing and proposed mobile units and poultry houses would have ranging areas, which are represented by three area sources within ADMS (EX1_4K_RAN, 20K_RAN and 40K_RAN). Note that the area sources cover the parts of the ranges most likely to be used frequently and not the whole ranging area. Details of the area source parameters are shown in Table 3c.

The positions of the volume, point and area sources in the existing and proposed scenarios may be seen in Figures 3a and 3b.

Table 3a. Volume source parameters

Source ID	Length Y (m)	Width X (m)	*Depth (m)*	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
EX1_4K	12.0	42.0	0.5	0.0	Ambient	0.032347
EX2_4K	11.0	46.0	0.5	0.0	Ambient	0.032347

Table 3b. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
EX16K a, b & c	6.5	0.8	11.0	21.0	0.011898
PR24K a, b & c	6.5	0.8	11.0	21.0	0.017847

Table 3c. Area source parameters

Source ID	Area (m^2)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
EX1_4K_RAN	4,025.53	0.0	Ambient	0.005171
20K_RAN	4,808.95	0.0	Ambient	0.025857
40K_RAN	5,852.93	0.0	Ambient	0.051715

4.3 Modelled buildings

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

4.4 Discrete receptors

Fifteen discrete receptors have been defined: four at the AWs (1 to 4) and eleven at the SSSIs (5 to 15). These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4, where they are marked by enumerated pink rectangles.

4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report and to define the spatially varying deposition field used in the detailed modelling a regular Cartesian grid has been defined at ground level within ADMS. The position of the Cartesian grid may be seen in Figure 4, where it is 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. A 10 km x 10 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the detailed modelling runs. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field is approximately 300 m for the preliminary modelling runs and 150 m for the detailed modelling runs.

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 3a. The positions of the existing modelled buildings and sources

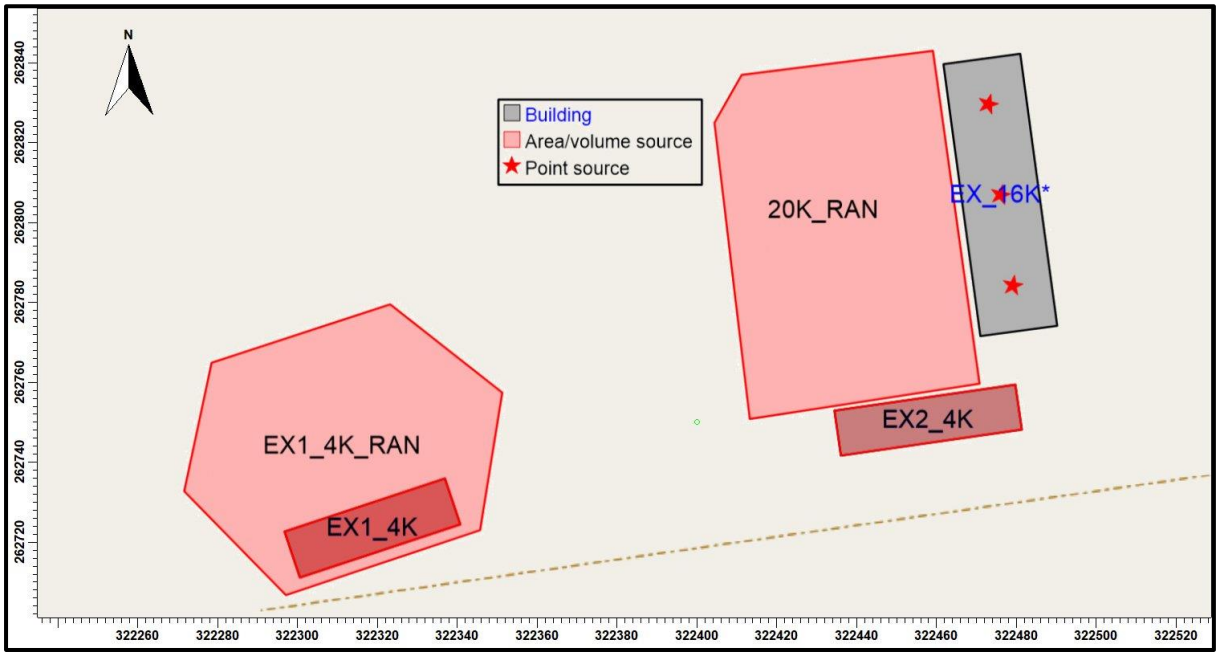


Figure 3b. The positions of the proposed modelled buildings and sources

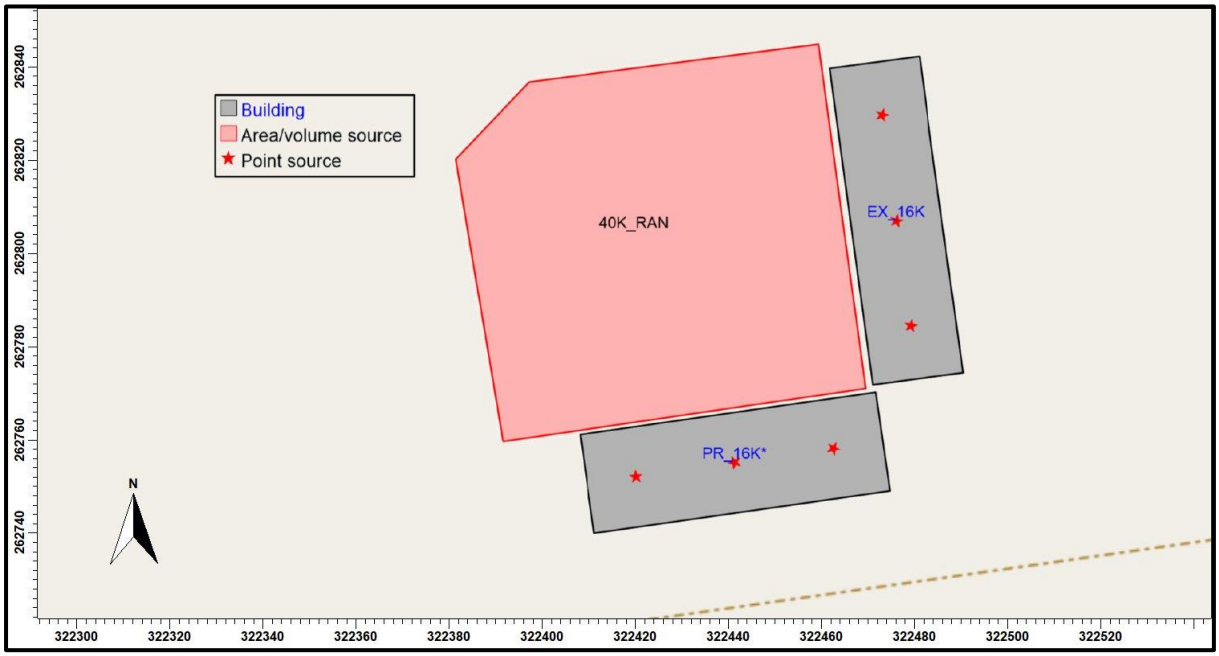
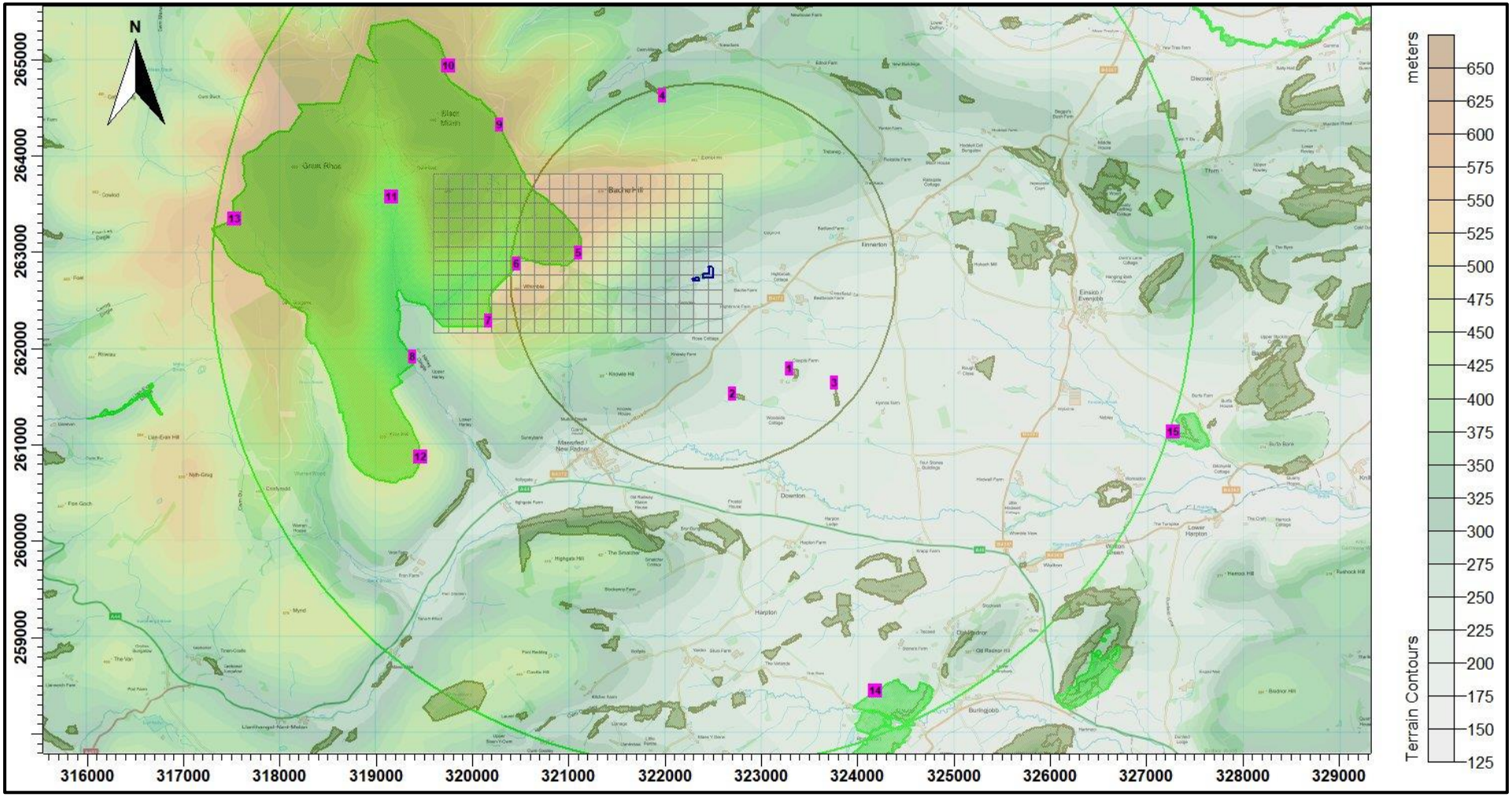


Figure 4. The discrete receptors and regular Cartesian grid



4.8 Deposition

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

In summary, the method is as follows:

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

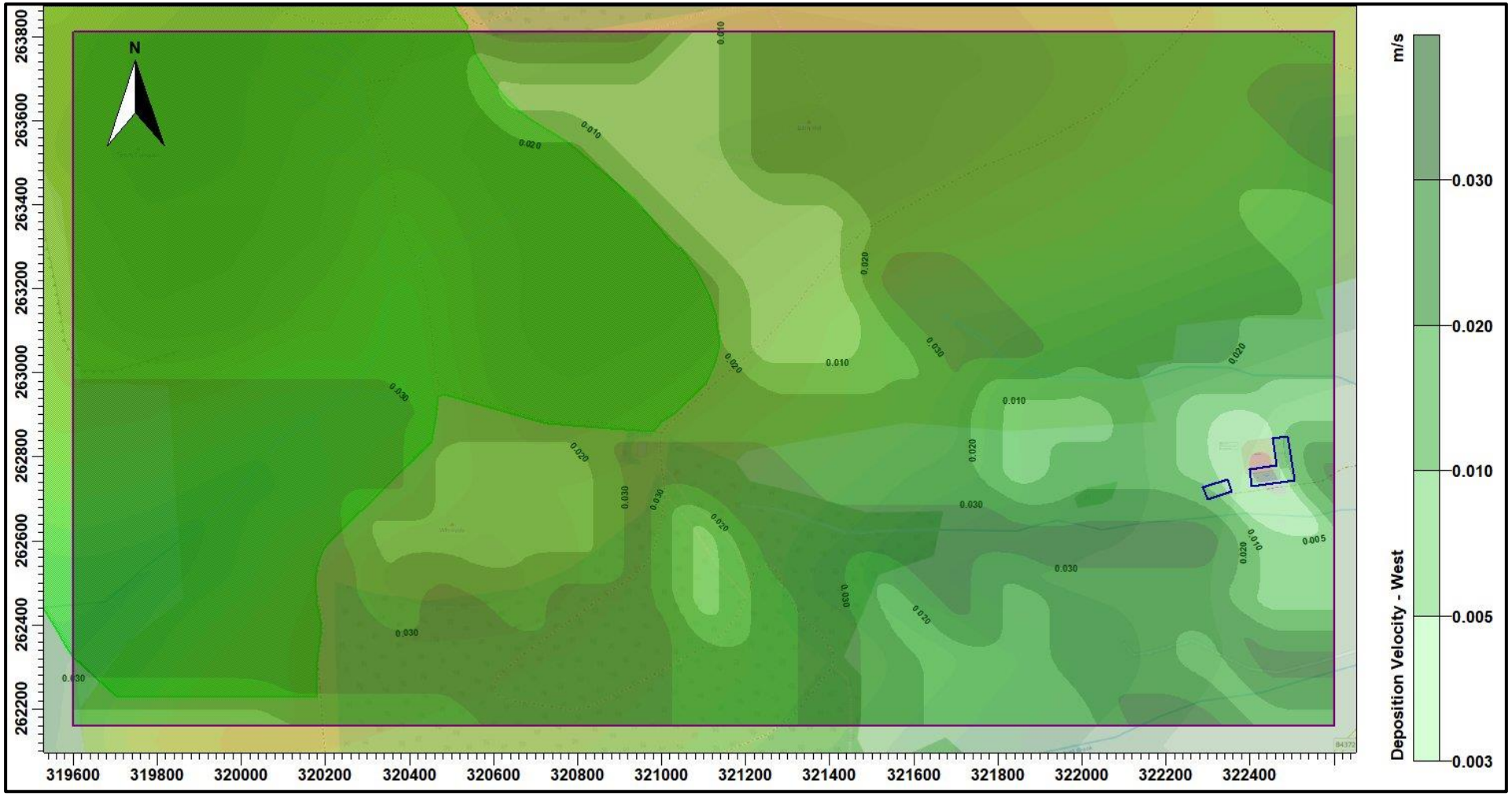
Table 4. Deposition velocities

NH_3 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.

A contour plot of the spatially varying deposition field is provided in Figure 5.

Figure 5. The spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling

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

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

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

Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. In the Table, predicted ammonia concentrations, including those that would lead to a nitrogen deposition rate, that are in excess of the Natural Resources Wales upper threshold (8% of Critical Level or Load for a SSSI and 100% of a Critical Level or Load for an AW) are coloured red. Concentrations in the range between the Natural Resources Wales upper threshold and lower threshold (1% to 8% for a SSSI and 50%[1] to 100% for an AW) are coloured blue. For convenience, cells referring to the SSSIs are shaded green and cells referring to the AWs are shaded olive.

1. The Pre-February 2016 figure is retained.

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

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)							
				Existing				Proposed			
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Dep 0.003 m/s	GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Dep 0.003 m/s
1	323289	261790	Unnamed AW	0.123	0.123	0.036	0.031	0.077	0.077	0.032	0.028
2	322705	261531	Unnamed AW	0.120	0.120	0.043	0.034	0.063	0.063	0.042	0.032
3	323756	261646	Unnamed AW	0.089	0.089	0.033	0.028	0.063	0.063	0.029	0.026
4	321977	264620	Unnamed AW	0.080	0.080	0.029	0.018	0.054	0.054	0.025	0.015
5	321105	262995	Radnor Forest SSSI	**0.136**	**0.136**	**0.105**	**0.031**	**0.082**	**0.082**	**0.074**	**0.020**
6	320453	262879	Radnor Forest SSSI	**0.078**	**0.078**	**0.038**	**0.014**	**0.049**	**0.049**	**0.026**	0.010
7	320171	262285	Radnor Forest SSSI	**0.066**	**0.066**	**0.030**	**0.012**	**0.043**	**0.043**	**0.023**	0.009
8	319381	261915	Radnor Forest SSSI	**0.039**	**0.039**	**0.019**	0.008	**0.027**	**0.027**	**0.013**	0.006
9	320279	264321	Radnor Forest SSSI	**0.035**	**0.035**	**0.016**	0.006	**0.023**	**0.023**	**0.013**	0.005
10	319750	264929	Radnor Forest SSSI	**0.023**	**0.023**	0.007	0.003	**0.015**	**0.015**	0.006	0.002
11	319156	263574	Radnor Forest SSSI	**0.027**	**0.027**	**0.012**	0.005	**0.019**	**0.019**	0.008	0.004
12	319460	260879	Radnor Forest SSSI	**0.029**	**0.029**	**0.016**	0.007	**0.020**	**0.020**	**0.013**	0.006
13	317526	263342	Radnor Forest SSSI	**0.017**	**0.017**	0.003	0.001	**0.012**	**0.012**	0.003	0.001
14	324184	258446	Dolyhir Quarry SSSI/Dolyhir Meadows SSSI	**0.015**	**0.015**	0.006	0.004	**0.010**	**0.010**	0.007	0.004
15	327275	261139	Burfa Boglands SSSI	**0.020**	**0.020**	**0.010**	0.008	**0.018**	**0.018**	0.010	0.009

5.2 Detailed deposition modelling

The detailed modelling was carried out over a restricted domain where the preliminary modelling indicated that annual mean ammonia concentrations could potentially exceed the relevant lower threshold percentage of the precautionary Critical Level of 1.0 μg-NH_3/m^3. The domain covers the existing and proposed poultry houses and ranges at Bache Farm and the closest parts of Radnor Forest SSSI. At all other receptors considered, the preliminary modelling indicated that ammonia levels (and nitrogen and acid deposition rates) would be below the Natural Resources Wales lower threshold percentage of the relevant Critical Level/Load for the designation of the site.

The predicted maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 6. 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 and 100% of Critical Level or Load for an AW) are coloured red. Concentrations that are in the range between the Natural Resources Wales lower and upper thresholds (1% to 8% for a SSSI and 50%[1] to 100% for an AW) are coloured blue.

Contour plots of the predicted ground level maximum annual mean ammonia concentration in the existing and proposed scenarios are shown in Figures 6a and 6b respectively. Contour plots of the predicted ground level maximum nitrogen deposition rates in the existing and proposed scenarios are shown in Figures 7a and 7b respectively.

1. The Pre-February 2016 figure is retained.

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

Receptor number	X(m)	Y(m)	Name	Site Parameters			Existing				Proposed			
							Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate		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	Process Contribution (µg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
5	321105	262995	Radnor Forest SSSI	0.020	1.0	5.0	0.02	**1.6**	0.08	**1.6**	0.01	**1.0**	0.05	**1.1**
6	320453	262879	Radnor Forest SSSI	0.020	1.0	5.0	0.01	0.6	0.03	0.6	0.00	0.5	0.02	0.5
7	320171	262285	Radnor Forest SSSI	0.030	1.0	5.0	0.00	0.5	0.04	0.7	0.00	0.4	0.03	0.6

Figure 6a. Maximum annual ammonia concentration – existing scenario

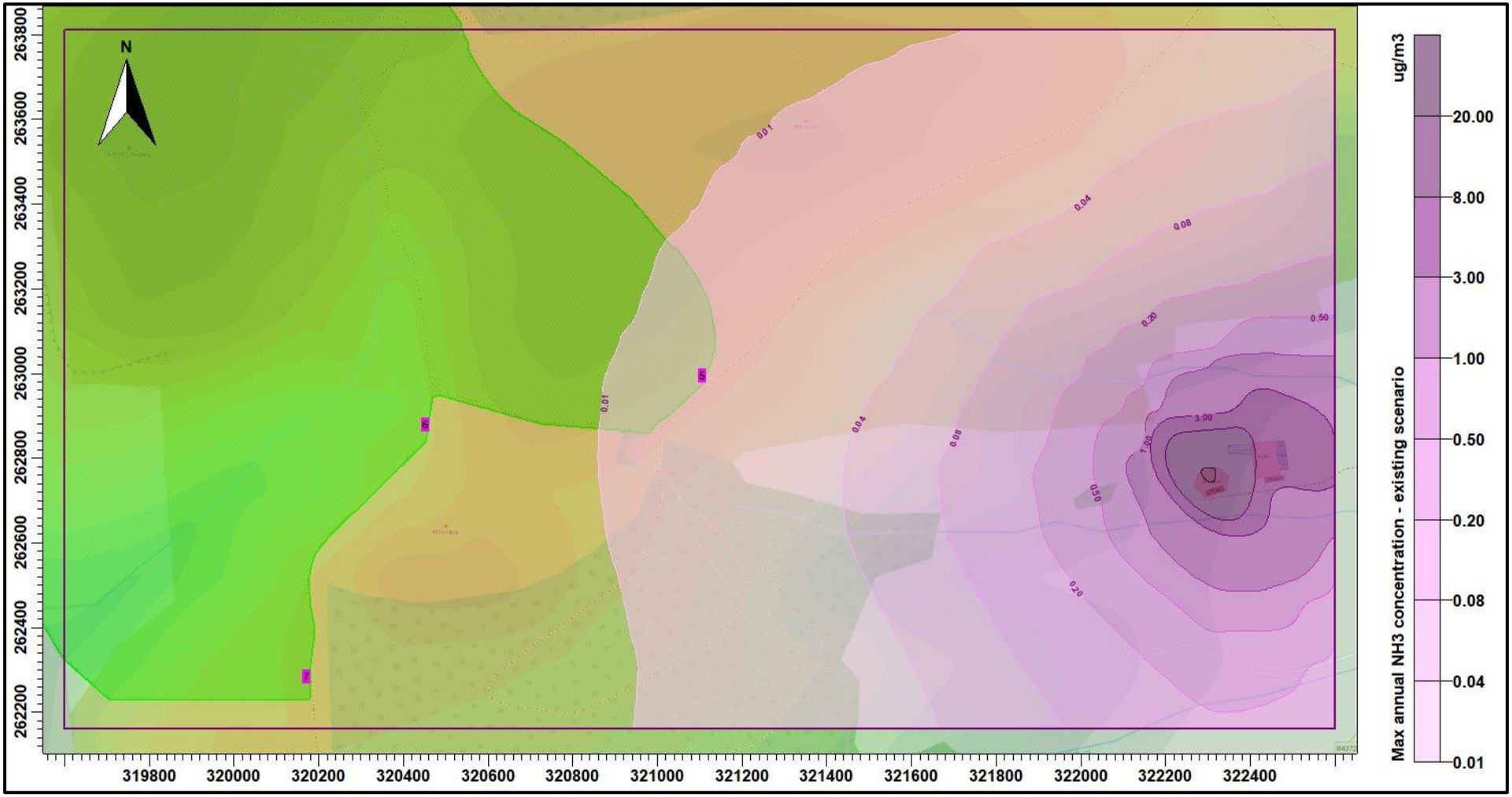


Figure 6b. Maximum annual ammonia concentration – proposed scenario

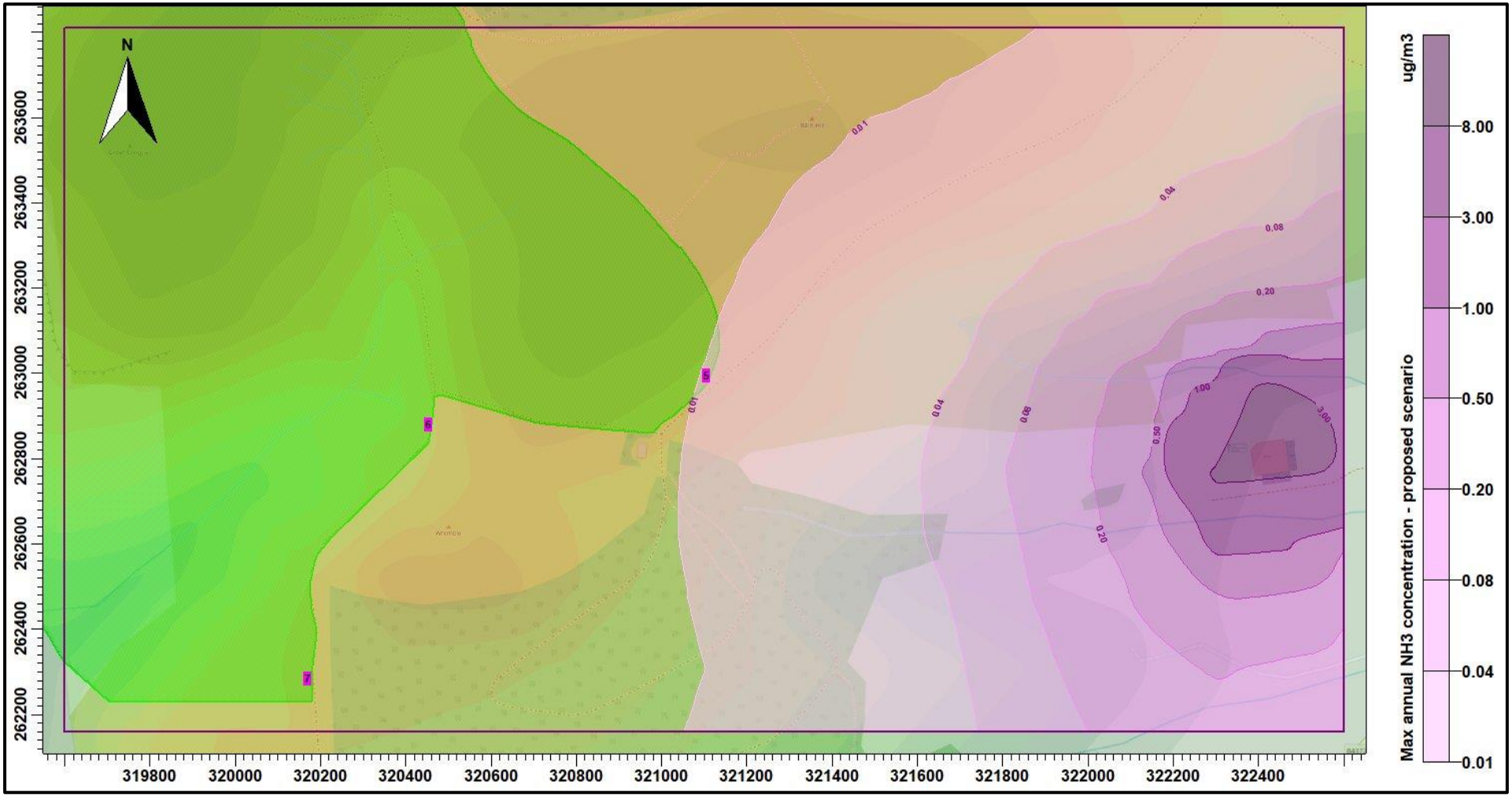


Figure 7a. Maximum annual nitrogen deposition rate – existing scenario

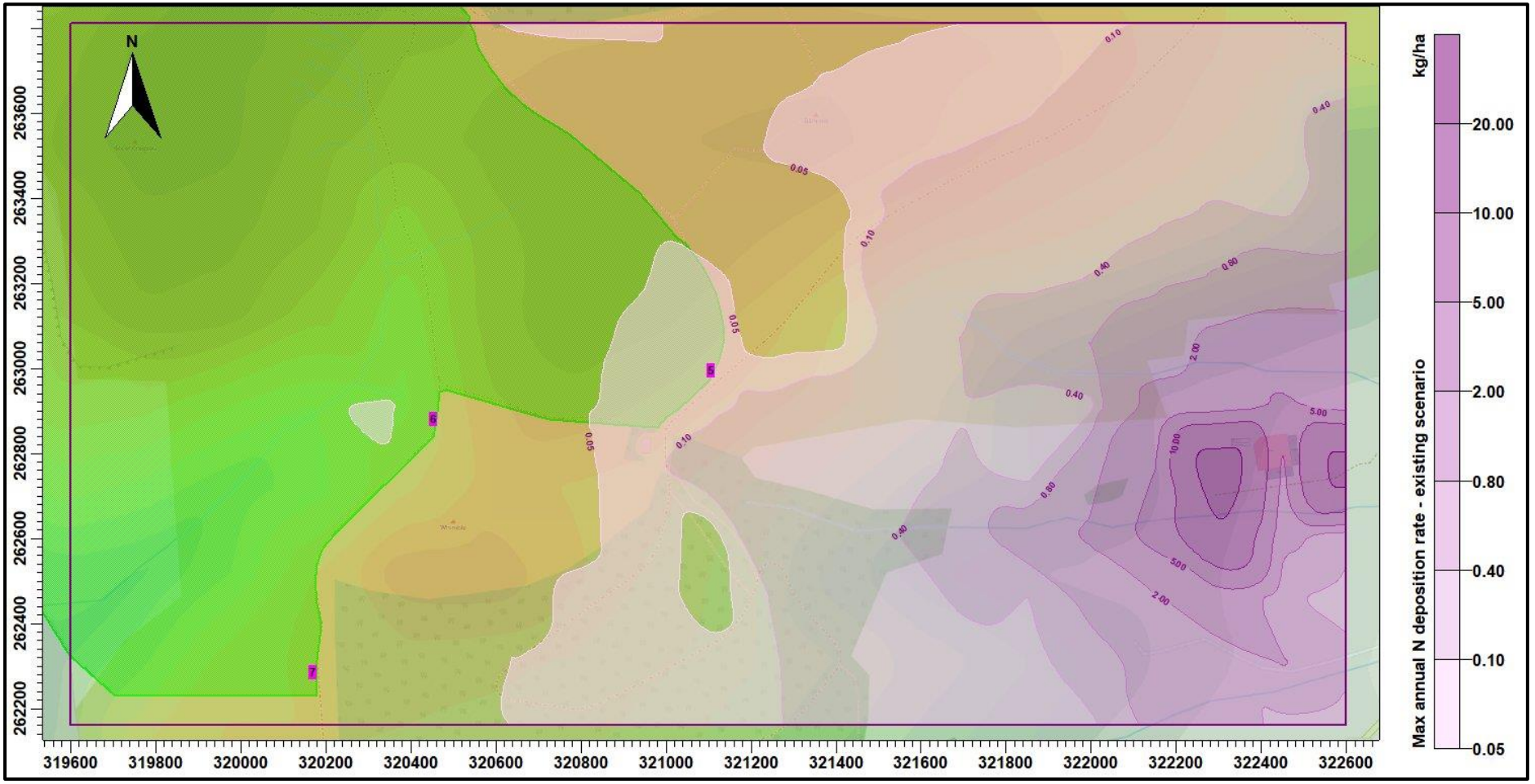
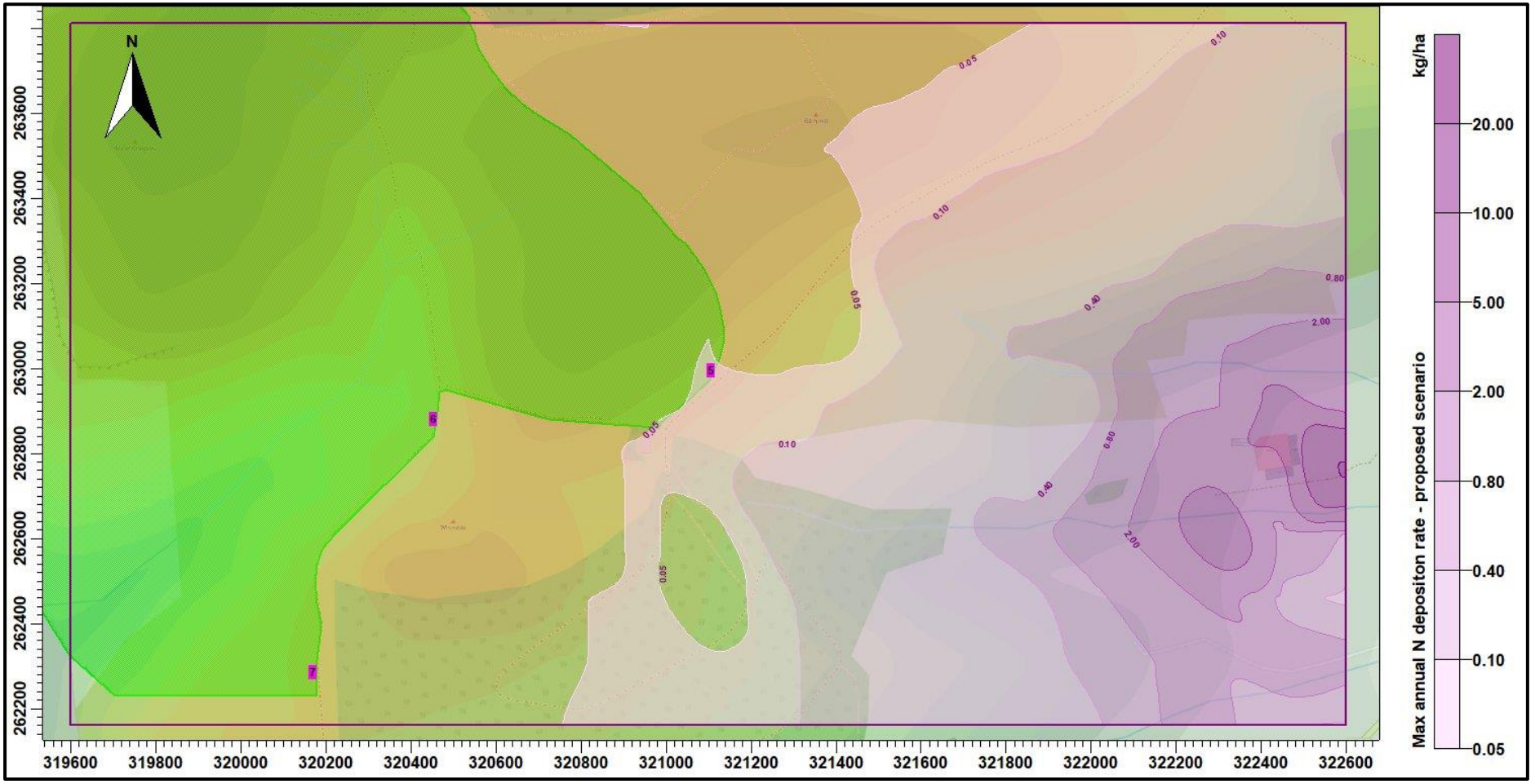


Figure 7b. Maximum annual nitrogen deposition rate – proposed scenario



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Geraillt Davies of Roger Parry & Partners LLP, on behalf of Owen and Christine Hardwick, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed free range egg laying chicken houses at Bache Farm, New Radnor, Powys. LD8 2TG.

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

Preliminary modelling

The preliminary modelling predicts that:

- Under the proposed scenario, the process contribution to annual mean ammonia concentrations at the closest parts of Radnor Forest SSSI would potentially exceed Natural Resources Wales lower threshold (1% for a SSSI) of the precautionary Critical Level of 1.0 µg-NH_3/m^3 by a small margin. However, the magnitude of the exceedance is significantly reduced compared to the existing scenario.

- At all other sites considered, the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below Natural Resources Wales lower threshold percentage of the Critical Level for the site (1% for a SSSI and 100% for non-statutory sites).

Detailed deposition modelling

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

- Under the proposed scenario, the process contribution to the annual mean ammonia concentration and nitrogen deposition rate at Radnor Forest SSSI are predicted to exceed the Natural Resources Wales upper threshold percentage (100%) of the Critical Level of 1.0 µg-NH_3/m^3 and the Critical Load of 5.0 kg/ha/y over approximately 0.33 ha of the eastern edge of the SSSI. However, the extent and magnitude of the exceedance is significantly reduced compared to the existing scenario, where the exceedance covers approximately 7.5 ha of the SSSI.

- At all other sites considered, the process contribution to the annual ammonia concentration and the nitrogen deposition rate would be below Natural Resources Wales lower threshold percentage of the Critical Level for the site (1% for a SSSI and 100% for non-statutory sites).

Mitigation

Where there is a predicted exceedance of the Natural Resources Wales lower threshold percentage of Critical Level or Critical Load at a SSSI, but the upper threshold in not exceeded, the proposal may or may not be deemed acceptable, depending on the presence, or not, of other installations that may have in-combination effects, background ammonia concentrations and the sensitivity of the wildlife sites involved and some form of mitigation may be required.

7. References

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