A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Broiler Rearing Houses at Coombe Farm, near Llanvair Discoed in Monmouthshire

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Steve Raasch, on behalf of Mr. Gareth Adams to use computer modelling to assess the impact of ammonia emissions from the existing and proposed broiler rearing houses at Coombe Farm, Llanvair Discoed, Chepstow, Monmouthshire. NP16 6LN.

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.

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

Coombe Farm is in an isolated rural area approximately 1.5 km to the north-east of the village of Llanvair Discoed in Monmouthshire. The surrounding land is used primarily for arable and livestock farming, although there are some semi-natural wooded areas. The site is at an altitude of around 105 m with the land rising towards hills and mountains to the north and falling towards the coastal plain of the River Severn Estuary to the south.

Currently, there are four poultry rearing houses at Coombe Farm. These poultry houses provide accommodation for up to 220,000 broiler chickens. The chickens are raised from day old chicks to up to around 42 days old and there are approximately 7 flocks per year. The poultry houses are ventilated primarily by high speed ridge mounted fans, each with a short chimney and there are also gable end fans to provide supplementary ventilation in hot weather conditions.

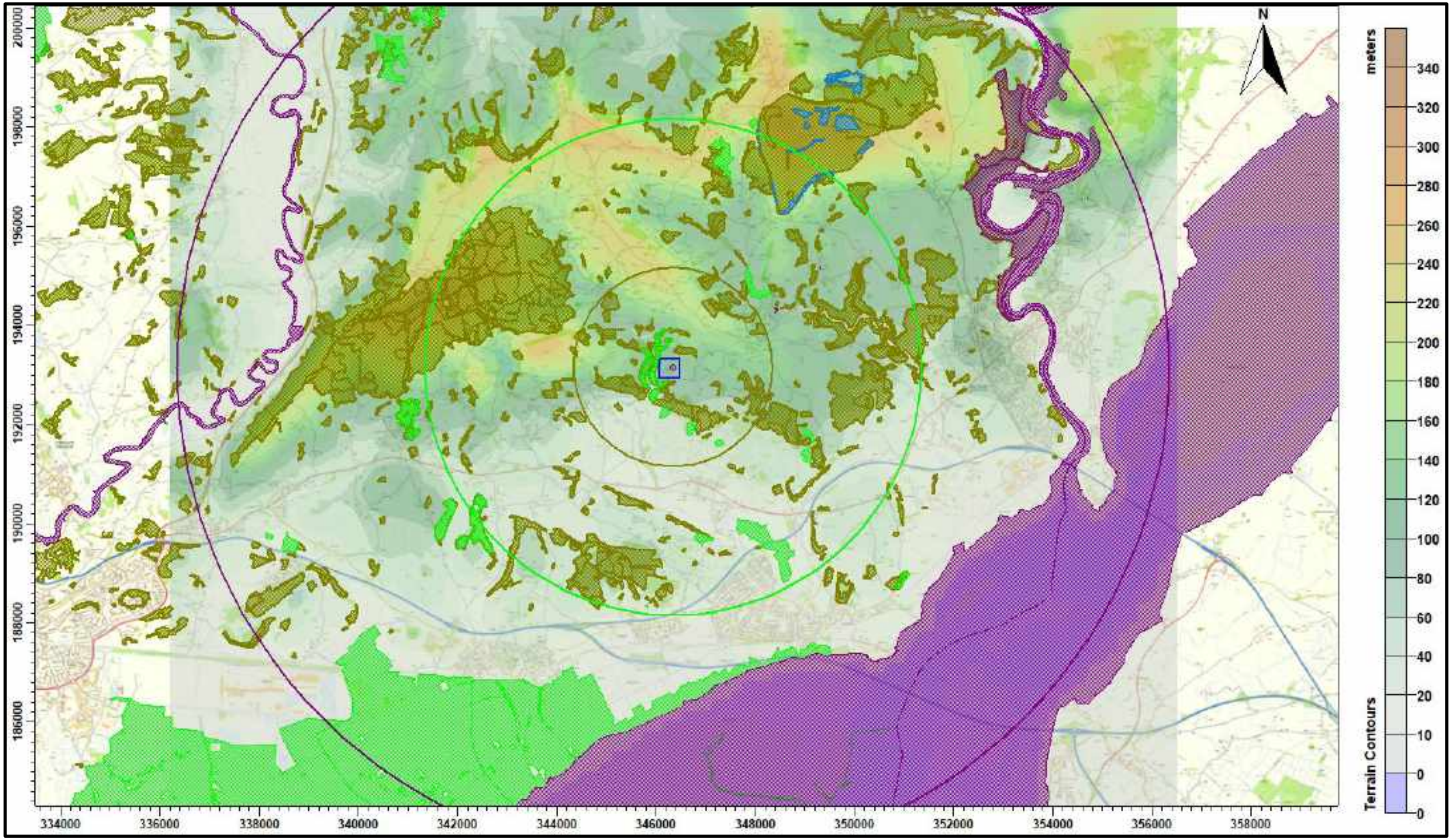
Under the proposals, two additional poultry houses would be constructed to the south-east of the existing poultry houses at Coombe Farm. These new poultry houses would be ventilated by high speed ridge fans, each with a short chimney and there would also be gable end fans providing supplementary ventilation in periods of hot weather. In addition, heat exchanger units would be installed to provide indirect heating to the existing and proposed poultry houses. Under the proposals, the poultry houses at Coombe Farm would provide accommodation for up to 300,000 broiler chickens.

There are a number of areas that are designated as Local Wildlife Sites (LWSs) or Ancient Woodlands (AWs) within 2 km of Coombe Farm, some of the AWs are defined as sensitive to ammonia concentrations and nitrogen deposition by Natural Resources Wales (ammonia sensitive AWs). There are also a number of areas that are designated as Sites of Special Scientific Interest (SSSIs) within 5 km of the farm, the closest of which is Coombe Valley Woodlands SSSI, which is approximately 200 m from the poultry houses at Coombe Farm. Beyond these there are Special Areas of Conservation (SACs) and Ramsar sites within 10 km of the farm. Further details of the closest SSSIs are provided below:

- Coombe Valley Woodlands SSSI. A complex of calcareous woodlands located in a narrow steep sided valley.
- Dinham Meadows SSSI. Five areas of unimproved grassland managed as hay meadows and pasture, notable for a diverse range of grass and herb flora and associated invertebrates.
- Llwyn Y Celyn Wetland SSSI. An area of spring mire and swamp plant communities with unusual species rich mire vegetation.
- Nedernbrook Wetlands, Caldicot SSSI. Improved grassland, unimproved pasture, woodland and scrub associated with a low lying wet meadowland on either side of the Nedern Brook.
- Brockwells Meadows SSSI. Species rich ancient pasture on lime rich soils, including a number of herbaceous plant species of limited distribution and invertebrate fauna.
- Penhow Woodlands SSSI. Two areas of ancient woodland located on the steep slopes or summit of limestone hills with calcareous soils.
- Plantation Farm and The Gethley SSSI. Species rich neutral grassland.

A map of the surrounding area showing the position of the poultry houses at Coombe Farm, the LWSs, the AWs, the SSSIs, the SACs and the Ramsar sites is provided in Figure 1. In the figure, the AWs and LWSs are shaded in olive, the ammonia sensitive AWs are shaded blue, the SSSIs are shaded in green, the SACs/Ramsar sites are shaded purple and the location of Coombe Farm is outlined in blue.

Figure 1. The area surrounding Coombe Farm – with concentric circle radii at 2.0 km (olive), 5.0 km (green) and 10.0 km (purple)



3. Ammonia, Background Levels, Critical Levels & Loads & Emission Rates

3.1 Ammonia concentration and nitrogen and acid deposition

When assessing potential impact on ecological receptors, ammonia concentration is usually expressed in terms of micrograms of ammonia per metre cubed of air (µg-NH_3/m^3) as an annual mean. Ammonia in the air may exert direct effects on the vegetation, or indirectly affect the ecosystem through deposition which causes both hyper-eutrophication (excess nitrogen enrichment) and acidification of soils. Nitrogen deposition, specifically in this case the nitrogen load due to ammonia deposition/absorption, is usually expressed in kilograms of nitrogen per hectare per year (kg-N/ha/y). Acid deposition is expressed in terms of kilograms equivalent (of H^+ ions) per hectare per year (keq/ha/y).

3.2 Background ammonia levels and nitrogen and acid deposition

The background ammonia concentration (annual mean) in the area around Coombe Farm is 1.64 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 26.74 kg-N/ha/y and to short vegetation is 16.24 kg-N/ha/y. The background acid deposition rate to woodland is 1.98 keq/ha/y and to short vegetation is 1.22 keq/ha/y. The source of these background figures is the Air Pollution Information System (APIS, April 2021).

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. 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)
Combe Valley Woodlands SSSI	3.0 [1]	10 [2]	1.781 [3]
AWs and LWSs	1.0 [4]	10 [2]	1.781 [3]
Other SSSI and SACs designated for flora	1.0 [4]	-	-

1. Based upon the citation for the site and information from Natural Resources Wales (Website).
2. The lower bound of the range of Critical Loads for broad-leaved woodlands obtained from APIS. (N.B. as the soils in the area are calcareous, a higher Critical Load may be more appropriate).
3. Obtained from APIS. (N.B. as the soils in the area are calcareous, a higher Critical Load may be more appropriate).
4. A precautionary figure, used where details of the site are unavailable, or citations indicate that sensitive lichens and bryophytes may be present.

3.4 Guidance on the significance of ammonia emissions

In June 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.

The latter Natural Resources Wales document OGN 020 contains essentially the same thresholds.

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

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

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

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

3.5 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.

For poultry housing, the Environment Agency provides an Intensive farming guidance note which lists standard ammonia emission factors for a variety of livestock, including broiler chickens. The emission factor for broiler chickens is 0.034 kg-NH_3/bird place/y; this figure is used to calculate the emissions from the poultry houses in the existing scenario. Under the proposals, the existing and new poultry houses would be fitted with heat exchanger units. The use of heat exchangers has been shown to reduce ammonia emissions and regulators have previously accepted a reduction of 35% from the standard emission factor for broiler chickens; however, this is usually accompanied by monitoring conditions. The following points should be noted:

- It is thought that heat exchangers are effective where they lead to a reduction in moisture in the housing by replacing direct heating, leading to a reduction in the moisture content of litter and consequently a reduction in microbial activity and ammonia production.
- The monitoring trials from which the 35% reduction was obtained were conducted on older style broiler housing with direct heating and that in modern housing where other indirect heating systems are already installed, there is probably very little scope for further reductions in moisture levels in the housing due to the use of heat exchangers.

Details of the animal numbers and types and emission factors used and calculated ammonia emission rates are provided in Table 2, for the existing and proposed poultry housing at Coombe Farm.

Table 2. Details of poultry numbers and ammonia emission rate

Source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Existing scenario	220,000	Broiler Chickens	0.034 (EA standard emission factor)	0.323218
Proposed scenario	300,000	Broiler Chickens	0.0221 (EA standard emission factor mitigated by heat exchangers)	0.215479

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 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).

The GFS is a spectral model: the physics/dynamics model has an equivalent resolution of approximately 13 km (latterly 9km); terrain is understood to be resolved at a resolution of approximately 2 km, with sub-13/9 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[1]). 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 raw GFS wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, wind speeds and directions will be further modified. The raw GFS wind rose is shown in Figure 2a and the terrain and roughness length modified wind rose for the location of the poultry houses at Coombe Farm is shown in Figure 2b. Note that elsewhere in the modelling domain, the modified wind roses may differ more markedly and that the resolution of the wind field in terrain runs is approximately 300 m. 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[2].

1. Note that FLOWSAR 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).
2. 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 point sources emissions, may cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013). 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. GFS derived data for 51.643 N, 2.775 W, 2017-2020

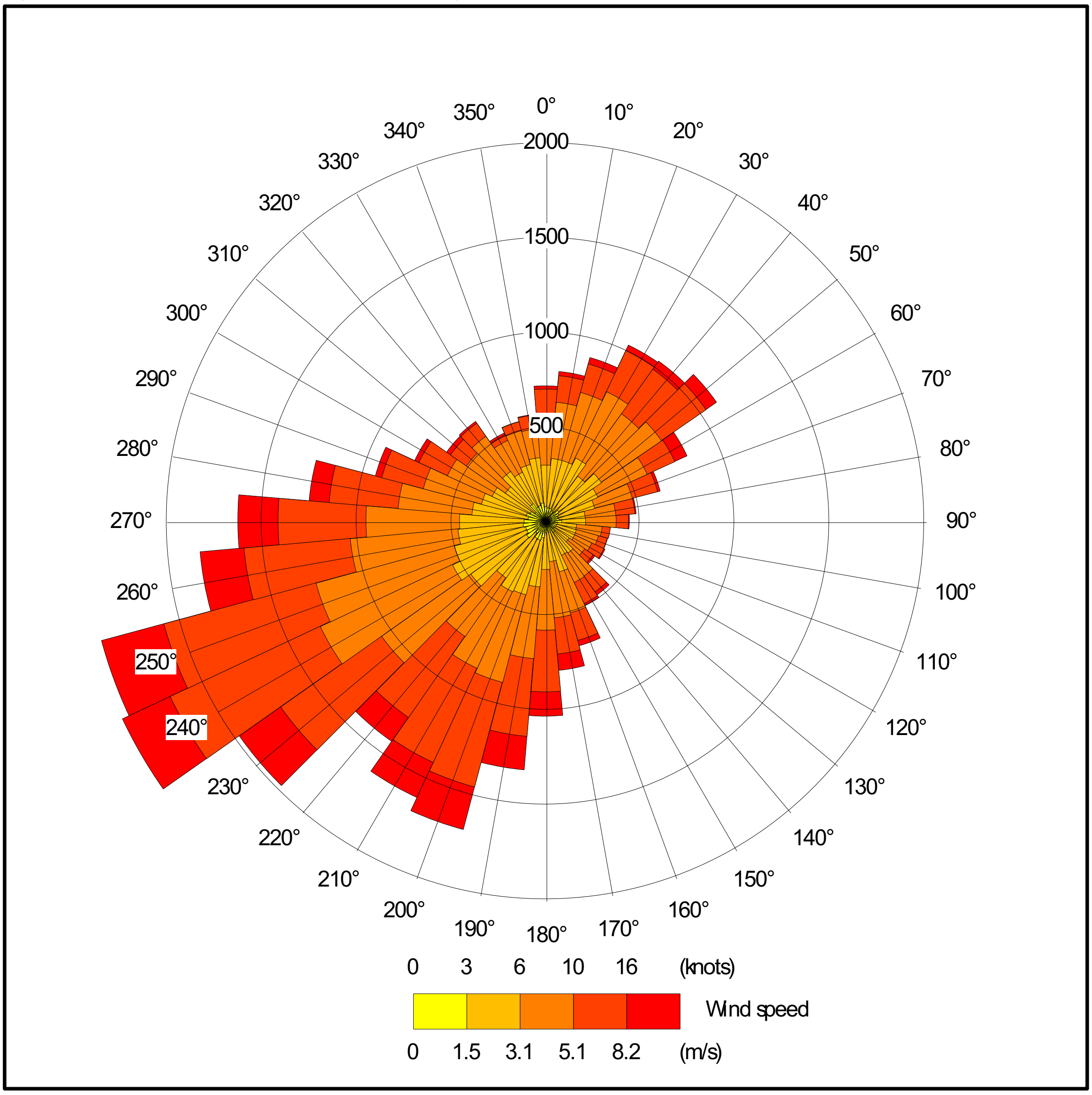
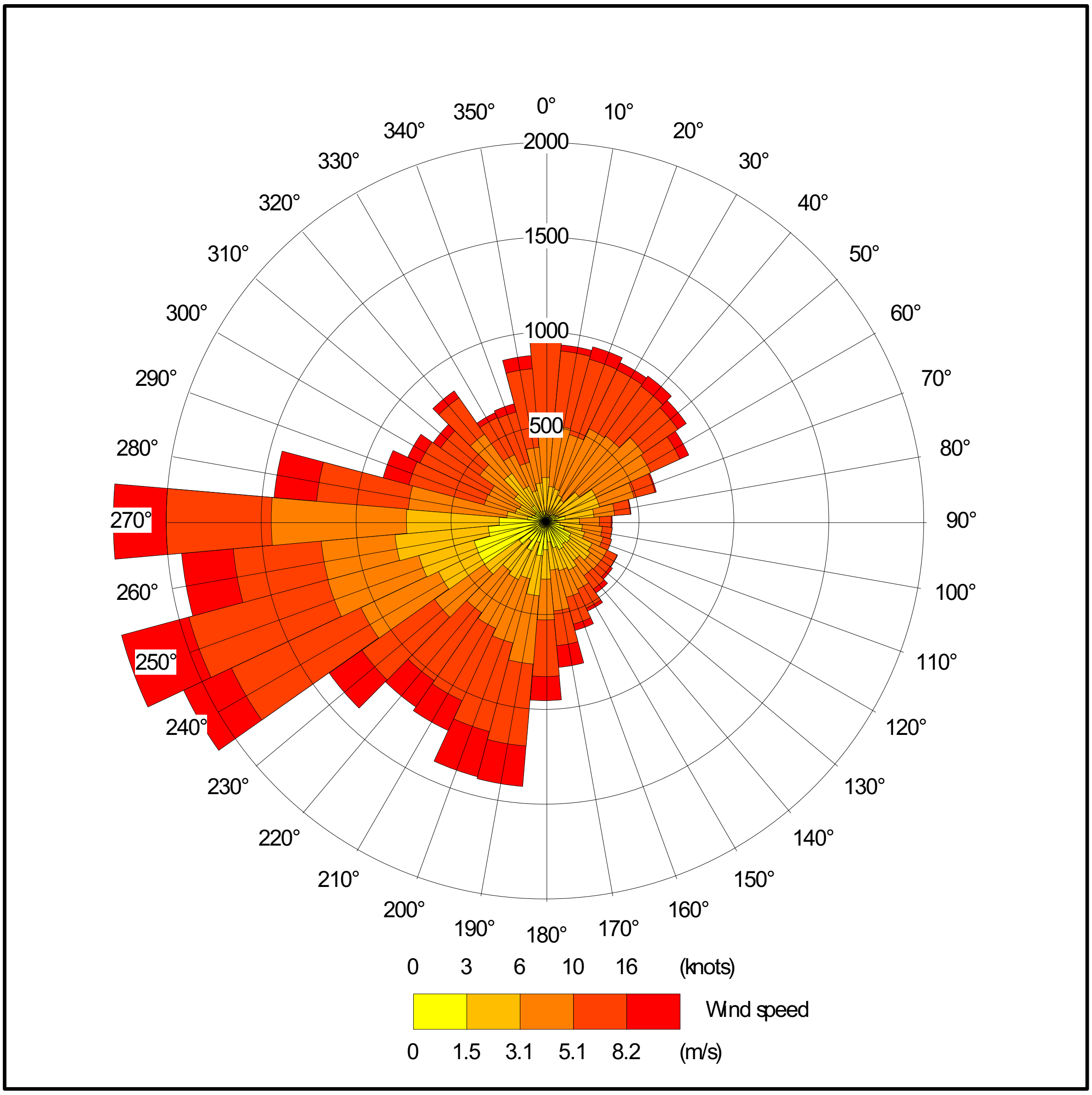


Figure 2b. The wind rose. FLOWSTAR derived data for NGR 346350, 193150, 2017-2020



4.2 Emission sources

Emissions from the uncapped chimneys of the high speed ridge fans that are, or would be, used as primary ventilation for the existing and proposed poultry houses, have been represented by point sources within ADMS (PR1 to PR6, 1, 2 and 3). Emissions from the gable end fans that are, or would be, used to provide additional ventilation during periods of hot weather have been represented by volume sources within ADMS (PR1_gab to PR6_gab).

Under the proposals, heat exchanger units would be installed, serving all six of the existing and proposed poultry houses at Coombe Farm. Emissions from the chimneys of the heat exchangers have been represented by point sources within ADMS (HEX1 to HEX6). Note, for the proposed scenario, emissions from the heat exchanger units are assumed to account for 20% of the emissions and emissions from the high speed ridge fans are assumed to account for 80% of the emissions, both of which are reduced by half when the gable end fans are running, which are assumed to account for 50% of the total house emissions during periods of hot weather. Also note, the modelling has been performed based on 50,000 broiler chickens per shed.

Details of the source parameters are shown in Table 3a, for the volume sources and Table 3b, for the point sources. The positions of the sources may be seen in Figure 3.

Table 3a. Volume source parameters

Source ID	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate ($g\text{-}NH_3/s$)
PR1_gab to PR6_gab [1]	25.5	5.0	3.0	0.0	Ambient	0.026935 [2]

Table 3b. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (°C)	Emission rate per source ($g\text{-}NH_3/s$)
PR1 to PR6; 1, 2 & 3 [1]	6.8	0.8	11.3	22.0	0.017957 [3]
HEX1_s to HEX6_s	5.5	0.8	10.5	22.0	0.053870 [4]

1. PR1 to PR4 included in existing scenario; PR1 to PR6 included in proposed scenario.
2. 50% of the total house emissions based on 50,000 broiler chickens per house, operating only when ambient temperatures equal or exceed 21 C.
3. 100% of the house emissions assuming 50,000 broiler chickens in the houses. Reduced to 80% in the proposed scenario under normal operating conditions and to 40% when the ambient temperature equals or exceeds 21 C.
4. 100% of the house emissions assuming 50,000 broiler chickens in the houses. Reduced to 20% in the proposed scenario under normal operating conditions and to 10% when the ambient temperature equals or exceeds 21 C.

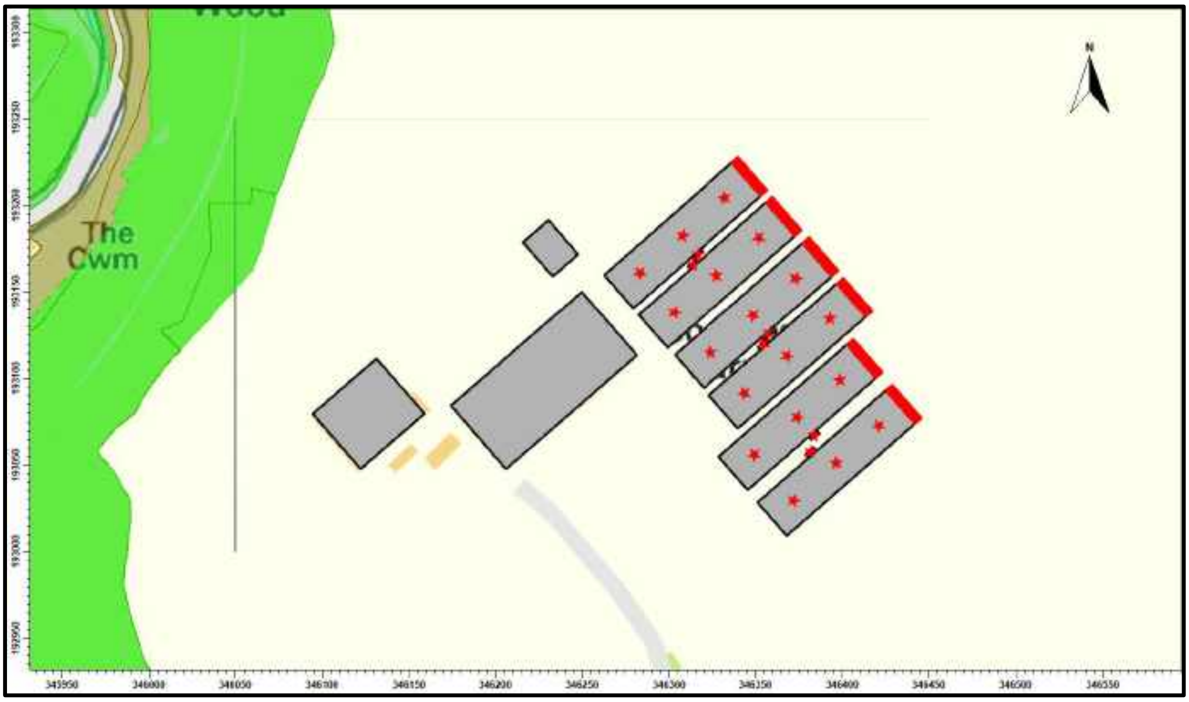
4.3 Modelled buildings

The structure of the proposed poultry houses and other nearby buildings 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, where they are marked by blue rectangles.

4.4 Discrete receptors

Seventy-three discrete receptors have been defined at the LWSs, the AWs, the SSSIs, the SACs and the Ramsar sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4a and Figure 4b, where they are marked by enumerated pink rectangles.

Figure 3. The positions of modelled sources and buildings



4.5 Cartesian grid

To produce the contour plots presented in Section 5 of this report, two regular Cartesian grids, one at a horizontal resolution of 500 m and one at a horizontal resolution of 50 m have been defined within ADMS. The individual grid receptors are defined at ground level within ADMS. The positions 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 by 20.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 64 by 64 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 300 m.

4.7 Roughness Length

A fixed surface roughness length of 0.35 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 0.325 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations.

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

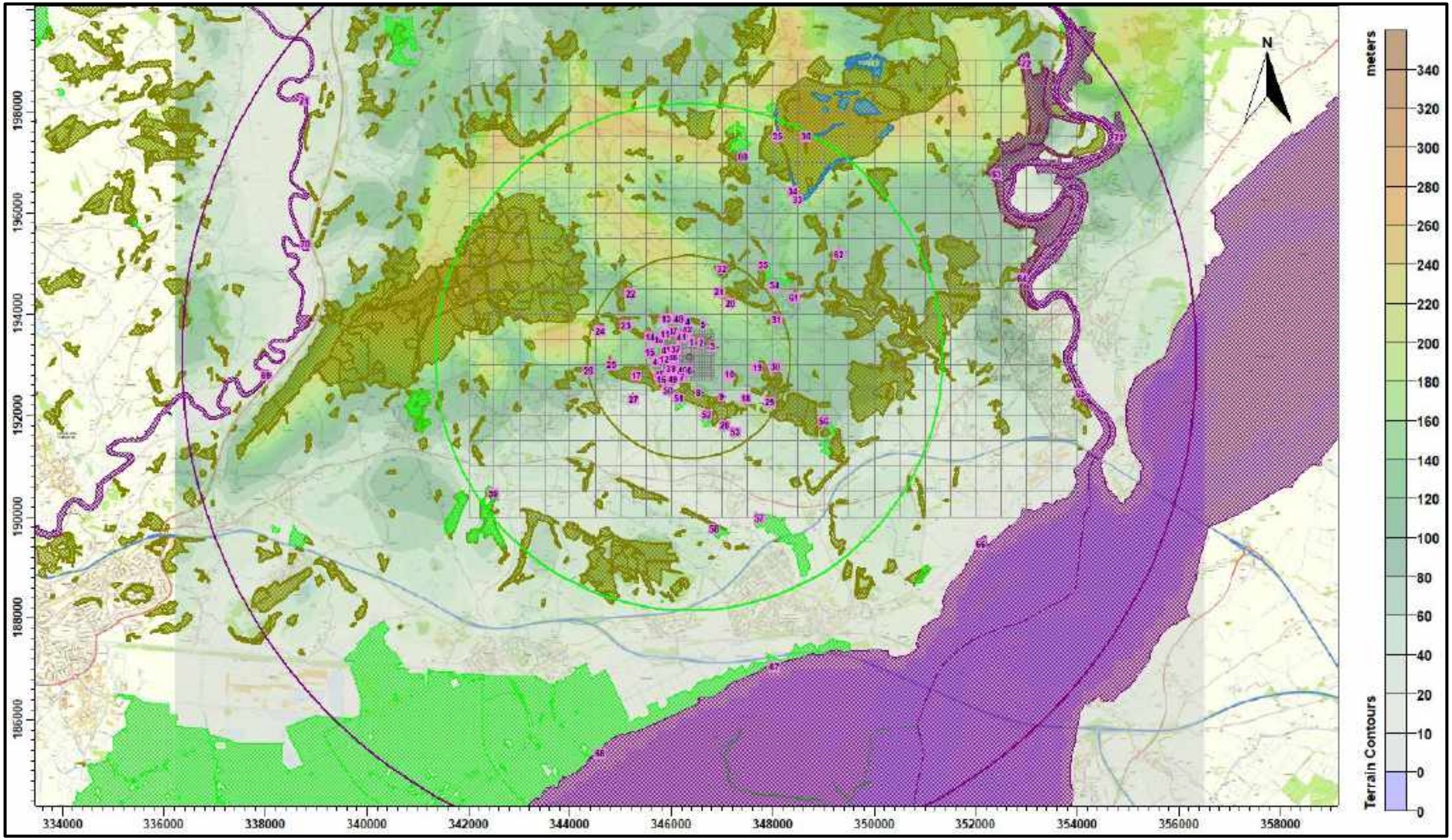
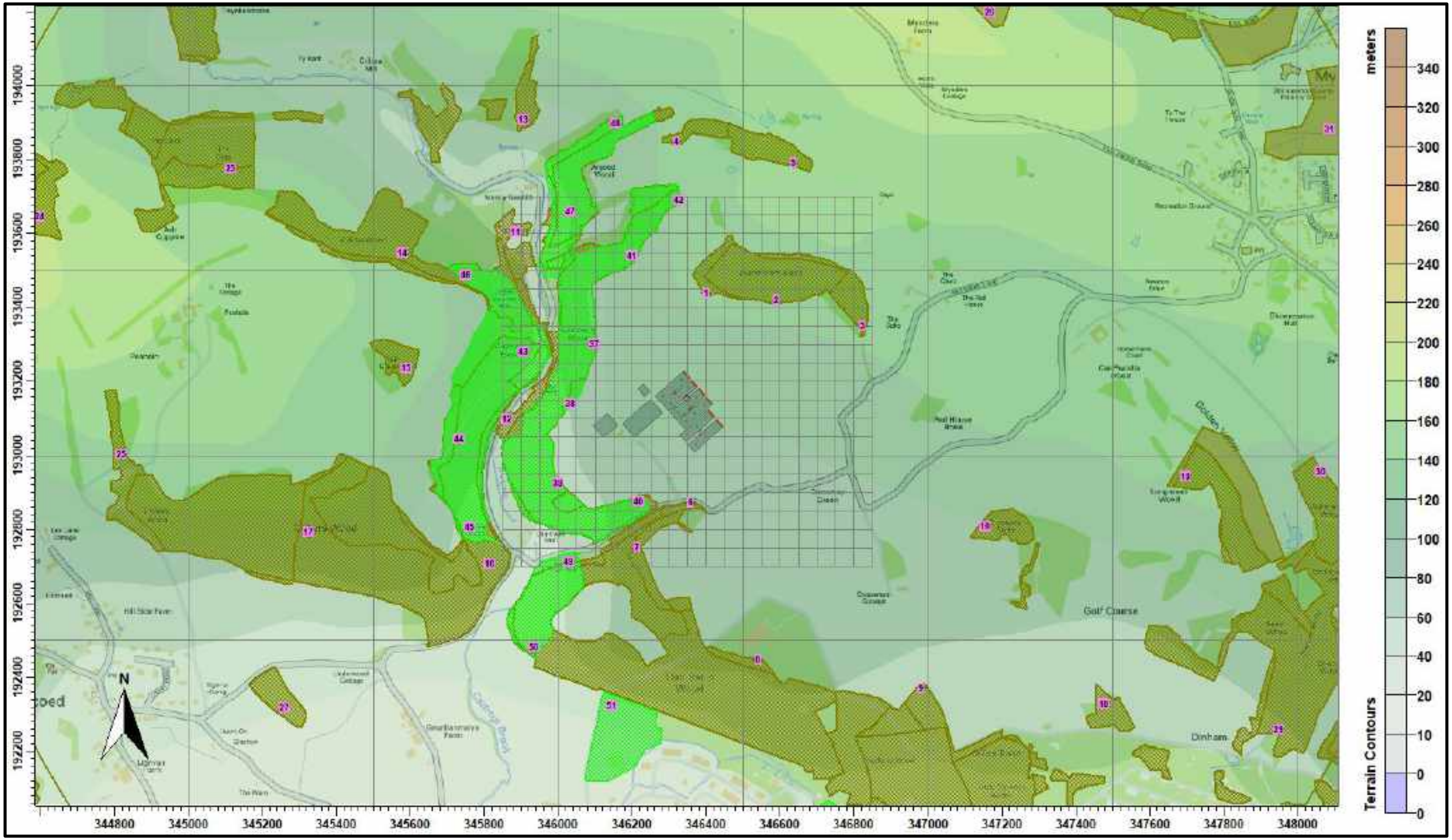


Figure 4b. The discrete receptors and Cartesian grids – a closer view



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 poultry housing and 0.010 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 is used to define a deposition velocity field. The deposition velocities used are provided in Table 4.

Table 4. Deposition velocities

NH_3 concentration (PC + background) (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 (0.010 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.

Contour plots of the spatially varying deposition fields are provided in Figure 5a and Figure 5b.

In this case, the model has also been run with a fixed deposition at 0.003 m/s and similarly to not modelling deposition at all, the predicted ammonia concentrations (and nitrogen and acid deposition rates) are always higher than if spatially varying deposition were modelled explicitly, particularly where there is some distance between the source and a receptor.

Figure 5a. The spatially varying deposition field – 500 m resolution domain

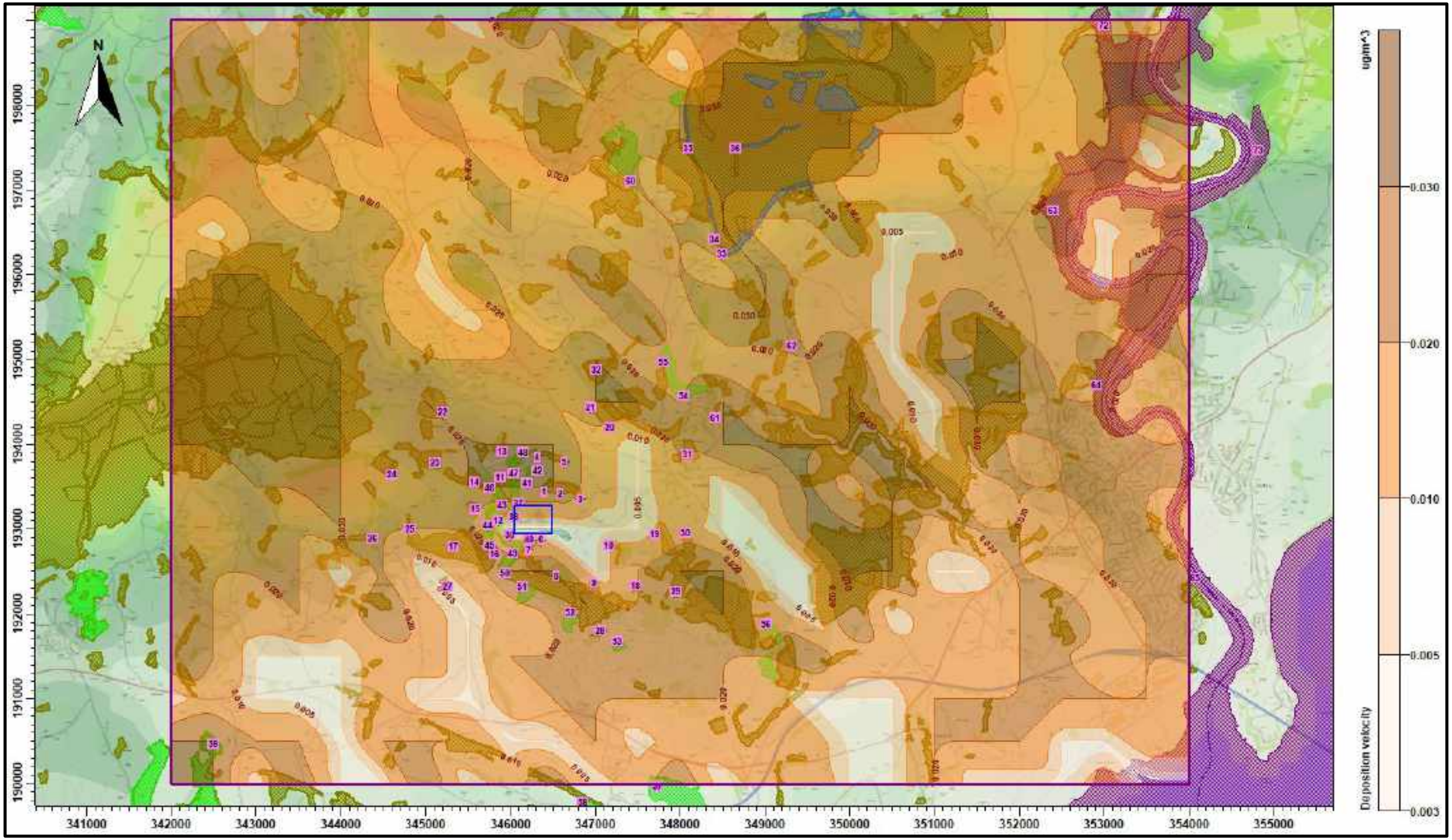
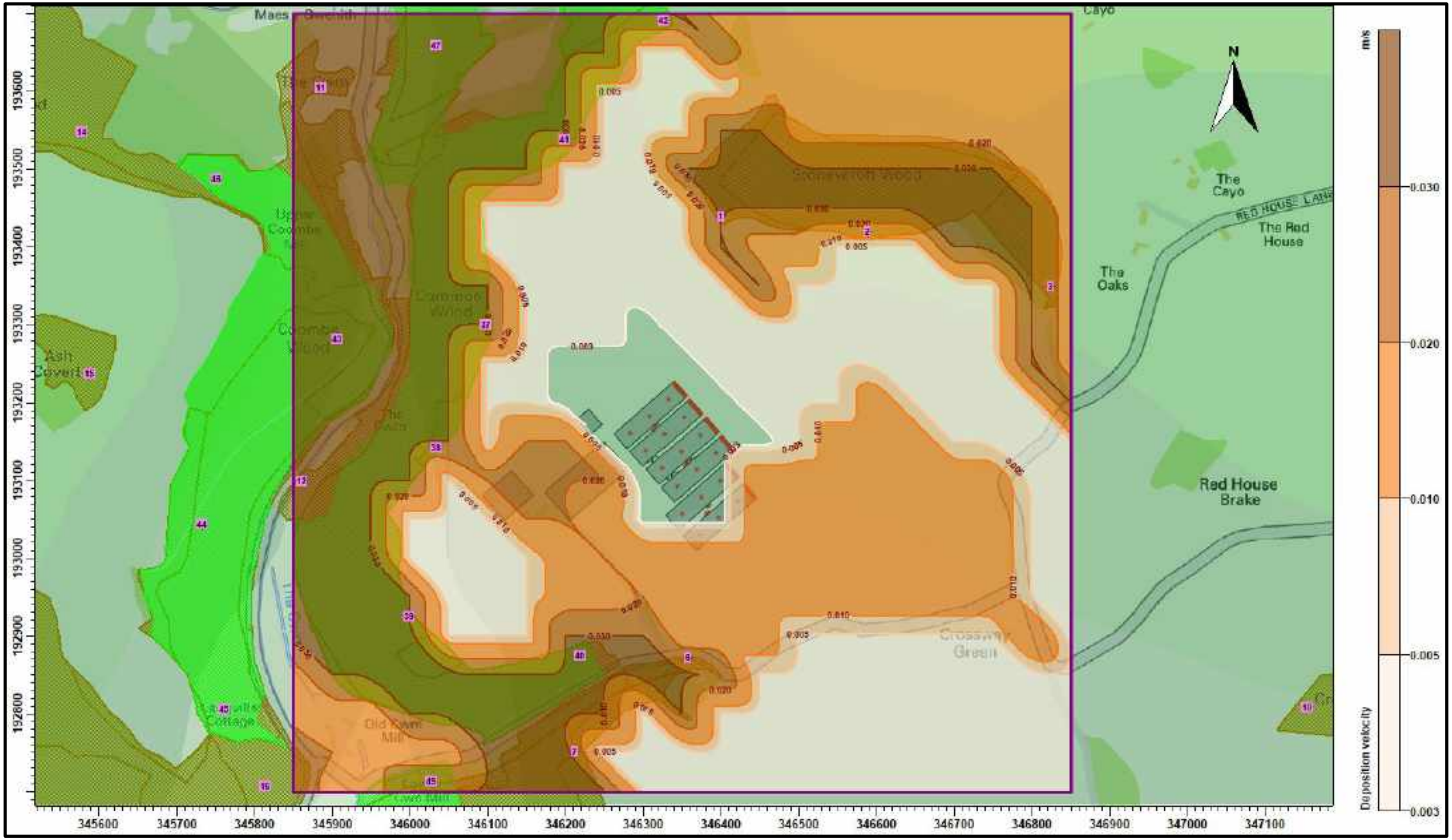


Figure 5b. The spatially varying deposition field – 50 m resolution domain



5. Details of the Model Runs and Results

5.1 Preliminary modelling

ADMS was run a total of thirty-two times; once for each year of the meteorological record, for the existing and proposed scenarios and in the following four modes:

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

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

Details of the predicted process contribution from the existing scenario and the proposed scenario to annual mean ammonia concentrations at each receptor are provided in Table 5. In the Table, predicted ammonia concentrations (or those equivalent to nitrogen deposition rates) that are in excess of the Natural Resources Wales upper percentage threshold of the relevant Critical Level or Critical Load (8% for an ammonia sensitive AW, SSSI, SACs or Ramsar and 100% for a non-statutory site) are coloured red. Predicted ammonia concentrations (or those equivalent to nitrogen deposition rates) that are in the range between the Natural Resources Wales upper percentage threshold and lower percentage threshold of the relevant Critical Level or Critical Load (1% to 8% for an ammonia sensitive AW, SSSI, SACs or Ramsar and 100% to 100% for a non-statutory site) are coloured blue. For convenience, cells referring to the LWSs or AWs are shaded olive, the ammonia sensitive AWs are shaded blue, the SSSIs are shaded green and the SAC/Ramsar sites are shaded lilac.

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

Receptor number	X(m)	Y(m)	Site	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 Depo	GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo
1	346400	193440	Unnamed AW/LWS	0.895	0.880	0.843	0.785	0.690	0.685	0.646	0.601
2	346589	193420	Unnamed AW/LWS	0.847	0.832	0.818	0.735	0.699	0.688	0.671	0.604
3	346824	193350	Unnamed AW/LWS	0.626	0.622	0.654	0.608	0.559	0.554	0.572	0.525
4	346319	193849	Unnamed AW/LWS	0.178	0.178	0.190	0.156	0.150	0.149	0.158	0.129
5	346635	193791	Unnamed AW/LWS	0.270	0.266	0.237	0.199	0.227	0.223	0.199	0.167
6	346358	192872	Unnamed AW/LWS	0.687	0.681	0.688	0.658	0.802	0.794	0.762	0.736
7	346213	192751	Unnamed AW/LWS	0.504	0.500	0.427	0.408	0.497	0.492	0.405	0.390
8	346540	192447	Unnamed AW/LWS	0.130	0.131	0.113	0.106	0.128	0.128	0.112	0.103
9	346982	192369	Unnamed AW/LWS	0.097	0.097	0.161	0.132	0.092	0.092	0.154	0.126
10	347154	192808	Unnamed AW/LWS	0.164	0.164	0.126	0.114	0.158	0.157	0.121	0.110
11	345885	193605	Unnamed AW/LWS	0.095	0.095	0.169	0.156	0.083	0.083	0.145	0.134
12	345862	193099	Unnamed AW/LWS	0.220	0.216	0.143	0.136	0.184	0.182	0.122	0.115
13	345906	193909	Unnamed AW/LWS	0.089	0.088	0.095	0.081	0.077	0.076	0.082	0.069
14	345578	193548	Unnamed AW/LWS	0.062	0.061	0.076	0.062	0.055	0.054	0.069	0.055
15	345588	193237	Unnamed AW/LWS	0.100	0.098	0.057	0.049	0.083	0.082	0.053	0.044
16	345814	192707	Unnamed AW/LWS	0.244	0.242	0.211	0.201	0.211	0.210	0.178	0.169
17	345325	192791	Unnamed AW/LWS	0.086	0.086	0.047	0.040	0.070	0.070	0.043	0.036
18	347475	192329	Unnamed AW/LWS	0.068	0.068	0.120	0.090	0.065	0.065	0.111	0.083
19	347698	192943	Unnamed AW/LWS	0.098	0.099	0.069	0.063	0.092	0.092	0.068	0.062
20	347166	194199	Unnamed AW/LWS	0.112	0.110	0.132	0.096	0.098	0.096	0.111	0.082
21	346946	194429	Unnamed AW/LWS	0.095	0.094	0.092	0.070	0.083	0.082	0.079	0.060
22	345199	194384	Unnamed AW/LWS	0.028	0.028	0.031	0.025	0.025	0.025	0.028	0.022
23	345116	193776	Unnamed AW/LWS	0.034	0.033	0.040	0.030	0.031	0.030	0.038	0.027
24	344599	193647	Unnamed AW/LWS	0.026	0.026	0.022	0.014	0.023	0.023	0.021	0.013

Receptor number	X(m)	Y(m)	Site	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 Depo	GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo
25	344819	193002	Unnamed AW/LWS	0.049	0.048	0.021	0.016	0.043	0.042	0.019	0.014
26	344379	192888	Unnamed AW/LWS	0.036	0.036	0.014	0.011	0.032	0.032	0.013	0.010
27	345260	192318	Unnamed AW/LWS	0.083	0.083	0.071	0.065	0.073	0.073	0.061	0.056
28	347060	191794	Unnamed AW/LWS	0.054	0.055	0.055	0.048	0.050	0.050	0.051	0.045
29	347949	192257	Unnamed AW/LWS	0.053	0.053	0.070	0.052	0.050	0.050	0.064	0.047
30	348062	192956	Unnamed AW/LWS	0.073	0.073	0.049	0.044	0.067	0.067	0.048	0.043
31	348085	193883	Unnamed AW/LWS	0.083	0.082	0.120	0.093	0.075	0.074	0.106	0.083
32	347007	194878	Unnamed AW/LWS	0.064	0.062	0.067	0.049	0.056	0.055	0.057	0.042
33	348495	196240	Ammonia sensitive AW	**0.028**	**0.028**	**0.030**	**0.016**	**0.025**	**0.025**	**0.025**	**0.014**
34	348407	196413	Ammonia sensitive AW	**0.027**	**0.026**	**0.027**	**0.015**	**0.024**	**0.024**	**0.023**	**0.013**
35	348103	197492	Ammonia sensitive AW	**0.019**	**0.019**	**0.015**	0.009	**0.017**	**0.017**	**0.013**	0.008
36	348657	197485	Ammonia sensitive AW	**0.019**	**0.019**	**0.013**	0.007	**0.017**	**0.017**	**0.011**	0.006
37	346098	193300	Coombe Valley Woodlands SSSI	**0.318**	**0.314**	**0.399**	**0.380**	**0.262**	**0.259**	**0.336**	**0.314**
38	346034	193141	Coombe Valley Woodlands SSSI	**0.406**	**0.400**	**0.334**	**0.323**	**0.329**	**0.324**	**0.281**	**0.268**
39	345999	192925	Coombe Valley Woodlands SSSI	**0.525**	**0.520**	**0.409**	**0.395**	**0.410**	**0.407**	**0.319**	**0.308**
40	346218	192875	Coombe Valley Woodlands SSSI	**0.883**	**0.875**	**0.706**	**0.686**	**0.883**	**0.874**	**0.700**	**0.683**
41	346199	193539	Coombe Valley Woodlands SSSI	**0.320**	**0.318**	**0.388**	**0.358**	**0.265**	**0.264**	**0.315**	**0.293**
42	346326	193691	Coombe Valley Woodlands SSSI	**0.272**	**0.272**	**0.282**	**0.245**	**0.225**	**0.224**	**0.230**	**0.198**
43	345907	193281	Coombe Valley Woodlands SSSI	**0.177**	**0.175**	**0.181**	**0.170**	**0.147**	**0.146**	**0.157**	**0.144**
44	345732	193043	Coombe Valley Woodlands SSSI	**0.156**	**0.153**	**0.085**	**0.079**	**0.134**	**0.132**	**0.074**	**0.068**
45	345761	192805	Coombe Valley Woodlands SSSI	**0.232**	**0.230**	**0.163**	**0.154**	**0.189**	**0.188**	**0.130**	**0.123**
46	345751	193488	Coombe Valley Woodlands SSSI	**0.085**	**0.084**	**0.113**	**0.099**	**0.075**	**0.074**	**0.102**	**0.087**
47	346034	193659	Coombe Valley Woodlands SSSI	**0.150**	**0.149**	**0.209**	**0.189**	**0.128**	**0.128**	**0.175**	**0.159**
48	346155	193898	Coombe Valley Woodlands SSSI	**0.126**	**0.125**	**0.125**	**0.103**	**0.109**	**0.108**	**0.108**	**0.088**
49	346028	192712	Coombe Valley Woodlands SSSI	**0.374**	**0.366**	**0.290**	**0.281**	**0.342**	**0.334**	**0.275**	**0.266**

Receptor number	X(m)	Y(m)	Site	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 Depo	GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo
50	345936	192480	Coombe Valley Woodlands SSSI	0.201	0.196	0.168	0.160	0.189	0.185	0.158	0.150
51	346144	192324	Dinham Meadows SSSI	0.165	0.164	0.154	0.142	0.152	0.151	0.136	0.128
52	346702	192016	Dinham Meadows SSSI	0.067	0.067	0.060	0.054	0.063	0.063	0.057	0.051
53	347260	191673	Dinham Meadows SSSI	0.046	0.046	0.054	0.046	0.042	0.042	0.051	0.042
54	348039	194569	Llwyn Y Celyn Wetland SSSI	0.059	0.058	0.103	0.069	0.052	0.051	0.089	0.060
55	347803	194963	Llwyn Y Celyn Wetland SSSI	0.051	0.050	0.074	0.047	0.046	0.045	0.063	0.041
56	349010	191875	Dinham Meadows SSSI	0.030	0.030	0.033	0.023	0.028	0.028	0.030	0.021
57	347739	189961	Nedern Brook Wetlands, Caldicot SSSI	0.019	0.019	0.015	0.013	0.017	0.018	0.014	0.012
58	346854	189768	Brockwells Meadows SSSI	0.021	0.021	0.019	0.012	0.019	0.019	0.016	0.011
59	342494	190459	Penhow Woodlands SSSI	0.014	0.014	0.011	0.009	0.013	0.013	0.010	0.008
60	347417	197104	Plantation Farm And The Gethley SSSI	0.021	0.020	0.021	0.013	0.018	0.018	0.018	0.011
61	348419	194312	Mwyngloddfa Mynydd-Bach SSSI/Wye Forest And Forest of Dean Bat Sites SAC	0.057	0.057	0.099	0.071	0.051	0.051	0.089	0.063
62	349316	195162	Wye Valley Lesser Horseshoe Bat Sites SSSI/Wye Forest And Forest of Dean Bat Sites SAC	0.032	0.031	0.052	0.033	0.028	0.028	0.046	0.029
63	352402	196754	Pierce, Alcove And Piercefield Woods SSSI/Wye Valley Woodlands SAC	0.013	0.013	0.018	0.011	0.012	0.012	0.016	0.010
64	352910	194691	Pierce, Alcove And Piercefield Woods SSSI/Wye Valley Woodlands SAC	0.016	0.016	0.018	0.010	0.014	0.014	0.017	0.009
65	354076	192419	River Wye (Lower Wye) SSSI/River Wye SAC	0.011	0.011	0.007	0.005	0.010	0.010	0.007	0.005
66	352103	189460	Severn Estuary SSSI/Ramsar/SAC	0.009	0.009	0.011	0.007	0.008	0.008	0.010	0.006
67	348038	187038	Severn Estuary SSSI/Ramsar/SAC	0.009	0.009	0.005	0.004	0.008	0.008	0.004	0.003
68	344600	185334	Severn Estuary SSSI/Ramsar/SAC	0.008	0.008	0.005	0.004	0.007	0.007	0.004	0.003
69	338023	192778	River Usk(Lower Usk) SSSI/River Usk SAC	0.007	0.007	0.003	0.002	0.006	0.006	0.003	0.002

Receptor number	X(m)	Y(m)	Site	Maximum annual mean ammonia concentration (µg/m^3)							
				Existing				Proposed			
				GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo	GFS No Calms No terrain	GFS Calms No Terrain	GFS No Calms Terrain	GFS No Calms Terrain Fixed Depo
70	338800	195379	River Usk(Lower Usk) SSSI/River Usk SAC	0.005	0.005	0.002	0.001	0.005	0.005	0.001	0.001
71	338770	198189	River Usk(Lower Usk) SSSI/River Usk SAC	0.004	0.004	0.002	0.001	0.004	0.004	0.002	0.001
72	353000	198937	Blackcliff-Wyndcliff SSSI/Wye Valley Woodlands SAC	0.009	0.009	0.009	0.005	0.008	0.008	0.008	0.004
73	354824	197472	River Wye (Lower Wye) SSSI/River Wye SAC	0.009	0.009	**0.011**	0.006	0.008	0.008	0.010	0.006

5.2 Detailed deposition modelling

The detailed modelling, which includes ammonia deposition and consequent plume depletion, was carried out over a domain that includes the poultry houses at Coombe Farm and all of the discrete receptors included in the preliminary modelling. Where discrete receptors at ecological sites are located beyond the spatially varying deposition domains, a fixed deposition velocity of 0.003 m/s has been assumed.

Terrain effects may be significant at some receptors; therefore, the detailed deposition runs were made with terrain included. Calms cannot be used with terrain or spatially varying deposition and have not been included in the detailed modelling; in this case, the results of the preliminary modelling show that the effects of calms are negligible.

The results of the detailed deposition modelling of ammonia emissions from the existing and proposed poultry houses are shown in Table 6. In the Table, the predicted process contribution to maximum annual mean ground level ammonia concentrations and nitrogen deposition rates that are in excess of the Natural Resources Wales upper threshold percentage of the relevant Critical Level or Critical Load (8% for an ammonia sensitive AW, SSSI, SACs or Ramsar and 100% for a non-statutory site) are coloured red. Ammonia concentrations and nitrogen deposition rates that are in the range between the Natural Resources Wales lower and upper threshold percentages of the relevant Critical Level or Critical Load (1% to 8% for an ammonia sensitive AW, SSSI, SACs or Ramsar and 100% to 100% for a non-statutory site) are coloured blue. Note, the abbreviations PC, CLe and CLo in Table 6 refer to Process Contribution, Critical Level and Critical Load, respectively.

Contour plots for the domain where the spatially varying deposition rates have been applied, of the predicted process contribution of the existing and proposed poultry houses to ground level maximum annual mean ammonia concentration and the maximum nitrogen deposition rate are shown in Figure 6a and Figure 6b for the existing poultry houses and in Figure 7a and Figure 7b for the proposed poultry houses.

Table 6. Predicted process contribution to annual mean ammonia concentrations and nitrogen deposition rates at the discrete receptors

Receptor number	X(m)	Y(m)	Site	Maximum annual mean ammonia concentration (µg/m³)				Maximum annual mean nitrogen deposition rate (kg/ha)				Maximum annual mean acid deposition rate (keq/ha)			
				Existing		Proposed		Existing		Proposed		Existing		Proposed	
				PC (µg/m³)	%age of Cle	PC (µg/m³)	%age of Cle	PC (kg/ha)	%age of Clo	PC (kg/ha)	%age of Clo	PC (keq/ha)	%age of Clo	PC (keq/ha)	%age of Clo
1	346400	193440	Unnamed AW/LWS	0.699	23.3	0.537	17.9	5.445	54.4	4.182	41.8	0.389	21.8	0.299	16.8
2	346589	193420	Unnamed AW/LWS	0.697	23.2	0.568	18.9	5.427	54.3	4.428	44.3	0.388	21.8	0.316	17.8
3	346824	193350	Unnamed AW/LWS	0.509	17.0	0.443	14.8	3.968	39.7	3.454	34.5	0.283	15.9	0.247	13.9
4	346319	193849	Unnamed AW/LWS	0.121	4.0	0.100	3.3	0.945	9.4	0.782	7.8	0.067	3.8	0.056	3.1
5	346635	193791	Unnamed AW/LWS	0.162	5.4	0.137	4.6	1.263	12.6	1.067	10.7	0.090	5.1	0.076	4.3
6	346358	192872	Unnamed AW/LWS	0.559	18.6	0.634	21.1	4.357	43.6	4.938	49.4	0.311	17.5	0.353	19.8
7	346213	192751	Unnamed AW/LWS	0.341	11.4	0.333	11.1	2.659	26.6	2.596	26.0	0.190	10.7	0.185	10.4
8	346540	192447	Unnamed AW/LWS	0.084	2.8	0.081	2.7	0.652	6.5	0.634	6.3	0.047	2.6	0.045	2.5
9	346982	192369	Unnamed AW/LWS	0.122	4.1	0.115	3.8	0.949	9.5	0.897	9.0	0.068	3.8	0.064	3.6
10	347154	192808	Unnamed AW/LWS	0.110	3.7	0.106	3.5	0.859	8.6	0.830	8.3	0.061	3.4	0.059	3.3
11	345885	193605	Unnamed AW/LWS	0.118	3.9	0.101	3.4	0.922	9.2	0.790	7.9	0.066	3.7	0.056	3.2
12	345862	193099	Unnamed AW/LWS	0.112	3.7	0.095	3.2	0.869	8.7	0.742	7.4	0.062	3.5	0.053	3.0
13	345906	193909	Unnamed AW/LWS	0.058	1.9	0.051	1.7	0.456	4.6	0.395	3.9	0.033	1.8	0.028	1.6
14	345578	193548	Unnamed AW/LWS	0.048	1.6	0.042	1.4	0.372	3.7	0.328	3.3	0.027	1.5	0.023	1.3
15	345588	193237	Unnamed AW/LWS	0.041	1.4	0.037	1.2	0.321	3.2	0.288	2.9	0.023	1.3	0.021	1.2
16	345814	192707	Unnamed AW/LWS	0.168	5.6	0.143	4.8	1.313	13.1	1.113	11.1	0.094	5.3	0.079	4.5
17	345325	192791	Unnamed AW/LWS	0.032	1.1	0.029	1.0	0.250	2.5	0.224	2.2	0.018	1.0	0.016	0.9
18	347475	192329	Unnamed AW/LWS	0.071	2.4	0.065	2.2	0.553	5.5	0.510	5.1	0.039	2.2	0.036	2.0
19	347698	192943	Unnamed AW/LWS	0.061	2.0	0.059	2.0	0.473	4.7	0.463	4.6	0.034	1.9	0.033	1.9
20	347166	194199	Unnamed AW/LWS	0.080	2.7	0.068	2.3	0.621	6.2	0.530	5.3	0.044	2.5	0.038	2.1
21	346946	194429	Unnamed AW/LWS	0.054	1.8	0.046	1.5	0.417	4.2	0.359	3.6	0.030	1.7	0.026	1.4
22	345199	194384	Unnamed AW/LWS	0.017	0.6	0.015	0.5	0.132	1.3	0.117	1.2	0.009	0.5	0.008	0.5
23	345116	193776	Unnamed AW/LWS	0.022	0.7	0.020	0.7	0.171	1.7	0.154	1.5	0.012	0.7	0.011	0.6
24	344599	193647	Unnamed AW/LWS	0.010	0.3	0.010	0.3	0.080	0.8	0.075	0.7	0.006	0.3	0.005	0.3

Receptor number	X(m)	Y(m)	Site	Maximum annual mean ammonia concentration (µg/m³)				Maximum annual mean nitrogen deposition rate (kg/ha)				Maximum annual mean acid deposition rate (keq/ha)			
				Existing		Proposed		Existing		Proposed		Existing		Proposed	
				PC (µg/m³)	%age of Cle	PC (µg/m³)	%age of Cle	PC (kg/ha)	%age of Clo	PC (kg/ha)	%age of Clo	PC (keq/ha)	%age of Clo	PC (keq/ha)	%age of Clo
25	344819	193002	Unnamed AW/LWS	0.013	0.4	0.011	0.4	0.099	1.0	0.089	0.9	0.007	0.4	0.006	0.4
26	344379	192888	Unnamed AW/LWS	0.008	0.3	0.007	0.2	0.065	0.6	0.058	0.6	0.005	0.3	0.004	0.2
27	345260	192318	Unnamed AW/LWS	0.056	1.9	0.049	1.6	0.435	4.4	0.379	3.8	0.031	1.7	0.027	1.5
28	347060	191794	Unnamed AW/LWS	0.034	1.1	0.032	1.1	0.267	2.7	0.250	2.5	0.019	1.1	0.018	1.0
29	347949	192257	Unnamed AW/LWS	0.038	1.3	0.034	1.1	0.293	2.9	0.266	2.7	0.021	1.2	0.019	1.1
30	348062	192956	Unnamed AW/LWS	0.037	1.2	0.036	1.2	0.292	2.9	0.282	2.8	0.021	1.2	0.020	1.1
31	348085	193883	Unnamed AW/LWS	0.074	2.5	0.067	2.2	0.580	5.8	0.523	5.2	0.041	2.3	0.037	2.1
32	347007	194878	Unnamed AW/LWS	0.036	1.2	0.031	1.0	0.278	2.8	0.240	2.4	0.020	1.1	0.017	1.0
33	348495	196240	Ammonia sensitive AW	0.01133	1.1	0.0098	1.0	0.088	0.9	0.077	0.8	0.006	0.4	0.005	0.3
34	348407	196413	Ammonia sensitive AW	0.00996	1.0	0.009	0.9	0.078	0.8	0.068	0.7	0.006	0.3	0.005	0.3
35	348103	197492	Ammonia sensitive AW	0.006	0.6	0.005	0.5	0.044	0.4	0.039	0.4	0.003	0.2	0.003	0.2
36	348657	197485	Ammonia sensitive AW	0.005	0.5	0.004	0.4	0.036	0.4	0.031	0.3	0.003	0.1	0.002	0.1
37	346098	193300	Coombe Valley Woodlands SSSI	0.011	0.4	0.010	0.3	0.088	0.9	0.077	0.8	0.006	0.4	0.005	0.3
38	346034	193141	Coombe Valley Woodlands SSSI	0.010	0.3	0.009	0.3	0.078	0.8	0.068	0.7	0.006	0.3	0.005	0.3
39	345999	192925	Coombe Valley Woodlands SSSI	0.006	0.2	0.005	0.2	0.044	0.4	0.039	0.4	0.003	0.2	0.003	0.2
40	346218	192875	Coombe Valley Woodlands SSSI	0.005	0.2	0.004	0.1	0.036	0.4	0.031	0.3	0.003	0.1	0.002	0.1
41	346199	193539	Coombe Valley Woodlands SSSI	0.302	10.1	0.247	8.2	2.351	23.5	1.927	19.3	0.168	9.4	0.138	7.7
42	346326	193691	Coombe Valley Woodlands SSSI	0.204	6.8	0.167	5.6	1.590	15.9	1.303	13.0	0.114	6.4	0.093	5.2
43	345907	193281	Coombe Valley Woodlands SSSI	0.142	4.7	0.119	4.0	1.105	11.0	0.931	9.3	0.079	4.4	0.067	3.7
44	345732	193043	Coombe Valley Woodlands SSSI	0.691	23.0	0.688	22.9	5.387	53.9	5.362	53.6	0.385	21.6	0.383	21.5
45	345761	192805	Coombe Valley Woodlands SSSI	0.286	9.5	0.234	7.8	2.232	22.3	1.821	18.2	0.159	9.0	0.130	7.3
46	345751	193488	Coombe Valley Woodlands SSSI	0.194	6.5	0.160	5.3	1.515	15.1	1.243	12.4	0.108	6.1	0.089	5.0
47	346034	193659	Coombe Valley Woodlands SSSI	0.148	4.9	0.125	4.2	1.152	11.5	0.971	9.7	0.082	4.6	0.069	3.9
48	346155	193898	Coombe Valley Woodlands SSSI	0.068	2.3	0.059	2.0	0.528	5.3	0.460	4.6	0.038	2.1	0.033	1.8
49	346028	192712	Coombe Valley Woodlands SSSI	0.155	5.2	0.120	4.0	1.209	12.1	0.938	9.4	0.086	4.8	0.067	3.8
50	345936	192480	Coombe Valley Woodlands SSSI	0.077	2.6	0.067	2.2	0.599	6.0	0.521	5.2	0.043	2.4	0.037	2.1

Receptor number	X(m)	Y(m)	Site	Maximum annual mean ammonia concentration (µg/m³)				Maximum annual mean nitrogen deposition rate (kg/ha)				Maximum annual mean acid deposition rate (keq/ha)			
				Existing		Proposed		Existing		Proposed		Existing		Proposed	
				PC (µg/m³)	%age of Cle	PC (µg/m³)	%age of Cle	PC (kg/ha)	%age of Clo	PC (kg/ha)	%age of Clo	PC (keq/ha)	%age of Clo	PC (keq/ha)	%age of Clo
51	346144	192324	Dinham Meadows SSSI	0.143	**14.3**	0.120	**12.0**	-	-	-	-	-	-	-	-
52	346702	192016	Dinham Meadows SSSI	0.079	**7.9**	0.067	**6.7**	-	-	-	-	-	-	-	-
53	347260	191673	Dinham Meadows SSSI	0.244	**24.4**	0.233	**23.3**	-	-	-	-	-	-	-	-
54	348039	194569	Llwyn Y Celyn Wetland SSSI	0.130	**13.0**	0.123	**12.3**	-	-	-	-	-	-	-	-
55	347803	194963	Llwyn Y Celyn Wetland SSSI	0.113	**11.3**	0.102	**10.2**	-	-	-	-	-	-	-	-
56	349010	191875	Dinham Meadows SSSI	0.042	**4.2**	0.039	**3.9**	-	-	-	-	-	-	-	-
57	347739	189961	Nedern Brook Wetlands, Caldicot SSSI	0.034	**3.4**	0.031	**3.1**	-	-	-	-	-	-	-	-
58	346854	189768	Brookwells Meadows SSSI	0.053	**5.3**	0.046	**4.6**	-	-	-	-	-	-	-	-
59	342494	190459	Penhow Woodlands SSSI	0.036	**3.6**	0.031	**3.1**	-	-	-	-	-	-	-	-
60	347417	197104	Plantation Farm And The Gethley SSSI	0.016	**1.6**	0.014	**1.4**	-	-	-	-	-	-	-	-
61	348419	194312	Mwyngloddfa Mynydd-Bach SSSI/Wye Forest And Forest of Dean Bat Sites SAC	0.009	0.9	0.008	0.8	-	-	-	-	-	-	-	-
62	349316	195162	Wye Valley Lesser Horseshoe Bat Sites SSSI/Wye Forest And Forest of Dean Bat Sites SAC	0.010	1.0	0.009	0.9	-	-	-	-	-	-	-	-
63	352402	196754	Pierce, Alcove And Piercefield Woods SSSI/Wye Valley Woodlands SAC	0.006	0.6	0.006	0.6	-	-	-	-	-	-	-	-
64	352910	194691	Pierce, Alcove And Piercefield Woods SSSI/Wye Valley Woodlands SAC	0.008	0.8	0.007	0.7	-	-	-	-	-	-	-	-
65	354076	192419	River Wye (Lower Wye) SSSI/River Wye SAC	0.054	**5.4**	0.048	**4.8**	-	-	-	-	-	-	-	-
66	352103	189460	Severn Estuary SSSI/Ramsar/SAC	0.023	**2.3**	0.020	**2.0**	-	-	-	-	-	-	-	-
67	348038	187038	Severn Estuary SSSI/Ramsar/SAC	0.007	0.7	0.006	0.6	-	-	-	-	-	-	-	-
68	344600	185334	Severn Estuary SSSI/Ramsar/SAC	0.006	0.6	0.006	0.6	-	-	-	-	-	-	-	-

Receptor number	X(m)	Y(m)	Site	Maximum annual mean ammonia concentration (µg/m³)				Maximum annual mean nitrogen deposition rate (kg/ha)				Maximum annual mean acid deposition rate (keq/ha)			
				Existing		Proposed		Existing		Proposed		Existing		Proposed	
				PC (µg/m³)	%age of Cle	PC (µg/m³)	%age of Cle	PC (kg/ha)	%age of Clo	PC (kg/ha)	%age of Clo	PC (keq/ha)	%age of Clo	PC (keq/ha)	%age of Clo
69	338023	192778	River Usk(Lower Usk) SSSI/River Usk SAC	0.003	0.3	0.003	0.3	-	-	-	-	-	-	-	-
70	338800	195379	River Usk(Lower Usk) SSSI/River Usk SAC	0.005	0.5	0.004	0.4	-	-	-	-	-	-	-	-
71	338770	198189	River Usk(Lower Usk) SSSI/River Usk SAC	0.002	0.2	0.002	0.2	-	-	-	-	-	-	-	-
72	353000	198937	Blackcliff-Wyndcliff SSSI/Wye Valley Woodlands SAC	0.003	0.3	0.003	0.3	-	-	-	-	-	-	-	-
73	354824	197472	River Wye (Lower Wye) SSSI/River Wye SAC	0.001	0.1	0.001	0.1	-	-	-	-	-	-	-	-

Figure 6a. Process contribution to maximum annual mean ammonia concentrations – existing poultry houses

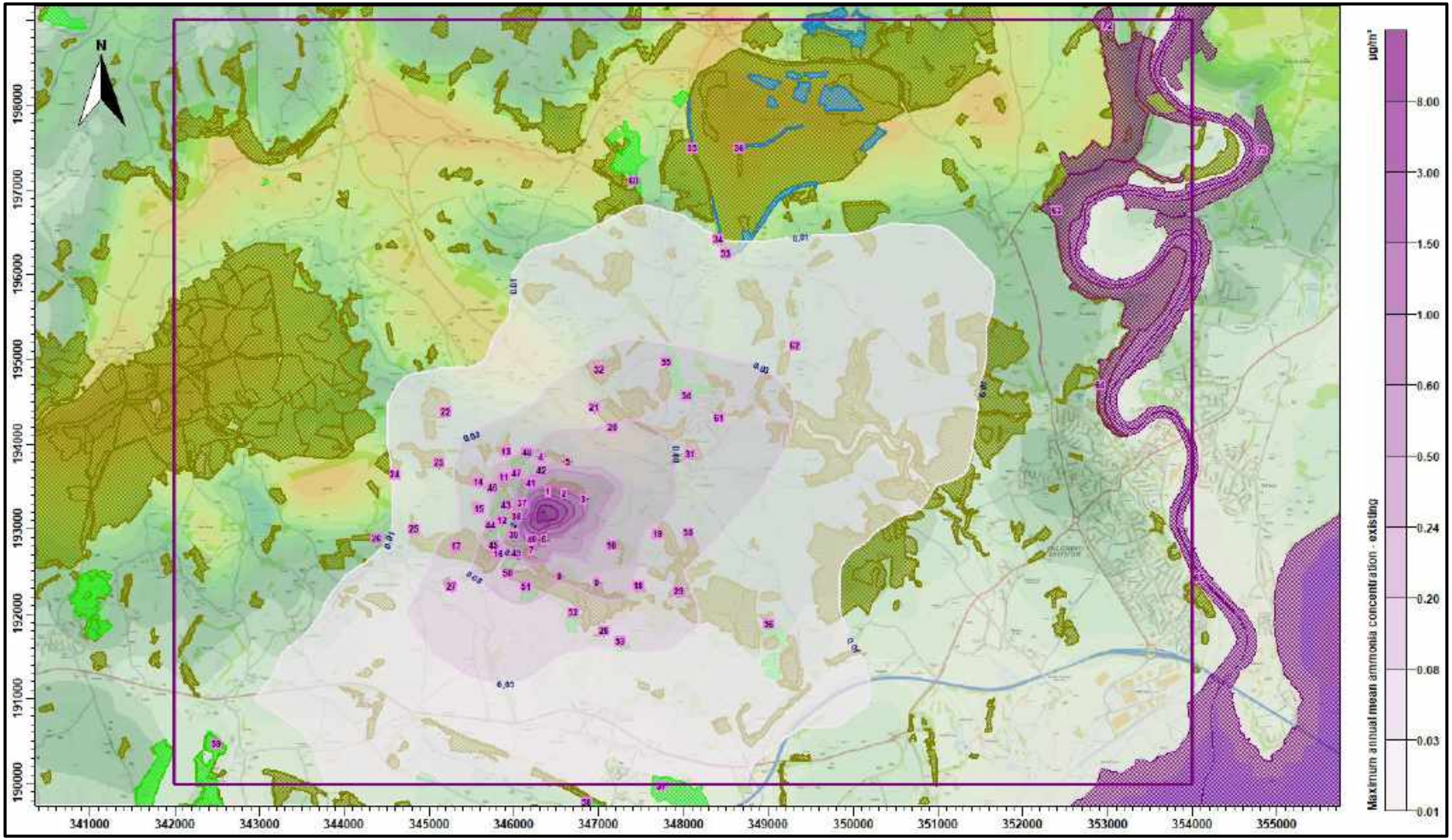


Figure 6b. Process contribution to maximum annual mean nitrogen deposition rate – existing poultry houses

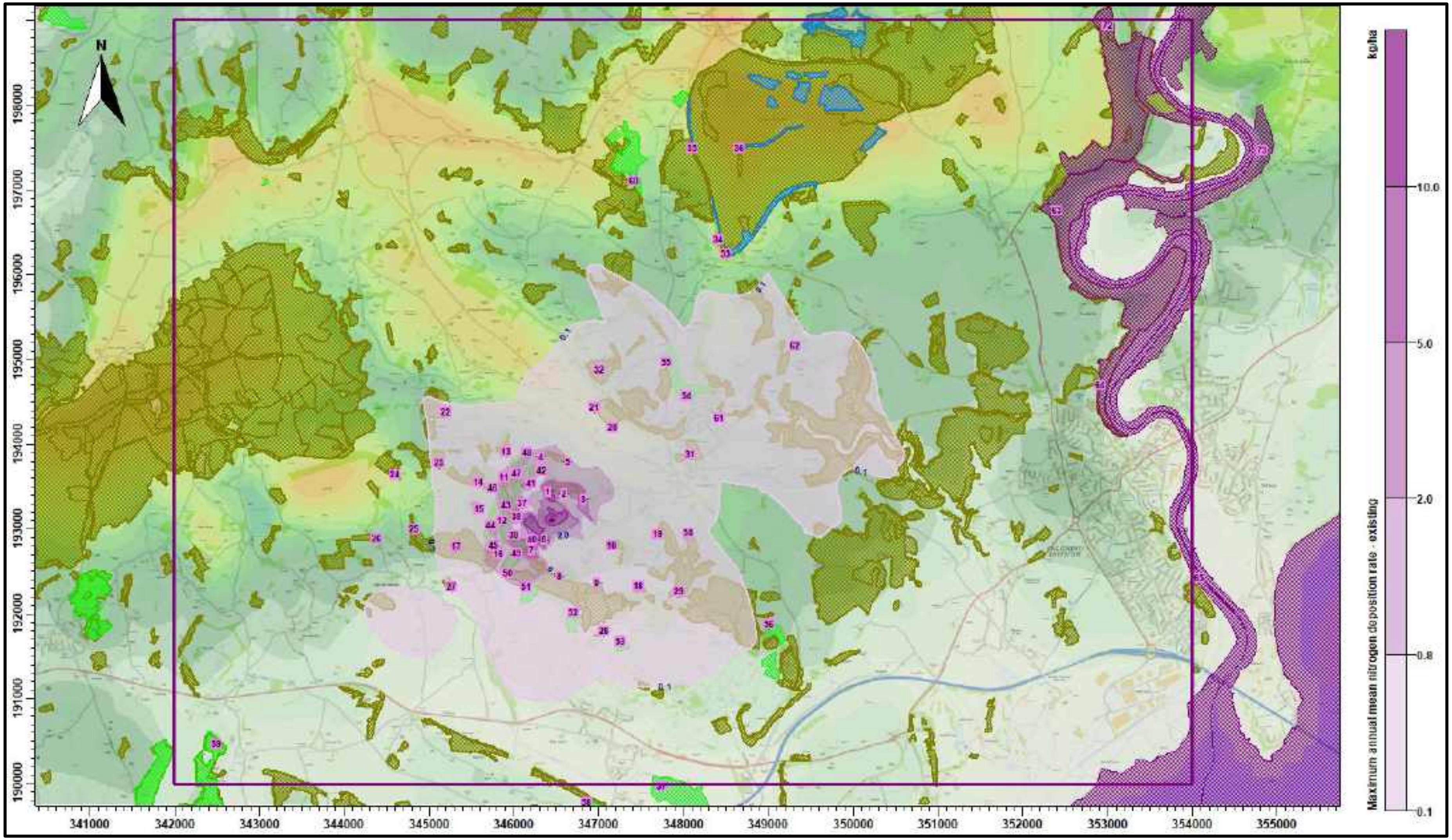


Figure 7a. Process contribution to maximum annual mean ammonia concentrations – proposed poultry houses

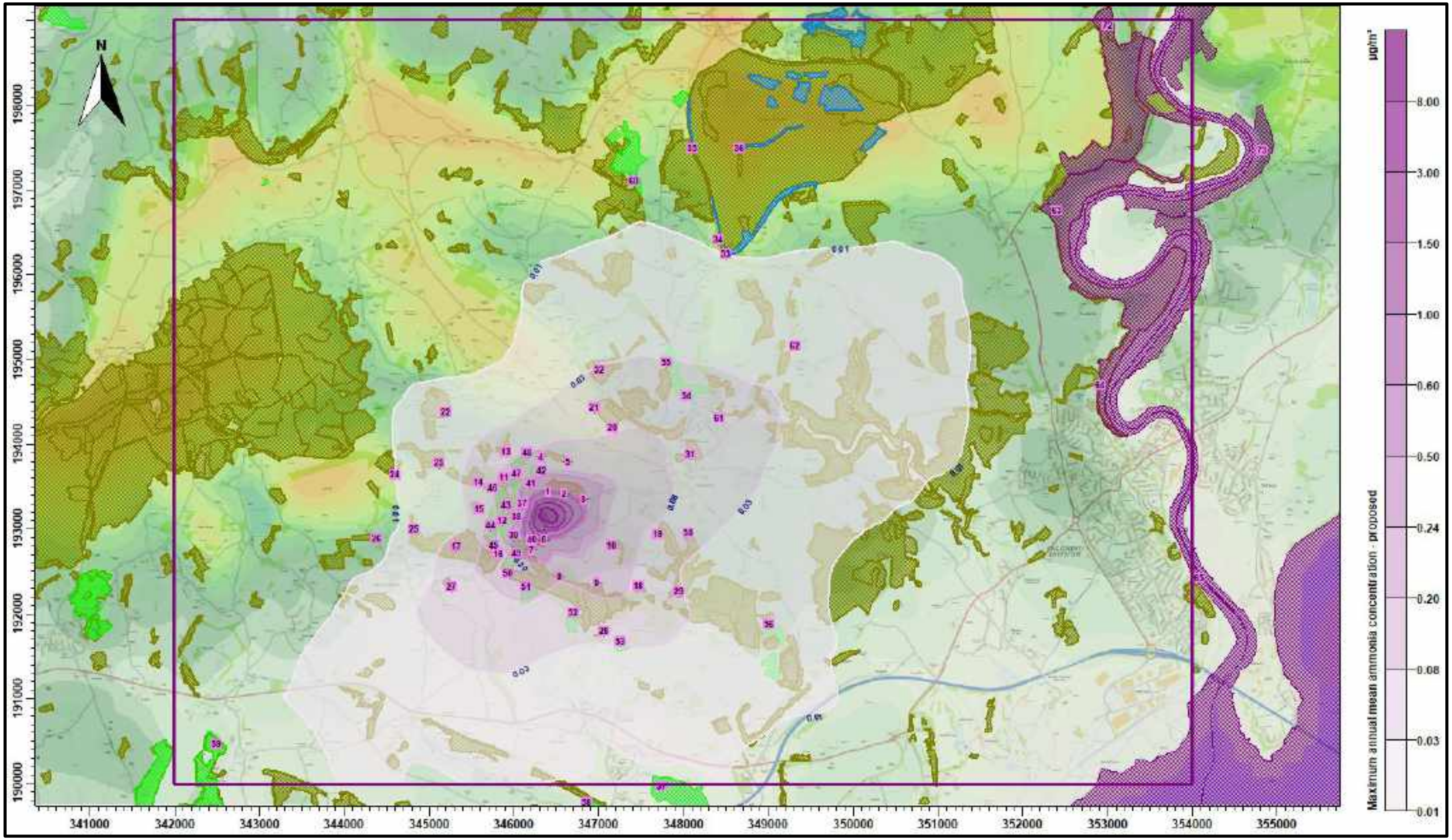
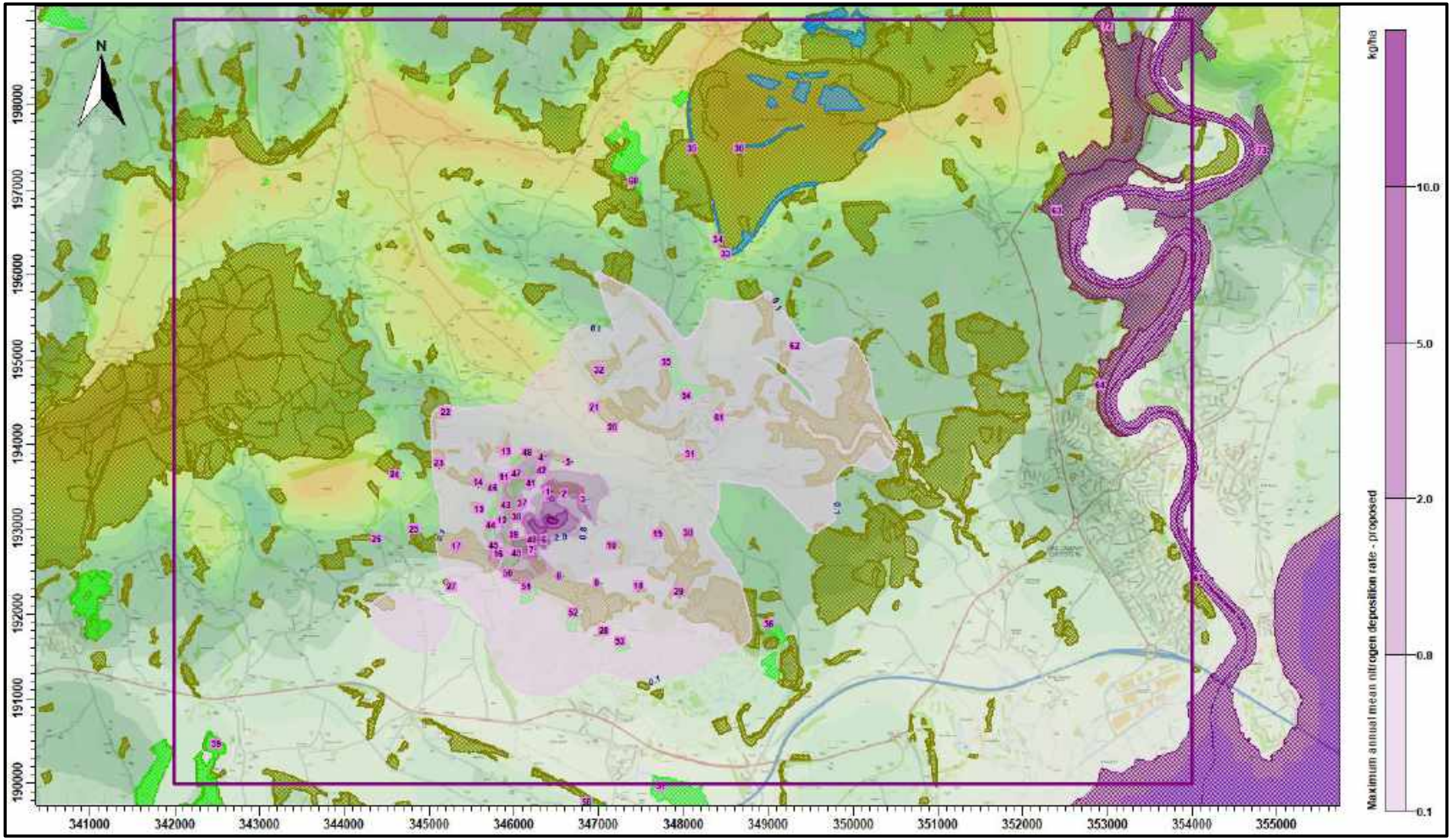


Figure 7b. Process contribution to maximum annual mean nitrogen deposition rate – proposed poultry houses



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Steve Raasch, on behalf of Mr. Gareth Adams to use computer modelling to assess the impact of ammonia emissions from the existing and proposed broiler rearing houses at Coombe Farm, Llanvair Discoed, Chepstow, Monmouthshire. NP16 6LN.

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.

The modelling predicts that:

- Should the proposals proceed and the two proposed poultry houses be constructed and heat exchangers installed on these and the existing poultry houses, ammonia concentrations and acid and nitrogen deposition rates are predicted to be reduced at all of the discrete receptors included in the modelling. It should be noted that this conclusion assumes that the heat exchangers fitted to the poultry houses would lead to a reduction in ammonia emissions of at least 35%, compared to houses without heat exchangers.

- There are exceedances of the Natural Resources Wales upper threshold percentage of the relevant Critical Level or Critical Loads by process contributions from the existing and proposed poultry houses at Coombe Valley Woodlands SSSI, Dinham Meadows SSSI and Llwyn Y Celyn Wetland SSSI. In all cases the magnitude and extent of these exceedances are reduced under the proposed scenario.

- There are also exceedances of the Natural Resources Wales lower threshold percentage of the relevant Critical Level or Critical Loads at these SSSIs and Nedern Brook Wetlands, Caldicot SSSI, Brookwells Meadows SSSI, Penhow Woodlands SSSI, Plantation Farm and The Gethley SSSI, River Wye (Lower Wye) SSSI/SAC and Severn Estuary SSSI/Ramsar/SAC. In all cases the magnitude and extent of these exceedances are reduced under the proposed scenario.

- Under the proposed scenario, there are no exceedances of the Natural Resources Wales lower threshold of the precautionary Critical Level or Critical Load at any of the non-statutory sites, including the ammonia sensitive AWs.

7. References

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