A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Pig Rearing Houses at Goodmanham Lodge Farm, Goodmanham, Market Weighton, near York

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Kevin Brook, of KB Environmental Consulting Ltd., on behalf of Messrs L. Hiles & Sons, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed pig rearing houses at Goodmanham Lodge Farm, Goodmanham, Market Weighton, York. YO43 3NA.

Ammonia emission rates from the existing and proposed pig rearing houses have been estimated 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 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 pig rearing houses at Goodmanham Lodge Farm is in a rural area approximately 4 km to the east-north-east of the town of Market Weighton. The surrounding land is used primarily for arable farming and there are isolated wooded areas nearby. Goodmanham Lodge Farm is at an elevation of approximately 75 m in an east-west aligned incised valley in the Yorkshire Wolds.

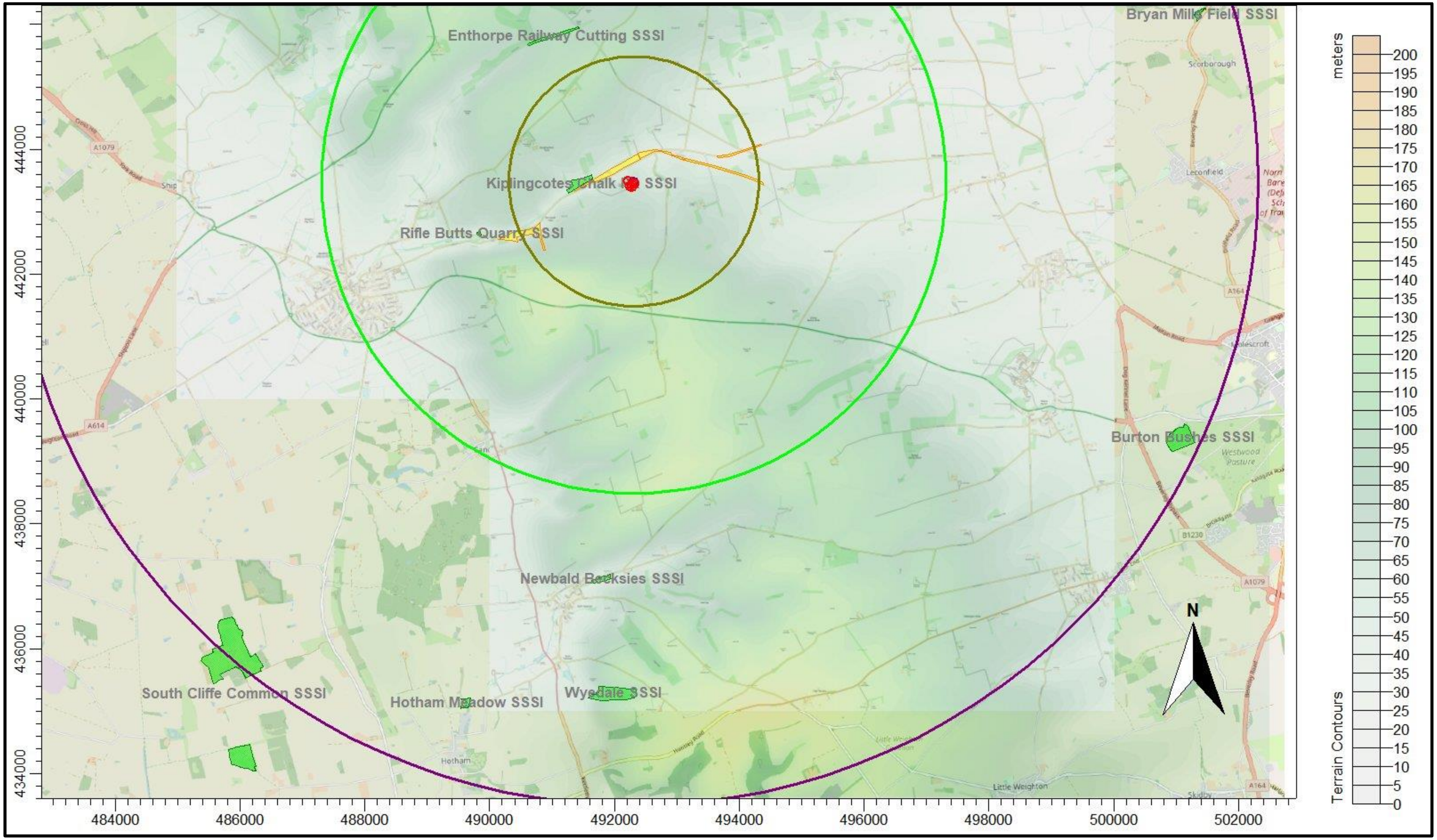
Under the proposals, a new pig rearing house would be constructed to the east of the existing pig rearing house at Goodmanham Lodge Farm. The existing and proposed pig rearing houses would provide accommodation for up to 3,400 pigs reared from a weight of around 40 kg to a finishing weight of around 110 kg. Both houses would have solid flooring with straw litter/bedding and would be ventilated using uncapped high speed ridge/roof mounted fans.

There are three areas designated as a Local Wildlife Sites (LWSs) within 2 km (the normal screening distance for non-statutory wildlife sites) of the proposed pig rearing house. There are also nine areas designated as Sites of Special Scientific Interest (SSSIs) within 10 km (the normal screening distance for statutory sites) of the farm. There are no internationally designated wildlife sites within the statutory screening distance. Some further details of the SSSIs that are sensitive to ammonia emissions are provided below; other SSSIs are designated for geological features only:

- **Kiplingcotes Chalk Pit SSSI** - Approximately 600 m to the west. A revegetated quarry noted for its chalk grassland flora and associated invertebrate fauna. The site has a particularly diverse butterfly fauna, with sixteen species recorded.
- **Newbald Becksies SSSI** - Approximately 6.2 km to the south. A mosaic of habitats with a rich flora which include base-rich bryophyte or mosses dominated flushes, marshland, wet and neutral grassland and tall fen vegetation, all developed along the spring line along the base of a chalk slope. There are some woodlands in drier areas.
- **Wyedale SSSI** - Approximately 8.0 km to the south. A small chalk dale incised in the western edge of the Yorkshire Wolds. Uncultivated, the site supports a rich flora with invasion by hawthorn scrub as the site is not grazed.
- **Hotham Meadow SSSI** - Approximately 8.6 km to the south-south-west. A meadow with a range of plant communities which reflect underlying soils. Herb-rich neutral grassland developed on glacial sands, clays and silts.
- **South Cliffe Common SSSI** - Approximately 9.5 km to the south-west. Heathland and acidic grassland. Bunny Hill is a mosaic of ericaceous heath and acid grassland. There are some areas of woodland plantations. There are areas of open sand, lichen rich heath and neutral grassland. Hotham Carr is a mixture of wet acid grassland, fen and woodland with some small areas of mire and bog pools. Noted for insects and other invertebrates and breeding and wintering birds.
- **Burton Bushes SSSI** - Approximately 9.3 km to the east-south-east. An ancient oak woodland typical of Holderness Till soils. The tree canopy comprises oak *Quercus robur*, birch *Betula pubescens*, field maple *Acer compestre* and wych elm *Ulmus glabra* and the understorey is well developed. The wood is grazed by cattle, leaving the floor to be grassy or bare, but there are some herb remnants.
- **Bryan Mills Field SSSI** - Approximately 9.4 km to the east-north-east. A tall fen community in the centre of an ungrazed field, surrounded by trees. Surface water is created by spring heads, encouraging marsh and fen species to develop.

A map of the surrounding area showing the position of Goodmanham Lodge Farm and the nearby wildlife sites is provided in Figure 1. In the figure the LWSs are shaded in yellow, the SSSIs are shaded in green and the site of the pig rearing houses at the farm are outlined in red.

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

The APIS figures for background ammonia concentration in the area around the site is 2.04 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 34.27 kg-N/ha/y and to short vegetation is 18.92 kg-N/ha/y. The background acid deposition rate to woodland is 2.43 keq/ha/y and to short vegetation is 1.31 keq/ha/y.

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

3.3 Critical Levels & Critical Loads

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

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

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

For ammonia concentration in air, the Critical Level for higher plants is 3.0 µg-NH_3/m^3 as an annual mean. For sites where there are sensitive lichens and bryophytes present, or where lichens and bryophytes are an integral part of the ecosystem, the Critical Level is 1.0 µg-NH_3/m^3 as an annual mean.

Critical Loads for nutrient nitrogen are set under the Convention on Long-Range Transboundary Air Pollution. They are based on empirical evidence, mainly observations from experiments and gradient studies. Critical Loads are given as ranges (e.g. 10-20 kg-N/ha/y); these ranges reflect variation in ecosystem response across Europe.

The Critical Levels and Critical Loads at the wildlife sites assumed in this study are provided in Table 1. Note, the SSSI citations for Rifle Butts Quarry SSSI and Enthorpe Railway Cutting SSSI indicate that they have been designated due to their geology; therefore, they have not been considered further. 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)
Unnamed LWS	1.0 [1]	-	-
South Cliffe Common SSSI	1.0 [1]	5.0 [3]	-
Wyedale SSSI, Kiplingcotes Chalk Pit SSSI, Hotham Meadow SSSI	3.0 [2]	10.0 [3]	-
Newbald Becksies SSSI, Burton Bushes SSSI	1.0 [1]	15.0 [3]	-
Bryan Mills Field SSSI	3.0 [2]	15.0 [3]	-

1. A precautionary figure, used where details of the site are unavailable, or citations indicate that sensitive lichens and bryophytes may be present.
2. Based upon the citation for the site.
3. The lower bound of the range of Critical Loads for the site/species present.

3.4 Guidance on the significance of ammonia emissions

3.4.1 Environment Agency Criteria

The Environment Agency web-page titled “Intensive farming risk assessment for your environmental permit”, contains a set of criteria, with thresholds defined by percentages of the Critical Level or Critical Load, for: internationally designated wildlife sites (Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar sites); Sites of Special Scientific Interest (SSSIs) and other non-statutory wildlife sites. The lower and upper thresholds are: 4% and 20% for SACs, SPAs and Ramsar sites; 20% and 50% for SSSIs and 100% and 100% for non-statutory wildlife sites.

If the predicted process contributions to Critical Level or Critical Load are below the lower threshold percentage, the impact is usually deemed acceptable.

If the predicted process contributions to Critical Level or Critical Load are in the range between the lower and upper thresholds; 4% to 20% for SACs, SPAs and Ramsar sites; 20% to 50% for SSSIs and

100% to 100% for other non-statutory wildlife sites, whether or not the impact is deemed acceptable is at the discretion of the Environment Agency. In making their decision, the Environment Agency will consider whether other farming installations might act in-combination with the farm and the sensitivities of the wildlife sites. 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%).

3.4.2 Natural England advisory criteria

Natural England are a statutory consultee at planning and usually advise that, if predicted process contributions exceed 1% (or lower in some circumstances) of Critical Level or Critical Load at a SSSI, SAC, SPA or Ramsar site, then the local authority should consider whether other farming installations[1] might act in-combination or cumulatively with the farm and the sensitivities of the wildlife sites.

1. The process contribution from most farming installations is already included in the background ammonia concentrations and nitrogen and acid deposition rates. Therefore, it is normally only necessary to consider new installations and installations with extant planning permission and proposed developments when understanding the additional impact of a proposal upon nearby ecologies. However, established farms in close proximity may need to be considered given the background concentrations and deposition rates are derived as an average for a 5 km by 5 km grid.

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

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

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

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

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

- Where site-relevant thresholds have been derived these can be applied to see if it is possible to avoid further assessment effort on the basis of site specific circumstances.
- If site-relevant thresholds have not yet been derived, further assessment in combination with other plans and projects is required.

3.5 Quantification of ammonia emissions

Ammonia emission rates from livestock housing 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 annual statistics it is not usually 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.

Ammonia emission rates have been derived based upon emission factors provided by the Environment Agency (https://www.gov.uk/guidance/ammonia-emission-factors-for-pig-and-poultry-screening-modelling-and-reporting#ammonia-emission-factors-for-pigs).

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

Table 2. Details of animal numbers and ammonia emission rates

Source	Number of Pigs	Emission Factor ($kg-NH_3/pl/y$)	Emission Rate ($g-NH_3/s$)
EX1	1,400	1.888	0.083758
PR1	2,000	1.888	0.119654
Source	Tonnage	Emission Factor ($kg-NH_3/t/y$)	Emission Rate ($g-NH_3/s$)
MAN	250	0.85	0.006734

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

The Atmospheric Dispersion Modelling System (ADMS) ADMS 6 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters; the boundary layer depth and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

Dispersion under convective meteorological conditions uses a skewed Gaussian concentration distribution (shown by validation studies to be a better representation than a symmetrical Gaussian expression).

ADMS has a number of model options 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)[1].

The GFS is a discrete model. The physics/dynamics model has a resolution or had a resolution of approximately 7 km over the central UK; terrain is understood to be resolved at a resolution of approximately 2 km, with sub-7 km terrain effects parameterised. Site specific data may be extrapolated from nearby archive grid points or a most representative grid point chosen. The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR[2]). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional observational records may be overrepresented, 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.

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a. Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the site is shown in Figure 2b. Please note that FLOWSTAR[2] is used to obtain a local flow field, not to explicitly model dispersion in complex terrain as defined in the ADMS User Guide; therefore, the ADMS default value for minimum turbulence length has been amended [3].

1. The GFS data used is derived from the high-resolution operational GFS datasets, the data is not obtained from the lower resolution (0.5 degree) long-term archive.
2. Note that FLOWSTAR requirements are for meteorological data representative of the upwind flow over the modelling domain and that single site meteorological data (observational or from high resolution modelled data) that is representative of the application site is not generally suitable (personal correspondence: CERC 2019 and UK Met O 2015). If data are deemed representative of a particular application site, either wholly or partially, then these data cannot also be representative of the upstream flow over the modelling domain. Furthermore, it would be extremely poor practice to use such data as the boundary conditions for a flow-solver, such as FLOWSTAR.

3. When modelling complex terrain with ADMS, by default, the minimum turbulence length has 0.1 m added to the flat terrain value (calculated from the Monin-Obukhov length). Whilst this might be appropriate over hill/mountain tops in terrain with slopes > 1:10 (and quite possibly only in certain wind directions) in lesser terrain it introduces model behaviour that is not desirable where FLOWSTAR is simply being used to modify the upwind flow. Specifically, the parameter sigma z of the Gaussian plume model is overly constrained, which for elevated point sources emissions, may on occasion cause over prediction of ground level concentrations in stable weather conditions and light winds (Steven R. Hanna & Biswanath Chowdhury, 2013), conversely for low level emission sources, this will cause gross under prediction. Note that this becomes particularly important overnight and if calm and light wind conditions are not being ignored, as they often are when using traditional observational meteorological datasets. To reduce this behaviour, where terrain is modelled, AS Modelling & Data Ltd. have set a minimum turbulence length of 0.025 m in ADMS. This approximates the normal behaviour of ADMS with flat terrain.

Figure 2a. The wind rose. Raw GFS derived data for 53.879 N, 0.596 W, 2021-2024

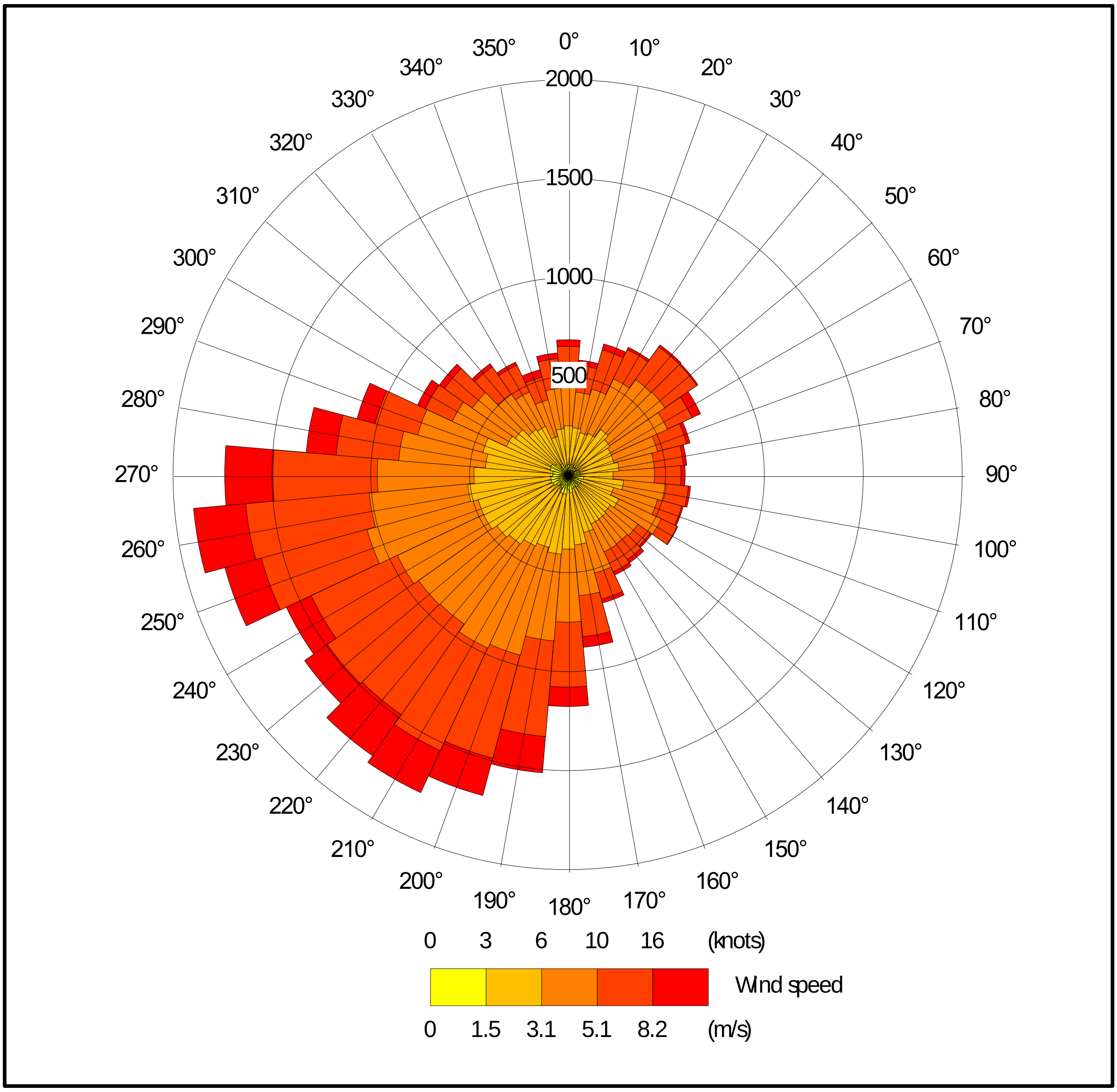
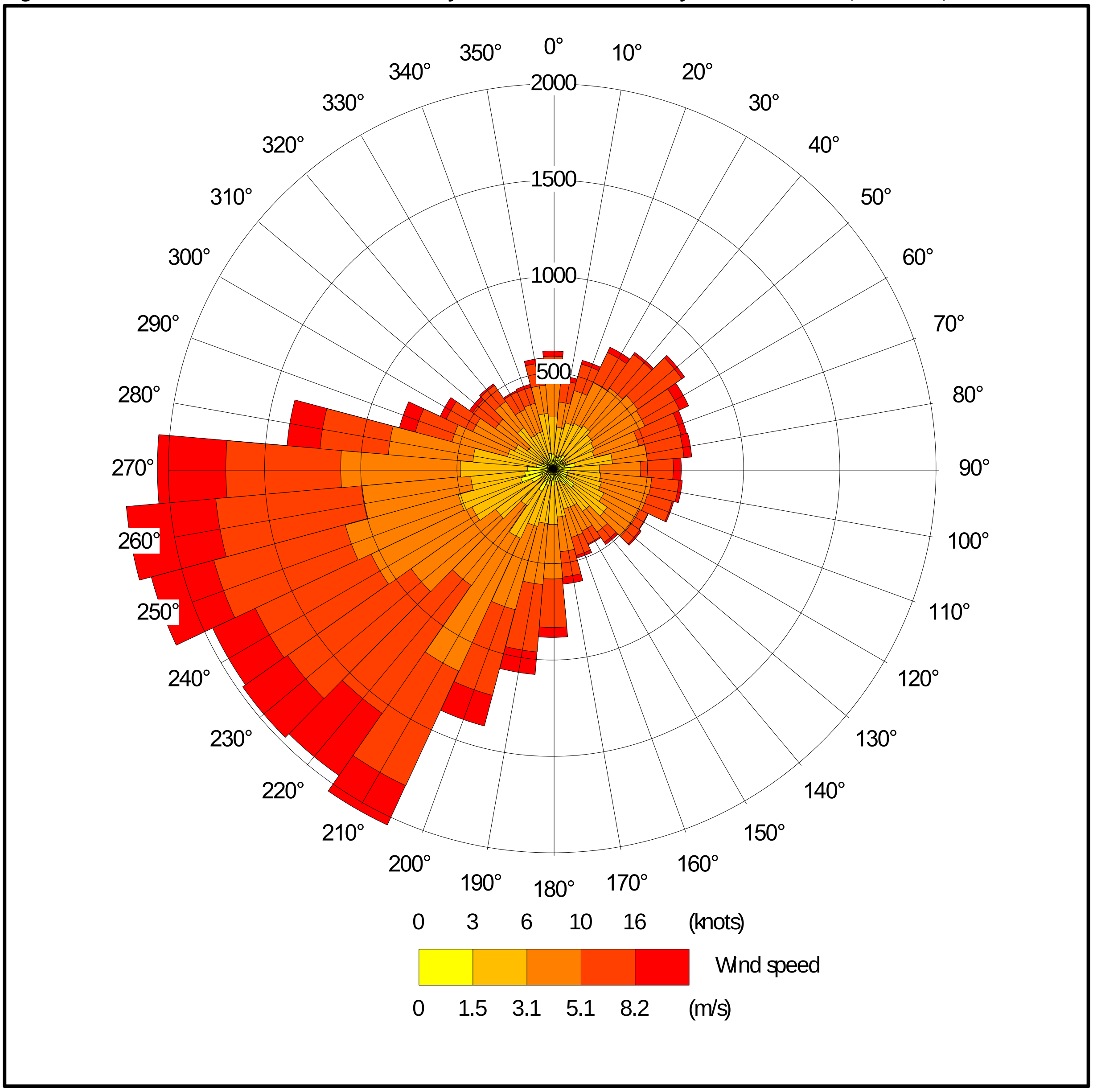


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 492300, 443500, 2021-2024



4.2 Emission sources

Emissions from the uncapped chimneys of the fans that would be used to ventilate the existing and proposed pig rearing houses have been represented by three point sources per house within ADMS. Emission from the manure storage area are represented by a single volume source.

Details of the point source parameters are shown in Table 3a and details of the volume source parameters are shown in Table 3b. The positions of the emission sources used are shown in Figure 3 (the point sources are marked by green circles and the volume source is marked by a red shaded rectangle).

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
EX 1, 2 & 3	8.0	0.8	11.0	22.0	0.027919
PR 1, 2 & 3	8.0	0.8	11.0	22.0	0.039885

Table 3b. Volume source parameters

Source ID	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
MAN	15.0	10.0	3.0	0.0	Ambient	0.006734

4.3 Modelled buildings

The structure of the pig rearing houses and other farm buildings may affect the plumes from the point sources. Therefore, these buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3, where they are marked by grey rectangles.

4.4 Discrete receptors

Thirty discrete receptors have been defined at the wildlife sites. These receptors are defined at ground level within ADMS. The positions of the discrete receptors may be seen in Figure 4 (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 velocity field, two regular Cartesian grids have been defined within ADMS. The grid receptors are defined at ground level within ADMS. The positions of the Cartesian grid receptors may be seen in Figure 4 (marked by grey gridlines).

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. The resolution of FLOWSTAR is 64 by 64 grid points; therefore, the effective resolution of the wind field is approximately 300 m.

4.7 Roughness Length

In this case, a spatially varying roughness length file has been defined, this is based upon the Defra Living Landscapes land use database. The GFS meteorological data is assumed to have a roughness length of 0.128 m (arithmetic average of the spatially varying roughness over the modelling domain). A sample of the central area of the spatially varying roughness length field is shown in Figure 5.

Figure 3. The modelled buildings and sources

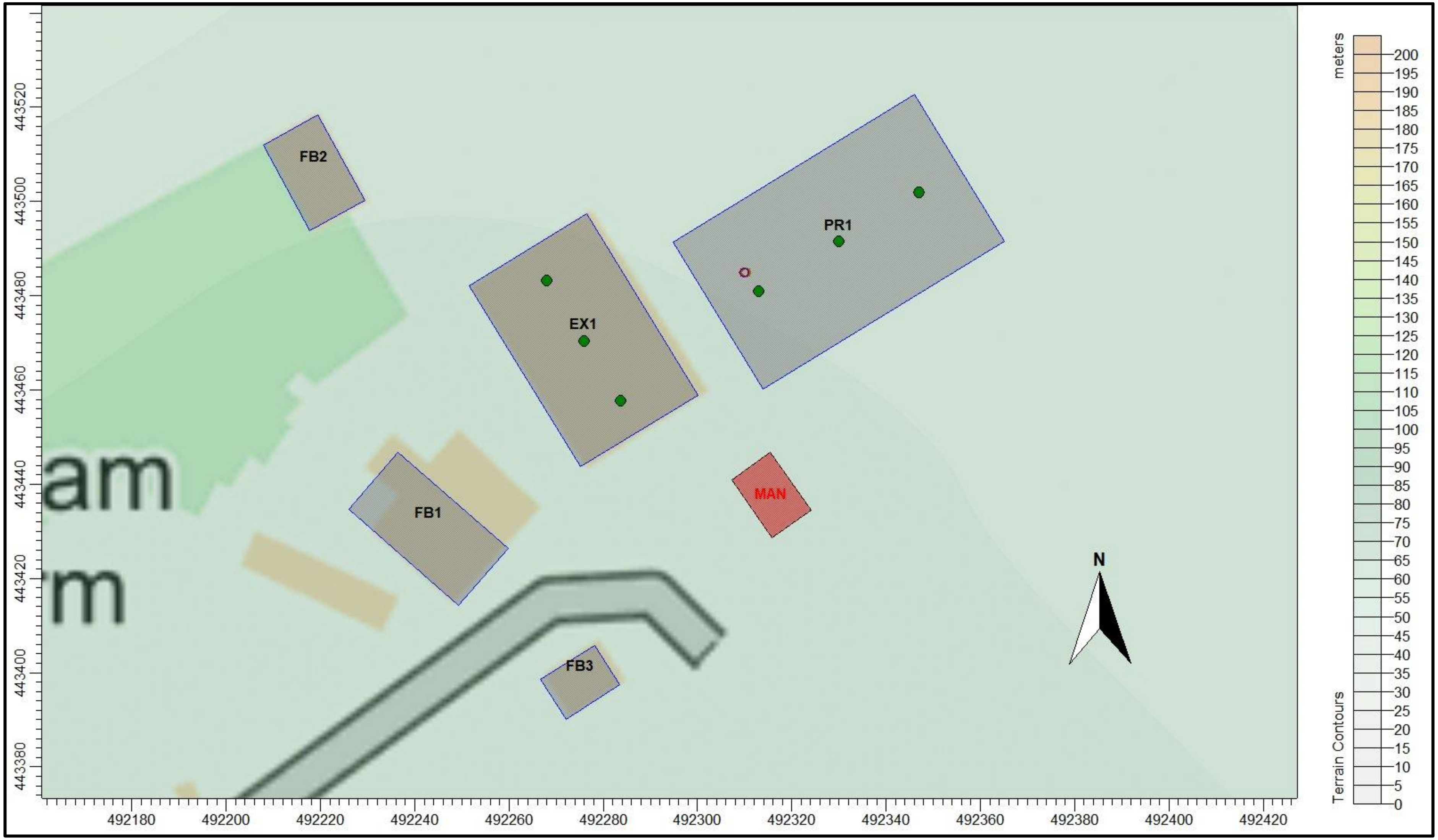


Figure 4. The discrete receptors and Cartesian grids

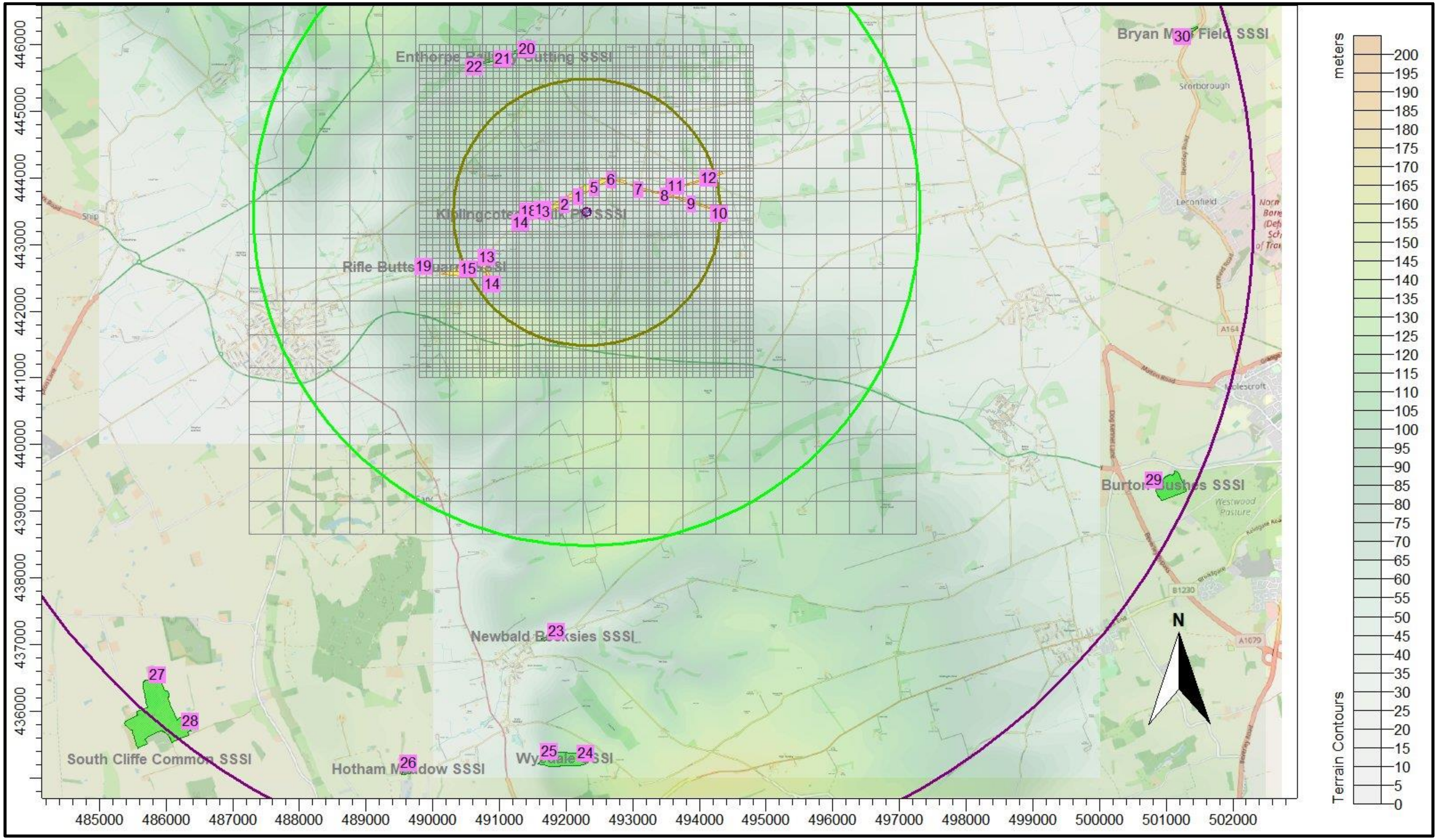
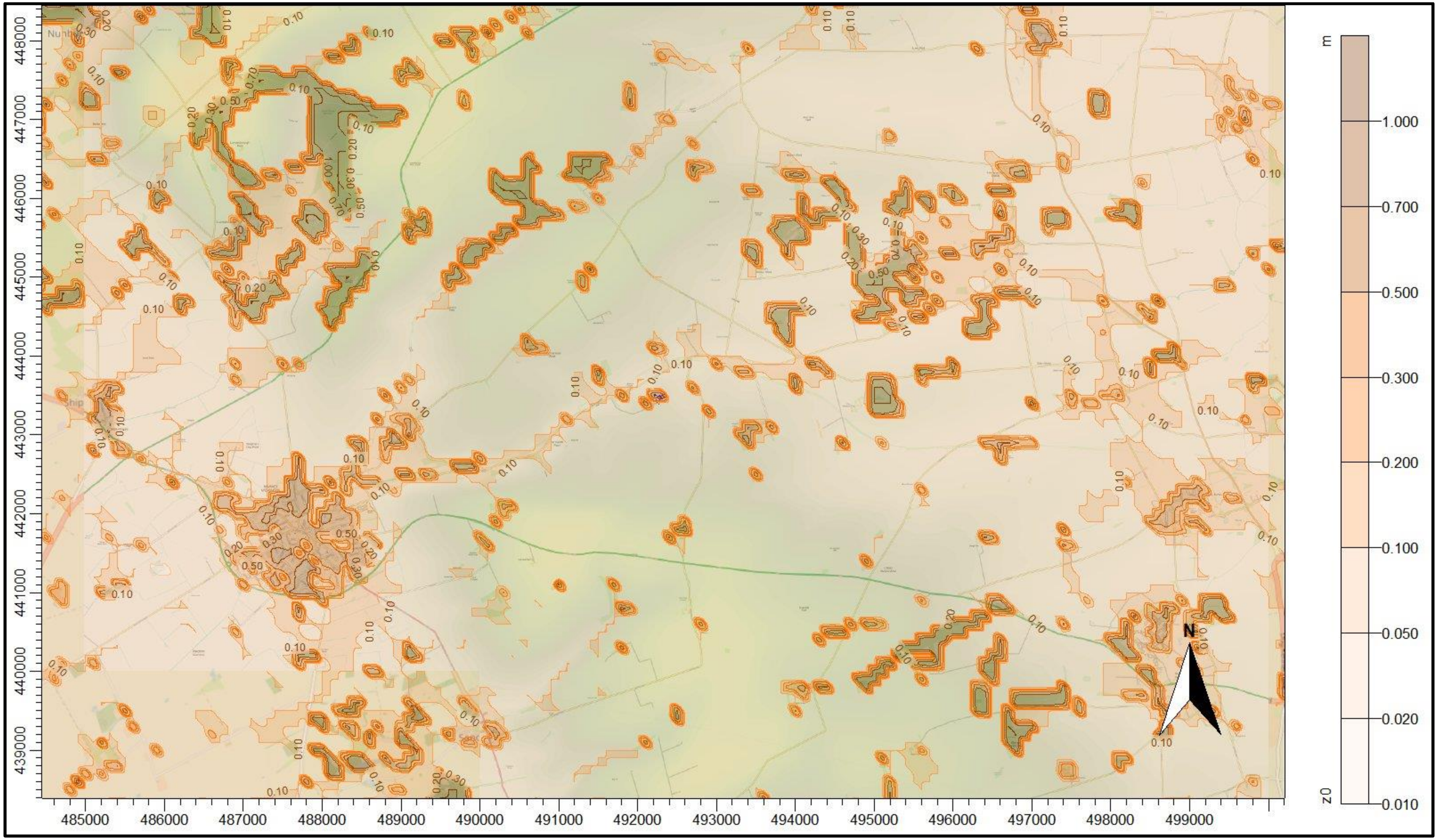


Figure 5. The spatially varying surface roughness field (central area)



4.8 Deposition

The method used to model deposition of ammonia and consequent plume depletion is based primarily upon Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004-2013). AS Modelling & Data Ltd. has restricted deposition over arable farmland and heavily grazed and fertilised pasture; this is to compensate for possible saturation effects due to fertilizer application and to allow for periods when fields are clear of crops (Sutton), the deposition is also restricted over areas with little or no vegetation and the deposition velocity is set to 0.002 m/s where grid points are over the housing and 0.010 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. Land usage is derived from the Defra Living Landscapes land use database.

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.

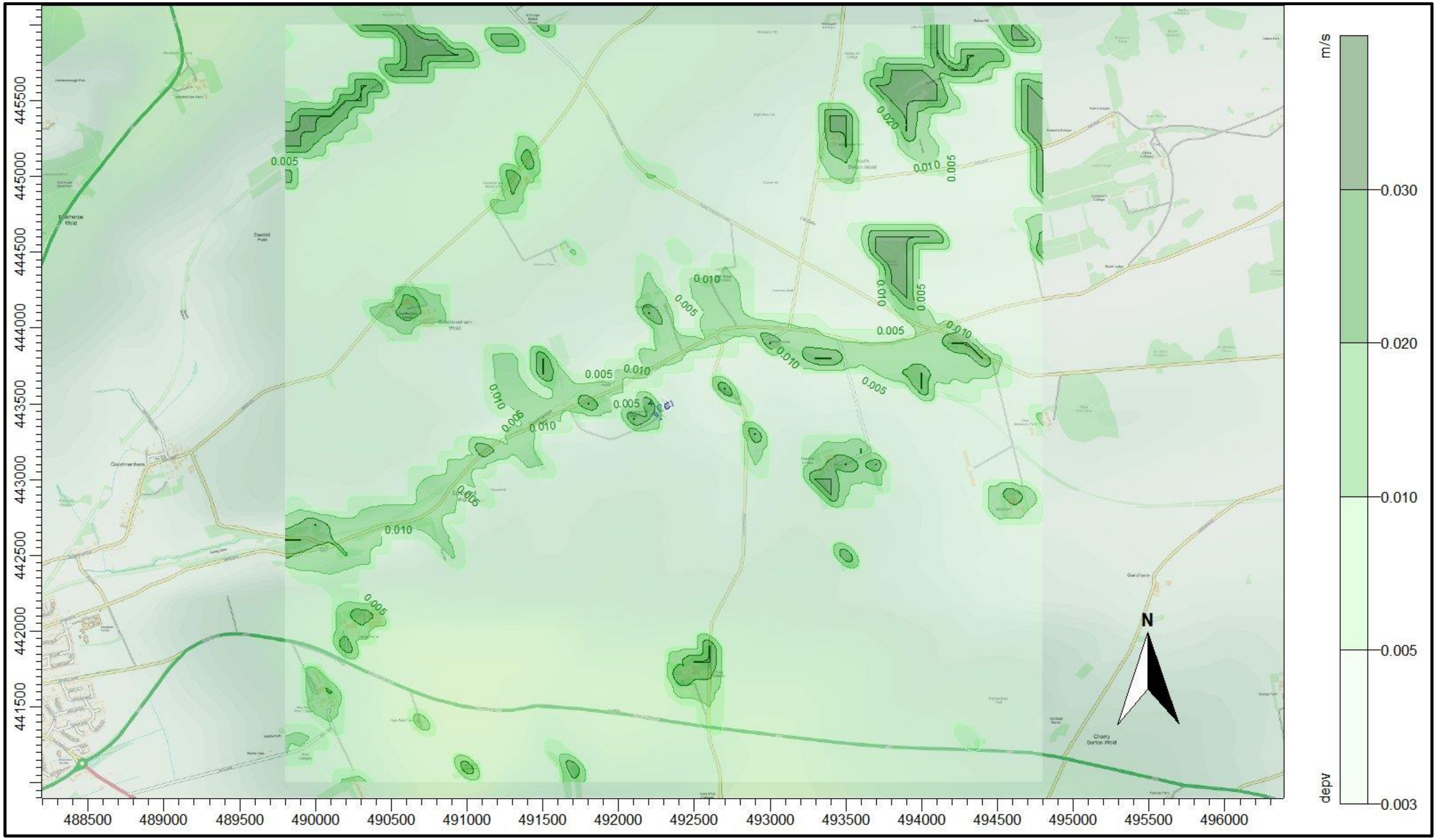
Table 4. Deposition velocities

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

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

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

Figure 6. The spatially varying deposition field



5. Details of the Model Runs and Results

5.1 Preliminary modelling and model sensitivity tests

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

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – GFS data.

For each mode, statistics for the maximum annual mean ammonia concentration at each receptor were compiled. Details of the predicted annual mean ammonia concentrations at each receptor are provided in Table 5. The primary purpose of the preliminary modelling is to assess the effect of calms on the results.

Table 5. Predicted maximum annual mean ammonia concentration - preliminary modelling

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - ($\mu g/m^3$)	
				GFS No Calms No Terrain	GFS Calms No Terrain
1	492185	443724	LWS	0.532	0.532
2	491981	443599	LWS	0.373	0.373
3	491700	443485	LWS	0.153	0.153
4	491380	443334	LWS	0.092	0.092
5	492417	443844	LWS	0.710	0.710
6	492674	443965	LWS	0.368	0.368
7	493085	443824	LWS	0.247	0.247
8	493476	443735	LWS	0.159	0.158
9	493882	443615	LWS	0.111	0.111
10	494300	443466	LWS	0.080	0.080
11	493650	443872	LWS	0.126	0.126
12	494144	444002	LWS	0.087	0.087
13	490818	442805	LWS	0.050	0.050
14	490891	442409	LWS	0.052	0.052
15	490532	442642	LWS	0.040	0.040
16	491654	443529	Kiplingcotes Chalk Pit SSSI	0.136	0.136
17	491318	443335	Kiplingcotes Chalk Pit SSSI	0.084	0.084
18	491441	443508	Kiplingcotes Chalk Pit SSSI	0.089	0.089
19	489865	442669	Rifle Butts Quarry SSSI	0.027	0.027
20	491417	445932	Enthorpe Railway Cutting SSSI	0.029	0.029
21	491055	445791	Enthorpe Railway Cutting SSSI	0.027	0.027
22	490623	445667	Enthorpe Railway Cutting SSSI	0.027	0.024
23	491860	437197	Newbald Becksies SSSI	0.010	0.010
24	492300	435371	Wyedale SSSI	0.008	0.008
25	491749	435401	Wyedale SSSI	0.008	0.008
26	489638	435226	Hotham Meadow SSSI	0.007	0.007
27	485867	436543	South Cliffe Common SSSI	0.007	0.007
28	486358	435851	South Cliffe Common SSSI	0.007	0.007
29	500822	439467	Burton Bushes SSSI	0.010	0.010
30	501246	446119	Bryan Mills Field SSSI	0.014	0.014

5.2 Detailed deposition modelling

In this case, detailed modelling has been carried out over a high resolution 5 km x 5 km domain centred on the site. The primary purpose is to determine the magnitude of deposition of ammonia and consequent plume depletion close to the sources where it is of the greatest importance, but also to provide results should any further non-statutory sites be identified. Outside of the 5 km x 5 km domain a fixed deposition velocity of 0.005 m/s is assumed (with appropriate deposition velocities applied post-modelling at the discrete receptors).

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

The predicted maximum annual mean ground level ammonia concentrations and annual nitrogen deposition rates at the discrete receptors are shown in Table 6.

In the Table, there are no predicted ammonia concentrations or nitrogen deposition rates as a percentage of the Critical Level or Critical Load that are in excess of the Environment Agency's upper threshold for the site (50% for a SSSI and 100% for a non-statutory site) nor are there any in the range between the upper threshold and lower threshold (20% and 50% for a SSSI and 100% and 100% for a non-statutory site). Process contributions that exceed 1% of the relevant Critical Level or Critical Load at a statutory wildlife site are highlighted with bold text.

Contour plots of the predicted process contributions of the existing and proposed pig rearing houses to ground level maximum annual mean ammonia concentrations and annual nitrogen deposition rates are shown in Figure 7a and Figure 7b.

Table 6. Predicted process contribution to maximum annual mean ammonia and nitrogen deposition at the discrete receptors - detailed modelling

Receptor number	X(m)	Y(m)	Designation	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level ($\mu g/m^3$)	Critical Load (kg/ha)	Process Contribution ($\mu g/m^3$)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	492185	443724	LWS	0.02	1.0	10.0	0.419	41.9	2.17	21.7
1	491981	443599	LWS	0.02	1.0	10.0	0.348	34.8	1.81	18.1
1	491700	443485	LWS	0.02	1.0	10.0	0.137	13.7	0.71	7.1
1	491380	443334	LWS	0.02	1.0	10.0	0.080	8.0	0.41	4.1
1	492417	443844	LWS	0.02	1.0	10.0	0.560	56.0	2.91	29.1
1	492674	443965	LWS	0.02	1.0	10.0	0.340	34.0	1.77	17.7
1	493085	443824	LWS	0.02	1.0	10.0	0.256	25.6	1.33	13.3
1	493476	443735	LWS	0.02	1.0	10.0	0.160	16.0	0.83	8.3
1	493882	443615	LWS	0.02	1.0	10.0	0.086	8.6	0.45	4.5
1	494300	443466	LWS	0.02	1.0	10.0	0.056	5.6	0.29	2.9
1	493650	443872	LWS	0.02	1.0	10.0	0.119	11.9	0.62	6.2
1	494144	444002	LWS	0.02	1.0	10.0	0.072	7.2	0.38	3.8
1	490818	442805	LWS	0.02	1.0	10.0	0.039	3.9	0.20	2.0
1	490891	442409	LWS	0.02	1.0	10.0	0.039	3.9	0.20	2.0
1	490532	442642	LWS	0.02	1.0	10.0	0.033	3.3	0.17	1.7
1	491654	443529	Kiplingcotes Chalk Pit SSSI	0.02	3.0	10.0	0.124	**4.1**	0.64	**6.4**
1	491318	443335	Kiplingcotes Chalk Pit SSSI	0.02	3.0	10.0	0.070	**2.3**	0.36	**3.6**
1	491441	443508	Kiplingcotes Chalk Pit SSSI	0.02	3.0	10.0	0.079	**2.6**	0.41	**4.1**
1	489865	442669	Rifle Butts Quarry SSSI	0.00	n/a	n/a	0.018	-	0.00	-
1	491417	445932	Enthorpe Railway Cutting SSSI	0.00	n/a	n/a	0.013	-	0.00	-
1	491055	445791	Enthorpe Railway Cutting SSSI	0.00	n/a	n/a	0.012	-	0.00	-
1	490623	445667	Enthorpe Railway Cutting SSSI	0.00	n/a	n/a	0.011	-	0.00	-
1	491860	437197	Newbald Becksies SSSI	0.02	1.0	10.0	0.005	0.5	0.03	0.3
1	492300	435371	Wyedale SSSI	0.02	3.0	10.0	0.003	0.1	0.01	0.1
1	491749	435401	Wyedale SSSI	0.02	3.0	10.0	0.003	0.1	0.01	0.1
1	489638	435226	Hotham Meadow SSSI	0.02	3.0	10.0	0.003	0.1	0.02	0.2
1	485867	436543	South Cliffe Common SSSI	0.02	1.0	5.0	0.003	0.3	0.02	0.3
1	486358	435851	South Cliffe Common SSSI	0.02	1.0	5.0	0.003	0.3	0.01	0.3
1	500822	439467	Burton Bushes SSSI	0.03	1.0	15.0	0.003	0.3	0.02	0.2
1	501246	446119	Bryan Mills Field SSSI	0.02	3.0	15.0	0.010	0.3	0.05	0.4

Figure 7a. Predicted process contribution to maximum annual mean ammonia concentration

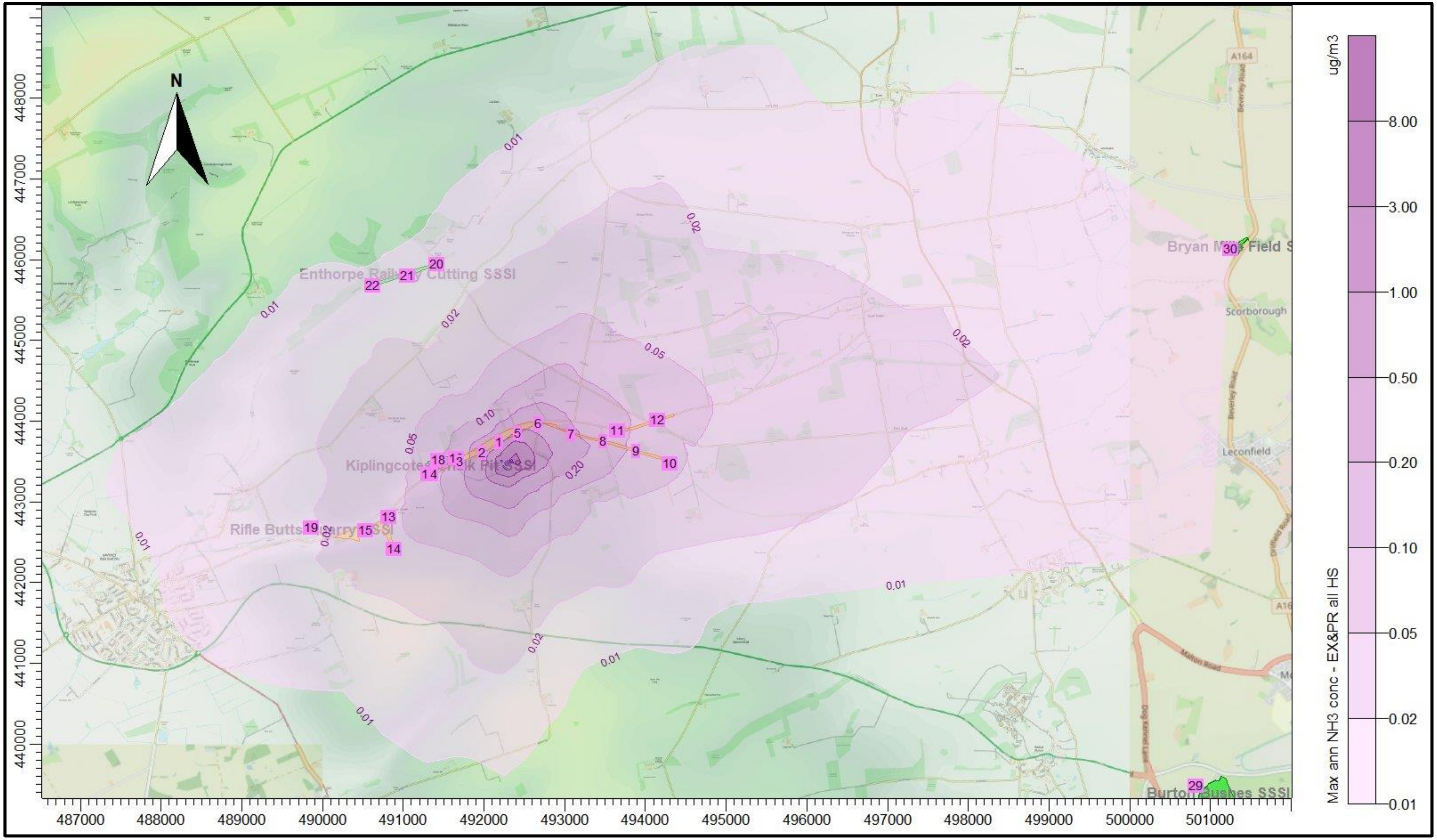
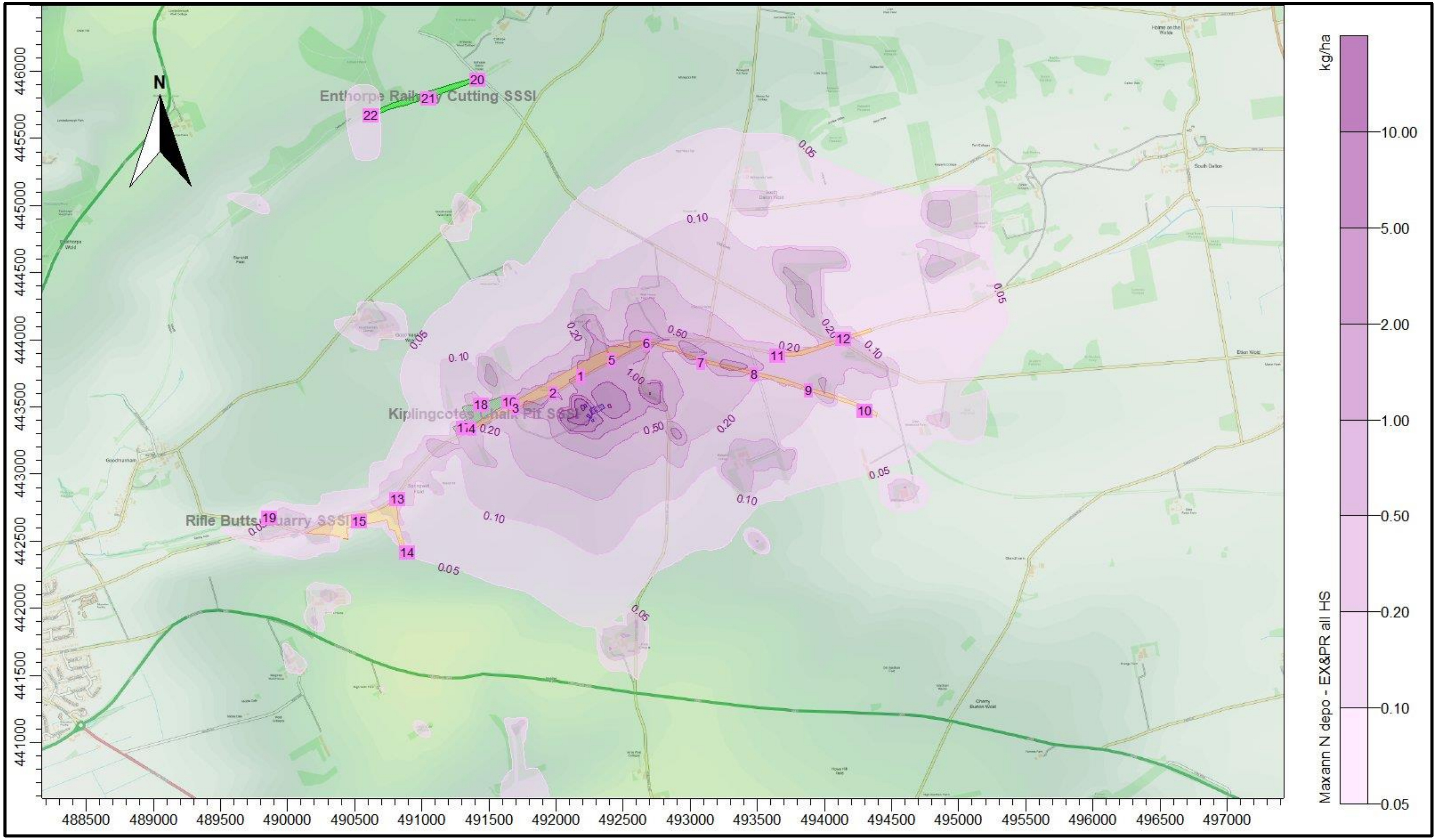


Figure 7b. Predicted process contribution to maximum annual nitrogen deposition rates



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Kevin Brook, of KB Environmental Consulting Ltd., on behalf of Messrs L. Hiles & Sons, to use computer modelling to assess the impact of ammonia emissions from the existing and proposed pig rearing houses at Goodmanham Lodge Farm, Goodmanham, Market Weighton, York. YO43 3NA.

Ammonia emission rates from the existing and proposed pig rearing houses have been estimated 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:

- Process contributions to ammonia concentration and nitrogen deposition would be below the Environment Agency's lower threshold percentage of the relevant Critical Level and Critical Load (20% for SSSIs and 100% for LWSs) at all wildlife sites considered.

- There are exceedances of 1% of the Critical Level and Critical Load at Kiplingcotes Chalk Pit SSSI.

- Process contributions to ammonia concentration and nitrogen deposition would be less than 1% of the relevant Critical Level and Critical Load at all of the other statutory sites considered in the modelling.

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