A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Piggeries at Southfield Pig Farm, near Out Newton in East Riding of Yorkshire

Prepared by Steve Smith

AS Modelling & Data Ltd.

www.asmodata.co.uk

Email: stevesmith@asmodata.co.uk

Telephone: 01952 462500

23rd July 2024

1. Introduction

AS Modelling & Data Ltd. has been instructed by Mrs. Lizzie Bentley of Yorkshire Farmers Livestock Marketing Ltd., on behalf of Cattle (Holderness) Ltd., to use computer modelling to assess the impact of ammonia emissions from the piggeries at Southfield Pig Farm, Out Newton, Withernsea, East Riding of Yorkshire. HU19 2RE.

Ammonia emission rates from the pig rearing buildings have been assessed and quantified based upon Environment Agency emission factors from the Pre-application screening reports. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

This report is arranged in the following manner:

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

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

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

- Section 5 contains the results of the modelling.

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

2. Background Details

The piggeries at Southfield Farm are in a rural area approximately 1.5 km to the north-north-east of the village of Skeffling in East Riding of Yorkshire. The surrounding land is used almost exclusively for arable cultivation. The farm is at an altitude of around 13 m with the land falling slightly to the south, along the course of the Punda and rising to slightly higher ground to the north-east.

There are a variety of pig rearing buildings at Southfield Farm which are used to both breed and rear pigs. Two scenarios are considered in this report:

Scenario 1 – A baseline scenario based on 2014 permit, with: 3,394 finisher pigs; 3,100 weaner/grower pigs; 1050 sows/gilts and 6 boar pigs.

Scenario 2 – The proposed farm used as a breeding unit with no finishing of production pigs: 2,509 sows/gilts/farrowing pigs and 6 boar pigs.

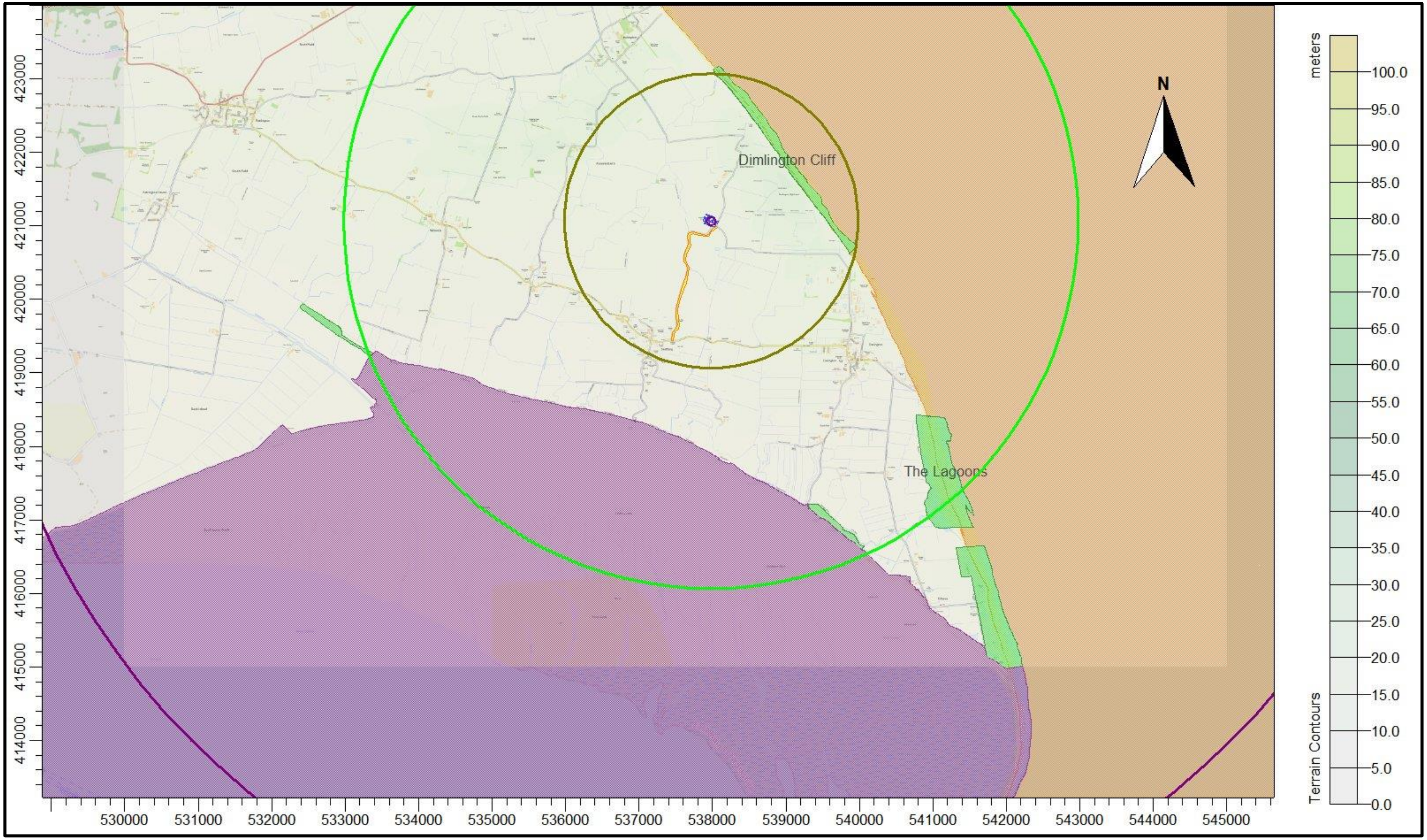
Further details of housing type/ventilation pig numbers and manure and slurry management are provided in Section 3.5 of this report.

AS Modelling & Data Ltd. have identified one area designated as a Local Wildlife Site (LWS) within 2 km (the normal screening distance for a non-statutory site) of Southfield Farm. There are three Sites of Special Scientific Interest (SSSIs) within 10 km (the normal screening distance for a SSSI). Parts of the Greater Wash Special Protection Area (SPA) are within 10 km and one of the SSSIs, the Humber Estuary SSSI, is also designated as a Special Area of Conservation (SAC), a Ramsar site and a SPA. Further details of the SSSIs/SPAs/SAC/Ramsar site are provided below:

- **Dimlington Cliff SSSI** - Approximately 1.2 km to the north-east - Geological.
- **The Lagoons SSSI** - approximately 3.7 km to the south-east - Coastal habitats including saltmarsh, shingle, sand dune, swamp and saline lagoons.
- **Humber Estuary SSSI/SAC/SPA/Ramsar site** - Approximately 2.8 km to the south at its closest point) - A nationally important site with a series of nationally important habitats. These are the estuary itself (with its component habitats of intertidal mudflats and sandflats and coastal saltmarsh) and the associated saline lagoons, sand dunes and standing waters.
- **Greater Wash Marine SPA** - Approximately 1.2 km to the north-east (closest point) - Marine.

A map of the surrounding area showing the positions of the pig rearing houses, the LWS, the SSSIs, The SAC and the SPA is provided in Figure 1. In this figure: the LWS is shaded in yellow; the SSSIs are shaded in green; the SPA is shaded in orange; the SAC is shaded in purple and the positions of the proposed pig rearing houses are outlined in blue.

Figure 1. The area surrounding Southfield Farm - concentric circles radii 2 km (olive), 5 km (green) and 10 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 ($\mu g\text{-}NH_3/m^3$) as an annual mean. Ammonia in the air may exert direct effects on the vegetation, or indirectly affect the ecosystem through deposition which causes both hyper-eutrophication (excess nitrogen enrichment) and acidification of soils. Nitrogen deposition, specifically in this case the nitrogen load due to ammonia deposition/absorption, is usually expressed in kilograms of nitrogen per hectare per year (kg-N/ha/y). Acid deposition is expressed in terms of kilograms equivalent (of H^+ ions) per hectare per year (keq/ha/y).

3.2 Background ammonia levels and nitrogen and acid deposition

The source of the background figures is the Air Pollution Information System (APIS, December 2023). 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 Southfield Farm is 1.55 $\mu g\text{-}NH_3/m^3$. The background nitrogen deposition rate to woodland is 23.95 kg-N/ha/y and to short vegetation is 12.61 kg-N/ha/y. The background acid deposition rate to woodland is 1.69 keq/ha/y and to short vegetation is 0.86 keq/ha/y.

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

3.3 Critical Levels & Critical Loads

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

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

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

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

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

The Critical Levels and Critical Loads at the wildlife sites assumed in this study are provided in Table 1. Where the Critical Level of 1.0 $\mu g\text{-}NH_3/m^3$ 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 does the Critical Load for acid deposition.

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

Site	Critical Level ($\mu g\text{-}NH_3/m^3$)	Critical Load Nitrogen Deposition (kg-N/ha/y)	Critical Load Acid Deposition (keq/ha/y)
LWS (roadside verge)	3.0 [4]	20.0 [4]	-
The Lagoons SSSI	1.0 [1]	5.0 [2 & 3]	-
Humber Estuary SAC/SPA/Ramsar/SSSI	3.0 [2]	5.0/10.0 [2 & 3]	-
Greater Wash Marine SPA	n/a [5]	n/a [5]	n/a [5]
Dimlington Cliff SSSI	n/a [6]	n/a [6]	n/a [6]

1. Used as a precautionary figure where details of the site ecology are unavailable, or where citation 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.
4. Environment Agency – Pre-application Report (11/07/24).
5. Marine.
6. Geological.

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 Environment Agency and Natural England May 2022 Air Quality Risk Assessment Interim Guidance

Although it seems important to include a reference to this document, it appears to be primarily a discussion document about internal Environment Agency screening models and the SCAIL model and AS Modelling & Data Ltd. have been unable to draw any conclusions from the document as to what thresholds may or may not apply, nor in what circumstances the thresholds may or may not apply.

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

The ammonia emission factors used in this modelling are the Environment Agency's published standard emission factors. In this case the Environment Agency are also mandating a emission factor for finishing pigs of 2.0 kn-N/ha/y, which is based upon AHDB trials. However, it should be noted that the figures obtained from the AHDB trials are low in comparison to other reported figures for ammonia emissions from finisher pig housing and that in the report titled "A data review – ammonia emission factors for permitted pig and poultry operations in the UK" (ADAS and Rothamsted Research January 2024, for the Environment Agency), states in response to the questions, "Is it legitimate for applicants to claim equivalence with AHDB pig trial results?", that "The inventory EFs were revised according to the inclusion of these new data. EFs on a 'per animal place' basis (derived using current N excretion estimates) will reflect the inclusion of these new trials data. As the trials provided only one or two data points per housing category, it is more robust to use the full dataset than rely on these values alone.".

Details of of the pig numbers and types and emission factors and calculated ammonia emission rates are provided in Table 2a (Scenario 1) and 2b (Scenario 2). Details of the emission from the middens and lagoon are provided in Table 2c. Figures obtained using the EA Mandated figures are bracketed.

Table 2a Details of pig numbers and ammonia emission rates – Scenario 1

Source	No. animals	Type	Floor	Ventilation	Emission Factor (kg-NH3/place/y)	Emission Rate (g/s)
FIN2A	1,200	Finishers	Slatts	ridge fans	3.11	0.118260 (0.076051)
FIN1	1,494	Finishers	Slatts	ridge fans	3.11	0.147234 (0.094684)
SOW3	250	Sows	Solid/Straw	nat/side	4.57	0.036204
SOW2	250	Sows	Solid/Straw	nat/side	4.57	0.036204
SOW4	200	Sows	Solid/Straw	nat/side	4.57	0.028963
	6	Boars			5.72	0.001088
SOW1	105	Sows	Solid/Straw	nat/side	4.57	0.015206
FAR1	125	Farrowers	Slatts	ridge fans	2.8	0.011091
FAR2	120	Farrowers	Slatts	ridge fans	2.8	0.010647
NURSE	1,350	Weaners	Slatts	nat/side	0.22	0.009411
	1,350	Growers			1.19	0.050907
FIN2B	800	Finishers	Slatts	ridge fans	3.11	0.078840 (0.050701)
WEAN12	200	Weaners	Slatts	nat/side	0.22	0.001394
	200	Growers			1.19	0.007542

Table 2b Details of pig numbers and ammonia emission rates – Scenario 2

Source	No. animals	Type	Floor	Ventilation	Emission Factor (kg-NH3/place/y)	Emission Rate (g/s)
SOW1	252	Sows	Slatts	ridge fans	2.26	0.018047
SOW2	600	Sows	Slatts	ridge fans	2.26	0.042969
SOW3	288	Sows	Solid/Straw	nat/side	4.57	0.041707
SOW4	216	Sows	Solid/Straw	nat/side	4.57	0.031280
SOW5	360	Sows	Slatts	ridge fans	2.26	0.025781
SOW6	160	Sows	Solid/Straw	nat/side	4.57	0.023170
SOW7	140	Sows	Solid/Straw	nat/side	4.57	0.020274
FAR1	125	Farrowers	Slatts	ridge fans	2.8	0.011091
FAR2	120	Farrowers	Slatts	ridge fans	2.8	0.010647
FAR3	150	Farrowers	Slatts	ridge fans	2.8	0.013309
FAR4	98	Farrowers	Slatts	ridge fans	2.8	0.008695
SERV	252	Sows	Slatts	nat/side	2.26	0.018047
	6	Boars			5.72	0.001088

Table 2c Details of middens and lagoon emission rates – Scenario 1 & 2

c	Area (m2)	Tonnage			Emission Factor (kg-NH3/y)	Emission Rate (g/s)
MID1	200	100			1.49	0.004722
MID2	200	100			1.49	0.004722
LAG	2700				0.56	0.047912

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

The Atmospheric Dispersion Modelling System (ADMS) ADMS 5 is a new generation Gaussian plume air dispersion model, which means that the atmospheric boundary layer properties are characterised by two parameters; the boundary layer depth, and the Monin-Obukhov length rather than in terms of the single parameter Pasquill-Gifford class.

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

ADMS has a number of model options including: dry and wet deposition; NO_x chemistry; impacts of hills, variable roughness, buildings and coastlines; puffs; fluctuations; odours; radioactivity decay (and γ-ray dose); condensed plume visibility; time varying sources and inclusion of background concentrations.

ADMS has an in-built meteorological pre-processor that allows flexible input of meteorological data both standard and more specialist. Hourly sequential and statistical data can be processed, and all input and output meteorological variables are written to a file after processing.

The user defines the pollutant, the averaging time (which may be an annual average or a shorter period), which percentiles and exceedance values to calculate, whether a rolling average is required or not and the output units. The output options are designed to be flexible to cater for the variety of air quality limits, which can vary from country to country, and are subject to revision.

4.1 Meteorological data

Computer modelling of dispersion requires hourly sequential meteorological data and to provide robust statistics the record should be of a suitable length; preferably four years or longer.

The meteorological data used in this study is obtained from assimilation and short term forecast fields of the Numerical Weather Prediction (NWP) system known as the Global Forecast System (GFS)[1].

Prior to April 2019 the GFS was a spectral model, post April 2019 the physics are discrete. The physics/dynamics model has a resolution or had an equivalent resolution of approximately 7 km over the UK; terrain is understood to be resolved at a resolution of approximately 2 km, with sub-7 km terrain effects parameterised. Site specific data may be extrapolated from nearby archive grid points or a most representative grid point chosen. The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR[2]). The use of NWP data has advantages over traditional meteorological records because:

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

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

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

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 2a. Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and because terrain data is included in the modelling, the raw GFS wind speeds and directions will be modified. The terrain and roughness length modified wind rose for the farm is shown in Figure 2b. Elsewhere in the modelling domain, the modified wind roses may differ markedly. The resolution of the wind field in terrain runs is approximately 30 m. Please also 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].

As discussed above, the use of NWP data (suitably processed and quality controlled), removes the usual uncertainties and gross errors associated with using "representative" data from a remote meteorological station.

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. GFS derived data, for 53.668 N, 0.089 E, 2020 - 2023

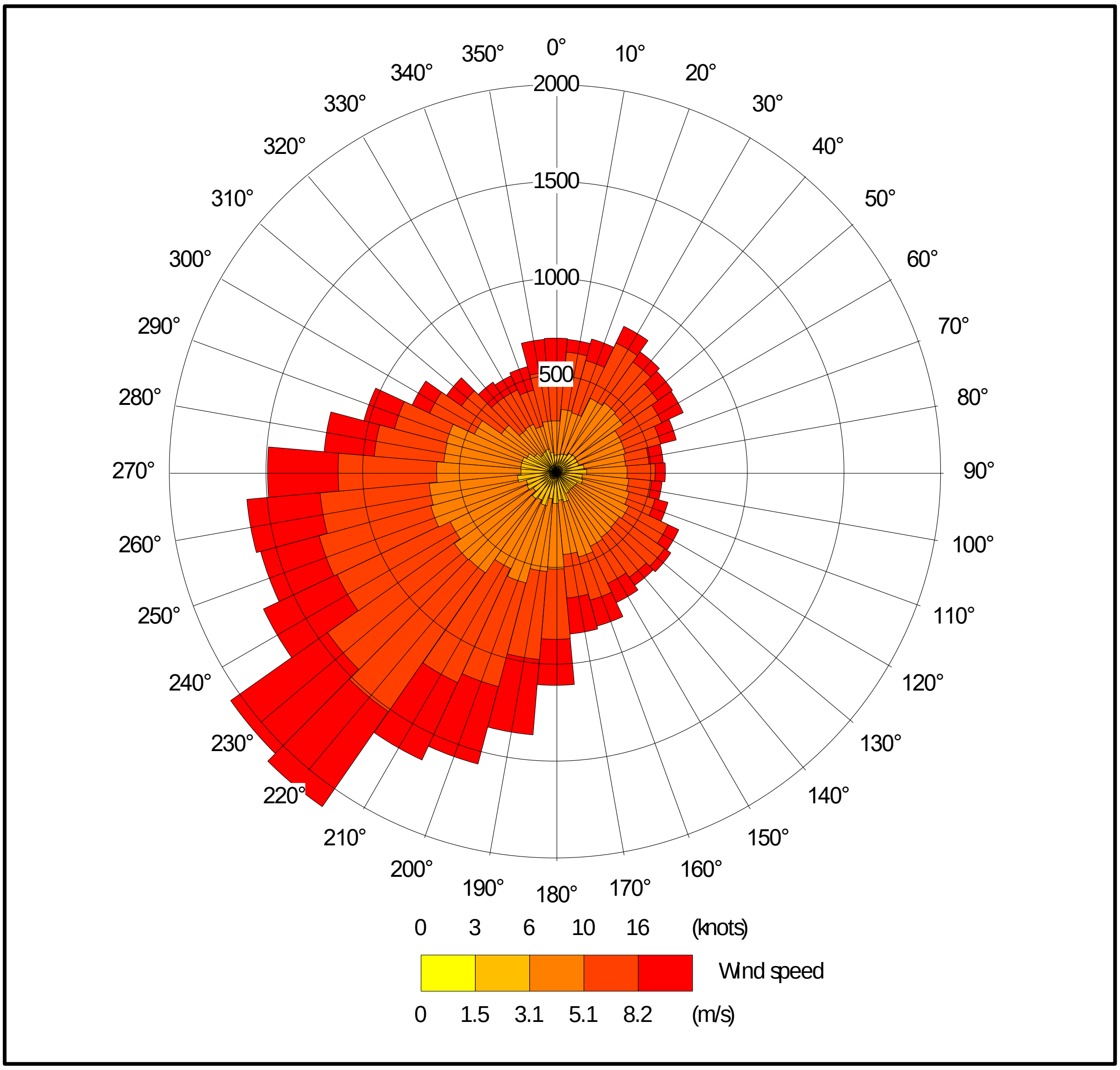
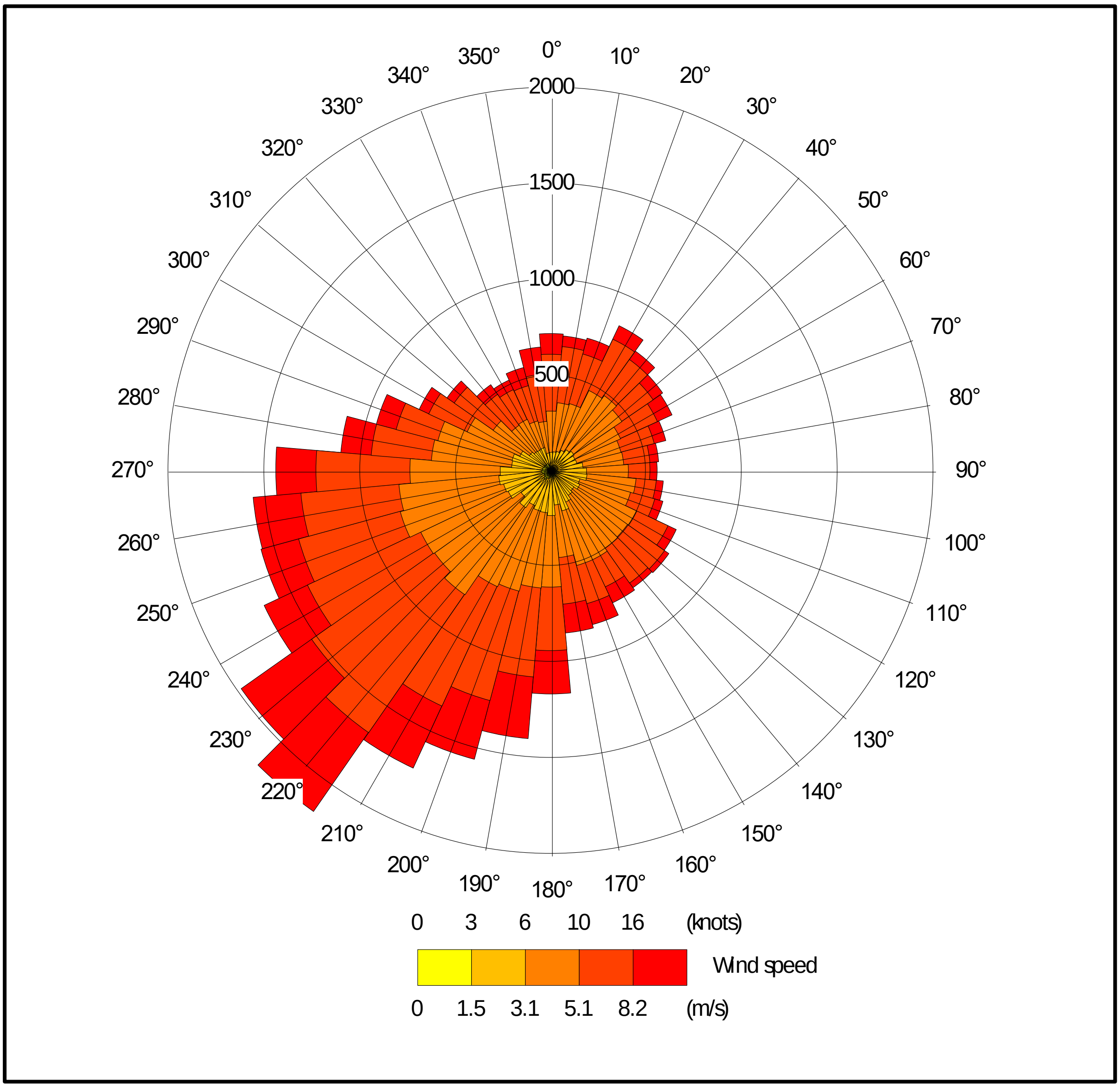


Figure 2b. The FLOWSTAR derived wind rose for NGR 538000, 421050, 2020 - 2023



4.2 Emission sources

Emissions from hosing ventilated by uncapped high speed ridge mounted fans are represented by point sources within ADMS. House that are naturally ventilated, or ventilated by side fans are represented by volume sources within ADMS; middens and the lagoon are also represented by volume sources, Details of the point and volume source parameters are shown in Tables 3a and 3b, respectively. The positions of the point and volume sources may be seen in Figures 3a (Scenario 1) and 3b (Scenario 2) (marked by green circles and red shaded rectangles, respectively).

Table 3a. Point source parameters - using Environment Agency published standard emission factors

Source ID (Scenario)	Height (m)	Diameter (m)	Efflux velocity m/s)	Emission temperature (˚C)	Emission rate per source (g-NH_3/s)
FIN2A 1, 2 &3 (1)	5.0	0.8	11.0	21.0	0.039420
FIN1 1, 2 &3 (1)	5.0	0.8	11.0	21.0	0.045793
SOW4 1, 2 &3 (1)	7.0	0.8	11.0	21.0	0.010017
FAR1 1, 2 &3 (1)	6.0	0.8	11.0	21.0	0.003697
FAR2 1, 2 &3 (1)	5.0	0.8	11.0	21.0	0.003549
NURSE 1, 2 &3 (1)	5.0	0.8	11.0	21.0	0.020106
FIN2B 1, 2 &3 (1)	5.0	0.8	11.0	21.0	0.026280
SOW1 1, 2 &3 (2)	5.0	0.8	11.0	21.0	0.006016
SOW2 1, 2 &3 (2)	5.0	0.8	11.0	21.0	0.014323
SOW5 1, 2 &3 (2)	7.0	0.8	11.0	21.0	0.008594
FAR1 1, 2 &3 (2)	6.0	0.8	11.0	21.0	0.003697
FAR2 1, 2 &3 (2)	5.0	0.8	11.0	21.0	0.003549
FAR3 1, 2 &3 (2)	5.0	0.8	11.0	21.0	0.004436
FAR4 1, 2 &3 (2)	5.0	0.8	11.0	21.0	0.002898

Table 3b. Volume source parameters - using Environment Agency published standard emission factors

Source ID (Scenario)	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate (g-NH_3/s)
SOW2 (1)	37.6	19.9	3.0	1.0	Ambient	0.036204
SOW1 (1)	27.4	46.7	3.0	1.0	Ambient	0.015206
MID1 (1)	10.0	20.0	2.0	1.5	Ambient	0.004722
MID2 (1)	10.0	20.0	2.0	1.5	Ambient	0.004722
LAG (1)	36.0	75.0	1.0	0.0	Ambient	0.047912
SOW3 (1)	36.7	19.9	2.0	1.5	Ambient	0.036204
WEAN (1)	22.0	7.0	2.0	1.5	Ambient	0.008936
SOW4 (2)	37.6	19.9	3.0	1.0	Ambient	0.036204
SOW6 (2)	14.0	32.2	3.0	1.0	Ambient	0.015206
SOW7 (2)	27.4	46.7	2.0	1.5	Ambient	0.004722
SERV (2)	19.7	45.3	2.0	1.5	Ambient	0.004722
MID1 (2)	10.0	20.0	1.0	1.5	Ambient	0.047912
MID2 (2)	10.0	20.0	2.0	1.5	Ambient	0.036204
LAG (2)	36.0	75.0	2.0	0.0	Ambient	0.008936

4.3 Modelled buildings

The structure of the buildings at the farm may affect the plumes from the point sources. Therefore, buildings are modelled within ADMS. The position of the modelled building may be seen in Figures 3a and 3b (marked by grey rectangles).

Figure 3a. The positions of modelled sources – Scenario 1

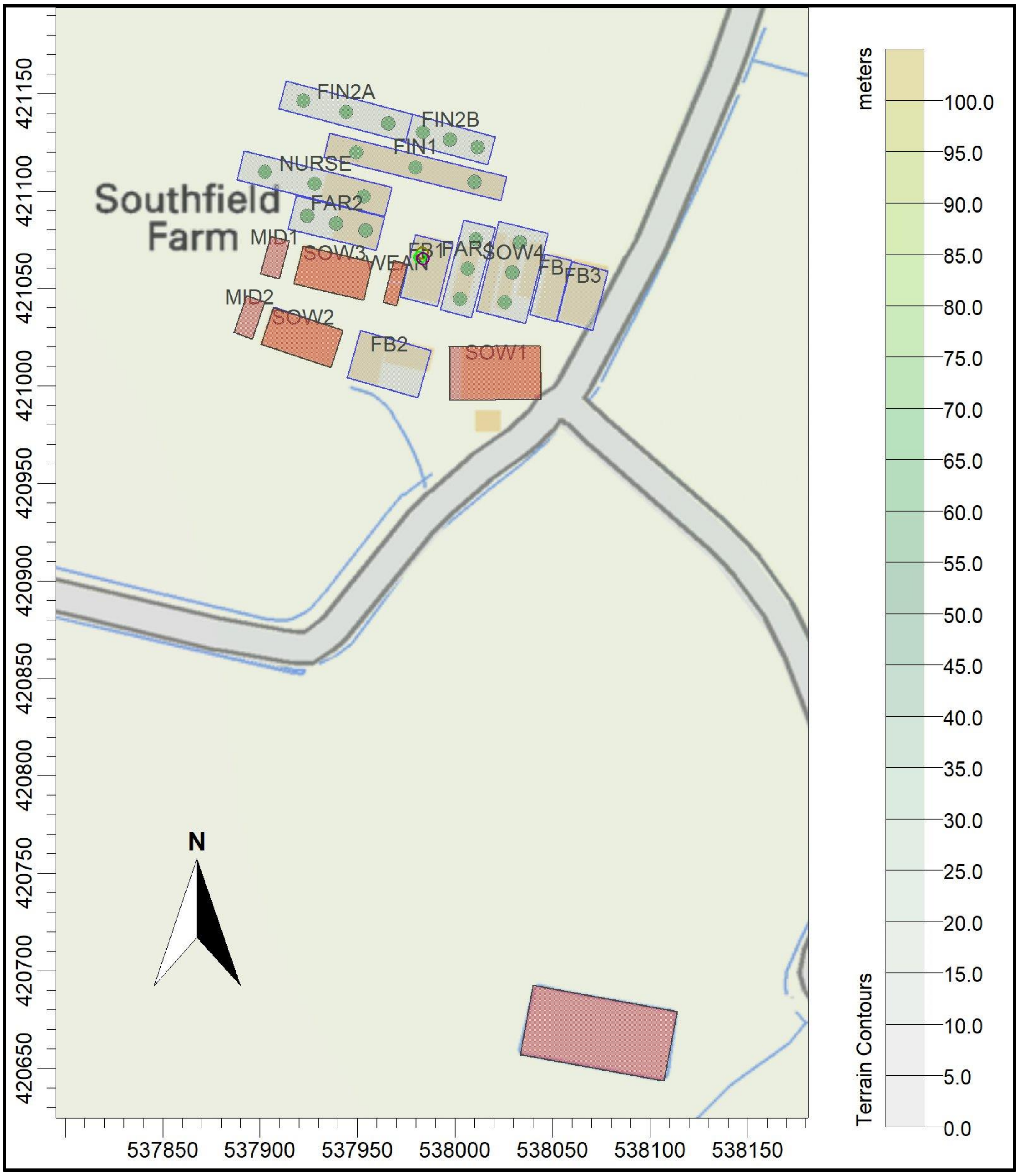
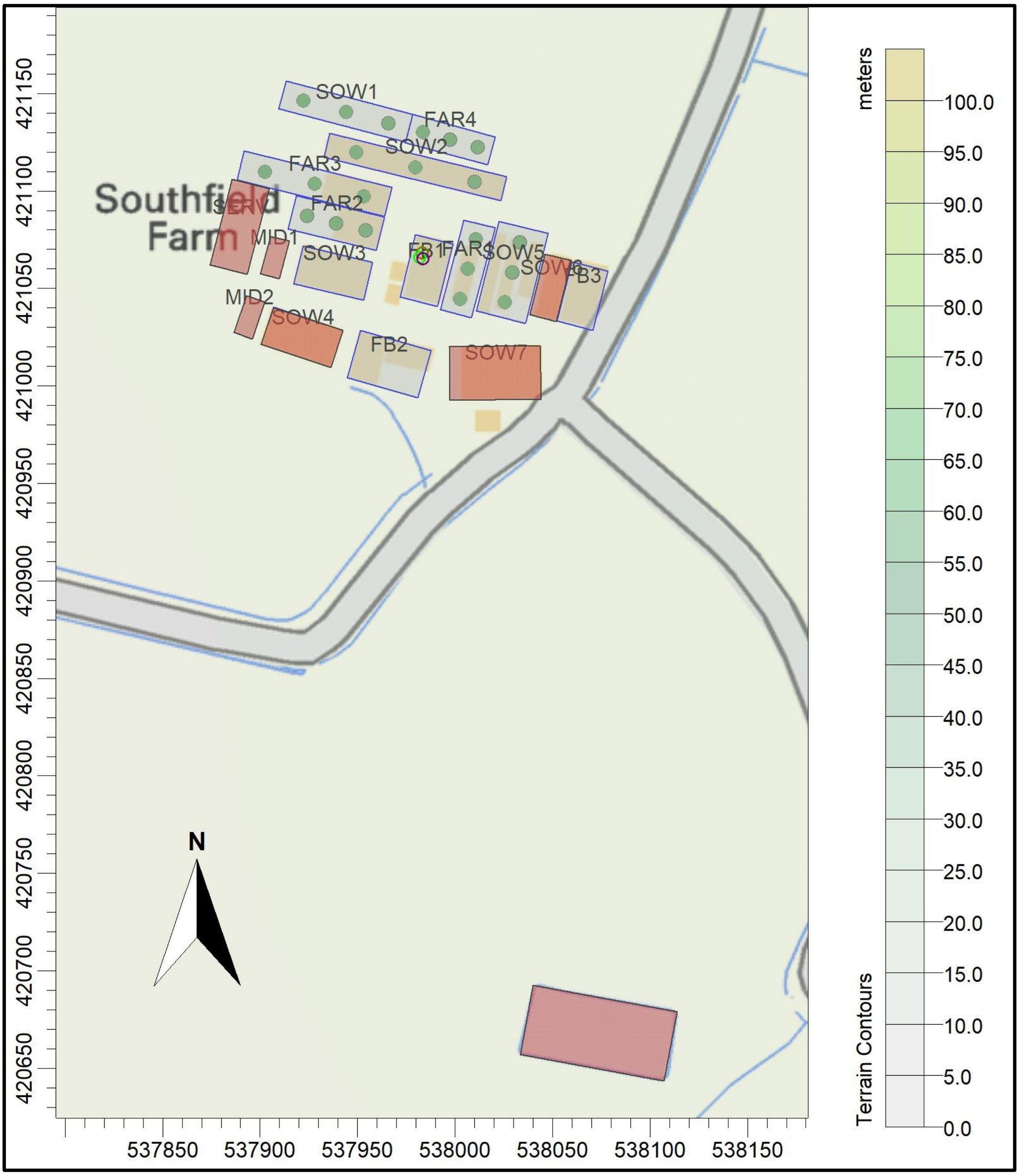


Figure 3b. The positions of modelled sources – Scenario 2



4.4 Discrete receptors

Thirty-two 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 individual grid receptors are defined at ground level within ADMS. The positions of the Cartesian grids may be seen in Figure 4 (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 23 km x 23 km domain has been resampled at 100 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 350 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 0.071 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 4. The discrete receptors and regular Cartesian grids

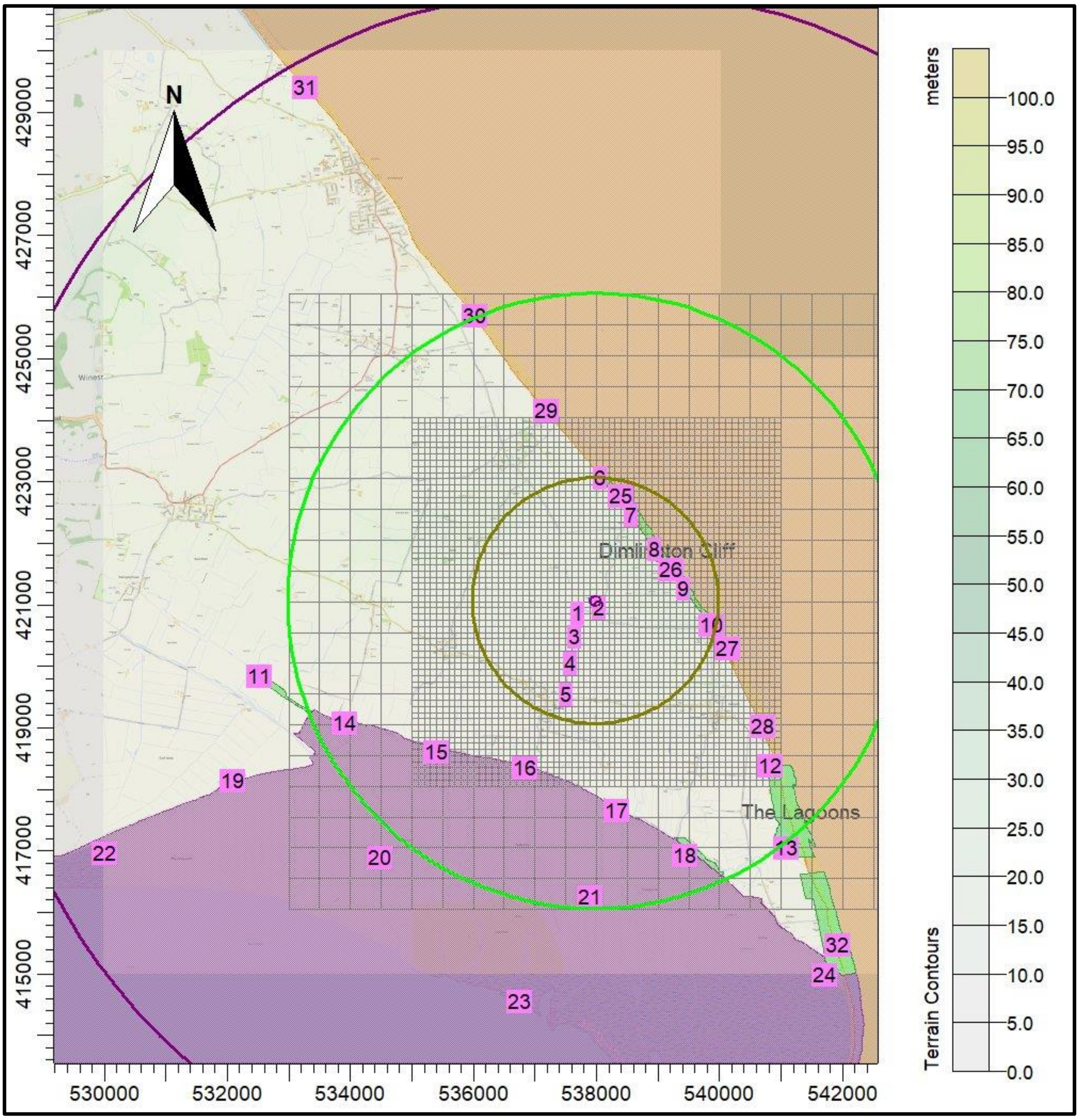
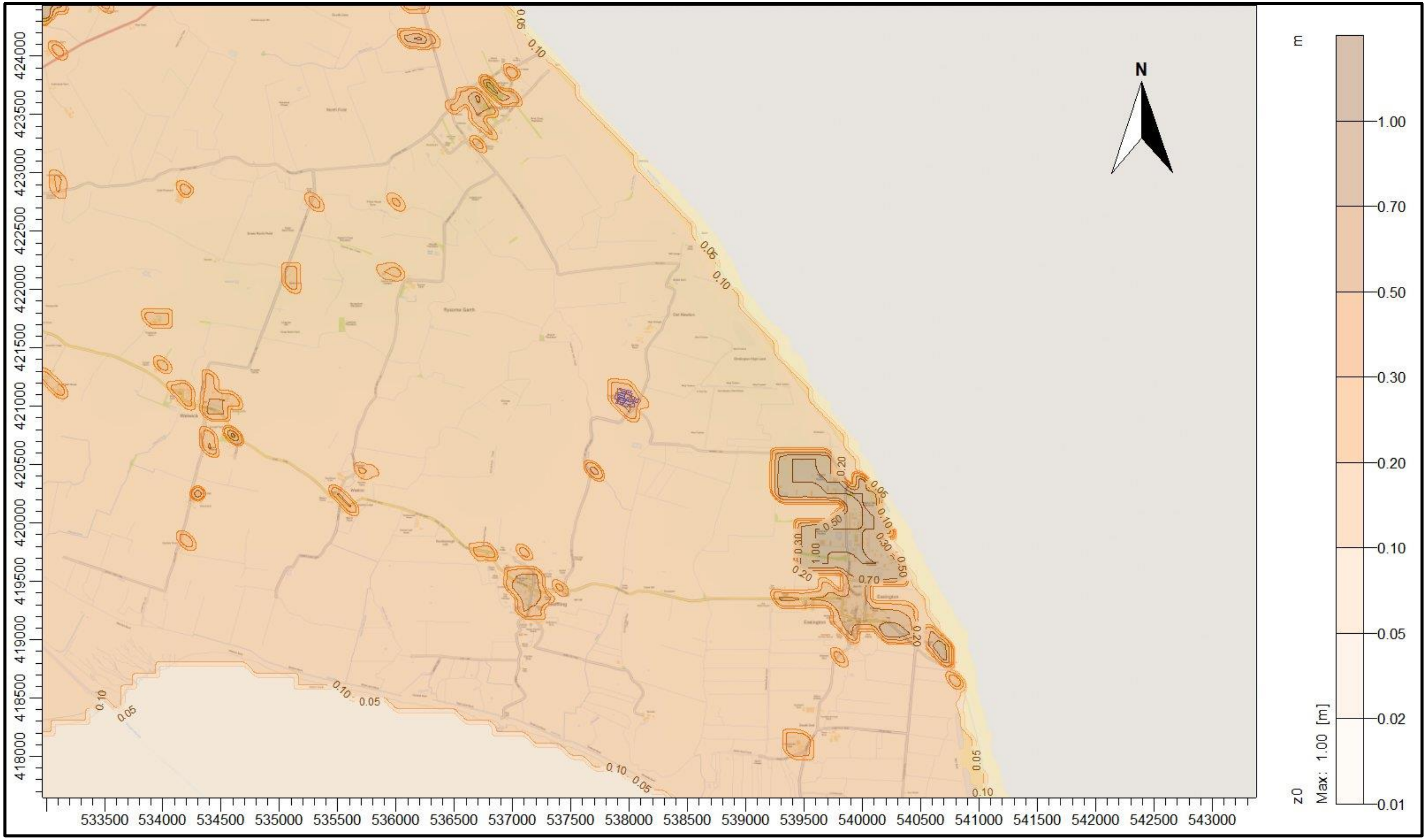


Figure 5. The spatially varying surface roughness field (central area)



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 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.

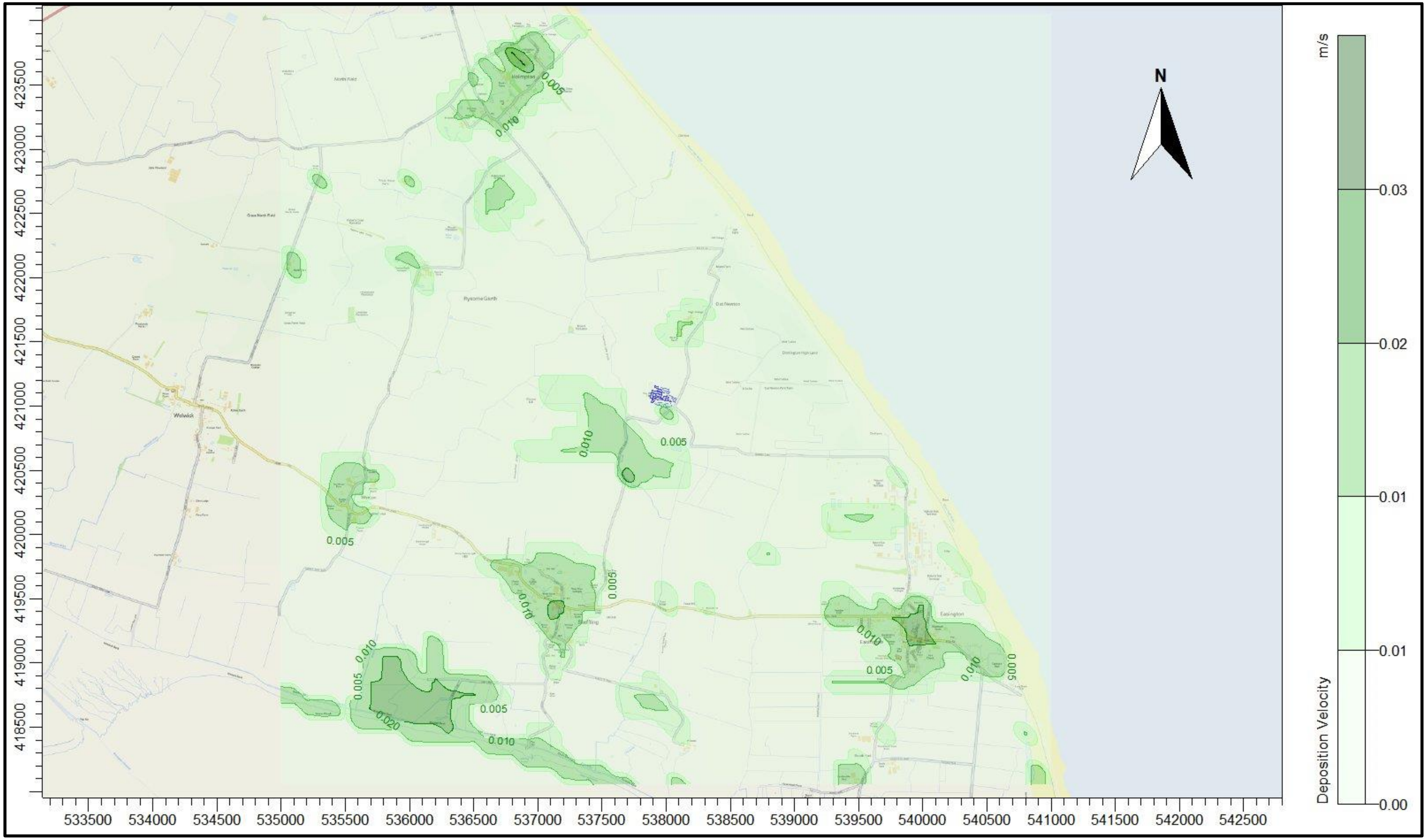
Table 4. Deposition velocities

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.

A contour plot of the spatially varying deposition field 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 run a total of eight times, once for each year in the meteorological record and for both scenarios, in the following modes:

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

The primary purpose of these runs is to determine if calms have an appreciable effect at closer receptors. 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.

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

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m^3)	
				GFS No Calms No Terrain	GFS Calms No Terrain
1	537676	420880	Roadside Verge LWS	1.163	1.418
2	538031	420964	Roadside Verge LWS	8.588	9.346
3	537631	420506	Roadside Verge LWS	0.574	0.642
4	537566	420064	Roadside Verge LWS	0.228	0.270
5	537493	419568	Roadside Verge LWS	0.116	0.140
6	538047	423085	Dimlington Cliff SSSI	0.090	0.104
7	538546	422481	Dimlington Cliff SSSI	0.177	0.193
8	538926	421924	Dimlington Cliff SSSI	0.248	0.273
9	539399	421281	Dimlington Cliff SSSI	0.203	0.229
10	539845	420690	Dimlington Cliff SSSI	0.148	0.157
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	0.014	0.017
12	540792	418407	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.033	0.039
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.020	0.025
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	0.017	0.020
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	0.025	0.032
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	0.040	0.043
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	0.035	0.042
18	539396	416950	Humber Estuary SAC/SPA/Ramsar/SSSI	0.022	0.026
19	532050	418166	Humber Estuary SAC/SPA/Ramsar/SSSI	0.010	0.011
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	0.013	0.015
21	537862	416273	Humber Estuary SAC/SPA/Ramsar/SSSI	0.020	0.025
22	529966	416978	Humber Estuary SAC/SPA/Ramsar/SSSI	0.006	0.007
23	536717	414564	Humber Estuary SAC/SPA/Ramsar/SSSI	0.011	0.014
24	541681	415006	Humber Estuary SAC/SPA/Ramsar/SSSI	0.011	0.013
25	538364	422785	Greater Wash SPA	0.125	0.139
26	539184	421599	Greater Wash SPA	0.224	0.255
27	540093	420315	Greater Wash SPA	0.124	0.130
28	540669	419035	Greater Wash SPA	0.046	0.052
29	537156	424178	Greater Wash SPA	0.040	0.046
30	535985	425720	Greater Wash SPA	0.020	0.023
31	533241	429422	Greater Wash SPA	0.008	0.009
32	541879	415481	Greater Wash SPA/The Lagoons SSSI	0.012	0.015

5.2 Detailed deposition modelling

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

Modelling was carried out for each of the four years in the meteorological record. The predicted process contributions to the maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Tables 6a (Scenario 1) and 6b (Scenario 2). Calms corrections are not applied.

In the Tables, 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 (20% for a SAC/SPA/Ramsar Site, 50% for a SSSI and 100% for a non-statutory site) are coloured red. Percentages that are in the range between the Environment Agency's upper threshold and lower threshold of the Critical Level or Critical Load for the site (4% and 20% for a SAC/SPA/Ramsar Site, 20% and 50% for a SSSI and 100% and 100% for a non-statutory site) are coloured blue. Additionally, percentages 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 from the proposed pig rearing houses to ground level maximum annual mean ammonia concentrations and nitrogen deposition rates are shown in Figure 7a and Figure 7b (Scenario 1) and 8a and Figure 8b (Scenario 2).

Table 6a. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors - Scenario 1

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	537676	420880	Roadside Verge LWS	0.02	3.0	10.0	1.120	37.3	5.82	58.2
2	538031	420964	Roadside Verge LWS	0.02	3.0	10.0	7.546	**251.5**	39.19	**391.9**
3	537631	420506	Roadside Verge LWS	0.02	3.0	10.0	0.462	15.4	2.40	24.0
4	537566	420064	Roadside Verge LWS	0.02	3.0	10.0	0.194	6.5	1.01	10.1
5	537493	419568	Roadside Verge LWS	0.02	3.0	10.0	0.103	3.4	0.53	5.3
6	538047	423085	Dimlington Cliff SSSI	0.02	n/a	n/a	0.108	-	0.56	-
7	538546	422481	Dimlington Cliff SSSI	0.02	n/a	n/a	0.224	-	1.17	-
8	538926	421924	Dimlington Cliff SSSI	0.02	n/a	n/a	0.364	-	1.89	-
9	539399	421281	Dimlington Cliff SSSI	0.02	n/a	n/a	0.252	-	1.31	-
10	539845	420690	Dimlington Cliff SSSI	0.02	n/a	n/a	0.122	-	0.63	-
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	0.02	3.0	5.0	0.010	0.3	0.05	1.0
12	540792	418407	The Lagoons SSSI	0.02	1.0	5.0	0.022	**2.2**	0.12	**2.3**
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.02	1.0	10.0	0.014	1.4	0.07	0.7
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	5.0	0.013	0.4	0.07	1.4
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.020	0.7	0.10	1.0
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.030	1.0	0.16	1.6
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.029	1.0	0.15	1.5
18	539396	416950	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.015	0.5	0.08	0.8
19	532050	418166	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.007	0.2	0.04	0.4
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.012	0.4	0.06	0.6
21	537862	416273	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.018	0.6	0.09	0.9
22	529966	416978	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.004	0.1	0.02	0.2
23	536717	414564	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.011	0.4	0.06	0.6
24	541681	415006	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.008	0.3	0.04	0.4
25	538364	422785	Greater Wash SPA	0.02	n/a	n/a	0.156	-	0.81	-
26	539184	421599	Greater Wash SPA	0.02	n/a	n/a	0.304	-	1.58	-
27	540093	420315	Greater Wash SPA	0.02	n/a	n/a	0.086	-	0.45	-
28	540669	419035	Greater Wash SPA	0.02	n/a	n/a	0.031	-	0.16	-
29	537156	424178	Greater Wash SPA	0.02	n/a	n/a	0.042	-	0.22	-
30	535985	425720	Greater Wash SPA	0.02	n/a	n/a	0.018	-	0.09	-
31	533241	429422	Greater Wash SPA	0.02	n/a	n/a	0.006	-	0.03	-
32	541879	415481	Greater Wash SPA/The Lagoons SSSI	0.02	1.0	5.0	0.009	0.9	0.04	0.9

Table 6b. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors - Scenario 2 (using standard published emission factors)

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	537676	420880	Roadside Verge LWS	0.02	3.0	10.0	1.133	37.8	5.88	58.8
2	538031	420964	Roadside Verge LWS	0.02	3.0	10.0	6.654	**221.8**	34.56	**345.6**
3	537631	420506	Roadside Verge LWS	0.02	3.0	10.0	0.468	15.6	2.43	24.3
4	537566	420064	Roadside Verge LWS	0.02	3.0	10.0	0.185	6.2	0.96	9.6
5	537493	419568	Roadside Verge LWS	0.02	3.0	10.0	0.085	2.8	0.44	4.4
6	538047	423085	Dimlington Cliff SSSI	0.02	n/a	n/a	0.109	-	0.57	-
7	538546	422481	Dimlington Cliff SSSI	0.02	n/a	n/a	0.228	-	1.18	-
8	538926	421924	Dimlington Cliff SSSI	0.02	n/a	n/a	0.370	-	1.92	-
9	539399	421281	Dimlington Cliff SSSI	0.02	n/a	n/a	0.249	-	1.29	-
10	539845	420690	Dimlington Cliff SSSI	0.02	n/a	n/a	0.124	-	0.64	-
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	0.02	3.0	5.0	0.009	0.3	0.04	0.9
12	540792	418407	The Lagoons SSSI	0.02	1.0	5.0	0.019	**1.9**	0.10	**1.9**
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.02	1.0	10.0	0.011	1.1	0.06	0.6
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	5.0	0.013	0.4	0.07	1.4
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.020	0.7	0.10	1.0
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.030	1.0	0.16	1.6
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.019	0.6	0.10	1.0
18	539396	416950	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.013	0.4	0.07	0.7
19	532050	418166	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.007	0.2	0.04	0.4
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.013	0.4	0.07	0.7
21	537862	416273	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.011	0.4	0.06	0.6
22	529966	416978	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.004	0.1	0.02	0.2
23	536717	414564	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.007	0.2	0.04	0.4
24	541681	415006	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.007	0.2	0.03	0.3
25	538364	422785	Greater Wash SPA	0.02	n/a	n/a	0.159	-	0.83	-
26	539184	421599	Greater Wash SPA	0.02	n/a	n/a	0.296	-	1.54	-
27	540093	420315	Greater Wash SPA	0.02	n/a	n/a	0.088	-	0.46	-
28	540669	419035	Greater Wash SPA	0.02	n/a	n/a	0.029	-	0.15	-
29	537156	424178	Greater Wash SPA	0.02	n/a	n/a	0.043	-	0.22	-
30	535985	425720	Greater Wash SPA	0.02	n/a	n/a	0.018	-	0.10	-
31	533241	429422	Greater Wash SPA	0.02	n/a	n/a	0.006	-	0.03	-
32	541879	415481	Greater Wash SPA/The Lagoons SSSI	0.02	1.0	5.0	0.007	0.7	0.04	0.7

Table 6c. Annual ammonia concentration and nitrogen deposition rate at the discrete receptors - Scenario 1 (using the EA mandated emission factor for finishers)

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (μg/m³)	Critical Load (kg/ha)	Process Contribution (μg/m³)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	537676	420880	Roadside Verge LWS	0.02	3.0	10.0	0.967	32.2	5.02	50.2
2	538031	420964	Roadside Verge LWS	0.02	3.0	10.0	6.930	**231.0**	36.00	**360.0**
3	537631	420506	Roadside Verge LWS	0.02	3.0	10.0	0.396	13.2	2.06	20.6
4	537566	420064	Roadside Verge LWS	0.02	3.0	10.0	0.164	5.5	0.85	8.5
5	537493	419568	Roadside Verge LWS	0.02	3.0	10.0	0.085	2.8	0.44	4.4
6	538047	423085	Dimlington Cliff SSSI	0.02	n/a	n/a	0.087	-	0.45	-
7	538546	422481	Dimlington Cliff SSSI	0.02	n/a	n/a	0.182	-	0.94	-
8	538926	421924	Dimlington Cliff SSSI	0.02	n/a	n/a	0.295	-	1.53	-
9	539399	421281	Dimlington Cliff SSSI	0.02	n/a	n/a	0.204	-	1.06	-
10	539845	420690	Dimlington Cliff SSSI	0.02	n/a	n/a	0.101	-	0.52	-
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	0.02	3.0	5.0	0.008	0.3	0.04	0.8
12	540792	418407	The Lagoons SSSI	0.02	1.0	5.0	0.018	**1.8**	0.09	**1.9**
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.02	1.0	10.0	0.011	1.1	0.06	0.6
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	5.0	0.011	0.4	0.05	1.1
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.016	0.5	0.08	0.8
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.025	0.8	0.13	1.3
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.024	0.8	0.12	1.2
18	539396	416950	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.012	0.4	0.06	0.6
19	532050	418166	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.006	0.2	0.03	0.3
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.010	0.3	0.05	0.5
21	537862	416273	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.014	0.5	0.07	0.7
22	529966	416978	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.004	0.1	0.02	0.2
23	536717	414564	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.009	0.3	0.04	0.4
24	541681	415006	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.006	0.2	0.03	0.3
25	538364	422785	Greater Wash SPA	0.02	n/a	n/a	0.127	-	0.66	-
26	539184	421599	Greater Wash SPA	0.02	n/a	n/a	0.245	-	1.27	-
27	540093	420315	Greater Wash SPA	0.02	n/a	n/a	0.071	-	0.37	-
28	540669	419035	Greater Wash SPA	0.02	n/a	n/a	0.025	-	0.13	-
29	537156	424178	Greater Wash SPA	0.02	n/a	n/a	0.034	-	0.17	-
30	535985	425720	Greater Wash SPA	0.02	n/a	n/a	0.014	-	0.07	-
31	533241	429422	Greater Wash SPA	0.02	n/a	n/a	0.004	-	0.02	-
32	541879	415481	Greater Wash SPA/The Lagoons SSSI	0.02	1.0	5.0	0.007	0.7	0.04	0.7

Table 7. Predicted changes in ammonia concentration and nitrogen deposition rate at the discrete receptors - Scenario 2 minus Scenario 1

Receptor number	X(m)	Y(m)	Name	Site Parameters			Maximum annual ammonia concentration		Maximum annual nitrogen deposition rate	
				Deposition Velocity	Critical Level (µg/m^3)	Critical Load (kg/ha)	Process Contribution (µg/m^3)	%age of Critical Level	Process Contribution (kg/ha)	%age of Critical Load
1	537676	420880	Roadside Verge LWS	0.02	3.0	10.0	0.013	0.4	0.07	0.7
2	538031	420964	Roadside Verge LWS	0.02	3.0	10.0	-0.892	-29.7	-4.63	-46.3
3	537631	420506	Roadside Verge LWS	0.02	3.0	10.0	0.006	0.2	0.03	0.3
4	537566	420064	Roadside Verge LWS	0.02	3.0	10.0	-0.010	-0.3	-0.05	-0.5
5	537493	419568	Roadside Verge LWS	0.02	3.0	10.0	-0.018	-0.6	-0.09	-0.9
6	538047	423085	Dimlington Cliff SSSI	0.02	n/a	n/a	0.002	-	0.01	-
7	538546	422481	Dimlington Cliff SSSI	0.02	n/a	n/a	0.004	-	0.02	-
8	538926	421924	Dimlington Cliff SSSI	0.02	n/a	n/a	0.006	-	0.03	-
9	539399	421281	Dimlington Cliff SSSI	0.02	n/a	n/a	-0.003	-	-0.02	-
10	539845	420690	Dimlington Cliff SSSI	0.02	n/a	n/a	0.002	-	0.01	-
11	532482	419860	Humber Estuary SPA/Ramsar/SSSI	0.02	3.0	5.0	-0.001	0.0	-0.01	-0.1
12	540792	418407	The Lagoons SSSI	0.02	1.0	5.0	-0.004	-0.4	-0.02	-0.4
13	541050	417070	Humber Estuary SPA/Ramsar/The Lagoons SSSI	0.02	1.0	10.0	-0.003	-0.3	-0.02	-0.2
14	533877	419096	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	5.0	0.000	0.0	0.00	0.0
15	535371	418631	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.000	0.0	0.00	0.0
16	536800	418365	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.000	0.0	0.00	0.0
17	538294	417668	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	-0.010	-0.3	-0.05	-0.5
18	539396	416950	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	-0.002	-0.1	-0.01	-0.1
19	532050	418166	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.000	0.0	0.00	0.0
20	534442	416904	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.000	0.0	0.00	0.0
21	537862	416273	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	-0.007	-0.2	-0.04	-0.4
22	529966	416978	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	0.000	0.0	0.00	0.0
23	536717	414564	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	-0.004	-0.1	-0.02	-0.2
24	541681	415006	Humber Estuary SAC/SPA/Ramsar/SSSI	0.02	3.0	10.0	-0.001	0.0	-0.01	-0.1
25	538364	422785	Greater Wash SPA	0.02	n/a	n/a	0.003	-	0.01	-
26	539184	421599	Greater Wash SPA	0.02	n/a	n/a	-0.007	-	-0.04	-
27	540093	420315	Greater Wash SPA	0.02	n/a	n/a	0.001	-	0.01	-
28	540669	419035	Greater Wash SPA	0.02	n/a	n/a	-0.002	-	-0.01	-
29	537156	424178	Greater Wash SPA	0.02	n/a	n/a	0.001	-	0.00	-
30	535985	425720	Greater Wash SPA	0.02	n/a	n/a	0.000	-	0.00	-
31	533241	429422	Greater Wash SPA	0.02	n/a	n/a	0.000	-	0.00	-
32	541879	415481	Greater Wash SPA/The Lagoons SSSI	0.02	1.0	5.0	-0.002	-0.2	-0.01	-0.2

Figure 7a. Maximum annual mean ammonia concentration - Scenario 1

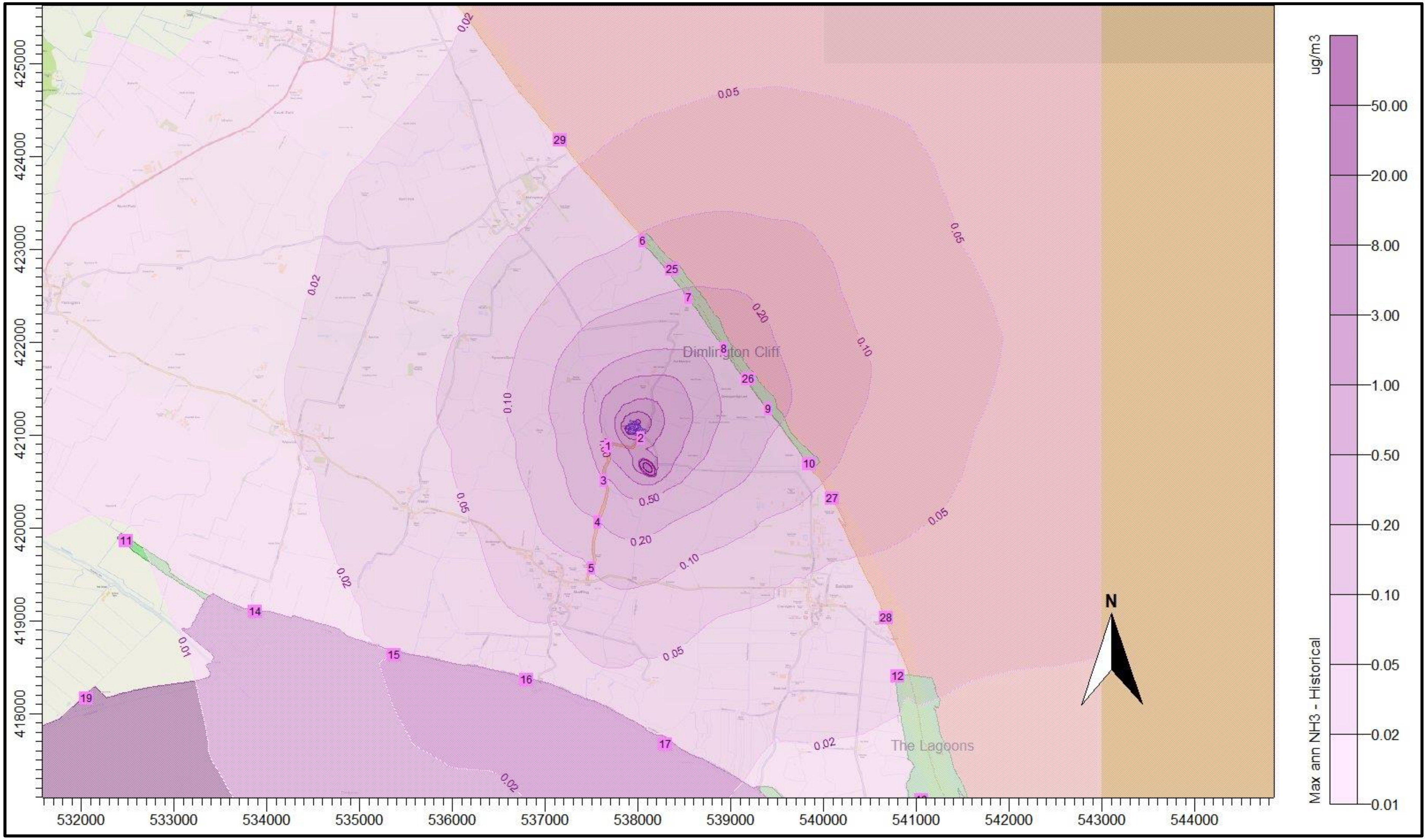


Figure 7b. Maximum annual nitrogen deposition rate - Scenario 1

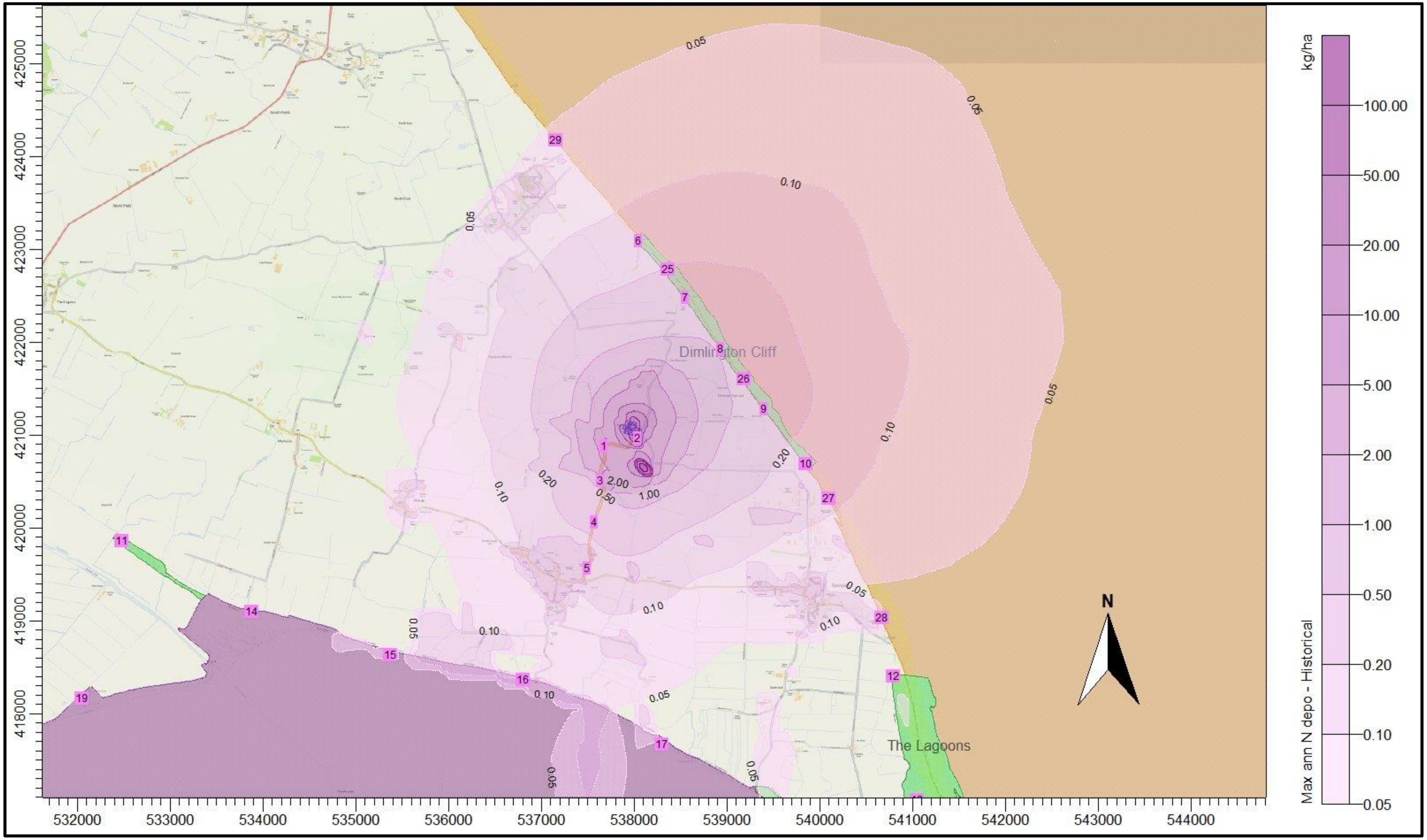


Figure 8a. Maximum annual mean ammonia concentration - Scenario 2

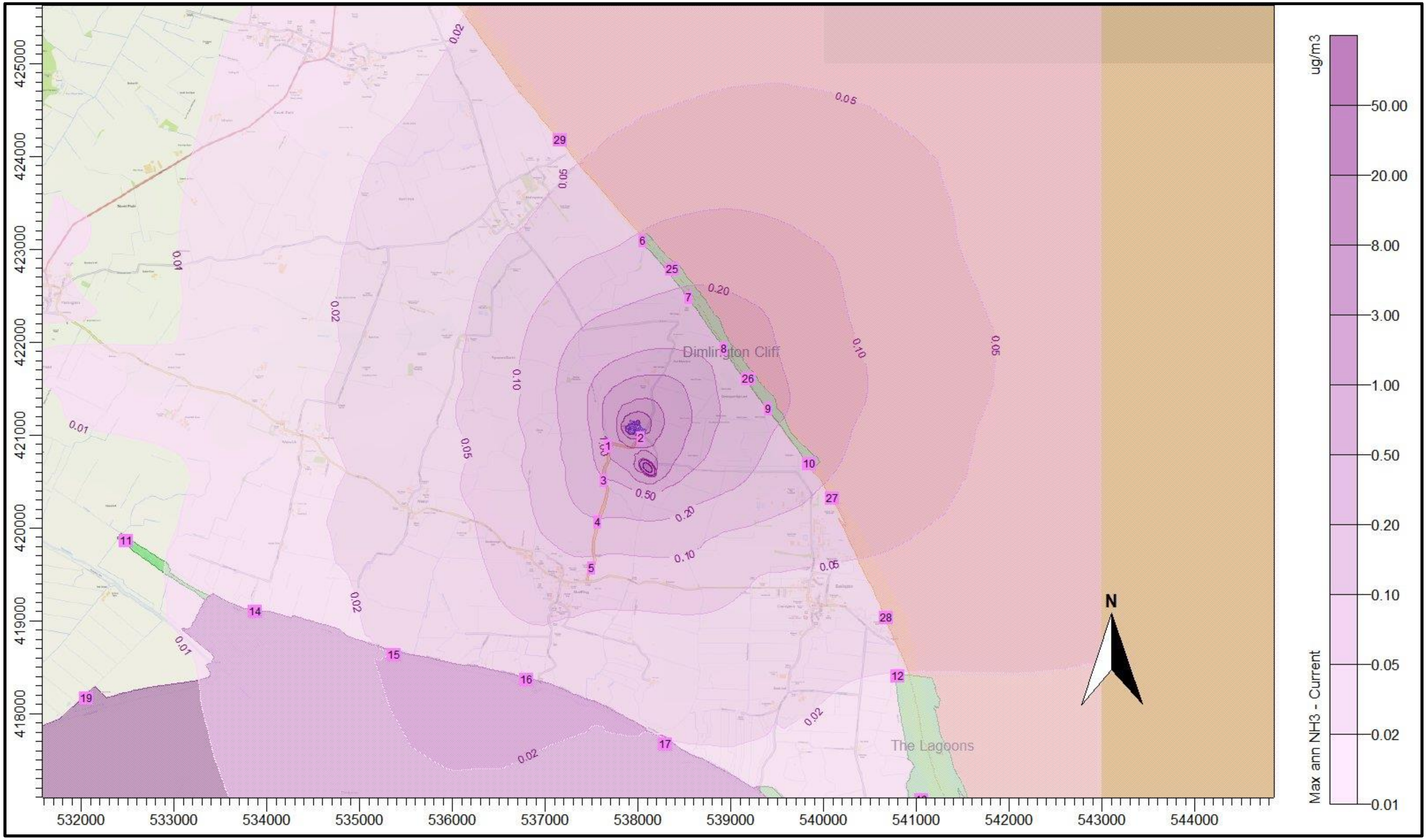
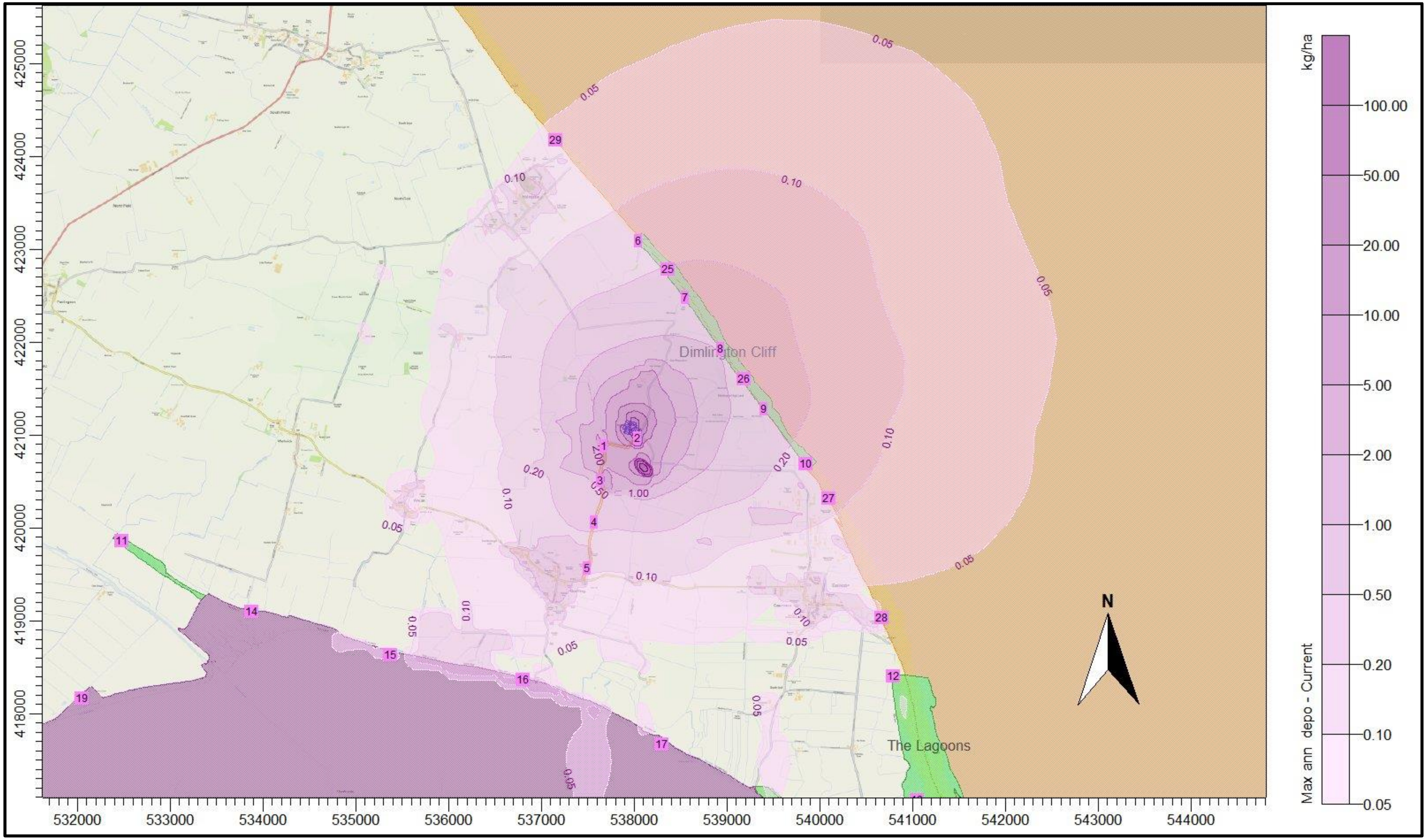


Figure 8b. Maximum annual nitrogen deposition rate - Scenario 2



6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mrs. Lizzie Bentley of Yorkshire Farmers Livestock Marketing Ltd., on behalf of Cattle (Holderness) Ltd., to use computer modelling to assess the impact of ammonia emissions from the piggeries at Southfield Pig Farm, Out Newton, Withernsea, East Riding of Yorkshire. HU19 2RE.

Ammonia emission rates from the pig rearing buildings have been assessed and quantified based upon Environment Agency emission factors from the Pre-application screening reports. The ammonia emission rates have then been used as inputs to an atmospheric dispersion and deposition model which calculates ammonia exposure levels and nitrogen and acid deposition rates in the surrounding area.

The modelling predicts that:

- The process contribution to ammonia concentrations and nitrogen deposition rates over northern parts of the roadside verge LWS is in excess of the Environment Agency's lower threshold percentage (100% for non-statutory sites) of the Critical Level and Critical Load under both scenarios. In Scenario 2, the extent and magnitude of the exceedances are very similar, or reduced from Scenario 1.

- The process contribution to ammonia concentrations and nitrogen deposition rates at all statutory wildlife considered is below the Environment Agency's lower threshold percentage of the relevant Critical Level and the Critical Load for the site (4% for internationally designated sites and 20% for a SSSI).

- The process contribution to ammonia concentrations and nitrogen deposition rates over northern parts of The Lagoons SSSI is in excess of 1% of the Critical Level and Load under both scenarios. In Scenario 2, the extent and magnitude of the exceedances are very similar Scenario 1.

7. References

Cambridge Environmental Research Consultants (CERC) (website).

Environment Agency H1 Risk Assessment (website).

Steven R Hanna, & Biswanath Chowdhury. Minimum turbulence assumptions and u* and L estimation for dispersion models during low-wind stable conditions.

Frederik Schrader and Christian Brümmer. Land Use Specific Ammonia Deposition Velocities: a Review of Recent Studies (2004–2013).

M. A. Sutton *et al*. Measurement and modelling of ammonia exchange over arable croplands.

United Nations Economic Commission for Europe (UNECE) (website).

UK Air Pollution Information System (APIS) (website).