A Report on the Modelling of the Dispersion and Deposition of Ammonia from the Existing and Proposed Broiler Chicken Rearing Houses at Thoresby Bridge Farm, near North Cotes in Lincolnshire

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1. Introduction

AS Modelling & Data Ltd. has been instructed by Mr. Ian Pick of Ian Pick Associates Ltd., on behalf of Chesterfield Poultry Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed broiler chicken rearing houses at Thoresby Bridge Farm, North Cotes, East Lindsay in Lincolnshire. DN36 5TY.

Ammonia emission rates from the existing and proposed poultry rearing 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

The site of the broiler chicken rearing houses at Thoresby Bridge Farm is in a rural area on the Lincolnshire coastal plain; a low lying area of arable land which is drained by narrow dykes. The site is at an altitude of around 2 m with the North Sea coast approximately 5 km to the east.

Currently, there are five naturally ventilated poultry houses which provide accommodation for up to 68,300 broiler chickens. The birds are reared from day old chicks to around 38 days old, with approximately 7.5 crops per annum.

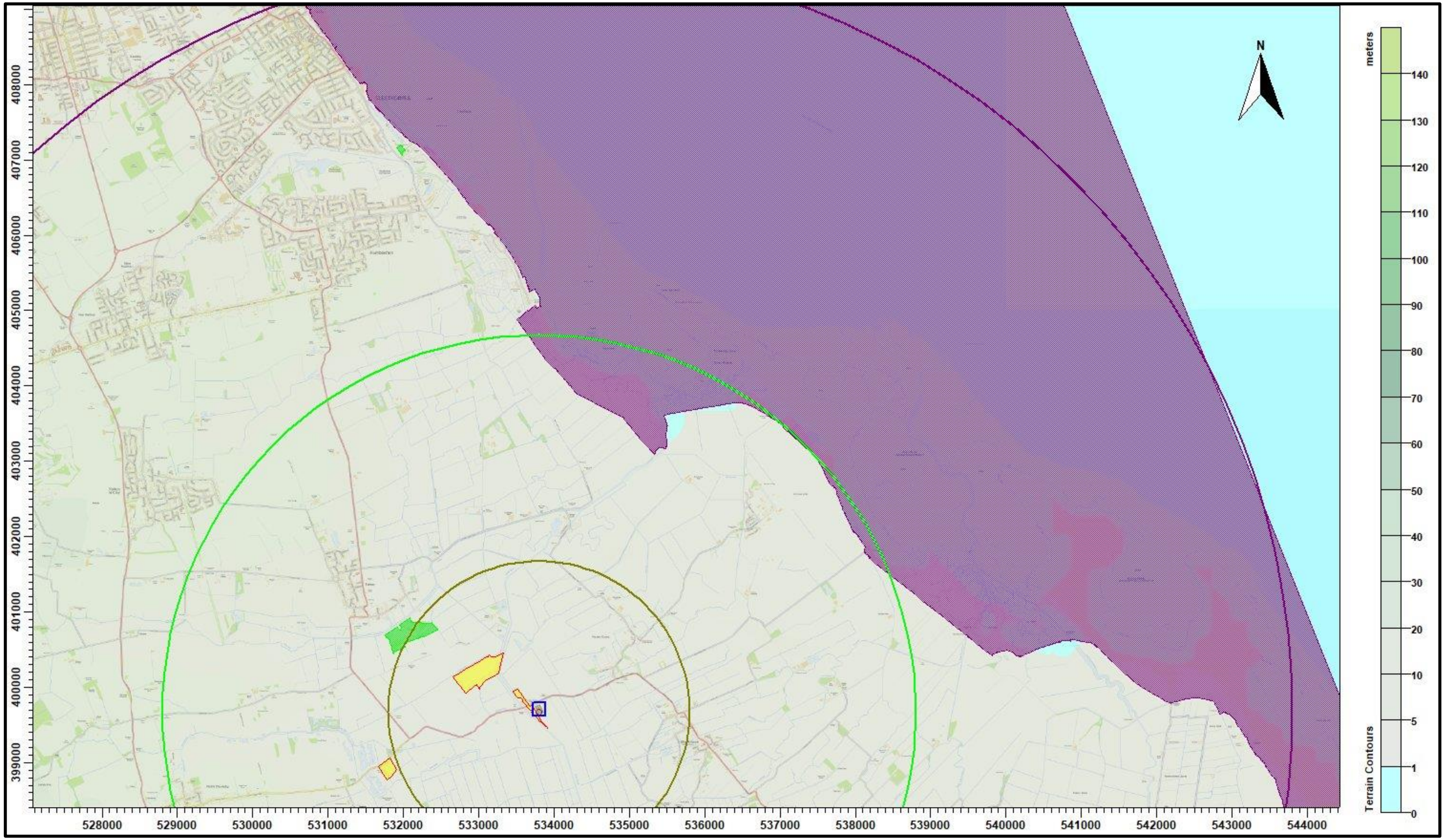
Under the proposals, these poultry houses would be replaced by two new poultry houses which would provide accommodation for up to 114,000 broiler chickens. The birds would be reared from day old chicks to around 38 days old, with approximately 7.5 crops per annum. These proposed poultry houses would be ventilated by high speed ridge fans, each with a short chimney and there would be gable end fans to provide supplementary ventilation during periods of hot weather.

There are four areas designated as Local Wildlife Sites (LWSs) within, or close to, 2 km (the normal screening distance for non-statutory sites) of the poultry houses at Thoresby Bridge Farm. There is one area designated as a Site of Special Scientific Interest (SSSI) within 5 km (the normal screening distance for SSSIs) of the farm, namely Tetney Blow Wells SSSI. Beyond this, there is another SSSI, which is also designated as a Special Area of Conservation (SAC), a Special Protection Area (SPA) and a Ramsar site, within 10 km (the normal screening distance for an internationally designated site) of the farm, namely Humber Estuary SSSI/SAC/SPA/Ramsar. Some further details of the SSSIs are provided below:

- **Tetney Blow Wells SSSI** - Approximately 1.5 km to the north-west. Reedbeds and base-rich fen and swamp vegetation fed by four artesian springs (blow wells). There are areas of willow Salix spp. and scrub as well and there is some neutral grassland.
- **Humber Estuary SSSI/SAC/SPA/Ramsar site** - Approximately 4.8 km to the east-north-east (closest). A nationally important wildlife site with a series of nationally important habitats. The area close to Thoresby Bridge Farm comprises saline lagoons, intertidal areas and beach areas that are home to the grey seal Halichoerus grypus. The Humber Estuary is an important site for these mammals along with wintering, breeding and passing birds, fish and invertebrates.

A map of the surrounding area showing the location of the poultry houses at Thoresby Bridge Farm, the LWSs, the SSSI and the SSSI/SAC/SPA/Ramsar site is provided in Figure 1. In the figure, the LWSs are shaded in yellow with a red outline, the SSSI is shaded in green, the SSSI/SAC/SPA/Ramsar site is are shaded in purple and the position of Thoresby Bridge Farm is outlined in blue.

Figure 1. The area surrounding Thoresby Bridge Farm – concentric circles radii 2.0 km (olive), 5.0 km (green) and 10.0 km (purple)



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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 2024). 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 Thoresby Bridge Farm is 1.76 µg-NH_3/m^3. The background nitrogen deposition rate to woodland is 27.27 kg-N/ha/y and to short vegetation is 16.0 kg-N/ha/y. The background acid deposition rate to woodland is 1.72 keq/ha/y and to short vegetation is 0.93 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 and Critical Loads

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

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

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

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

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

The Critical Levels and Critical Loads at the wildlife sites assumed in this study are provided in Table 1. N.B. Where the Critical Level of 1.0 $\mu g\text{-}NH_3/m^3$ 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 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)
LWSs	1.0 [1 & 3]	10.0 [3]	-
Tetney Blow Wells SSSI, Humber Estuary SSSI/SAC/SPA/Ramsar	3.0 [2]	15.0 [2 & 4]	-

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. A precautionary level used where details of the site are unavailable.
4. The lower bound of the range of Critical Loads for the site.

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 are derived from 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 threshold 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

3.5.1 General information

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 normally 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 Environment Agency provides an Intensive Farming guidance note which lists standard ammonia emission factors for a variety of livestock, including poultry. For broiler chickens, the Environment Agency figure is 0.034 kg-NH_3/bird place/year. Details of the poultry numbers and types and emission factors used and calculated ammonia emission rates are provided in Table 2.

Table 2. Details of poultry numbers and ammonia emission rates

Source	Animal numbers	Type or weight	Emission factor (kg-NH_3/place/y)	Emission rate (g-NH_3/s)
Existing poultry houses	68,300	Broiler Chickens	0.034	0.073586
Proposed poultry houses	114,000	Broiler Chickens	0.034	0.122823

3.5.2 Further details of the emission modelling

For the proposed houses, it is assumed for modelling purposes that 15% of the emissions are from the gable end fans when the temperature equals or exceeds 23 Celsius. When this occurs emissions from ridge fans are reduced by 15%. These estimates are based on a detailed emission model that calculates ventilation requirements (available upon request).

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)[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 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.

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 Thoresby Bridge Farm is shown in Figure 2b. Although there is little modification in this case, elsewhere in the modelling domain wind roses may differ more markedly, reflecting the local flow in that part of the domain. The resolution of the wind field in terrain runs is approximately 360 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].

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 53.477 N, 0.015 E, 2020-2023

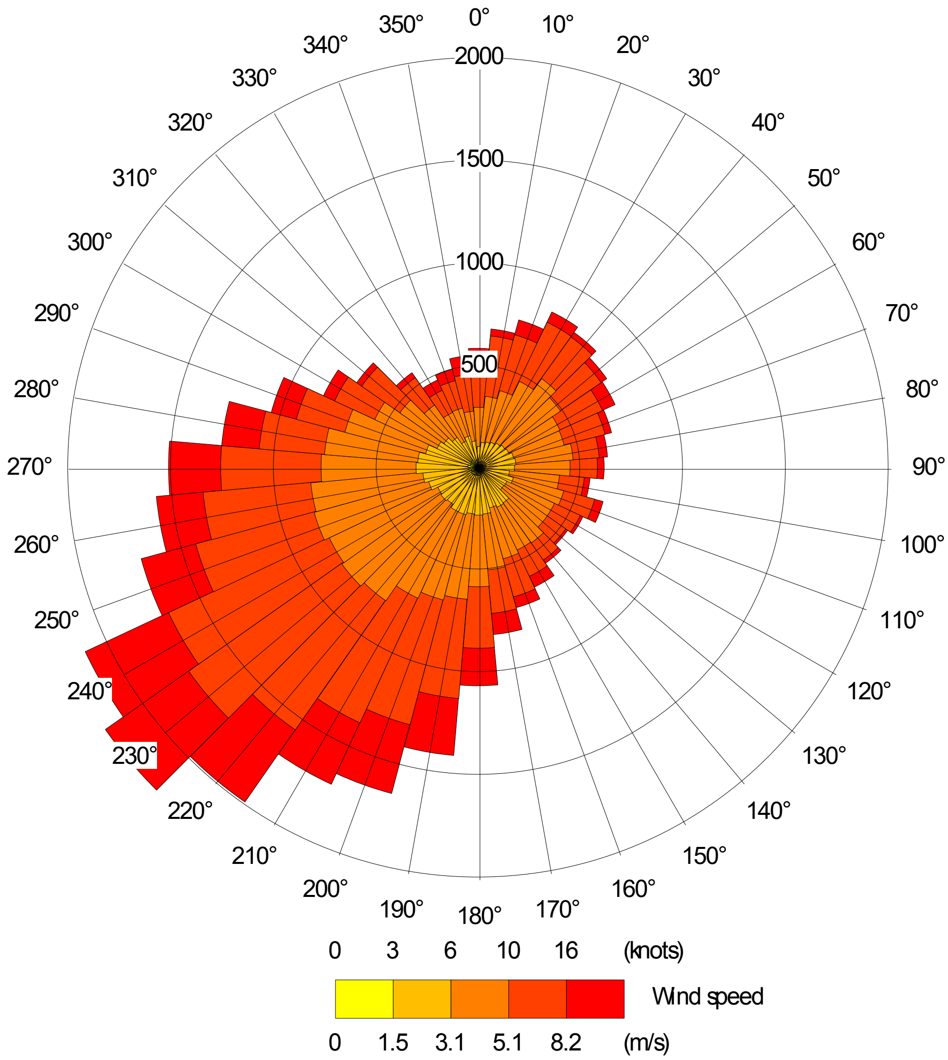
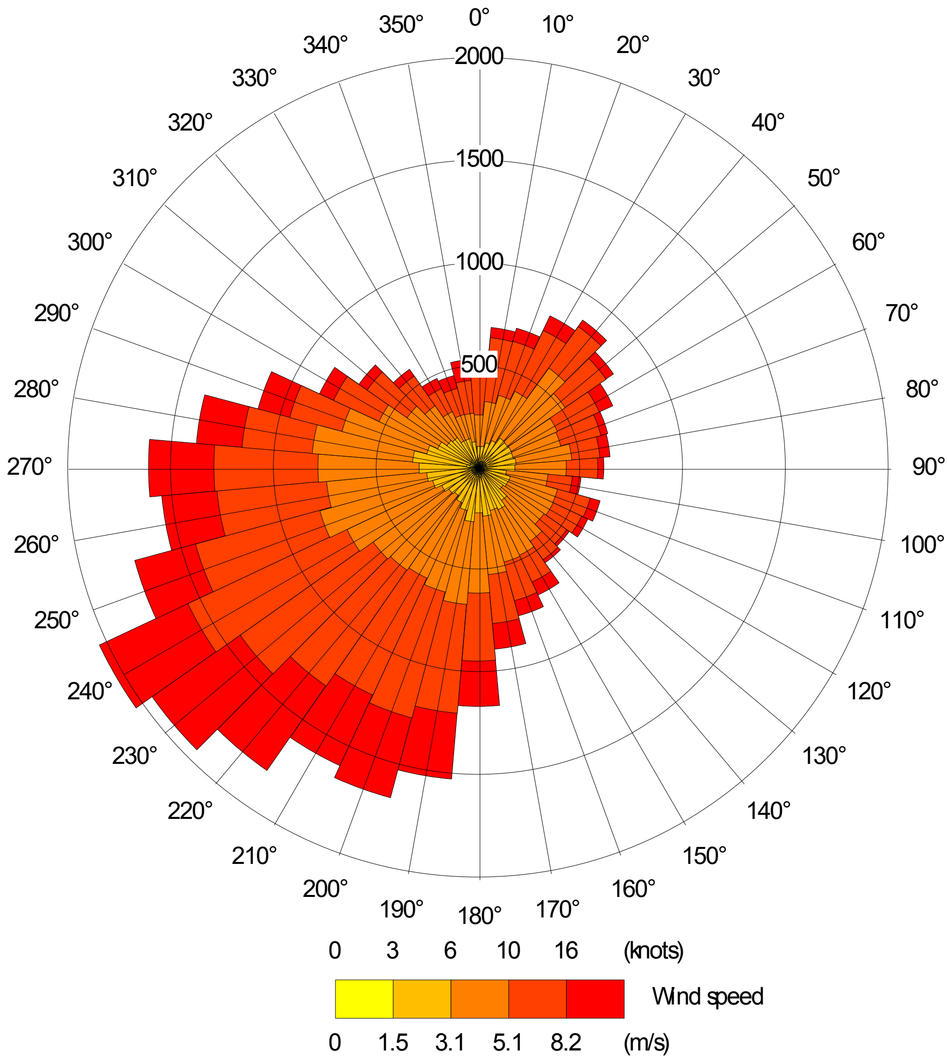


Figure 2b. The wind rose. FLOWSTAR modified GFS derived data for NGR 533800, 399650, 2020-2023



4.2 Emission sources

Emissions from the chimneys of the uncapped high speed ridge fans that would be used for the ventilation of the proposed poultry houses are represented by three point sources per house within ADMS (PR1 and PR2; 1, 2 & 3).

Emissions from the naturally ventilated existing poultry houses and from the gable end fans that would be used to supplement the primary ventilation of the proposed poultry houses have been represented by three volume sources within ADMS (EX1_vol to EX5_vol, PR1_gab and PR2_gab).

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 3a, for the existing poultry houses and in Figure 3b, for the proposed poultry houses (point sources are marked by red stars and the volume sources are marked by red shaded rectangles).

Table 3a. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (˚C)	Emission rate per source (g/s)
PR1 & PR2; 1, 2 & 3	5.5	0.8	12.0	Variable [1]	0.020471 [2]

Table 3b. Volume source parameters

Source ID	Length (m)	Width (m)	Depth (m)	Base height (m)	Emission temperature (°C)	Emission rate (g/s)
EX1_vol & EX2_vol	30.0	16.0	3.0	0.5	Ambient	0.012629
EX3_vol, EX4_vol & EX5_vol	40.0	16.0	3.0	0.5	Ambient	0.016109
PR1_gab & PR2_gab	21.0	5.0	3.0	0.5	Ambient	0.061412 [2]

1. Dependent on ambient temperature.
2. See section 3.5.2

4.3 Modelled buildings

The structure of the proposed poultry houses and other large farm buildings may affect the plumes from the point sources that would be used to ventilate the proposed poultry houses. Therefore, these buildings are modelled within ADMS. The positions of the modelled buildings may be seen in Figure 3b (marked by grey rectangles).

4.4 Discrete receptors

Thirty discrete receptors have been defined at the LWSs, SSSIs and SPA/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 (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 4a and Figure 4b (marked by grey lines).

Figure 3a. The positions of modelled buildings and sources – existing poultry houses

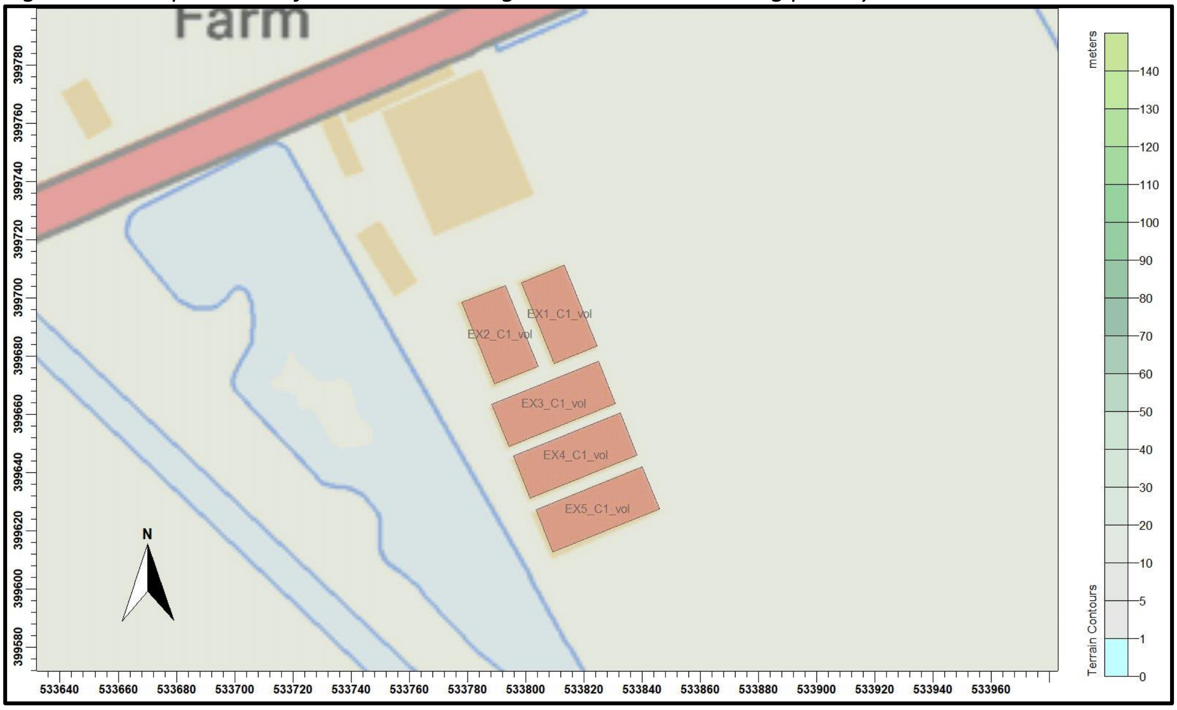


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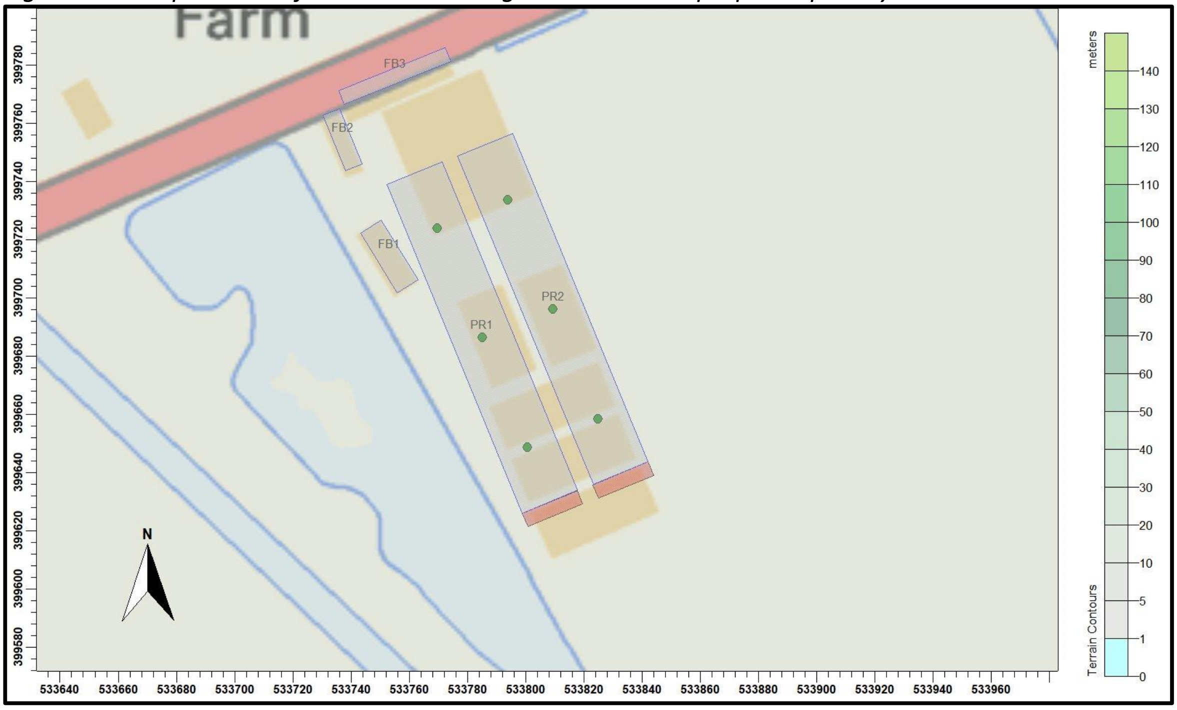
Figure 3b. The positions of modelled buildings and sources – proposed poultry houses



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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 23.0 km by 23.0 km domain has been resampled at 100 m horizontal resolution for use within ADMS for the modelling. The resolution of FLOWSTAR is 64 x 64 grid points; therefore, the effective resolution of the wind field for the terrain runs is approximately 360 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 0.04 m (arithmetic average of the spatially varying roughness over the modelling domain). The sample of the central area of the spatially varying roughness length field is shown in Figure 5.

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

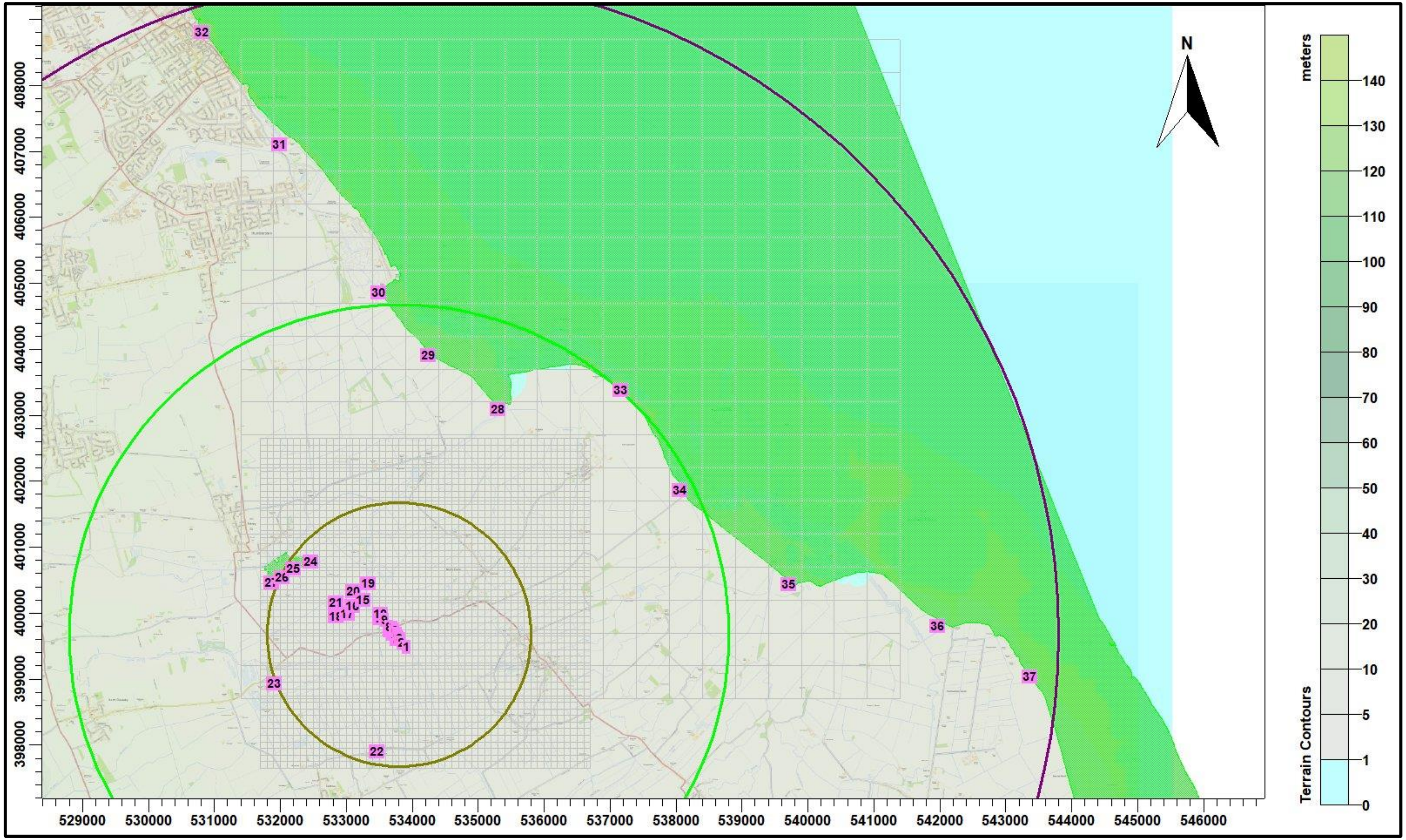

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Figure 4b. The discrete receptors and Cartesian grids – a closer view of the area around Thoresby Bridge Farm

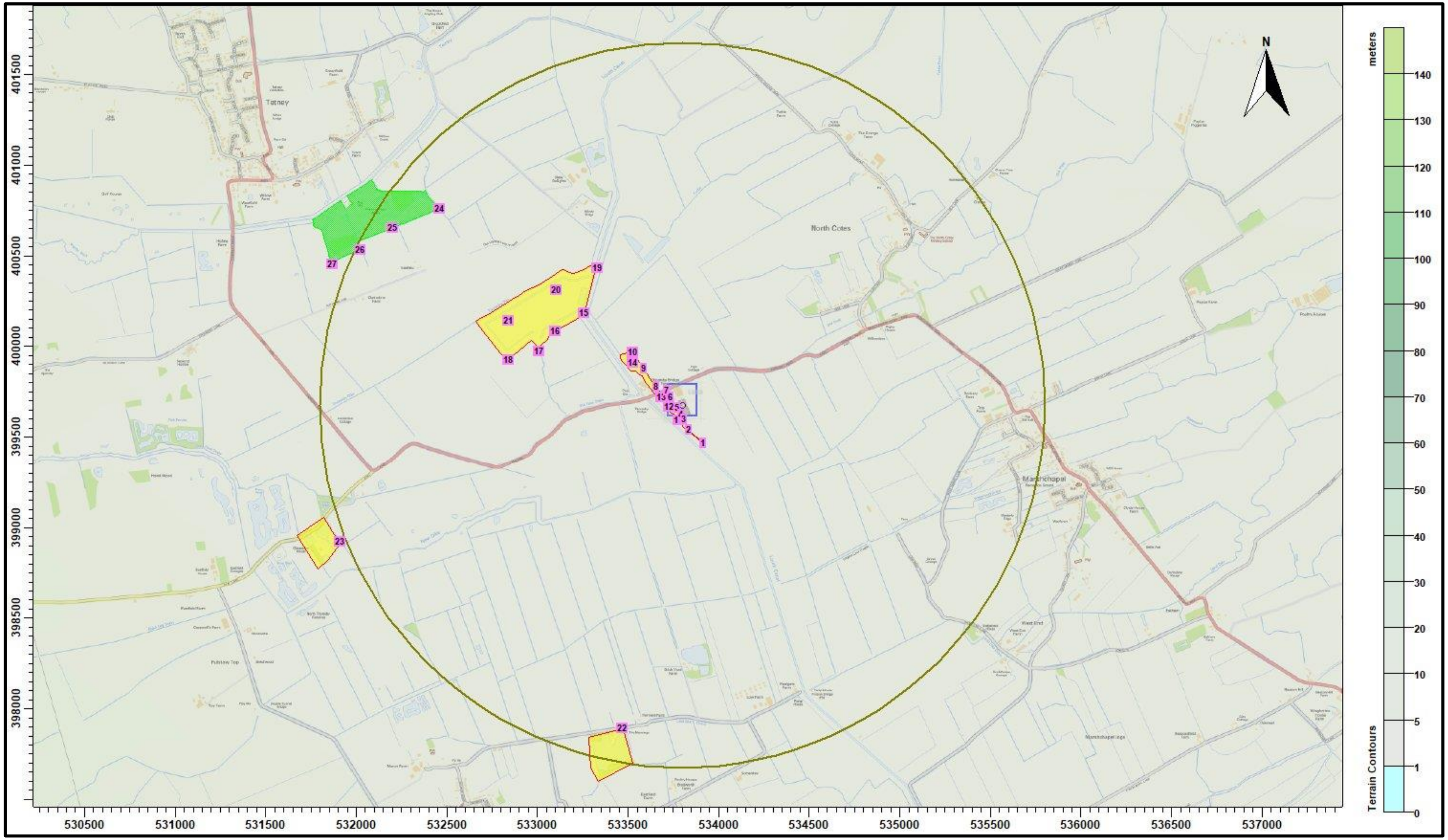

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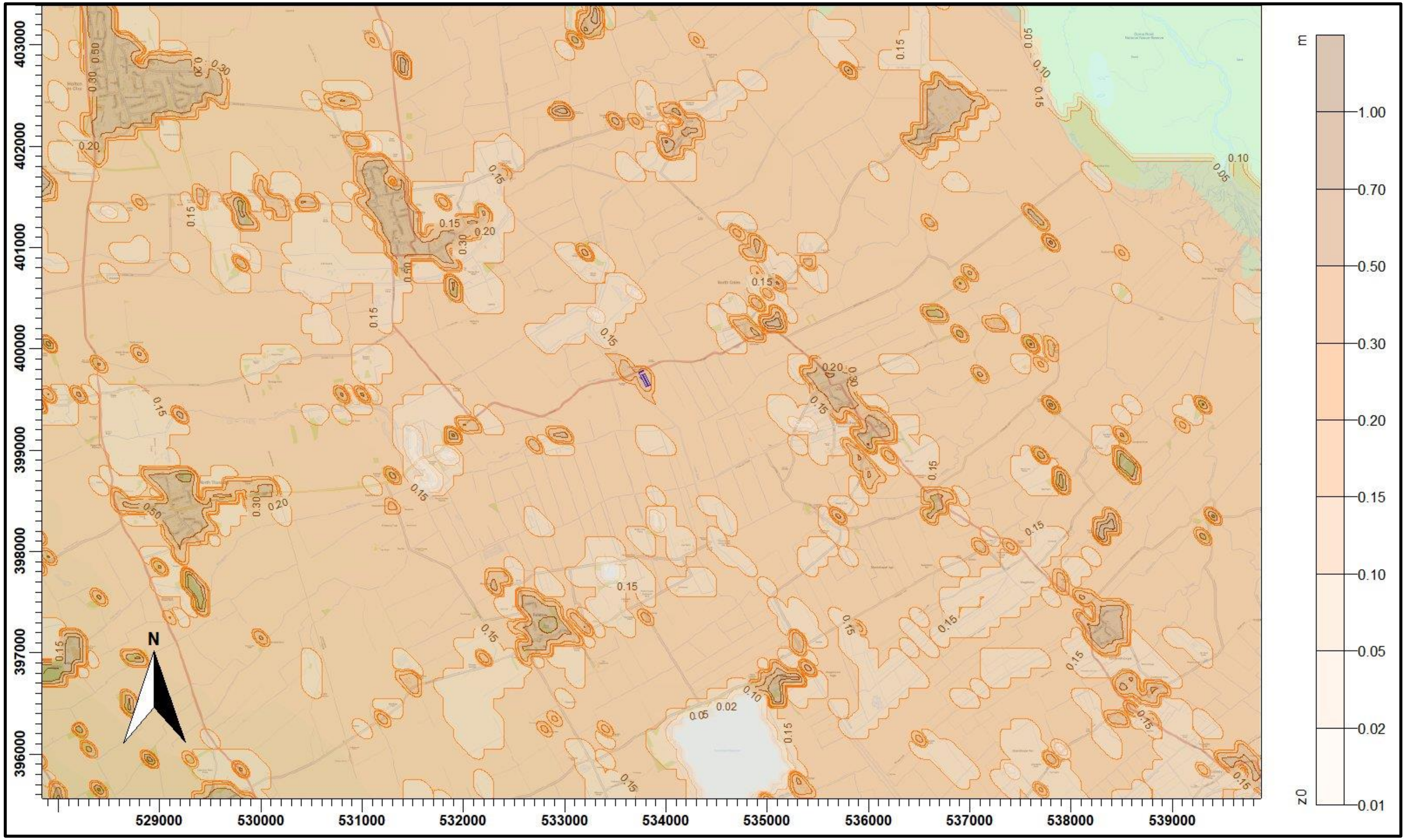
Figure 5. The spatially varying surface roughness field (central area)



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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, has been used to define a deposition velocity field. The deposition velocities used are provided in Table 4.

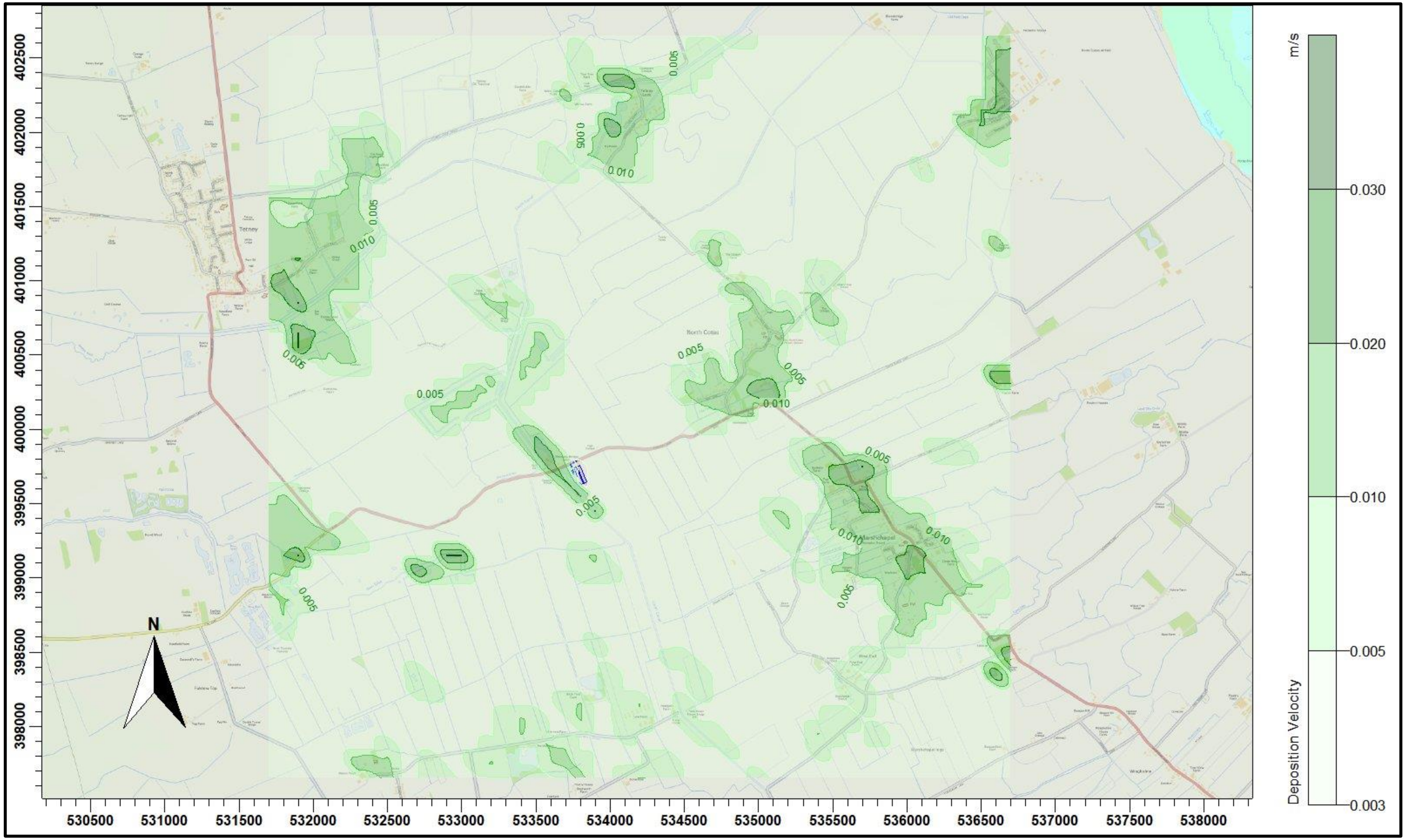
Table 4. Deposition velocities

NH_3 concentration (PC + background) (µg/m³)	< 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



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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 of the meteorological record and in the following two 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.

The primary purpose of this modelling is to determine the effects of calms.

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

Receptor number	X(m)	Y(m)	Designation	Maximum annual mean ammonia concentration - (µg/m³)			
				Existing		Proposed 2 houses	
				GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms No Terrain	GFS Calms No Terrain
1	533916	399467	Unnamed LWS	1.339	1.691	0.289	0.287
2	533836	399542	Unnamed LWS	3.341	4.125	0.772	0.764
3	533806	399600	Unnamed LWS	12.857	14.713	1.834	1.815
4	533791	399625	Unnamed LWS	19.120	21.411	2.461	2.434
5	533771	399662	Unnamed LWS	16.835	18.978	3.914	3.871
6	533735	399722	Unnamed LWS	5.375	6.441	1.612	1.596
7	533715	399755	Unnamed LWS	2.872	3.588	1.351	1.341
8	533653	399779	Unnamed LWS	1.574	1.968	0.629	0.625
9	533585	399876	Unnamed LWS	0.646	0.835	0.297	0.295
10	533524	399968	Unnamed LWS	0.397	0.491	0.181	0.180
11	533781	399594	Unnamed LWS	7.653	9.058	1.859	1.840
12	533726	399667	Unnamed LWS	6.509	7.500	1.706	1.689
13	533682	399717	Unnamed LWS	3.244	3.814	0.969	0.962
14	533524	399910	Unnamed LWS	0.465	0.606	0.206	0.205
15	533255	400184	Unnamed LWS	0.132	0.175	0.064	0.064
16	533101	400085	Unnamed LWS	0.143	0.179	0.055	0.055
17	533011	399971	Unnamed LWS	0.155	0.186	0.053	0.053
18	532840	399926	Unnamed LWS	0.124	0.146	0.040	0.040
19	533331	400433	Unnamed LWS	0.113	0.139	0.058	0.057
20	533106	400313	Unnamed LWS	0.088	0.118	0.044	0.044
21	532840	400142	Unnamed LWS	0.097	0.119	0.038	0.038
22	533471	397890	Unnamed LWS	0.025	0.034	0.018	0.018
23	531911	398920	Unnamed LWS	0.025	0.031	0.014	0.014
24	532459	400758	Tetney Blow Wells SSSI	0.033	0.044	0.017	0.017
25	532203	400652	Tetney Blow Wells SSSI	0.034	0.043	0.016	0.016
26	532021	400532	Tetney Blow Wells SSSI	0.034	0.042	0.016	0.016
27	531869	400451	Tetney Blow Wells SSSI	0.033	0.040	0.015	0.015
28	535301	403076	Humber Estuary SSSI/SAC/SPA/Ramsar	0.016	0.019	0.012	0.012
29	534245	403897	Humber Estuary SSSI/SAC/SPA/Ramsar	0.008	0.011	0.008	0.008
30	533486	404842	Humber Estuary SSSI/SAC/SPA/Ramsar	0.006	0.008	0.006	0.006
31	531983	407083	Humber Estuary SSSI/SAC/SPA/Ramsar	0.003	0.004	0.003	0.003
32	530808	408790	Humber Estuary SSSI/SAC/SPA/Ramsar	0.002	0.003	0.002	0.002
33	537159	403362	Humber Estuary SSSI/SAC/SPA/Ramsar	0.009	0.011	0.008	0.008
34	538054	401852	Humber Estuary SSSI/SAC/SPA/Ramsar	0.009	0.010	0.008	0.008
35	539705	400425	Humber Estuary SSSI/SAC/SPA/Ramsar	0.007	0.008	0.006	0.006
36	541971	399781	Humber Estuary SSSI/SAC/SPA/Ramsar	0.004	0.005	0.004	0.004
37	543369	399026	Humber Estuary SSSI/SAC/SPA/Ramsar	0.003	0.004	0.004	0.004

5.2 Detailed modelling

In this case, detailed modelling has been carried out over a high resolution 5.0 km by 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 by 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).

The predicted process contributions to maximum annual mean ground level ammonia concentrations and nitrogen deposition rates at the discrete receptors are shown in Table 6a, for the existing poultry houses and in Table 6b, for the proposed poultry houses. In these Tables, predicted ammonia concentrations or nitrogen deposition rates that are in excess of the Environment Agency's upper threshold percentage of the relevant Critical Level or Critical Load for the site (100% for a LWS, 50% for a SSSI and 20% for a SAC/SPA/Ramsar site) are coloured red. Ammonia concentrations or nitrogen deposition rates in the range between the Environment Agency's upper threshold and lower threshold percentage of the relevant Critical Level or Critical Load for the site (100% and 100% for a LWS, 50% and 20% for a SSSI and 20% and 4% for a SAC/SPA/Ramsar site) are coloured blue and ammonia concentrations or nitrogen deposition rates that exceed 1% of the Critical Level or Critical Load at the SSSIs or the SAC/SPA/Ramsar sites are highlighted with bold text.

Contour plots of the predicted process contributions from the proposed poultry houses to ground level maximum annual mean ammonia concentration and maximum annual nitrogen deposition rate are shown in Figure 7a and Figure 7b.

The predicted changes in maximum annual mean ammonia concentration and maximum annual nitrogen deposition rate are shown in Figure 8.

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. The results of the preliminary modelling indicate that the effects of calms are significant in the existing scenario; therefore, for the existing results (Table 6a) at receptors within 3 km are increased by a factor of 1.23.

Table 6a. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates – existing poultry houses

Receptor number	X(m)	Y(m)	Designation	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	533916	399467	Unnamed LWS	0.03	1.0	10.0	1.006	**100.6**	7.83	78.3
2	533836	399542	Unnamed LWS	0.03	1.0	10.0	2.796	**279.6**	21.79	**217.9**
3	533806	399600	Unnamed LWS	0.03	1.0	10.0	13.227	**1,322.7**	103.05	**1,030.5**
4	533791	399625	Unnamed LWS	0.03	1.0	10.0	19.636	**1,963.6**	152.98	**1,529.8**
5	533771	399662	Unnamed LWS	0.03	1.0	10.0	16.502	**1,650.2**	128.57	**1,285.7**
6	533735	399722	Unnamed LWS	0.03	1.0	10.0	4.887	**488.7**	38.08	**380.8**
7	533715	399755	Unnamed LWS	0.03	1.0	10.0	2.647	**264.7**	20.62	**206.2**
8	533653	399779	Unnamed LWS	0.03	1.0	10.0	1.255	**125.5**	9.78	97.8
9	533585	399876	Unnamed LWS	0.03	1.0	10.0	0.465	46.5	3.62	36.2
10	533524	399968	Unnamed LWS	0.03	1.0	10.0	0.266	26.6	2.07	20.7
11	533781	399594	Unnamed LWS	0.03	1.0	10.0	7.547	**754.7**	58.80	**588.0**
12	533726	399667	Unnamed LWS	0.03	1.0	10.0	5.088	**508.8**	39.64	**396.4**
13	533682	399717	Unnamed LWS	0.03	1.0	10.0	2.468	**246.8**	19.23	**192.3**
14	533524	399910	Unnamed LWS	0.03	1.0	10.0	0.305	30.5	2.38	23.8
15	533255	400184	Unnamed LWS	0.03	1.0	10.0	0.081	8.1	0.63	6.3
16	533101	400085	Unnamed LWS	0.03	1.0	10.0	0.064	6.4	0.50	5.0
17	533011	399971	Unnamed LWS	0.03	1.0	10.0	0.060	6.0	0.46	4.6
18	532840	399926	Unnamed LWS	0.03	1.0	10.0	0.045	4.5	0.35	3.5
19	533331	400433	Unnamed LWS	0.03	1.0	10.0	0.071	7.1	0.55	5.5
20	533106	400313	Unnamed LWS	0.03	1.0	10.0	0.052	5.2	0.40	4.0
21	532840	400142	Unnamed LWS	0.03	1.0	10.0	0.036	3.6	0.28	2.8
22	533471	397890	Unnamed LWS	0.03	1.0	10.0	0.014	1.4	0.11	1.1
23	531911	398920	Unnamed LWS	0.03	1.0	10.0	0.010	1.0	0.08	0.8
24	532459	400758	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.016	0.5	0.08	0.6
25	532203	400652	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.013	0.4	0.07	0.4
26	532021	400532	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.011	0.4	0.06	0.4
27	531869	400451	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.010	0.3	0.05	0.3
28	535301	403076	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.007	0.2	0.03	0.2
29	534245	403897	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.005	0.2	0.03	0.2
30	533486	404842	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.003	0.1	0.02	0.1
31	531983	407083	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.001	0.0	0.01	0.0
32	530808	408790	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.001	0.0	0.00	0.0

Table 6b. Predicted maximum annual mean ammonia concentrations and nitrogen deposition rates – proposed poultry houses

Receptor number	X(m)	Y(m)	Designation	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	533916	399467	Unnamed LWS	0.03	1.0	10.0	0.254	25.4	1.98	19.8
2	533836	399542	Unnamed LWS	0.03	1.0	10.0	0.672	67.2	5.24	52.4
3	533806	399600	Unnamed LWS	0.03	1.0	10.0	1.834	**183.4**	14.29	**142.9**
4	533791	399625	Unnamed LWS	0.03	1.0	10.0	2.530	**253.0**	19.72	**197.2**
5	533771	399662	Unnamed LWS	0.03	1.0	10.0	3.926	**392.6**	30.59	**305.9**
6	533735	399722	Unnamed LWS	0.03	1.0	10.0	1.740	**174.0**	13.56	**135.6**
7	533715	399755	Unnamed LWS	0.03	1.0	10.0	1.362	**136.2**	10.61	**106.1**
8	533653	399779	Unnamed LWS	0.03	1.0	10.0	0.591	59.1	4.61	46.1
9	533585	399876	Unnamed LWS	0.03	1.0	10.0	0.263	26.3	2.05	20.5
10	533524	399968	Unnamed LWS	0.03	1.0	10.0	0.157	15.7	1.22	12.2
11	533781	399594	Unnamed LWS	0.03	1.0	10.0	1.693	**169.3**	13.19	**131.9**
12	533726	399667	Unnamed LWS	0.03	1.0	10.0	1.608	**160.8**	12.53	**125.3**
13	533682	399717	Unnamed LWS	0.03	1.0	10.0	0.906	90.6	7.06	70.6
14	533524	399910	Unnamed LWS	0.03	1.0	10.0	0.179	17.9	1.39	13.9
15	533255	400184	Unnamed LWS	0.03	1.0	10.0	0.058	5.8	0.45	4.5
16	533101	400085	Unnamed LWS	0.03	1.0	10.0	0.050	5.0	0.39	3.9
17	533011	399971	Unnamed LWS	0.03	1.0	10.0	0.044	4.4	0.34	3.4
18	532840	399926	Unnamed LWS	0.03	1.0	10.0	0.031	3.1	0.25	2.5
19	533331	400433	Unnamed LWS	0.03	1.0	10.0	0.055	5.5	0.43	4.3
20	533106	400313	Unnamed LWS	0.03	1.0	10.0	0.038	3.8	0.30	3.0
21	532840	400142	Unnamed LWS	0.03	1.0	10.0	0.030	3.0	0.23	2.3
22	533471	397890	Unnamed LWS	0.03	1.0	10.0	0.015	1.5	0.12	1.2
23	531911	398920	Unnamed LWS	0.03	1.0	10.0	0.011	1.1	0.08	0.8
24	532459	400758	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.015	0.5	0.08	0.5
25	532203	400652	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.012	0.4	0.06	0.4
26	532021	400532	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.011	0.4	0.06	0.4
27	531869	400451	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.011	0.4	0.06	0.4
28	535301	403076	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.010	0.3	0.05	0.3
29	534245	403897	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.007	0.2	0.04	0.2
30	533486	404842	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.004	0.1	0.02	0.2
31	531983	407083	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.002	0.1	0.01	0.1
32	530808	408790	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.001	0.0	0.01	0.0

Table 7. Predicted changes in maximum annual mean ammonia concentrations and nitrogen deposition rates

Receptor number	X(m)	Y(m)	Designation	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	533916	399467	Unnamed LWS	0.03	1.0	10.0	-0.752	-75.2	-5.86	-58.6
2	533836	399542	Unnamed LWS	0.03	1.0	10.0	-2.124	-212.4	-16.55	-165.5
3	533806	399600	Unnamed LWS	0.03	1.0	10.0	-11.393	-1139.3	-88.76	-887.6
4	533791	399625	Unnamed LWS	0.03	1.0	10.0	-17.105	-1710.5	-133.27	-1332.7
5	533771	399662	Unnamed LWS	0.03	1.0	10.0	-12.576	-1257.6	-97.98	-979.8
6	533735	399722	Unnamed LWS	0.03	1.0	10.0	-3.147	-314.7	-24.52	-245.2
7	533715	399755	Unnamed LWS	0.03	1.0	10.0	-1.285	-128.5	-10.01	-100.1
8	533653	399779	Unnamed LWS	0.03	1.0	10.0	-0.664	-66.4	-5.17	-51.7
9	533585	399876	Unnamed LWS	0.03	1.0	10.0	-0.202	-20.2	-1.58	-15.8
10	533524	399968	Unnamed LWS	0.03	1.0	10.0	-0.109	-10.9	-0.85	-8.5
11	533781	399594	Unnamed LWS	0.03	1.0	10.0	-5.855	-585.5	-45.61	-456.1
12	533726	399667	Unnamed LWS	0.03	1.0	10.0	-3.480	-348.0	-27.11	-271.1
13	533682	399717	Unnamed LWS	0.03	1.0	10.0	-1.562	-156.2	-12.17	-121.7
14	533524	399910	Unnamed LWS	0.03	1.0	10.0	-0.126	-12.6	-0.98	-9.8
15	533255	400184	Unnamed LWS	0.03	1.0	10.0	-0.024	-2.4	-0.18	-1.8
16	533101	400085	Unnamed LWS	0.03	1.0	10.0	-0.015	-1.5	-0.11	-1.1
17	533011	399971	Unnamed LWS	0.03	1.0	10.0	-0.016	-1.6	-0.12	-1.2
18	532840	399926	Unnamed LWS	0.03	1.0	10.0	-0.014	-1.4	-0.11	-1.1
19	533331	400433	Unnamed LWS	0.03	1.0	10.0	-0.016	-1.6	-0.12	-1.2
20	533106	400313	Unnamed LWS	0.03	1.0	10.0	-0.013	-1.3	-0.10	-1.0
21	532840	400142	Unnamed LWS	0.03	1.0	10.0	-0.005	-0.5	-0.04	-0.4
22	533471	397890	Unnamed LWS	0.03	1.0	10.0	0.001	0.095	0.01	0.074
23	531911	398920	Unnamed LWS	0.03	1.0	10.0	0.000	0.029	0.00	0.023
24	532459	400758	Tetney Blow Wells SSSI	0.02	3.0	15.0	-0.001	-0.046	-0.01	-0.047
25	532203	400652	Tetney Blow Wells SSSI	0.02	3.0	15.0	-0.001	-0.019	0.00	-0.020
26	532021	400532	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.000	0.001	0.00	0.001
27	531869	400451	Tetney Blow Wells SSSI	0.02	3.0	15.0	0.001	0.043	0.01	0.045
28	535301	403076	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.003	0.100	0.02	0.104
29	534245	403897	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.002	0.064	0.01	0.067
30	533486	404842	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.001	0.045	0.01	0.047
31	531983	407083	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.001	0.028	0.00	0.029
32	530808	408790	Humber Estuary SSSI/SAC/SPA/Ramsar	0.02	3.0	15.0	0.001	0.020	0.00	0.021

Figure 7a. Maximum annual ammonia concentration – proposed poultry houses

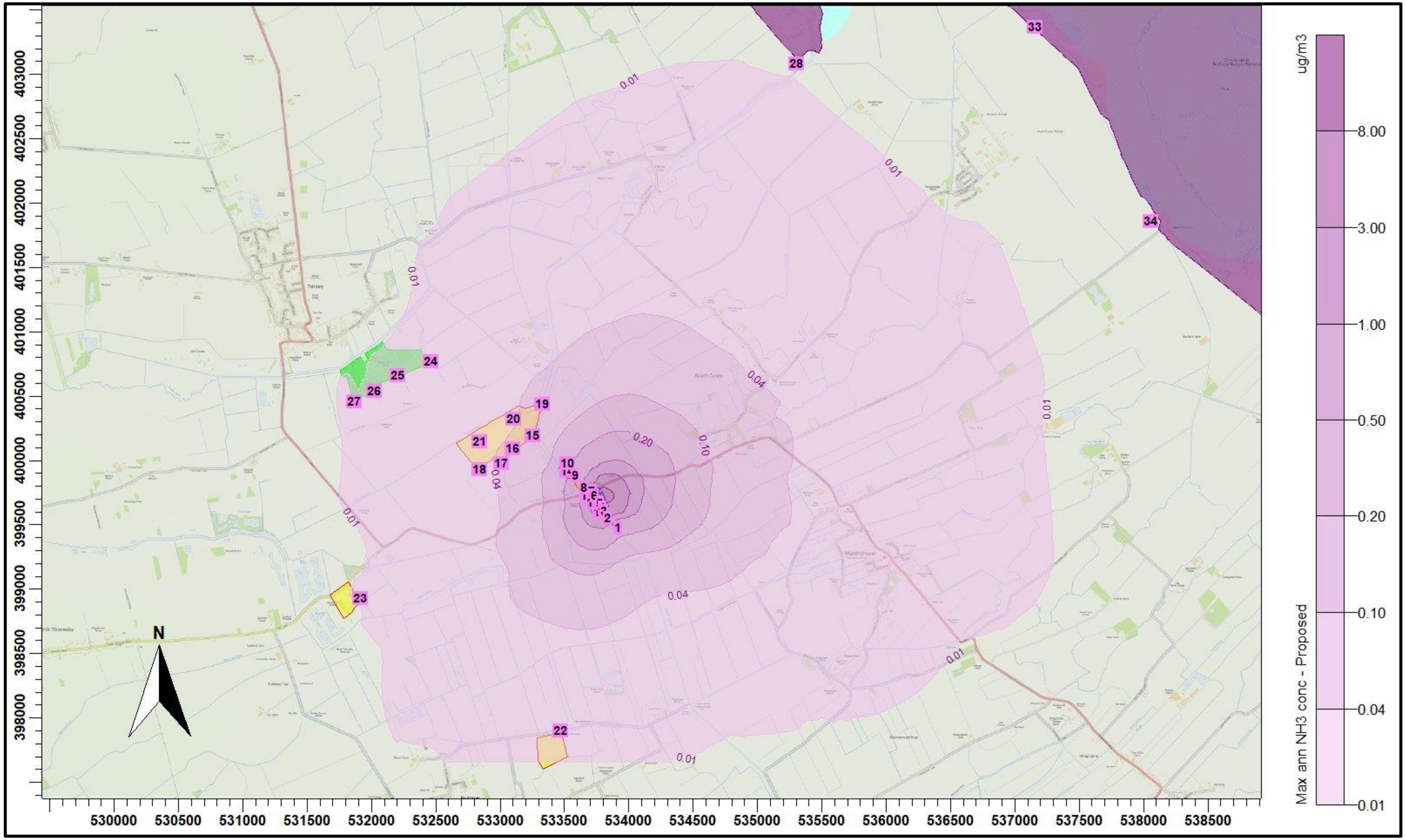

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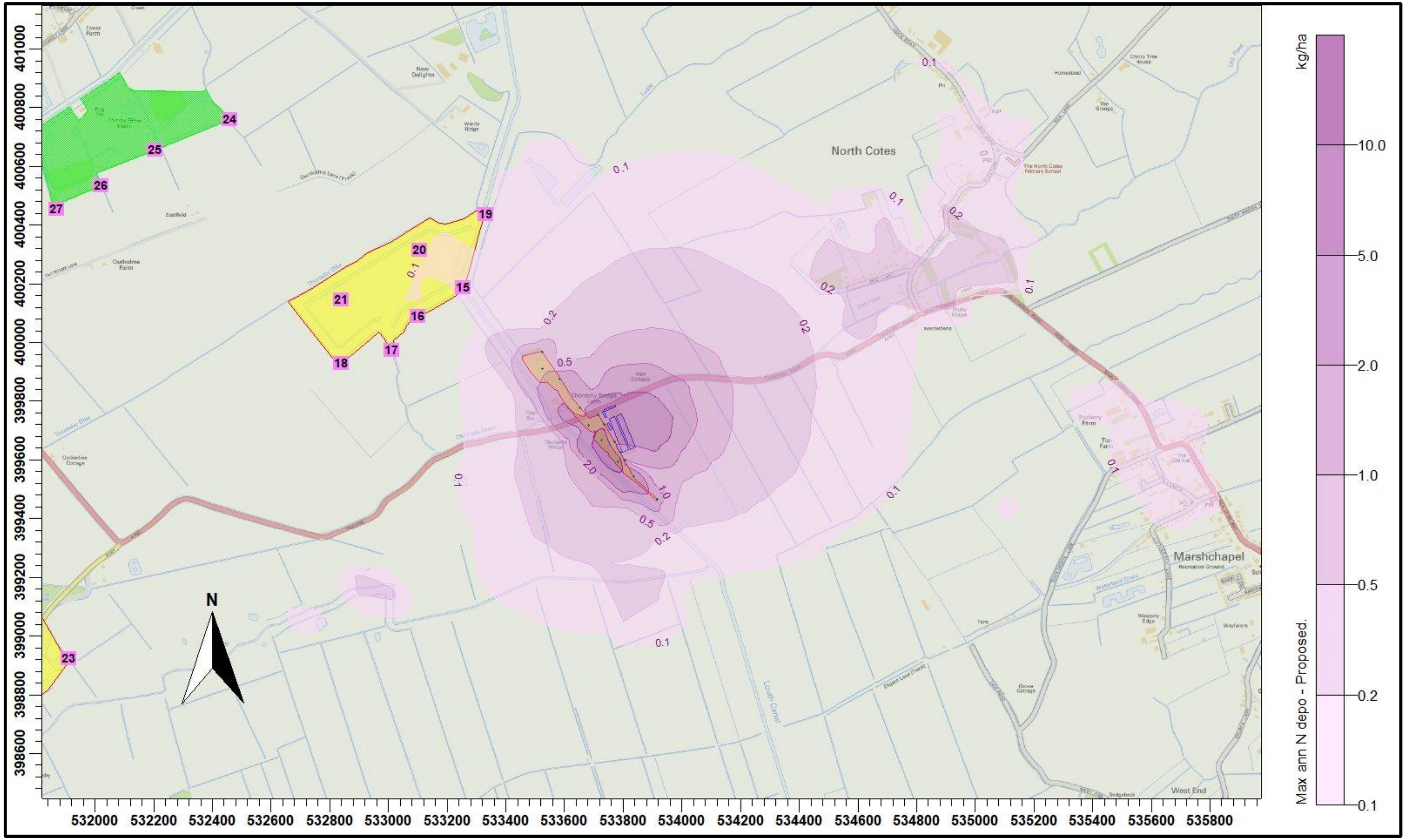
Figure 7b. Maximum annual nitrogen deposition rates – proposed poultry houses



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6. Summary and Conclusions

AS Modelling & Data Ltd. has been instructed by Mr. Ian Pick of Ian Pick Associates Ltd., on behalf of Chesterfield Poultry Ltd., to use computer modelling to assess the impact of ammonia emissions from the existing and proposed broiler chicken rearing houses at Thoresby Bridge Farm, North Cotes, East Lindsay in Lincolnshire. DN36 5TY.

Ammonia emission rates from the existing and proposed poultry rearing 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.

Existing poultry houses

The modelling predicts that:

- Process contributions to ammonia concentrations and nitrogen deposition exceed the Environment Agency's upper/lower threshold percentage of the precautionary Critical Level of 1.0 µg/m³ and the Critical Load of 10.0 kg/ha at some of the closer LWSs.

- Process contributions to ammonia concentrations and nitrogen deposition are below the Environment Agency's lower threshold percentage of the Critical/Load at all statutory wildlife sites.

- Process contributions to ammonia concentrations and nitrogen deposition are below 1% of the Critical/Load at all statutory wildlife sites.

Proposed poultry houses

The modelling predicts that:

- Although very significantly lower than under the existing scenario, process contributions to ammonia concentrations and nitrogen deposition would continue to exceed the Environment Agency's upper/lower threshold percentage of the precautionary Critical Level of 1.0 µg/m³ and the Critical Load of 10.0 kg/ha at some of the closer LWSs.

- Process contributions to ammonia concentrations and nitrogen deposition would remain below the Environment Agency's lower threshold percentage of the Critical/Load at all statutory wildlife sites.

- Process contributions to ammonia concentrations and nitrogen deposition would remain below 1% of the Critical/Load at all statutory wildlife sites.

7. References

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