An Odour Dispersion Modelling Study of the Impact of the Proposed Expansion to the Free Range Egg Laying Units at Rhosddu Farm, Llansantffraid-ym-mechain in Powys

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Submitted to:
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1 Introduction

ADAS has been commissioned by Mr Martyn Langford to use computer modelling to assess the impact of odour emissions from the existing and proposed free range egg laying units Rhosddu Farm, Llansantffraid-ym-mechain, Powys. SY22 6TH.

Odour emission rates from the existing and proposed poultry unit have been assessed and quantified based upon emission rates suggested by Natural Resources Wales. These odour emission rates have then been used as inputs to an atmospheric dispersion model which calculates odour exposure levels in the surrounding area.

This report is arranged in the following manner:

- Section 2 provides relevant details of the site and potentially sensitive receptors in the area.
- Section 3 provides some general information on odour; details of the method used to estimate odour emissions from the existing proposed poultry houses; relevant guidelines and precedents for odour exposure levels.
- Section 4 provides some information about ADMS, the dispersion model used for this study and details the modelling parameters and procedures.
- Section 5 contains the results of the modelling.
- Section 6 provides a discussion of the results and conclusions.

1.1 Background Details

The site of the proposed free range egg laying unit is in a relatively isolated and sparsely populated rural area. The surrounding land is used primarily for arable and livestock farming, although there are areas of semi-natural woodlands. The site is at an altitude of around 85 m in the River Vyrnwy Valley.

There are two existing poultry houses at Rhosddu Farm, these are used to accommodate up to 32,000 egg laying chickens. The houses are ventilated via end wall fans and pop holes on the sides of the houses provide access to an outside ranging area. In one of the houses, manure collects within the house (a so-called “deep pit” system) and it is cleared at the end of each flock cycle, which is approximately once per year. In the other house there is a belt system for collection of the droppings which are stored temporarily in a covered skip prior to removal from the site, usually twice a week.
It is proposed that a new egg laying chicken house, with a capacity of 24,000 birds, be constructed on a field to the south-south-west of the existing poultry houses at Rhosddu Farm. The new poultry house would be ventilated by ridge level, vertical discharge fan stacks, and pop holes on the side of the house would provide access to an outside ranging area. The house would be fitted with a belt manure removal system to collect droppings which would be stored temporarily in a covered skip, prior to removal from the site.

As an improvement scenario it has been proposed that the ventilation systems of the existing poultry houses will be upgraded to uncapped high speed ridge level discharge stacks or chimneys, similar to the proposed new building to help mitigate the emissions of the proposed enlarged poultry unit. A typical arrangement of roof fan locations has been assumed. The final layout may be based on a different layout, but ADAS experience from other, similar, projects is that this will not make a material difference to the modelling predictions of off-site impacts.

There are some residences and commercial properties in the area surrounding the site of the poultry unit at Rhosddu Farm. The closest are: the farmhouse at Rhosddu Farm, which is approximately 70 m from the nearest poultry house; “New Buildings” and “The Hollies” are approximately 380 m and approximately 420 m to the north-east; Penllyn is approximately 480 m to the south east; Prenrhwnin and Prernafal, which would be approximately 290m and approximately 310 m to the south east of the proposed poultry house and PIas-Bach-Issa, which would be approximately 360 m to the south-south-west of the proposed poultry house. It is understood that there have been no reports of any complaints or adverse odour impacts from these dwellings as result of the existing layer sheds. Furthermore there were no objections to the planning application for the new building which is a stricter test in the absence of complaints.

A map of the surrounding area is provided in Figure 1, where the site of the existing poultry houses is outlined in blue the site of the proposed poultry house is outlined in red.

Figure 1. The area surrounding the site of the poultry unit at Rhosddu Farm

2 Odour, Emission Rates &, Exposure Levels

2.1 Odour concentration, averaging times, percentiles and FIDOR

Odour concentration is expressed in terms of European Odour Units per cubic metre of air (ou_E/m^3). The following observations of how an odour might be perceived by a human with an average sense of smell may be useful. However, it should be noted that within a human population there is some variation in acuity of sense of smell.

- 1.0 ou_E/m^3 is defined as the limit of detection, in laboratory conditions.

- At 2.0 – 3.0 ou_E/m^3 a particular odour might be detected against background odours in an open environment.

- When the concentration reaches around 5.0 ou_E/m^3 a particular odour will usually be recognisable, if known, but would usually be described as faint.

- At 10.0 ou_E/m^3 most would describe the intensity of the odour as moderate or strong and if persistent, it is likely that the odour would become intrusive.

The character, or hedonic tone, of an odour is also important; typically odours are grouped into three categories.

Most offensive:
- Processes involving decaying animal or fish remains.
- Processes involving septic effluent or sludge.
- Biological landfill odours.

Moderately offensive:
- Intensive livestock rearing.
- Fat frying (food processing).
- Sugar beet processing.
- Well aerated green waste composting.

Less offensive:
- Brewery.
- Confectionery.
- Coffee roasting.
- Bakery.

Dispersion models usually calculate hourly mean odour concentrations; Environment Agency guidelines and findings from UK Water industry Research (UKWIR) are also framed in terms of hourly mean odour concentration.

The Environment Agency guidelines and findings from UKWIR use the 98th percentile hourly mean odour impact benchmarks; this is the hourly mean odour concentration that is equalled or exceeded for 2% of the time period considered, which is typically one year. The use of the 98th percentile statistics allows for some consideration of both frequency and intensity of the odours.

At some distance from a source, it would be unusual if odour concentration remained constant for an hour and in reality, due to air turbulence and changes in wind direction, short term fluctuations in concentration are observed. Therefore, although average exposure levels may be below the detection threshold, or a particular guideline, a population may be exposed to short term concentrations which are higher than the hourly average. It should be noted that a fluctuating odour is often more noticeable than a steady background odour at a low concentration. It is implicit that within the models hourly averaging time and the Environment Agency guidelines and findings from UKWIR that there would be variation in the odour concentration around this mean i.e. there would be short periods when odour concentration would be higher than the mean and lower than the mean.

The FIDOR acronym is a useful reminder of the factors that will determine the degree of odour pollution:

- **F**requency of detection.
- **I**ntensity as perceived.
- **D**uration of exposure.
- **O**ffensiveness.
- **R**eceptor sensitivity.

2.2 UK Water Industry Research findings

In 2001 the UK Water Industry Research (UKWIR) organisation undertook research into correlations between (dispersion) modelled odour impact and the distribution of odour complaints around wastewater (sewage) treatment works. The findings of this work are concisely summarised in a recent Chartered Institute of Water and Environmental Management document:

"The main source of research into odour impacts in the UK has been the wastewater industry and the most in-depth study published study in the UK of the correlation between of modelled odour impacts and human response (dose-effect) was published by UK Water industry Research (UKWIR) in 2001. This was based on a review of the correlation between reported odour complaints and modelled odour impacts in relation to 9 wastewater treatment works in the UK with ongoing odour complaints. The findings of this research (and subsequent UKWIR research) indicated the following:

- *At modelled exposures of below $C_{98,\ 1\text{-hour}}$ 5ou$_E$/m^3, complaints are relatively rare, at only 3% of the total registered;*
- *At modelled exposures between $C_{98,\ 1\text{-hour}}$ 5ou$_E$/m^3 and $C_{98,\ 1\text{-hour}}$ 10ou$_E$/m^3, a significant proportion of total registered complaints occur; 38% of the total;*

- *The majority of complaints occur in areas of modelled exposure greater than $C_{98,\ 1\text{-hour}}$ $10ou_E/m^3$, 59% of the total."*

In effect these findings demonstrated that with appropriate modelling, potential odour impact and annoyance is effectively controlled at 98th percentile hourly mean odour impacts of 5 ou_E/m^3 or less. These findings are consistent with the Newbiggin standard and ADAS experience of correlating odour impacts/complaints and dispersion modelling.

2.3 The Newbiggin Standard

This empirical standard, of 5.0 ou_E/m^3 at the 98th percentile, has been widely used in the intensive livestock and wastewater (sewage) sectors in the UK and elsewhere, to assess the likelihood of community annoyance. The standard was derived from an early 1990s planning appeal decision relating to an appeal by Northumberland Water for the construction of a wastewater treatment facility at Newbiggin-by-the-Sea in Northumberland in which evidence on potential off-site odour impacts was presented using odour dispersion modelling. The decision in this appeal case was the origin of the now well-established "Newbiggin" criteria that has been used, and is still is used, for odour impact assessments.

2.4 H4 Odour Guidance

The Environment Agency first published draft guidelines on odour regulation, assessment and control (IPPC H4: Horizontal Odour Guidance Parts 1 & 2) in 2002. The 2002 documents have now been withdrawn and various updated versions, for consultation purposes, were produced in the interim period. The final version (H4: Odour Management) was published in March 2011.

This Environment Agency guidance is specifically aimed at Environmental Permitting Regulations (EPR) permitted installations. Where the installation does not fall under EPR, the H4 guidance provides some informative context for the planning case. In this case the proposed development does not fall under EPR.

Odour detection thresholds and consideration of whether or not an odour is offensive are discussed in Appendix 2 of the updated H4. In Appendix 3, modelled odour concentration benchmark levels are presented for odours of varying degrees of offensiveness. Expressed as a 98th percentile of the hourly mean odour concentrations over a one year period, a threshold value of 6.0 European Odour Units per cubic metre of air (ou_E/m^3) is suggested in H4 as being appropriate for the least offensive odours. This means that a situation should be acceptable, provided that the value of 6.0 ou_E/m^3 is not exceeded for more than 2% of time. For moderately offensive and highly offensive odours, the threshold values are 3.0 ou_E/m^3 and 1.5 ou_E/m^3 respectively.

Odours from agricultural odour source are commonly placed in the moderately offensive category and the target suggested in H4 for moderately offensive odours is an hourly mean odour concentration of 3.0 ou_E/m^3 at the 98th percentile.

The EA, in the H4 guidance, recommends that a minimum of three years, and preferably five years, should be used to calculate the 98th percentile of the hourly mean odour concentrations, in order to represent conditions for an "average year". ADAS has used the 98th percentile of the hourly mean odour concentrations over a five year period to provide statistically robust results, smoothing out inter-annual variations as set out in the H4 guidance.

2.5 Irish Environmental Protection Agency

The Environmental Protection Agency (the EPA) commissioned research and subsequently set benchmarks of 3 and 6 ou_E/m^3 for existing and new intensive livestock units respectively. Subsequently researchers at the University of Dublin (Hayes et al) determined that even the 6 ou_E/m^3 EPA level advocated by the EPA was precautionary and that adverse impacts would be avoided at odour exposures up to 9.7 ou_E/m^3.

2.6 Suggested Odour Benchmarks for this Study

ADAS has generally found that a range of odours, including those from agricultural and organic waste sources are unlikely to cause adverse impacts with annual 98th percentile odour concentrations of less than 5.0 ou_E/m^3 over a five year period. However, once exposure exceeds 5.0 ou_E/m^3 at the annual 98th percentile, then there is an increasing risk of annoyance and complaints and at impacts above 10.0 ou_E/m^3 (as an hourly mean at the annual 98th percentile), then some complaint could normally be expected. The Courts have recognised that odour "tolerance" is affected by the character of the area (e.g. Hirose Electrical vs Peak Ingredients) and in this case the area around the proposed development is rural in character and there is no history of odour complaints or adverse impact from the existing poultry buildings. It is also noted that planning inspectors have also accepted this range of impact standards in appeal cases involving moderately offensive odours.

Odours from an agricultural source are commonly placed in the moderately offensive category and that would seem to be the most appropriate H4 benchmark in this case. The target suggested in H4 for moderately offensive odours is an hourly mean odour concentration of 3.0 ou_E/m^3 at the 98th percentile.

As a compromise between the various impact standards and planning inspectorate decisions, and taking account of the range and types of odour emissions rates and the character of the area, an hourly mean odour concentration range from 3.0 ou_E/m^3 to 5.0 ou_E/m^3 (at the 98th percentile) is used in this study as a guideline to assess the range above which some loss of residential amenity may start to occur.

It should be noted that the prediction that any particular property lies above the guideline concentration does not necessarily imply that a loss of residential amenity (or a nuisance) will follow. However, it is suggested that the probability of such an occurrence is increased in proportion to the exceedance of the guideline.

2.7 Quantification of Odour Emissions

Odour emission rates from poultry houses depend upon the odour concentration within the houses and the rate of extract ventilation emitted to the outside atmosphere. Internal odour concentrations depend upon many factors including the number and weight of the birds housed, building design and litter management, and the methods of provision of feed and drinking water. The minimisation of odour production is addressed by Defra in Section 4 of its Code of Good Agricultural Practice (Defra, 2009a) in which paragraphs 229 and 319 to 328 are especially relevant.

Odour emission rates from poultry houses depend on many factors and are highly variable. When only minimum ventilation is required the odour emission rate may be relatively small, but in hot weather ventilation requirements and odour emission rates increase.

In one of the existing poultry houses, manure collects within the house (a so-called deep pit arrangement) and is cleared at the end of the flock cycle, which is approximately once per year. In the other existing house and the proposed poultry house, manure from the birds is/would be collected continuously using a belt collection system. The manure is then/would then be stored temporarily prior to removal from the site, usually twice weekly. Odour production from this type of system is much lower than in more traditional egg laying houses where manure collects and is stored on or underneath the flooring over many months.

The chickens would have access to a ranging area and a small proportion of total emissions of odour will arise from the manure deposited on the ranging area.

Peak odour emission rates from deep-pit poultry housing may occur when the housing is cleared of manure at the end of each crop. This is the situation with the more traditional of the existing houses in which manure collects within the house throughout the flock cycles and emissions, from this house at clearing, may be several times greater than normal emissions from the housing, however, this event will occur less than once each year and it is a short duration event, and therefore of little significance in relation to long term odour impact

The belt-cleaned existing house and the proposed poultry house is/would be cleaned between flocks, because the manure is constantly removed via the belt system, at Rhosddu Farm peak emissions during cleaning do not/would not occur to the same extent for these houses.

Natural Resources Wales (NRW) have suggested precautionary odour emission rates for laying hens in this case and these are 0.47 ou_E/bird-place/s for hens in houses with belt collection of manure and 0.94 ou_E/bird-place/s for hens in houses where manure collects within the house of the lifetime of the flock. These emission rates are derived from a spring time emission rates detailed in Hayes *et al.* 2006. It has also been suggested by NRW that these emission factors should be used for all seasons under the assumption that summer emissions may be higher and winter emissions lower.

At Rhosddu Farm, the chickens have, or would have, access to a ranging area. The emissions from the ranging areas are assumed to be 20% of the emissions from the housing; thus an emission rate of 0.25 ou_E/bird/s has been used to calculate this figure and the emission is assumed to be continuous with no diurnal, seasonal, or temperature dependent variations. N.B. This emission is additional to the housing, is probably quite precautionary and is also intended to account for any fugitive emissions from the pop holes that allow the birds' access to the ranging area that might occur when ventilation rates are low. In reality droppings deposited outside will be exposed to aerobic conditions which will minimise emissions as the isolated individual dropping will dry and/or be washed into the ground, depending on weather conditions.

Table 1a. Summary of odour emission rates from the poultry house in which manure collects

Emission rate (ou_E/bird/s)				
Season	Average	Night-time Average	Day-time Average	Maximum
Winter	0.94	0.94	0.94	0.94
Spring	0.94	0.94	0.94	0.94
Summer	0.94	0.94	0.94	0.94
Autumn	0.94	0.94	0.94	0.94

Table 1b. Summary of odour emission rates from the poultry houses with belt cleaning

Emission rate (ou_E/bird/s)				
Season	Average	Night-time Average	Day-time Average	Maximum
Winter	0.47	0.47	0.47	0.47
Spring	0.47	0.47	0.47	0.47
Summer	0.47	0.47	0.47	0.47
Autumn	0.47	0.47	0.47	0.47

3 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, 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 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) and data from the meteorological recording station at Lake Vyrnwy.

The GFS is a spectral model and data are archived at a horizontal resolution of 0.5 degrees (approximately 50 km over the UK). The GFS resolution adequately captures major topographical features and the broad-scale characteristics of the weather over the UK. Smaller scale topological features may be included in the dispersion modelling by using the flow field module of ADMS (FLOWSTAR). The use of NWP data has advantages over traditional meteorological records because:

- Calm periods in traditional records may be over represented, this is 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.

Although the meteorological recording station at Lake Vyrnwy is only a few kilometres from Rhosddu Farm, it is at a higher altitude and does not have a similar aspect to Rhosddu Farm; but, of available metrological stations it probably provides the “best” available representation of the weather around Rhosddu Farm. However, it should be noted that the frequency of winds from a particular direction in the Lake Vyrnwy data may be either high or low in comparison to what might occur at Rhosddu Farm, which means mean concentrations downwind may be either over or under predicted. In particular, in this case, the relatively low frequency of north-westerly and south-easterly winds at Lake Vyrnwy may be of concern. Additionally, periods of light winds and calms cannot be properly modelled, which with low level and ground level sources means that in general predictions may be somewhat lower than would be obtained if calm conditions were considered. Therefore, the results obtained using the GFS data should be given more weight when interpreting the results of the modelling

A wind rose showing the distribution of wind speeds and directions in the GFS derived data is shown in Figure 3a.

Wind speeds are modified by the treatment of roughness lengths (see Section 4.7) and where terrain data is included in the modelling, wind speeds and directions will be modified. The terrain and roughness length modified wind rose for Rhosddu Farm is shown in Figure 3b. Note that elsewhere in the modelling domain, modified wind roses may differ markedly and that the resolution of the wind field in terrain runs is approximately 600 m.

The wind rose for Lake Vyrnwy is shown in Figure 3c.

Figure 3a. The wind rose. GFS derived data, for 51.119 N, 0.431 E, 2010 - 2013

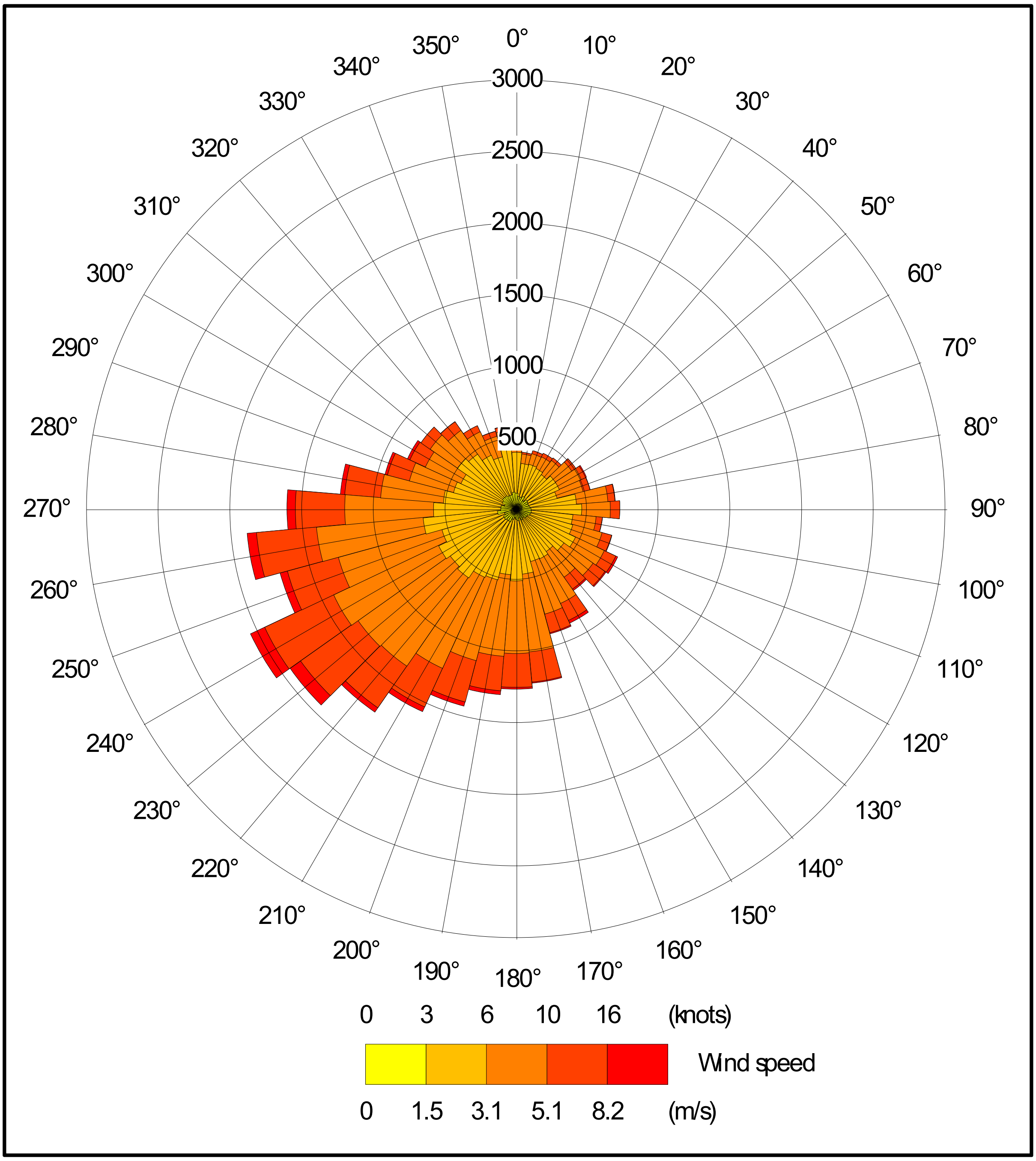


Figure 3b. The wind rose for the site of the proposed poultry unit derived from FLOWSTAR output

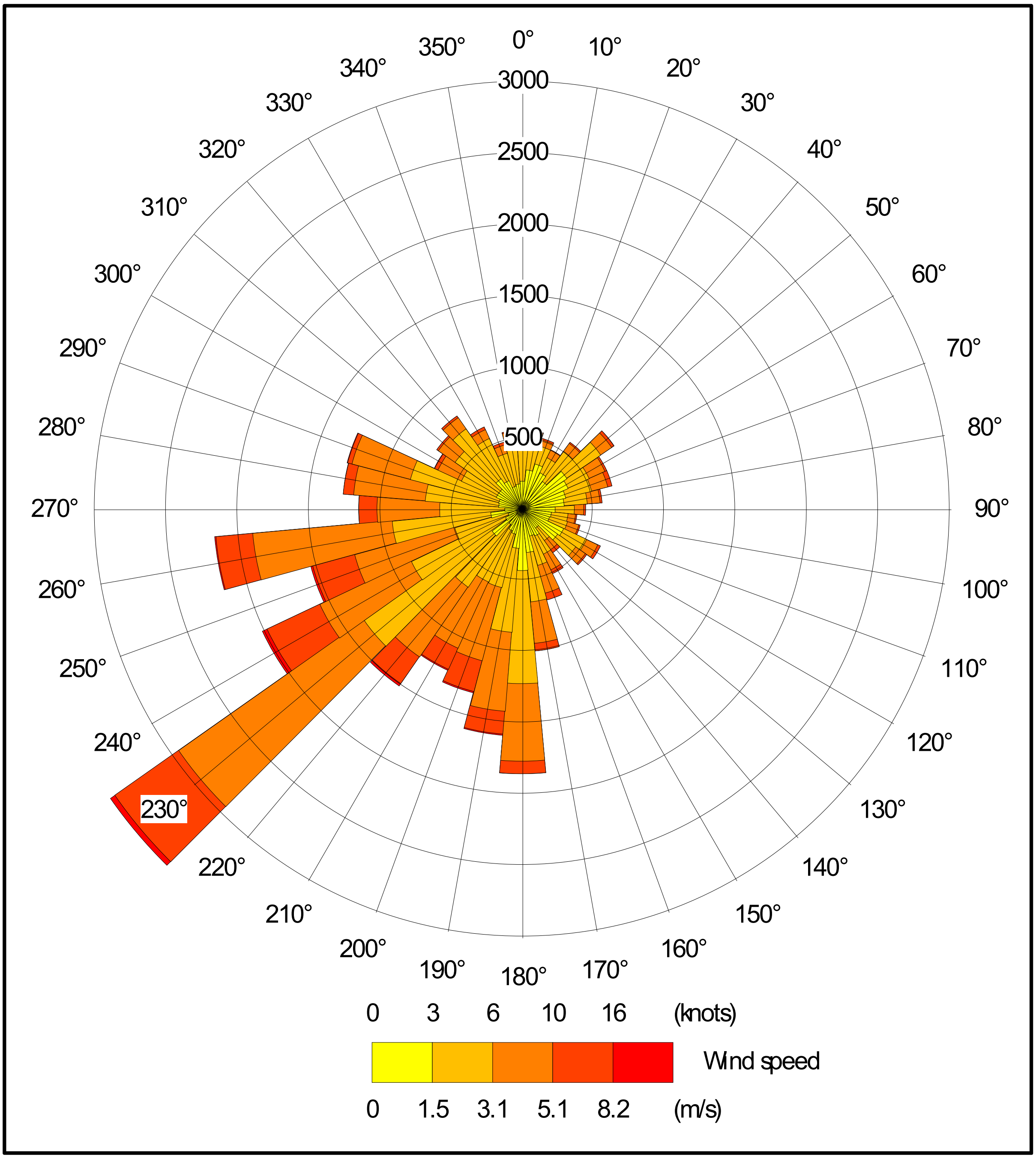
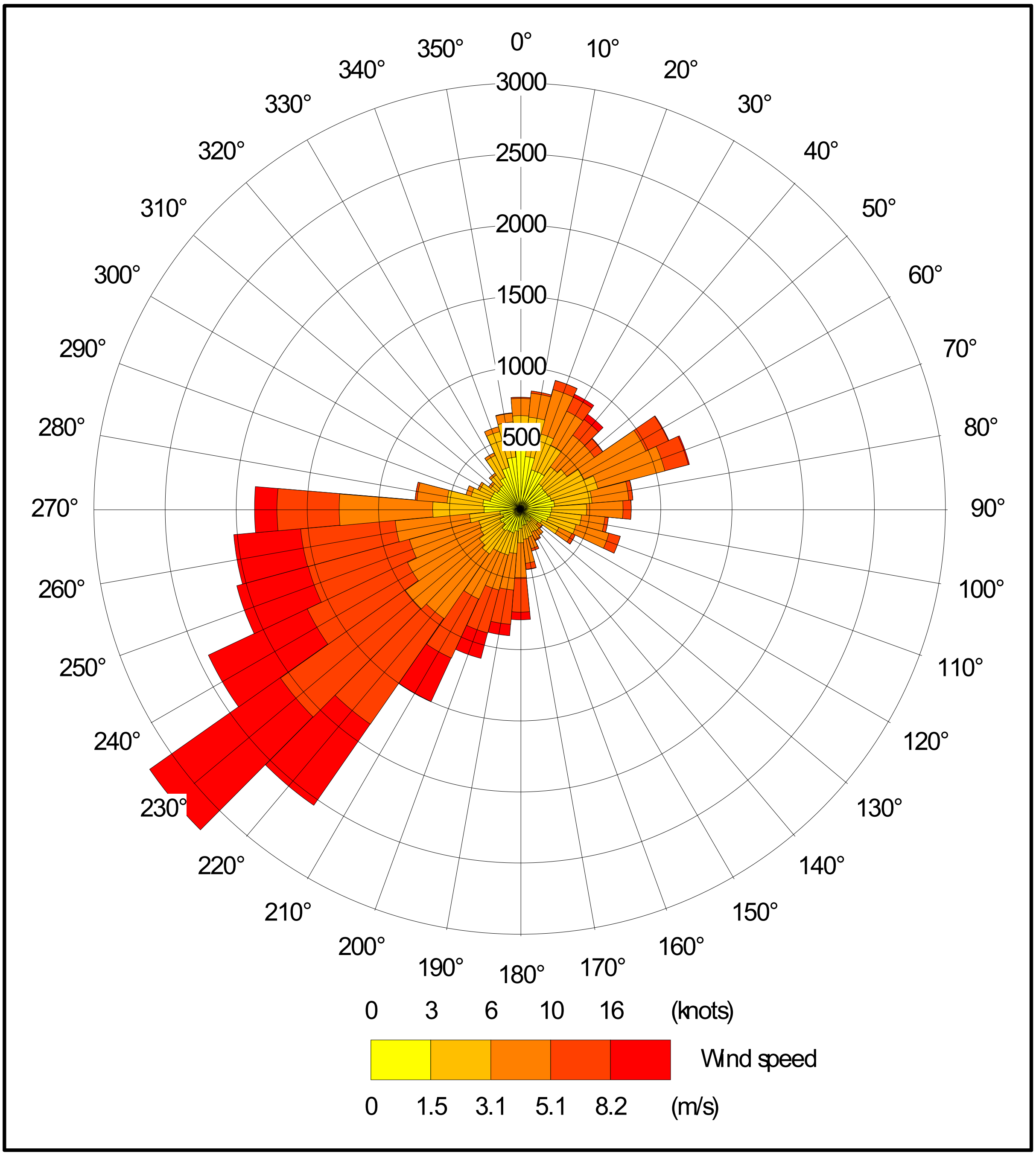


Figure 3c. The wind rose for Lake Vyrnwy



4.1 Emission sources

Emissions from the gable end wall fans of the poultry houses in the existing scenario are represented by a single volume source per house. Details of the volume source parameters are shown in Table 2a. The positions of the volume sources may be seen in Figure 4.

Table 2a. Volume source parameters

Source ID	Base Height (m)	Depth (m)	Volume (m^3)	Emission temperature (°C)	Emission rate (ou_E/s)
EX1_v	2.5	3.0	6202.2	Ambient	15,040
EX2_v	1.8	3.0	3920.4	Ambient	7,520
PR1_v	0.5	3.0	6545.1	Ambient	11,280

1. Dependant on ambient temperature

Emissions from the ranging areas are represented by area sources within ADMS. N.B. The area sources cover the parts of the range most likely to be used frequently, not the whole ranging area. Details of the area source parameters are shown in Table 2b. The positions of the area sources may be seen in Figure 4.

Table 2b. Area source parameters

Source ID	Height (m)	Area (m^2)	Emission temperature (°C)	Emission rate per source (ou_E/s)
EX1_RAN	0.0	5652.7	Ambient	800
EX2_RAN	0.0	4422.4	Ambient	800
PR1_RAN	0.0	11162.9	Ambient	1,200

Emissions from the chimneys of the uncapped high speed ridge fans that would be used to ventilate the existing (poultry shed under the proposed improvement scenario) and proposed poultry houses in the proposed scenario are represented by three point sources per house within ADMS. Details of the point source parameters are shown in Table 2c. The positions of the point sources may be seen in Figure 4a.

Table 2c. Point source parameters

Source ID	Height (m)	Diameter (m)	Efflux velocity (m/s)	Emission temperature (°C)	Emission rate per source (ou_E/s)
EX1 a, b & c	5.60	0.8	11.0	22.0	5,013.33
EX2 a, b & c	5.10	0.8	11.0	22.0	2,506.67
PR1 a, b & c	5.85	0.8	11.0	22.0	3,760.00

4.2 Modelled buildings

The structure of the poultry houses may affect the odour plumes from the point sources. Therefore, the buildings are modelled within ADMS. The position of the modelled buildings may be seen in Figure 4a, where they are marked by grey rectangles.

4.3 Discrete receptors

Twenty-one discrete receptors have been defined at a selection of nearby residences and commercial properties. The receptors are defined at 1.5 m above ground level within ADMS and their positions may be seen in Figure 5, where they are marked by enumerated pink rectangles.

4.4 Nested Cartesian grid

To produce the contour plots presented in Section 5 of this report, a nested Cartesian grid has been defined within ADMS. The grid receptors are defined at 1.5 m above ground level within ADMS. The positions of the receptors may be seen in Figure 5 where they are marked by green crosses.

Figure 4. The positions of area/volume modelled sources

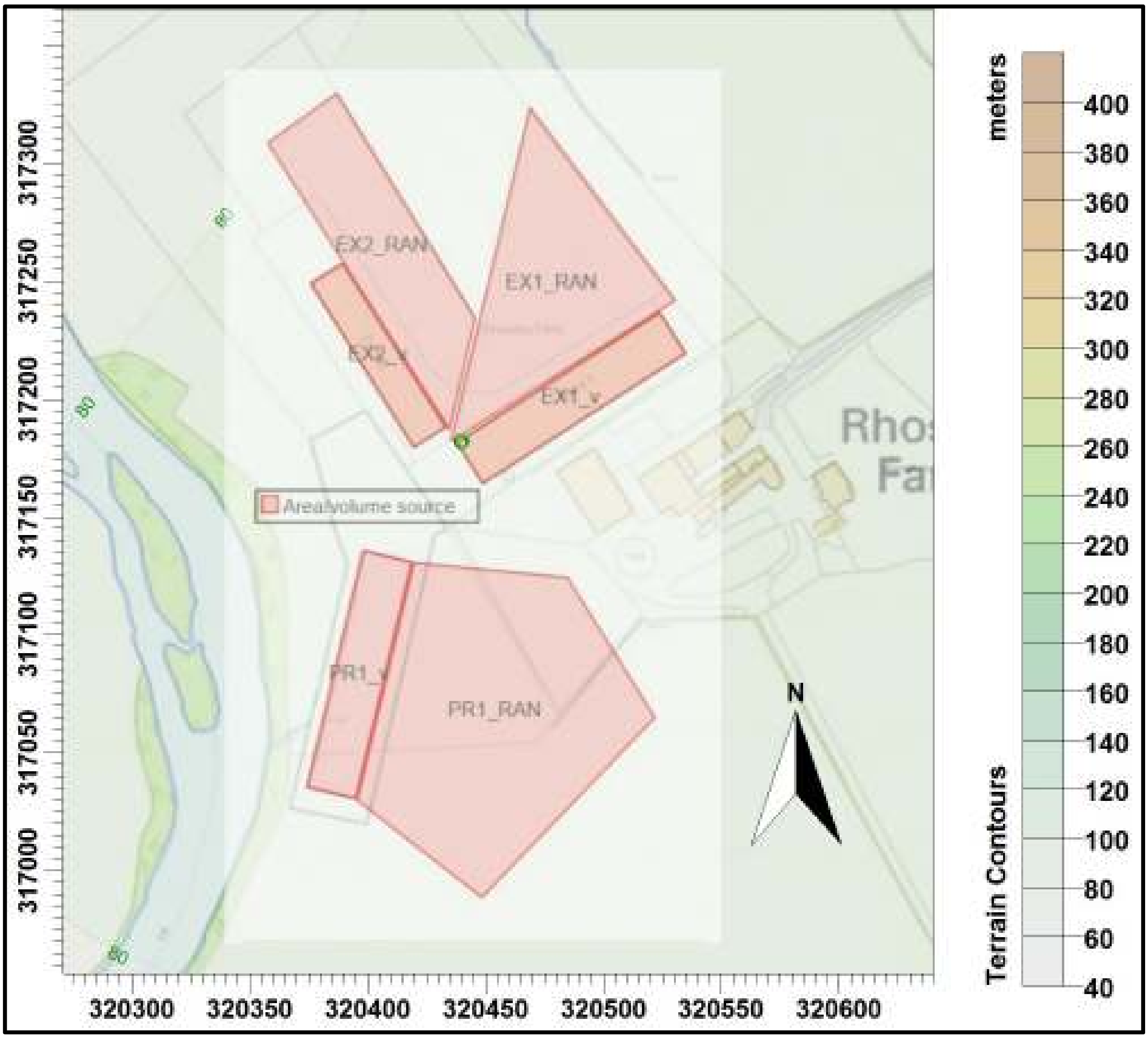
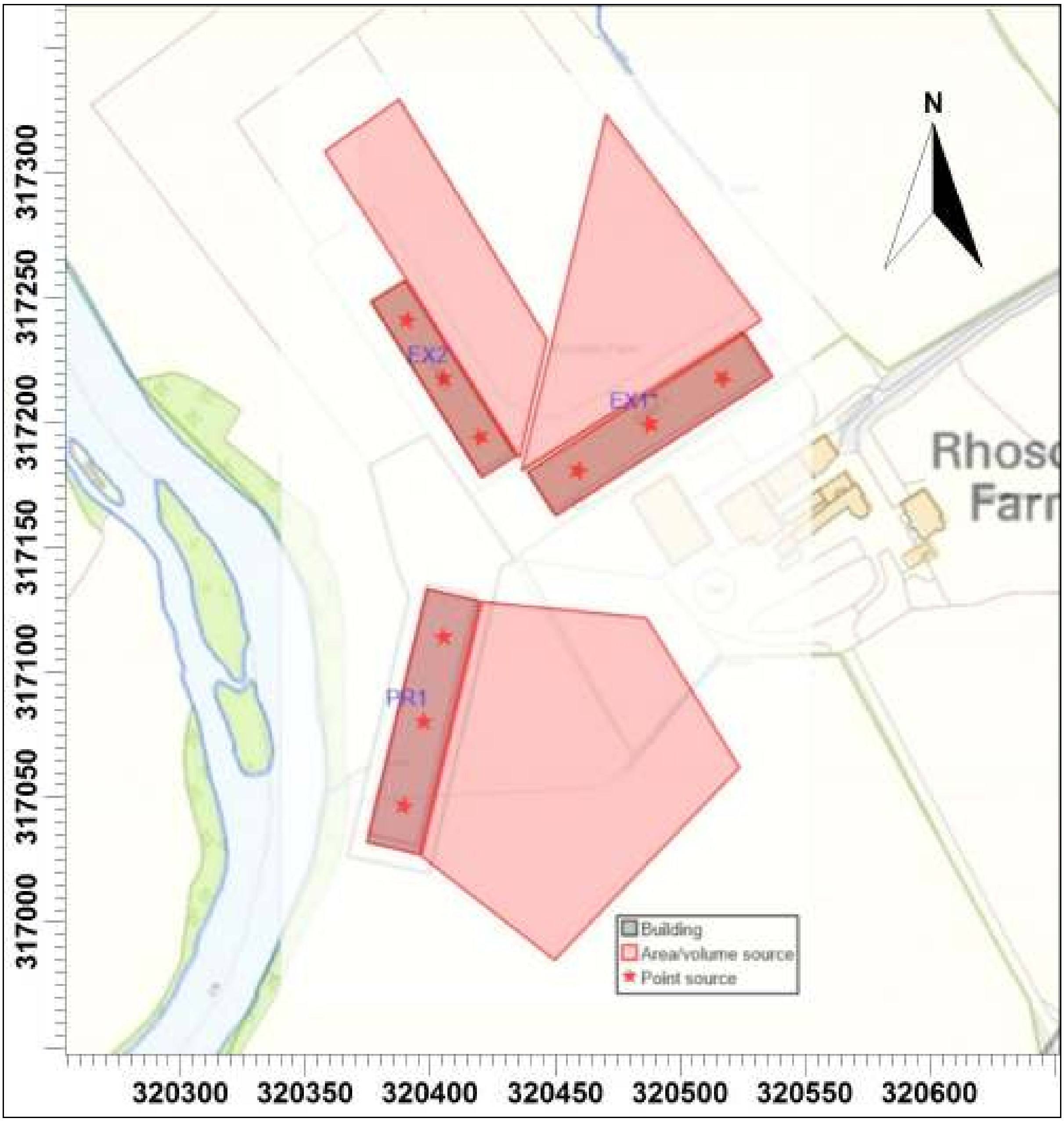


Figure 4a. The positions of modelled point sources



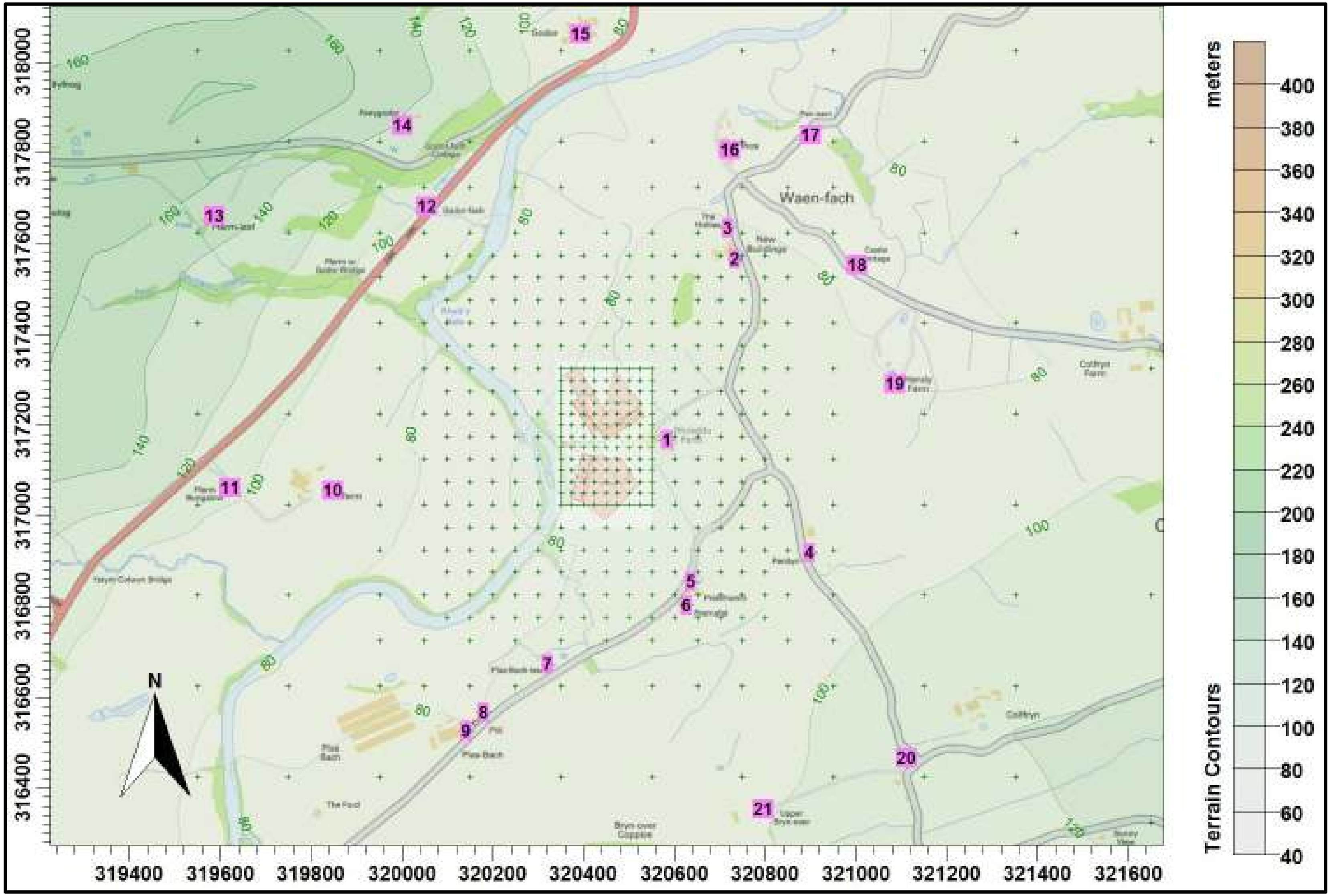
4.5 Terrain data

Terrain has been considered in the modelling. The terrain data are based upon the Ordnance Survey 50 m Digital Elevation Model. A 6.4 km x 6.4 km domain has been resampled at 50 m horizontal resolution for use within ADMS. N.B. The resolution of FLOWSTAR is 32 x 32 grid points; therefore, the effective resolution of the wind field for the terrain runs is 200 m.

4.6 Other model parameters

A fixed surface roughness length of 0.2 m has been applied over the entire modelling domain. As a precautionary measure, the GFS meteorological data is assumed to have a roughness length of 0.067 m. The effect of the difference in roughness length is precautionary as it increases the frequency of low wind speeds and the stability and therefore increases predicted ground level concentrations.

Figure 5. The discrete receptors and nested Cartesian grid receptors.



5 Details of the Model Runs and Results

Two scenario have been modelled. Scenario A (Existing Scenario) considers only the existing two builds with low level gable end wall fans.

Scenario B (Future Improved) considers the impact of the proposed new building plus the "improved" existing buildings with high level fan stacks on all three sheds.

For this study ADMS was run in four modes:

- In basic mode without calms, or terrain – GFS data.
- With calms and without terrain – GFS data.
- Without calms and with terrain – GFS data.
- In basic mode without calms, or terrain – Lake Vyrnwy data.

For each scenario (A & B) ADMS was run a total of sixteen times (once for each year of the four year meteorological record, in each of the four modes). Statistics for the annual 98th percentile hourly mean odour concentration at each receptor were compiled for each of the sixteen runs.

A summary of the results of these sixteen runs at the discrete receptors is shown in Table 3A (existing) and Table 3B (proposed) where the 5-year average annual 98th percentile hourly mean odour for each mode is shown. Results are reported as 5-year long term averages as set out in Appendix 3 of the 2011 H4 Odour guidance. ("*To represent conditions for an "average year" hourly meteorological data for a period of at least three, preferably five years should be used. Data can be sourced from the following sources*.")

As a sensitivity analysis maximum annual mean impact data is also included in Tables 4A and 4B along with contour plots of the maximum annual 98th percentile hourly mean odour concentration are shown in Figure 6a (existing) and Table 6b (proposed). N.B. These contour plots are the maximum of all GFS modes.

Table 3A. Predicted 5-year average annual 98th percentile hourly mean odour concentrations at the discrete receptors for the Existing Scenario

Receptor number	X(m)	Y(m)	Maximum annual 98th percentile hourly mean odour concentration - Existing (ou_E/m^3)			
			GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vyrnwy No Calms No Terrain
1	320584	317168	18.54	19.83	19.00	23.82
2	320733	317567	2.53	3.61	2.65	1.99
3	320717	317634	2.09	3.04	2.18	1.53
4	320898	316918	2.12	2.99	2.47	2.01
5	320636	316854	3.43	4.68	3.63	8.33
6	320626	316803	2.73	4.06	3.07	7.94
7	320322	316673	1.36	2.51	3.07	5.14
8	320179	316566	0.82	1.68	2.37	2.54
9	320141	316525	0.70	1.48	2.16	2.13
10	319848	317056	1.00	1.93	0.66	1.32
11	319622	317061	0.64	1.21	0.31	0.66
12	320055	317683	1.07	1.86	0.78	0.22
13	319587	317661	0.61	1.07	0.22	0.30
14	320001	317860	0.63	1.20	0.37	0.12
15	320394	318062	0.71	1.18	1.00	0.26
16	320723	317806	1.16	1.90	1.35	0.81
17	320900	317839	0.99	1.54	1.19	0.79
18	321002	317553	1.38	2.04	1.96	1.01
19	321086	317292	2.04	2.53	2.55	1.69
20	321110	316466	0.82	1.22	0.93	0.81
21	320795	316353	0.72	1.24	0.80	2.59

Table 3B. Predicted 5-year average annual 98th percentile hourly mean odour concentrations at the discrete receptors for the Proposed Scenario

Receptor number	X(m)	Y(m)	Mean annual 98th percentile hourly mean odour concentration - Proposed (ou_E/m^3)			
			GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vyrnwy No Calms No Terrain
1	320584	317168	3.00	3.19	2.92	3.31
2	320733	317567	1.24	1.22	1.39	0.94
3	320717	317634	1.07	1.05	1.18	0.78
4	320898	316918	0.92	0.91	0.82	0.82
5	320636	316854	1.35	1.33	1.33	1.58
6	320626	316803	1.19	1.17	1.17	1.65
7	320322	316673	0.73	0.73	1.07	1.31
8	320179	316566	0.47	0.48	0.91	0.78
9	320141	316525	0.41	0.41	0.83	0.69
10	319848	317056	0.69	0.67	0.55	0.70
11	319622	317061	0.45	0.44	0.27	0.45
12	320055	317683	0.64	0.63	0.41	0.19
13	319587	317661	0.40	0.39	0.19	0.20
14	320001	317860	0.45	0.45	0.22	0.12
15	320394	318062	0.49	0.48	0.44	0.22
16	320723	317806	0.74	0.73	0.91	0.50
17	320900	317839	0.64	0.63	0.93	0.43
18	321002	317553	0.84	0.83	1.00	0.59
19	321086	317292	0.90	0.88	0.89	0.73
20	321110	316466	0.44	0.43	0.40	0.26
21	320795	316353	0.40	0.39	0.42	0.68

Table 4A. Predicted maximum annual 98th percentile hourly mean odour concentrations at the discrete receptors for the Existing Scenario

Receptor number	X(m)	Y(m)	Maximum annual 98th percentile hourly mean odour concentration - Existing (ou_E/m^3)			
			GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vyrnwy No Calms No Terrain
1	320584	317168	21.62	22.07	22.32	26.28
2	320733	317567	2.91	3.94	3.00	2.59
3	320717	317634	2.35	3.12	2.44	2.03
4	320898	316918	3.38	3.67	3.77	2.35
5	320636	316854	4.69	5.31	5.33	10.29
6	320626	316803	3.34	4.36	3.87	10.34
7	320322	316673	2.07	2.85	4.73	6.19
8	320179	316566	1.25	2.11	3.96	2.86
9	320141	316525	1.09	1.87	3.77	3.14
10	319848	317056	1.56	2.24	1.02	1.73
11	319622	317061	1.07	1.44	0.50	1.01
12	320055	317683	1.36	2.10	0.94	0.34
13	319587	317661	0.91	1.27	0.27	0.47
14	320001	317860	0.87	1.51	0.44	0.18
15	320394	318062	1.09	1.53	1.90	0.29
16	320723	317806	1.23	2.00	1.43	1.05
17	320900	317839	1.14	1.63	1.36	1.05
18	321002	317553	1.68	2.23	2.35	1.09
19	321086	317292	2.27	2.73	2.77	2.80
20	321110	316466	1.53	1.62	1.74	1.38
21	320795	316353	0.87	1.33	0.97	3.36

Table 4B. Predicted maximum annual 98th percentile hourly mean odour concentrations at the discrete receptors for the Proposed Scenario

Receptor number	X(m)	Y(m)	Mean annual 98th percentile hourly mean odour concentration - Proposed 2 (ou_E/m^3)			
			GFS No Calms No Terrain	GFS Calms No Terrain	GFS No Calms Terrain	Lake Vyrnwy No Calms No Terrain
1	320584	317168	3.09	3.29	3.03	3.52
2	320733	317567	1.32	1.28	1.45	1.07
3	320717	317634	1.12	1.10	1.18	0.88
4	320898	316918	1.00	0.99	0.91	0.89
5	320636	316854	1.70	1.65	1.66	1.92
6	320626	316803	1.46	1.44	1.41	1.84
7	320322	316673	0.84	0.82	1.26	1.41
8	320179	316566	0.59	0.58	1.03	1.02
9	320141	316525	0.51	0.50	0.92	0.97
10	319848	317056	0.93	0.89	0.70	0.78
11	319622	317061	0.63	0.61	0.35	0.55
12	320055	317683	0.75	0.74	0.44	0.25
13	319587	317661	0.47	0.44	0.21	0.25
14	320001	317860	0.53	0.53	0.25	0.16
15	320394	318062	0.56	0.55	0.50	0.26
16	320723	317806	0.78	0.76	1.00	0.56
17	320900	317839	0.69	0.68	0.98	0.45
18	321002	317553	0.88	0.87	1.05	0.63
19	321086	317292	0.94	0.91	0.92	0.83
20	321110	316466	0.57	0.56	0.51	0.28
21	320795	316353	0.46	0.44	0.49	0.80

*Figure 6A. Predicted maximum annual 98th percentile hourly mean odour concentration in the area surrounding Rhosddu Farm –maximum of all GFS modes-**Existing Scenario***

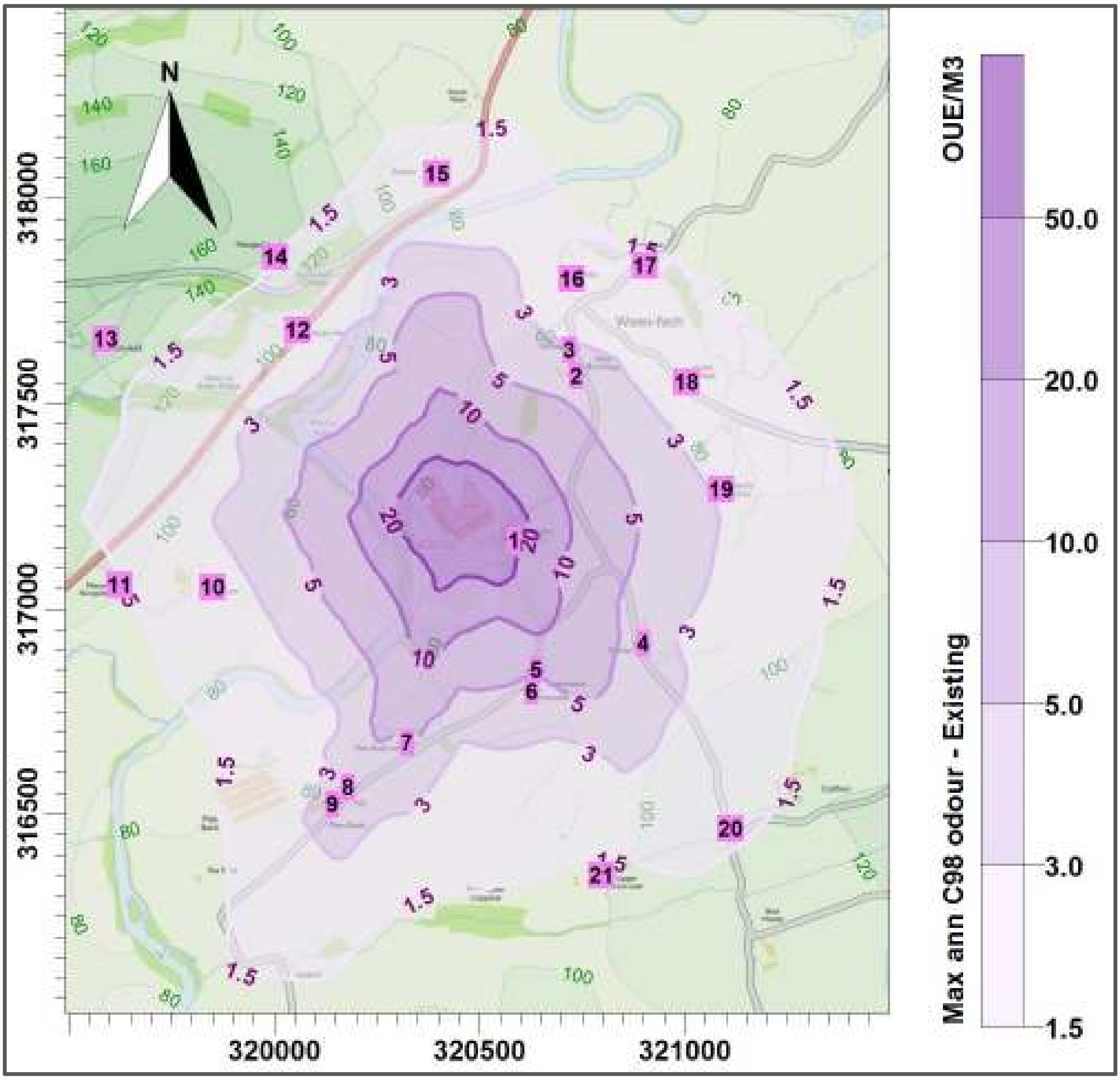
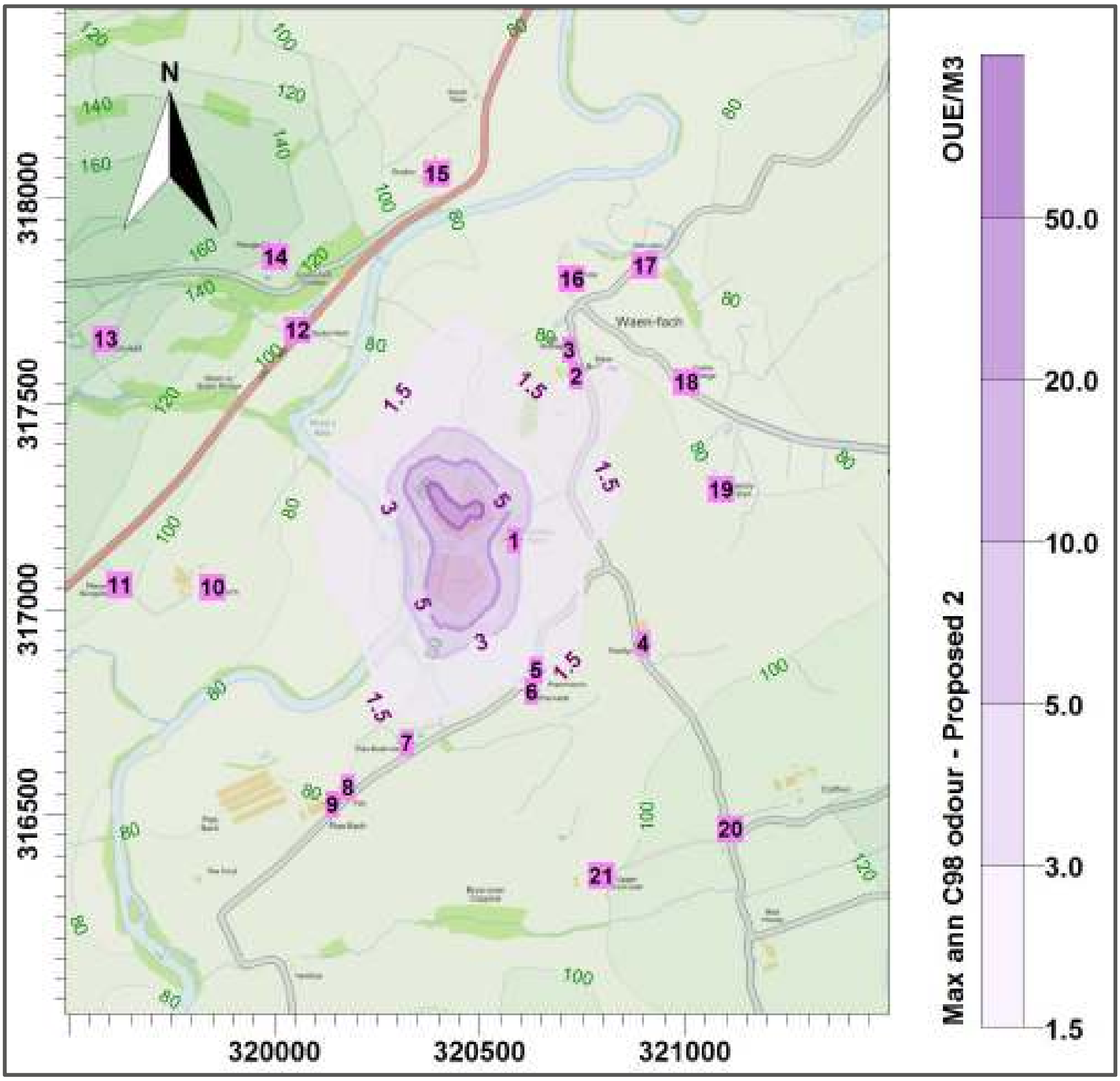


*Figure 6B. Predicted maximum annual 98th percentile hourly mean odour concentration in the area surrounding Rhosddu Farm –maximum of all GFS modes-**Proposed Scenario***



6 Summary and Conclusions

ADAS has been commissioned by Mr Martyn Langford of the to use computer modelling to assess the impact of odour emissions from two existing buildings and a proposed new free range egg laying building at Rhosddu Farm, Llansantffraid-ym-mechain, Powys. SY22 6TH.

Odour emission rates from the existing and proposed poultry unit have been assessed and quantified based on emission rates suggested by Natural Resources Wales. The odour emission rates obtained have then been used as inputs to an atmospheric dispersion model which calculates odour exposure levels in the surrounding area.

The long term average modelling results (Table 3A) for the Existing Scenario suggests that predicted odour concentrations at receptors 1 and a number of other receptors are in excess of the suggested benchmark range of 3 to 5 ou_E/m^3 and/or in excess of the Environment Agency's benchmark for moderately offensive odours (3.0 ou_E/m^3). Despite this there have been no reports of complaints and no objections to the planning application for the new building. This suggests that the 3 to 5 ou_E/m^3 impact criterion is suitable precautionary.

The long term average modelling results (Table 3B) for the Proposed Scenario shows that predicted odour concentrations at receptors 1 and all other receptors would be lower than currently and in the case of Receptor 1 would be significantly lower. There are no exceedances of the suggested benchmark range of 3 to 5 ou_E/m^3 and only very minor exceedances of the Environment Agency's benchmark for moderately offensive odours (3.0 ou_E/m^3) at Receptor 1 with two of the four terrain/weather combinations.

The results for the proposed scenario therefore demonstrate a marked improvement in off-site odour impacts in comparison with the existing scenario.

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